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ASSOCIATION EUROPÉENNE DES CONSTRUCTEURS DE POMPES
EUROPÄISCHE VEREINIGUNG DER PUMPENHERSTELLER



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EUROPUMP-Guideline

for the application of EC-Directive 94/9/EC

**„Equipment and protective systems intended for use in
potentially explosive atmospheres“**

in respect to pumps and pump units

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1 Foreword

EUROPUMP is the European Association of Pump Manufacturers. EUROPUMP consists of seventeen national industry associations of pump manufacturers in Europe: AFCP (F), Asociacion Espanola (E), ASSOPOMPE (I), BPMA (UK), CPMA (CZ), FABRIMETAL (B), Fachverband der Maschinen- und Stahlbauindustrie Österreich (A), FIMET (FIN), Foreningen of Danske Pumpefabrikante (DK), Holland Pump Group (NL), NVS (N), RPMA (RUS), SLOVPOMP (SK), Swedish Pump Supplier's Association (S), Union of Greek Metal Industry (GR), VDMA (D) and VSM (CH). Within the EU, the member associations represent more than 400 enterprises with a collective annual production worth more than 6 billion ECU's.

This EUROPUMP-Guideline has been established by EUROPUMP Standards Commission.

2 Introduction

Hazards derived from ignition sources in environments that may be explosive have been recognised for many years. Formal requirements have been derived for electrical equipment, and experience has led to local or industry related requirements for mechanical or other hazards.

Electrical hazards have been reduced by the use of design standards and by different certification schemes. Non-electrical hazards are sometimes covered by legally enforceable requirements such as those concerning underground mining or gasoil pipelines. Others have been imposed by contract by national and commercial undertakings.

In order to achieve cross-border recognition of these hazard reduction arrangements and so to encourage cross-border trade, the member states of the EU have agreed essential safety requirements for equipment intended to be used in potentially explosive atmospheres. Conformity to these requirements is indicated by a CE marking, and member states may not hinder the sale of such equipment within their territories. These essential requirements cover potential sources of electrical and non-electrical explosive hazards.

The European Commission has published Directive 94/9/EC which is an instruction to bring local law into approximate agreement with the contents of the Directive (often referred to as the ATEX-Directive).

The EC DIRECTIVE 94/9/EC came into force on 1. March 1996 but with a transition period until 30. June 2003.

This EUROPUMP-Guideline is intended to give guidance to pump manufacturers for application of the EC DIRECTIVE 94/9/EC for pumps and pump units.

3 Scope and field of application

3.1 Scope

The EC Directive 94/9/EC applies to equipment*, protective systems and components intended for use in potentially explosive atmospheres.

The main change in the EC DIRECTIVE 94/9/EC is that non-electrical hazards are now brought within the scope of the Directive. Where there had been some legal cover previously referring to these hazards, the change should make little difference to a manufacturer. Where previous practice was to apply experience or industry based requirements there may be more significant impact on design procedures. In all cases, the application of the EC Directive 94/9/EC will lead to more voluminous and more accurate record holding. This is particularly so where a third party becomes introduced for purposes of conformity assessment. However, the general shape of the essential requirements and of the conformity assessment is similar to that of other probably relevant Directives (Regulations) with which pump equipment needs to conform.

The scope of this guideline is restricted to pumps and pump units falling under group II, category II

3.2 Excluded equipment

EC-Directive 94/9/EC - Directive specifically identifies excluded equipment which may include some types of pumps. Pump manufacturers will need to examine the areas of applicability and exclusions before determining whether or not the product is subject to the EC Directive 94/9/EC. It will then be necessary to categorise the product by level of hazard/risk. Finally, the requirements and the route to assessment need to be considered and the preferred solutions implemented.

Equipment intended for the following purposes are not subject to the EC Directive 94/9/EC (§ 1, Art. 1 (4)):

- medical devices intended for use in a medical environment;
- equipment and protective systems where the explosion hazard results exclusively from the presence of explosive or chemically unstable substances;
- equipment intended for use in domestic and non-commercial environments where potentially explosive atmosphere may only rarely be created, solely as a result of the accidental leakage of a fuel gas;
- personal protective equipment subject to other Directives;
- seagoing vessels and mobile offshore units together with equipment on board such vessels or units;
- means of transport for goods or people other than vehicles intended for use in explosive atmospheres;
- equipment for military purposes.

* Wherever the term „equipment“ is used in the text of this guideline the reader should be reminded, that all recommendations and interpretations made in this guideline are referring to pumps and pump units.

4 Normative references

In addition to the common requirements of EN 809 specific requirements of hazardous locations are given in:

EN 1127-1: Explosive atmospheres - Explosion prevention and protection - Part 1: Basic concepts and methodology

prEN 13463: Non-electrical equipment for potentially explosive atmospheres - Part 1: Basic methodology and requirements

prEN 13463: Non-electrical equipment for potentially explosive atmospheres - Part 2: Protection by flow restricting enclosure `fr`

prEN 13463: Non-electrical equipment for potentially explosive atmospheres - Part 3: Protection by flameproof enclosure

prEN 13463: Non-electrical equipment for potentially explosive atmospheres - Part 4: Protection by inherent safety

prEN 13463: Non-electrical equipment for potentially explosive atmospheres - Part 5: Protection by constructional safety

prEN 13463: Non-electrical equipment for potentially explosive atmospheres - Part 6: Protection by control of ignition sources

prEN 13463: Non-electrical equipment for potentially explosive atmospheres - Part 7: Protection by pressurization

prEN 13463: Non-electrical equipment for potentially explosive atmospheres - Part 8: Protection by liquid immersion

For definitions see Appendix A of this guideline.

5 Equipment-groups and equipment categories

Equipment intended for use in potentially explosive atmospheres is divided into groups and categories which relate to the degree of protection. The divisions are shown in Table 1:

Table 1 — Equipment groups and categories

Equipment-groups (Annex I of the EC-Directive 94/9/EC)							
Group I (mines, mine gas and dust)		Group II (other explosive atmospheres gas/dust)					
Category M		Category 1		Category 2		Category 3	
1	2	G (gas) (Zone 0)	D (dust) (Zone 20)	G (gas) (Zone 1)	D (dust) (Zone 21)	G (gas) (Zone 2)	D (dust) (Zone 22)
for equipment providing a very high level of protection when endangered by an explosive atmosphere	for equipment providing a high level of protection when likely to be endangered by an explosive atmosphere	for equipment providing a very high level of protection when used in areas where an explosive atmosphere is very likely to occur		for equipment providing a high level of protection when used in areas where an explosive atmosphere is likely to occur		for equipment providing a normal level of protection when used in areas where an explosive atmosphere is less likely to occur	

NOTE There may be special cases when pumps and pump units will fall under Group II, Category 1 or in Group I. For these cases additional measures are necessary however, the minimum requirements according to this guideline apply.

Pumps and pump units for use in potentially explosive atmospheres will normally be classified under Group II, Categories 2 and 3.

It is the responsibility of the user to classify the zone and the corresponding group (dust or gas) in accordance with the EC – Directive 1992/92/EC.

6 Criteria determining the classification of equipment-groups into categories

Annex I of the EC Directive 94/9/EC indicates the criteria determining the classification of equipment-groups into two parts, Equipment-group I and Equipment-group II.

6.1 Equipment-group I

6.1.1 Category M 1

Equipment in this category is intended for use in underground parts of mines as well as those parts of surface installations of such mines endangered by firedamp and/or combustible dust.

6.1.2 Category M 2

Equipment in this category is intended for use in underground parts of mines as well as those parts of surface installations of such mines likely to be endangered by firedamp and/or combustible dust.

6.2 Equipment-group II

6.2.1 Category 1

Equipment in this category is intended for use in areas in which explosive atmospheres caused by mixtures of air and gases, vapours or mists or by air/dust mixtures are present continuously, for long periods or frequently.

6.2.2 Category 2

Equipment in this category is intended for use in areas in which explosive atmospheres caused by gases, vapours, mists or air/dust mixtures are likely to occur.

6.2.3 Category 3

Equipment in this category is intended for use in areas in which explosive atmospheres caused by gases, vapours, mists or air/dust mixtures are unlikely to occur or, if they do occur, are likely to do so only frequently and for a short period only.

An example for classification of areas in which explosive atmospheres caused by gases, vapours, mists or air/dust mixtures may occur is given in Figure 1.

7 Requirements for equipment and protective systems

Essential health and safety requirements relating to the design and manufacturing of equipment and protective systems intended for use in potentially explosive atmospheres are given in Annex II of the EC-Directive 94/9/EC.

1. Common requirements for equipment and protective systems
2. Supplementary requirements in respect of equipment
3. Supplementary requirements in respect of protective systems

Equipment and protective systems intended for use in potentially explosive atmospheres shall be designed from the point of view of integrated explosion safety. If hazards due to mechanically induced sparks have been identified, special requirements for pumps and pump units shall comply with those mentioned in EN 1127-1: "Explosive atmospheres - Explosion prevention and protection - Part 1: Basic concepts and methodology". The use of aluminium, magnesium and similar materials should be avoided if possible.

In this connection, the manufacturer shall take measures:

- above all, if possible, to prevent the formation of explosive atmospheres which may be produced or released by equipment and by protective systems themselves;

NOTE: It may, in some cases, be necessary for the user to carry out a risk assessment to establish whether a risk could occur. The user has to confirm to the manufacturer if leakage, that might occur during operation with for example shaft seals, are acceptable.

- to prevent the ignition of explosive atmospheres, taking into account the nature of every electrical and non-electrical source of ignition;

- should an explosion nevertheless occur which could directly or indirectly endanger persons and, as the case may be, domestic animals or property, to halt it immediately and/or to limit the range of explosion flames and explosion pressures to a sufficient level of safety.

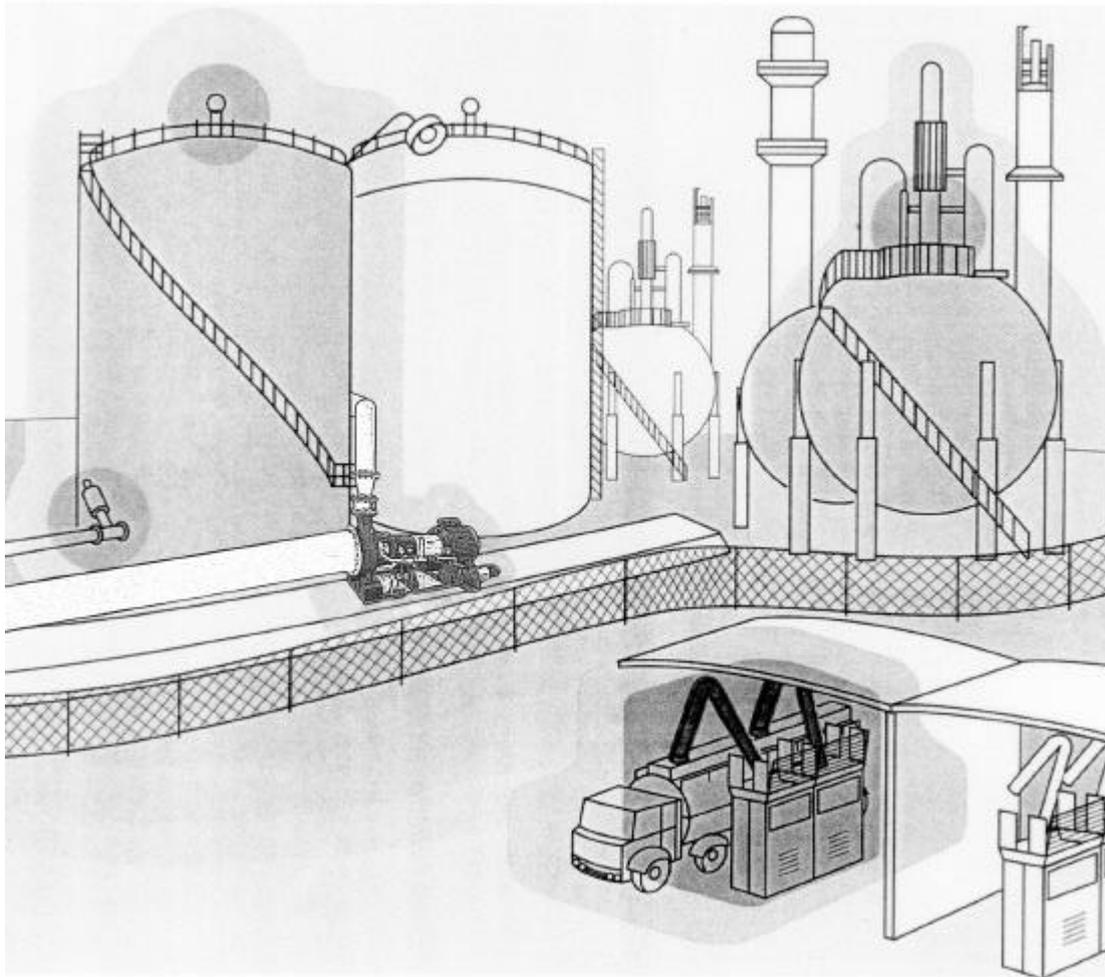


Figure 1 — Example for classification of explosive atmosphere areas

8 Measures to verify conformity

In general it is the pump manufacturer's responsibility to take those measures necessary to verify conformity to the EC-Directive 94/9/EC. This implies a risk assessment for the pump/pump unit and in some cases the procedure relating to product quality assurance.

For clarification the original text of the Directive 94/9/EC, chapter II, article 8 b,(ii) is added at this point..

...in the case of other equipment in these groups and categories, the manufacturer or his authorized representative established in the Community must, in order to affix the CE mark, follow the procedure relating to internal control of production (referred to in Annex VIII) and communicate the dossier provided for in Annex VIII, paragraph 3, to a notified body, which shall acknowledge receipt of it as soon as possible and shall retain it.

Appendix B of this guideline gives examples for a risk assessment relating to the use of rotodynamic pumps and pump units with shaft seal, magnetic drive, canned motor, submersible pumps and plastic pump as well as for positive displacement pumps (reciprocating and rotary) in potentially explosive atmospheres.

9 Documentation

9.1 Instructions (contents)

According to Annex I, 1.0.5, all equipment and protective systems shall be accompanied by instructions, including at least the following particulars:

- a recapitulation of the information with which the equipment or protective system is marked, except for the serial number, together with any appropriate additional information to facilitate maintenance (e.g.: address of the importer, repairer, etc.);
- instructions for safe:
 - putting into service,
 - intended use,
 - assembling and dismantling,
 - maintenance (servicing and emergency repair),
 - installation,
 - adjustment;
- electrical and pressure parameters, maximum surface temperatures and other limit values;
- where necessary, an indication of the danger areas in front of pressure-relief devices;
- where necessary, training instructions;
- details which allow a decision to be taken beyond any doubt as to whether an item of equipment in a specific category or a protective system can be used safely in the intended area under the expected operating conditions;
- where necessary, special conditions of use, including particulars of possible misuse which experience has shown might occur;(see TableXXX, Annex B, Example XX)
- where necessary, the essential characteristics of tools which may be fitted to the equipment or protective system.
- Mechanical ignition sources.

NOTE: Other literature (e.g. leaflets, booklets etc.) describing the equipment or protective system shall not contradict the instructions with regard to safety aspects.

9.2 Instruction's language

The instructions shall be drawn up in one of the Community languages by the manufacturer or his authorized representative established in the Community.

On being put into service, all equipment and protective systems shall be accompanied by a translation of the safety related instructions in the language or languages of the country in which the equipment or protective system is to be used and by the instructions in the original language.

This translation shall be made by either the manufacturer or his authorized representative established in the Community or the person introducing the equipment or protective system into the language area in question.

By way of derogation from this requirement, the maintenance instructions for use by the specialist personnel employed by the manufacturer or his authorized representative established in the Community may be drawn up in a single Community language understood by that personnel.

9.3 Drawings, diagrams

The instructions shall contain the drawings and diagrams necessary for the putting into service, maintenance, inspection, checking of correct operation and, where appropriate, repair of the equipment or protective system, together with all useful instructions, in particular with regard to safety.

10 Marking (CE, x)

According to Annex I, 1.0.5, of the EC–Directive 94/9/EC all pumps and pump units and their protective systems shall be marked legibly and indelibly with the following minimum particulars;

- name and address of the manufacturer,
- CE marking,
- designation of series or type,
- serial number, if any,
- year of construction,
- the specific marking of explosion protection Ex followed by the symbol of the equipment group and category,
- for equipment-group II, the letter 'G' (concerning explosive atmospheres caused by gases, vapours or mists), and/or the letter 'D' (concerning explosive atmospheres caused by dust),
- the temperature class

NOTE The maximum temperature of a pump depends on primarily on the pump liquid. Therefore it is recommended to give a range of allowable temperature classes. Details shall be given in the technical documentation.

Furthermore, where required, they shall also be marked with all information essential for their safe use (such as e.g. particular temperature limits).

11 EC-Declaration of conformity

11.1 General

All electrical equipment and components of category 2 need a certification by a notified body in form of the type-examination certificate.

According to the EC-Directive 94/9/EC the declaration of conformity has to be issued by the manufacturer/supplier of the pump. In case of a pump unit the declaration of conformity has to be issued with the documentation.

11.2 Contents

The EC declaration of conformity shall contain the following elements (Annex X, Part B of ATEX 100a):

- the name or identification mark and the address of the manufacturer or his authorized representative established within the Community;
- a description of the pump or pump unit, its protective system, or device referred to in Article 1 (2) of the EC-Directive 94/9/EC
- all relevant provisions fulfilled by the equipment, protective system, or device referred to in Article 1 (2) of the EC-Directive 94/9/EC
- where appropriate, the name, identification number and address of the notified body and the number of the EC-type-examination certificate
- where appropriate, reference to the harmonized standards
- where appropriate, the standards and technical specifications which have been used
- where appropriate, references to other Community Directives which have been applied
- identification of the signatory who has been empowered to enter into commitments on behalf of the manufacturer or his authorized representative established within the Community

Annex A — Definitions

The EC Directive 94/9/EC contains the following definitions (§ 1, Art. 1 (3)):

,equipment' — machines, apparatus, fixed or mobile devices, control components and instrumentation thereof and detection or prevention systems which, separately or jointly, are intended for the generation, transfer, storage, measurement, control and conversion of energy or the processing of material and which are capable of causing an through their own potential sources of ignition.

,protective systems' — design units which are intended to halt incipient explosions immediately and/or to limit the effective range of explosion flames and explosion pressures; protective systems may be integrated into equipment or separately placed on the market for use as autonomous systems.

,devices — safety devices, controlling devices and regulating devices intended to use outside potentially explosive atmospheres but required for or contributing to the safe functioning of equipment and protective systems with respect to the risks of explosion.

,component — any item essential to the safe functioning of equipment and protective systems but with no autonomous function.

,intended use — the use of equipment, protective systems, and devices in accordance with the equipment group and category and with all the information supplied by the manufacturer which is required for the safe functioning of equipment, protective systems and devices.

,explosive atmosphere — the mixture with air, under atmospheric conditions, of flammable substances in the form of gases, vapours, mists or dusts in which, after ignition has occurred, combustion spreads to the entire unburned mixture.

,potentially explosive atmosphere — an atmosphere which could become explosive due to local and operational conditions.

NOTE: Further definitions are given in EN 1127-1: Explosive atmospheres - Explosion prevention and protection - Part 1: Basic concepts and methodology and EN 50014: „Electrical apparatus for potentially explosive atmospheres - General requirements“.

Appendix B — Risk assessment relating to the use of pumps and pump units in potentially explosive atmospheres

The risk assessments given below are intended to give pump manufacturers guidance and should be considered as examples, only.

EXAMPLE 1.

Rotodynamic pump/rotary positive displacement pump with shaft sealing

Sources of hazards	Potential hazards	Frequency of hazards		Recommended measures
Unvented cavities	Build up of explosive gas		very rare	Ensure that pump is totally filled; operating manual
Casing/Impeller/Casing cover	Unintended mechanical contact		very rare	Ensure that pump is totally filled; operating manual
Pump external surfaces	Excess temperature Electrostatic charging	rare		User has to ensure temperature limits; operating manual Ground contact
gaskets	Pump liquid leakage Build up of explosive gas		very rare	Service plan (operator); operating manual
Pump casing/Casing cover	Leakage (if flammable)		very rare	Ductile material; corrosion resistant if applicable; operating manual
Shaft seal	Excess temperature Unintended mechanical contact pump liquid leakage (if flammable) Build up of explosive gas	rare rare rare	very rare	selection of seal system to be suitable for the particular application
Auxiliary system for shaft sealing	Pump liquid leakage Build up of explosive gas	rare		Auxiliary system to be suitable for the particular application operating manual
Rotation direction test	Excess temperature		very rare	Operating manual
Internal clearance/lantern ring/gland	Excess temperature Unintended mechanical contact		very rare	selection of seal system to be suitable for the particular application
Closed valve condition	Excess temperature; excess pressure		very rare	operating manual
Shaft	Random induced current		very rare	Ground contact
Antifriction bearing	Excess temperature (Loss of lubricant)	rare		Service plan (operator); operating manual
Mechanical coupling	Mechanical slipping/break-up		very rare	Nonsparking; operating manual
Guard	Mechanical contact	rare		Nonsparking; operating manual; impact test

Plastic parts (rotating contact) exposed to atmosphere	Electrostatic charge Friction, melting, burning		very rare	Service plan (operator); operating manual
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EXAMPLE 2.**Rotodynamic pump/rotary positive displacement pump with magnetic drive**

Sources of hazards	Potential hazards	Frequency of hazards		Recommended measures
Unvented cavities	Build up of explosive gas		very rare	Level control (pump and auxiliary systems); operating manual
Casing/Impeller/Casing cover	Unintended mechanical contact		very rare	Level control; operating manual
Pump external surfaces	Excess temperature Electrostatic charge	rare		Temperature control (operator); operating manual Ground contact
Sealing arrangements	Gas/liquid leakage	rare		Service plan (operator); operating manual
Internal clearance	Excess temperature Unintended mechanical contact		very rare	Level control; operating manual; nonsparking material
Closed internal liquid circuit	Excess temperature	rare		Temperature control at containment shell
Closed valve condition	Excess temperature; excess pressure		very rare	operating manual
Antifriction bearing	Excess temperature (loss of lubricant)	rare		Service plan (operator); operating manual
Mechanical coupling	Mechanical slipping/break-up		very rare	Nonsparking; operating manual
Guard	Mechanical contact	rare		Nonsparking; operating manual
Pump casing/Casing cover / pressure containing parts	Leakage (if flammable)		very rare	Ductile material; operating manual
Plastic parts (rotating contact) exposed to atmosphere	Electrostatic charge Deterioration due to heat		very rare	Service plan (operator); operating manual
Shaft	Random induced current		very rare	Ground contact
Pump liquid lubricated plain bearing	Excess temperature due to loss of lubrication		very rare	Level control; operating manual
Inner rotor/Shell clearance	Mechanical contact		very rare	Level control; operating manual
Containment shell (metallic)	Excess temperature (induced eddy current losses)		very rare	Level control; temperature control; operating manual
Decoupling of inner rotor (mag drive)	Excess temperature		very rare	Level control; operating manual Temperature control, power monitoring
Outer rotor / Secondary containment / Brackets	Mechanical contact		very rare	Non sparking material

EXAMPLE 3.

Rotodynamic pump with canned motor

Sources of hazards		Potential hazards	Frequency of hazards		Recommended measures
Unvented cavities		Build up of explosive gas		very rare	Level control (pump and auxiliary systems); operating manual
Casing/Impeller/Casing cover		Unintended mechanical contact		very rare	Level control; operating manual
Pump external surfaces (wet end)		Excess temperature	rare		Temperature control (operator); operating manual Ground contact
		Electrostatic charging		rare	
Sealing arrangements		Gas/liquid leakage Build up of explosive gas	rare		Service plan (operator); operating manual
Internal clearance		Excess temperature Unintended mechanical contact		very rare	Level control; operating manual
Closed valve condition		Excess temperature; excess pressure		very rare	operating manual
Closed internal liquid circuit		Excess temperature	rare		Temperature control rotor chamber
Auxiliary systems		Liquid leakage		very rare	Service plan (operator); operating manual
		Build up of explosive gas		very rare	
Pump casing/Casing cover/pressure containing parts		Leakage (if flammable)		very rare	Ductile material; operating manual
Plain bearing		Excess temperature due to loss of lubrication		very rare	Level control; temperature control; operating manual
Rotor/liner		Unintended mechanical contact		very rare	Level control; operating manual
D R I V E U N I T	Stator housing	Excess temperature Short circuit Build up of explosive gas			} Explosion protection acc. to EN 50014
	Motor casing	Excess temperature Liquid leakage			
	Terminal box	Sparks Short circuit Build up of explosive gas			

EXAMPLE 4.

Submersible pump (not including deep well pumps)

Sources of hazards		Potential hazards	Frequency of hazards		Recommended measures
Unvented cavities		Build up of explosive gas		very rare	Level control; operating manual
Casing/Impeller/Casing cover		Unintended mechanical contact		very rare	Level control; operating manual
Pump external surfaces (wet end)		Excess temperature	rare		Temperature control (operator); operating manual
Sealing arrangements		Gas/liquid leakage Build up of explosive gas	rare		Service plan (operator); operating manual
Internal clearance		Excess temperature Unintended mechanical contact		very rare	Level control; operating manual
Closed valve condition		Excess temperature; excess pressure		very rare	operating manual
Pump casing/Casing cover/pressure containing parts		Leakage (if flammable)		very rare	Ductile material; operating manual
Cutting device		Mechanical contact	rare		Level control; operating manual
D R I V E U N I T	Motor housing	Mechanical contact Excess temperature Short circuit Chemical reaction Build up of explosive gas Liquid leakage			} Explosion protection acc. to EN 50014
	Motor casing surfaces	Excess temperature			
	Terminal box	Sparks Short circuit Liquid leakage Chemical reaction Build up of explosive gas			
	Cable	Short circuit Temperature Compatibility Mechanical damage			
Installation device		Sparks		very rare	Non sparking material, venting

EXAMPLE 5.**Rotodynamic plastic pump with shaft sealing**

Sources of hazards	Potential hazards	Frequency of hazards		Recommended measures
Unvented cavities	Build up of explosive gas		very rare	Level control (pump and auxiliary systems); operating manual
Casing/Impeller/Casing cover	Unintended mechanical contact and hence melting of plastics, e.g. achieving the burning temperature of the plastic by rubbing contact		very rare	Level control; operating manual
Pump external surfaces	Electrostatic charge (depending on fluid properties) Excess temperature	rare		Conductive material Temperature control (operator); operating manual
Closed valve condition	Excess temperature; excess pressure		very rare	Operating manual
Sealing arrangements	Gas/liquid leakage Build up of explosive gas	rare		Service plan (operator); operating manual
Mechanical seal	Excess temperature due to loss of lubrication Mechanical contact Liquid leakage (if flammable) Build up of explosive gas		very rare	Double mechanical seal required; with monitored pressurised system
Auxiliary system for shaft sealing	Liquid leakage Build up of explosive gas		very rare	Service plan (operator); operating manual
Rotation direction test	Excess temperature		very rare	Operating manual
Shaft	Random induced current		very rare	Ground contact
Antifriction bearing	Excess temperature (Loss of lubrication)	rare		Service plan (operator); operating manual
Mechanical coupling	Mechanical slipping/break-up		very rare	Non sparking; operating manual
Guard	Mechanical contact	rare		Non sparking; operating manual
Plastic parts (rotating contact) exposed to atmosphere	Electrostatic charge Friction, melting, burning		very rare	Service plan (operator); operating manual

EXAMPLE 6.**Rotodynamic plastic pump with magnetic coupling**

Sources of hazards	Potential hazards	Frequency of hazards		Recommended measures
Unvented cavities	Build up of explosive gas		very rare	Level control (pump and auxiliary systems); operating manual
Casing/Impeller/Casing cover	Unintended mechanical contact and hence melting of plastics, e.g. achieving the burning temperature of the plastic by rubbing contact		very rare	Level control; operating manual
Pump external surfaces	Electrostatic charge (depending on fluid properties) Excess temperature	rare	very rare	Conductive material Temperature control (operator); operating manual
Closed valve condition	Excess temperature; excess pressure		very rare	Operating manual
Sealing arrangements	Gas/liquid leakage Build up of explosive gas	rare rare		Service plan (operator); operating manual
Pump liquid lubricated bearing	Excess temperature due to loss of lubrication		very rare	Level control; operating manual
Inner rotor/Shell clearance	Unintended mechanical contact and hence melting of plastics, e.g. achieving the burning temperature of the plastic by rubbing contact		very rare	Level control; operating manual
Containment shell	Gas/liquid leakage		very rare	leakage control
Outer rotor/Shell/Lantern	Unintended mechanical contact		very rare	Non sparking material
Antifriction bearing	Excess temperature (Loss of lubricant)	rare		Service plan (operator); operating manual
Mechanical coupling	Mechanical slipping/break-up		very rare	Non sparking; operating manual
Guard	Mechanical contact	rare		Non sparking; operating manual
Auxiliary systems	Liquid leakage Build up of explosive gas	rare		Service plan (operator); operating manual

EXAMPLE 7.**Positive displacement pumps - plunger pumps**

Sources of hazards	Potential hazards	Frequency of hazards		Recommended measures
Unvented cavities	Built up of explosive gas		very rare	Ensure that pump is totally vented; operating manual
Closed valve condition	Excess pressure	rare		For plunger pumps a safety valve is mandatory
Safety valve	Liquid leakage	rare		Flow from safety valves to a safe area; service schedule
Mechanical coupling	Mechanical slipping/break-up		very rare	Suitable coupling; operating manual; service schedule
Coupling guard	Mechanical contact	rare		Non sparking; operating manual
Motive parts	Electrostatic charging	rare		Any motive parts to be antistatic
Plunger sealing	Liquid leakage Excess temperature because of incorrect handling	rare		Selection of seal system to be suitable for the particular application. Active maintenance with trained personnel. Operating manual.
Liquid end connections	Liquid leakage		very rare	Proper installation; trained operators; operating manual
Liquid end external surfaces	Excess temperature	rare		User has to ensure temperature limits; trained operators; operating manual
Pump external surfaces	Electrostatic charging	rare		Conductive material; proper earthing
Drive unit splash lubricated integrated worm gear and bearings	Excess temperature due to loss of lubrication		very rare	Level control; operating manual
	Excess temperature due to overload		very rare	Protection against overload
	Excess temperature due to loss of cooling (if applicable)		very rare	Control of temperatures of lubricant
Drive unit with forced feed lubrication (if applicable)	Excess temperature		very rare	Control of lube pressure and temperature
Combustion engine driver	emission of sparks		very rare	Engines to be fitted with spark arrestors etc.
Antifriction bearing	Excess temperature (loss of lubricant)	rare		Service schedule (operator); operating manual
Rotation direction	Excess temperature		very rare	Rotation direction arrow; rotation direction test; operating manual

EXAMPLE 8.**Positive Displacement Pumps - diaphragm pumps**

Sources of hazards	Potential hazards	Frequency of hazards		Recommended measures
Unvented cavities	Built up of explosive gas		very rare	Ensure that pump is totally vented; operating manual.
Closed valve condition	Excess pressure; excess temperature	rare		For pumps with integrated pressure limiting valve external protection not required if pump is source of pressure; temperature of hydraulic fluid may require monitoring
Mechanical coupling	Mechanical slipping/break-up		very rare	Suitable coupling; operating manual; service schedule
Coupling guard	Mechanical contact	rare		Non sparking; operating manual
Motive parts	Electrostatic charging	rare		Any motive parts to be antistatic
Liquid end connections	Liquid leakage		very rare	Proper installation; trained operators; operating manual
Diaphragm	Liquid leakage after diaphragm failure	rare		Sandwich diaphragm with diaphragm condition monitoring recommended
Hydraulic circuit	Loss of hydraulic fluid causing dry operation		very rare	Level control; operating manual
Pump head external surfaces	Excess temperature	rare		User has to ensure temperature limits; operating manual
Pump external surfaces	Electrostatic charging	rare		Conductive material; proper earthing
Drive unit liquid lubricated integrated worm gear and liquid lubricated bearings	Excess temperature due to loss of lubrication		very rare	Level control; operating manual
	Excess temperature due to failure of cooling (if applicable)		very rare	Control of temperatures of lubricant
Drive unit with forced feed lubrication (if applicable)	Excess temperature		very rare	Control of lube pressure and temperature
Combustion engine driver	emission of sparks		very rare	Engines to be fitted with spark arrestors etc.
Antifriction bearing	Excess temperature (loss of lubricant)	rare		Service schedule (operator); operating manual
Rotation direction	Excess temperature		very rare	Rotation direction arrow; rotation direction test; operating manual