BRITISH STANDARD

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1834-1:2000

Reciprocating internal combustion engines — Safety requirements for design and construction of engines for use in potentially explosives atmospheres —

Part 1: Group II engines for use in flammable gas and vapour atmospheres

The European Standard EN 1834-1:2000 has the status of a British Standard

ICS 13.230; 27.020

National foreword

This British Standard is the official English language version of EN 1834-1:2000.

The UK participation in its preparation was entrusted by Technical Committee MCE/14, RIC engines, to Subcommittee MCE/14/-/1, Engines to be used in potentially explosive atmospheres, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Cross-references

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Contents

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 270, Internal combustion engines, the Secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by July 2000, and conflicting national standards shall be withdrawn at the latest by July 2000.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this standard.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

The standards prepared by CEN/TC 270 are specific to internal combustion engines and supplement those A and B standards concerned with safety.

Normative and informative annexes to this standard are indicated in the contents list. General Safety requirements for internal combustion engines are given in EN 1679-1:1998.

0 Introduction

This European Standard has been prepared to be a harmonized standard to provide one means of conforming with the essential safety requirements of the Machinery (98/37/EEC) and ATEX (94/9/EEC) Directives, and associated EFTA regulations. This European standard is a type C standard as defined in EN 292:1991.

The extent to which hazards are covered are indicated in the scope of this standard. In addition, machinery shall comply as appropriate with part 1 and 2 of EN 292:1991 for hazards which are not covered by this standard.

The requirements of this standard apply to designers, manufacturers, suppliers and importers of reciprocating internal combustion engines.

This standard also contains the information to be provided by the manufacturer to the user of reciprocating internal combustion engines.

1 Scope

This European Standard specifies the safety requirements and/or measures to remove the hazards and limit the risks on reciprocating internal combustion compression ignition engines hereinafter referred to as ‘engines’ of group II categories 2 and 3 for use in potentially explosive atmospheres of flammable gas and vapour.

This European Standard does not apply to flammable gas and vapour atmospheres containing carbon disulphide (CS_2).

This European Standard does not define requirements relating to the driven machinery. These requirements can be found in the appropriate application standards.

This European standard does not apply to engines used in premises for the processing manufacture or storage of explosives.

The safety requirements for engines for use in potentially explosive atmospheres for underground applications are given in EN 1834-2:2000.

The safety requirements for engines for used in explosive atmospheres with combustible dust are given in EN 1834-3:2000.

This European Standard does not apply to spark ignition engines.

The hazards applicable are listed in clause 4 and relate to the additional hazards of operation in an atmosphere that may become explosive. The tests which the engine and its ancillary fittings are required to undergo to verify compliance with this specification are detailed in this standard.

General safety requirements i.e. those common to all RIC engines, are covered in EN 1679-1:1998.

This European Standard is applicable to engines which are manufactured after the date of issue of this standard.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of, any of these publications apply to this European standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 292-1	1991	Safety of machinery - Basic concepts, general principles for design - Part 1: Basic terminology, methodology
EN 292-2:1991/+A1:1995		Safety of machinery - Basic concepts, general principles for design - Part 2: Technical principles and specifications
EN 1050	1996	Safety of machinery – Principles for risk assessment
EN 1127-1	1997	Explosive atmospheres - Explosion prevention and protection – Part 1: Basic concepts and methodology
EN 1679-1	1998	Reciprocating internal combustion engines - Safety - Part 1: Compression ignition engines
EN 1834-3	2000	Reciprocating internal combustion engines - Safety requirements for design and construction of engines for use in potentially explosive atmospheres - Part 3: Group II engines for use in flammable dust atmospheres

EN 50014	1997	Electrical apparatus for potentially explosive atmospheres – General requirements
EN 50015	1994	Electrical apparatus for potentially explosive atmospheres – Oil immersion ‘o’
EN 50016	1995	Electrical apparatus for potentially explosive atmospheres - Pressurized apparatus ‘p’
EN 50017	1994	Electrical apparatus for potentially explosive atmospheres - Powder filling ‘q’
EN 50018	1994	Electrical apparatus for potentially explosive atmospheres - Flameproof enclosures ‘d’
EN 50019	1994	Electrical apparatus for potentially explosive atmospheres - Increased safety ‘e’
EN 50020	1994	Electrical apparatus for potentially explosive atmospheres - Intrinsic safety ‘I’
prEN 50021	1998	Electrical apparatus for potentially explosive atmospheres - Type of protection ‘n’
EN 50028	1987	Electrical apparatus for potentially explosive atmospheres - Encapsulation ‘m’
EN 50039	1980	Electrical apparatus for potentially explosive atmospheres - Intrinsic safety systems ‘I’
prEN 50154	1993	Electrical installations in potentially explosive gas atmospheres (other than mines)
ISO 1813	1979	Antistatic endless V belts - Electrical conductivity - Characteristics and method of test
ISO 2710	1978	Reciprocating internal combustion engines - Vocabulary
ISO 3046-3	1989	Reciprocating internal combustion engines - Performance - Part 3: Test measurements
ISO 7967-1	1987	Reciprocating internal combustion engines - Vocabulary of components and systems - Part 1: Structure and external covers
ISO 7967-2	1987	Reciprocating internal combustion engines - Vocabulary of components and systems - Part 2: Main running gear
ISO 7967-3	1987	Reciprocating internal combustion engines - Vocabulary of components and systems - Part 3: Valves, camshaft drive and actuating mechanisms
ISO 7967-4	1988	Reciprocating internal combustion engines - Vocabulary of components and systems - Part 4: Pressure charging and air/exhaust gas ducting systems
ISO 7967-8	1994	Reciprocating internal combustion engines - Vocabulary of components and systems - Part 8: Starting systems
ISO 9563	1990	Belt drives - Electrical conductivity of antistatic endless synchronous belts - Characteristics and test method
IEC 60243-1	1996	Methods of test for electric strength of solid insulating materials - Part 1: Tests at power frequencies

3 Definitions

For the purposes of this standard, the definitions in ISO 2710:1978 and ISO 7967-1:1987, ISO 7967-2:1987, ISO 7967-3:1987, ISO 7967-4:1988 and ISO 7967-8:1994 and the following definitions apply:

3.1 Explosive atmosphere

A mixture with air, under atmospheric conditions of combustible material in the form of gas, vapour, mist or dust, in which after ignition, combustion spreads throughout the unconsumed mixture

NOTE: See 3.15 in EN 1127-1:1997. For the purposes of this standard dust is excluded.

3.2 Zones for gas and vapour

The definitions given in 6.4.2 of EN 1127-1:1997 apply

3.3 Potentially explosive atmosphere

An atmosphere which could become explosive due to local and operational conditions

3.4 Categories

Category 2 and 3 of equipment group II are defined in annex 1 of the ATEX Directive. In the meaning of ATEX directive RIC engines are equipments.

NOTE: The letter G is included to identify engines designed according to this European Standard

3.5 Temperatures

3.5.1 Ignition temperature of an explosive atmosphere

The definition is given in 3.28 of EN 1127-1:1997

3.5.2 Maximum surface temperature

The highest temperature attained under the most adverse operating conditions of the external surfaces to which the surrounding atmosphere has access. This includes the engine, its fittings, its ancillary equipments including flameproof enclosure, flame arrester, spark arrester, ducts, etc

3.5.3 Maximum temperature

The maximum temperature is the greatest under the most adverse operating conditions of:

a) the maximum surface temperature as defined in 3.5.2,

b) the maximum gas temperature of:

- the exhaust gas emitted into the atmosphere immediately after the flame arrester;

- the charge air at the outlet of the boosting device.

3.6 Flameproof enclosure

A gas permeable enclosure which can withstand the pressure developed during an internal explosion and which prevents the ignition of the surrounding atmosphere

3.7 Flame arrester

A device fitted to the opening of an enclosure or to the connecting pipework of a system of enclosures to permit the transmission of a gas/air mixture but to prevent the passage of a flame. A flame arrester consists of the flame arrester element and the flame arrester housing

3.8 Joints

3.8.1 Closed joint

Any assembly between two parts without open path leading to the surrounding atmosphere

3.8.2 Open joint

Any continuos open path through a joint or opening excluding flame arrester (example: valve guide)

4 List of hazards

Only the specific hazards for engine applications in potentially explosive atmospheres are listed below according to EN 1050:1996.

- hazards generated by materials and substances processed, used, exhausted or ejected by machinery including fire or explosion hazards (see 5.2, 5.10);

- hazards caused by failure or malfunction of the control system (see 5.15);

- hazards caused by incorrect position or absence of guards or safety related devices including starting and stopping devices, also including safety signs and signals, warning devices or information (see 5.5, 5.6, 5.7).

The main sources of ignition are:

Hot surfaces,
Flames and hot gases,
Mechanically generated sparks,
Electrical apparatus and systems,
Static electricity.

The potential sources of ignition likely to ignite the surrounding explosive atmosphere are listed in annex A2.

5 Safety requirements and/or measures

5.1 General

Engines of group II shall meet the requirements of EN 1679-1:1998.
No ignition of the explosive atmosphere outside the flameproof enclosure by hot surfaces, hot gases, flames, sparks or electrical apparatus shall occur.

The relation between the classification of hazardous zones and conformity categories is given in table C.1 (see 6.3.2 of prEN 1127-1:1997).

For the category 3 G engines, only normal operating conditions need to be taken into account. Malfunctions need not be considered (see annex A.1.1).

For the category 2 G engines, normal operating conditions and reasonably foreseeable malfunctions shall be taken into account. Rare malfunctions and catastrophic failures need not be considered (see annex A.1.1 and A.1.2).

All safety requirements and/or measures apply to both categories 2 G and 3 G unless otherwise specified.

Engines for use in flammable gas and vapour atmospheres including flammable dust shall fulfil the requirements of EN 1834-3:2000 in addition to the requirements of this standard.

5.2 Gas grouping subdivision

Engines intended for use in areas with potentially explosive atmospheres are defined as group II engines. Engines of group II may be subdivided according to the nature of the potentially explosive atmosphere for which they are intended.

These subdivisions are IIA, IIB and IIC.

NOTE 1: These subdivisions come from annex A of EN 50014:1997 and correspond to the subdivision of gases, vapours and mists according to their maximum experimental safe gap (MESG).

NOTE 2: Engines marked IIB are suitable for applications requiring group IIA engines. Engines marked IIC are suitable for applications requiring group IIA and IIB engines.

5.3 Maximum temperature

The maximum temperature as defined in 3.5.3 shall not exceed the autoignition temperature of the explosive atmosphere.

This is achieved if the maximum temperature does not exceed the maximum temperature of the temperature class (see table1) or the maximum temperature declared by the engine manufacturer under the conditions of 6.3.

Table 1: Classification of maximum temperatures

Temperature class	Maximum temperature °C
T1	450
T2	300
T3	200
T4	135
T5	100
T6	85

NOTE : Equipment is normally designed for use in the ambient temperature range between –20°C and + 40°C.

5.4 Engine designation

Internal combustion engines for use in potentially explosive atmospheres of gases and vapour shall be designated by:

- ‘engine group II’,

- the category (2 G or 3 G),

- the gas group subdivision IIA, IIB or IIC given in annex A of EN 50014:1997,

- the temperature class given in table 1or the maximum temperature declared by the engine manufacturer.

5.5 Flameproof enclosure

The flame proof enclosure shall withstand:

- the pressure of an internal explosion when tested according to 6.2.1;

- the overpressure when tested according to 6.2.2;

and prevent

- transmission of an internal explosion when tested according to 6.2.3.

The number of mechanical connections in the flameproof enclosure shall be minimized.

Each connection of mechanical parts within the flameproof enclosure shall be either a closed joint, or an open joint.

Any open joint in the flameproof enclosure leading to the surrounding atmosphere shall be within the ratio of length versus gap shown in EN 50018:1994 for the relevant gas group subdivision.

Threaded joints shall be designed in accordance with table 3 or 4 of EN 50018:1994.

5.6 Air intake system

5.6.1 Air ducts from a non-hazardous area

The parts of the inlet ducts which pass through the hazardous area shall be leak tight when tested as specified in 6.5 (see figure 1A and 1B).

5.6.2 Air duct from the hazardous area

Each air inlet duct shall be fitted with a flame arrester complying with 5.9 and the part between the flame arrester and the engine shall comply with 5.5 (see figure 1C and 1D).

5.7 Exhaust system

5.7.1 Exhaust system duct into a non-hazardous area

That part of the exhaust duct which passes through the hazardous area shall:

- be leak tight and tested as specified in 6.5 (see figure 1A) if the combustion air is taken from a non hazardous area ;

- comply with 5.5 if the combustion air is taken from the hazardous area (see figure 1D).

5.7.2 Exhaust system duct into a hazardous area

Each exhaust system shall be fitted with a flame arrester complying with 5.9, unless tests have proved (see annex B) it is not necessary, and a spark arrester complying with 5.10 (see figure 1B and 1C).

The part of the exhaust system between the flame arrester and the engine shall comply with 5.5.

The spark arrester shall be located between the flame arrester and the atmosphere.

If a type tested spark arrester is used the characteristics of the engine (gas flow, swept volume of the engine, gas temperature) and the installation shall be the same as those of the engine used for the type test of the spark arrester (see 6.4.2).

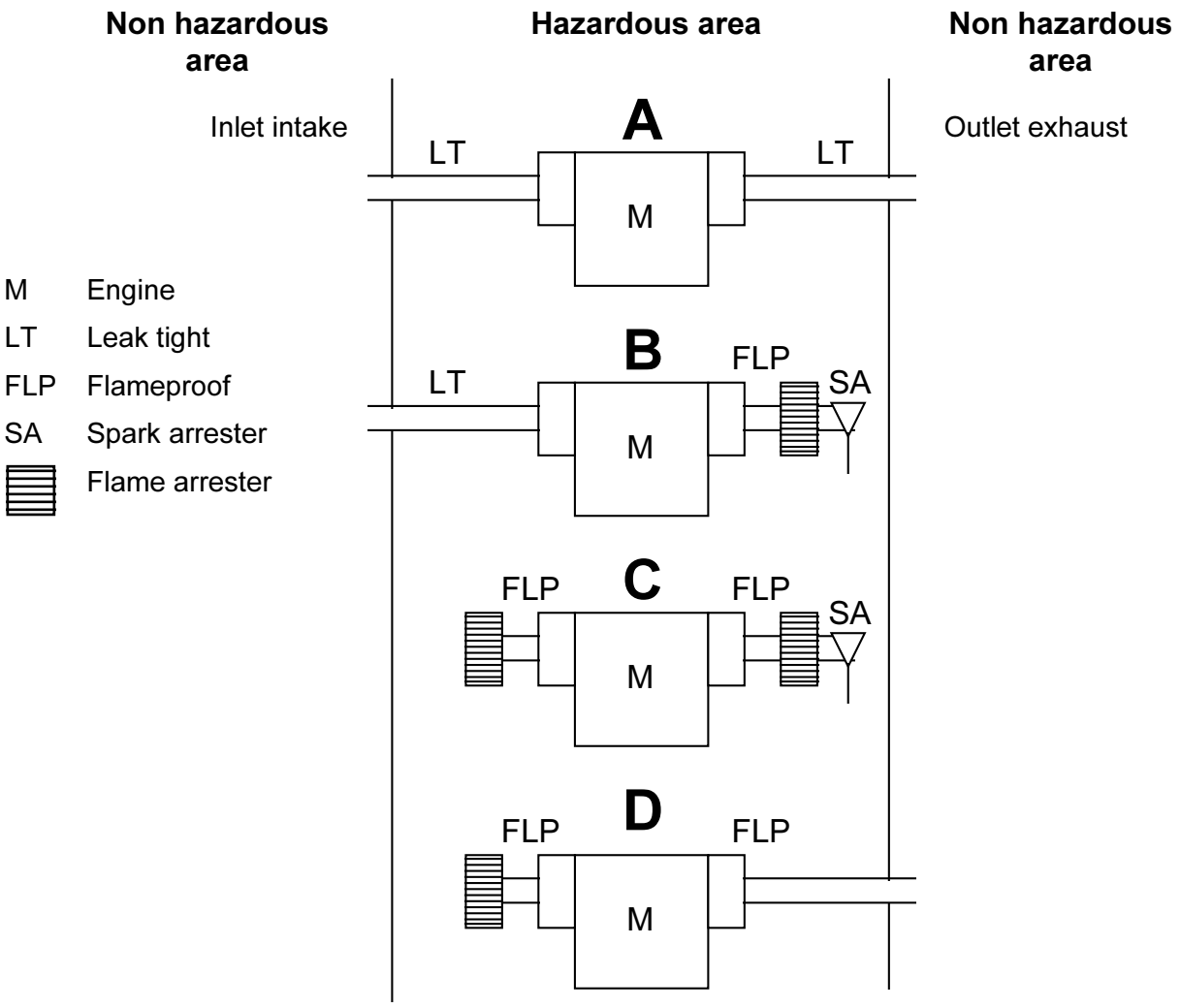

Figure 1

5.8 Other devices

5.8.1 Cold start devices

The cold start fluid device, if provided, shall be permanently installed, close to the cylinder head, down stream of the flame arrester if any. The inlet flame arrester shall be chosen in accordance with the fluid used.

The length and bore dimensions of the injector shall be designed in accordance with 5.5 and shall be tested with the inlet system according to 6.2.

For category 2 G engines, the injection system shall be mechanically protected to withstand the impact test defined in EN 50014:1997 (high risk) without leakage.

5.8.1.2 Air preheating devices

If air pre-heating devices are provided (such as electric glow plugs, electric grid heaters and pilot flame heaters) they shall be permanently installed downstream of any inlet flame arrester.

5.8.2 Valves and venting devices

Any valve and any venting device which gives direct access to the surrounding atmosphere shall fulfil the following requirement:

The discharge from these valves or venting devices shall either be vented into the flame proof enclosure between the inlet or the exhaust flame arresters and the engine, or be equipped with a flame arrester, conforming to 5.9.

5.8.3 Inlet air pressure boosting devices

The inlet air pressure boosting device shall be selected such that temperature and pressure within the air inlet pressure boosting device do not produce ignition conditions (see 5.3 and 5.11.1) and shall be fitted with an air filter to ensure that no foreign bodies can penetrate inside the air inlet pressure boosting device.

Alternatively the inlet air pressure boosting device shall be part of the flameproof enclosure and tested according to 6.2.

5.8.4 Reverse running

The engine shall be so designed that reverse running of the engine except for reversible engines, is not possible.

5.8.5 Crankcase

The crankcase shall either:

- contain an explosion: the engine can run with crankcase pressure positive or negative (see 6.2.4),

or

- not contain an explosion: the engine shall be designed to ensure positive pressure in the crankcase and in any connecting line. Any connecting line to the flame proof enclosure shall be equipped with a flame arrester conforming with 5.9.

5.9 Flame arresters

Flame arresters shall be chosen according to the maximum temperature reached in service according to 6.3.1 at the flame arrester and shall be tested according to 6.2.

The inlet flame arrester shall not be interchangeable with the exhaust flame arrester unless the two are identical in all respects.

The inlet flame arrester shall be constructed of a material with a corrosion and abrasion resistance appropriate to the engine operating environment.

If a water-based flame arrester is installed, it shall be constructed from materials that are resistant to the seal fluid, the exhaust gases and any product of mixing.

The water-based flame arrester shall be fitted with a liquid level monitoring device as specified in 5.15.

The materials used for the construction of exhaust flame arresters shall have corrosion and abrasion resistance properties equal to or better than stainless steel n° 14404 or n° 14435.

5.10 Spark arresters

5.10.1 General requirements

The materials used for the construction of spark arresters shall have corrosion and abrasion resistance properties equal to or better than stainless steel n° 14404 or n° 14435.

5.10.2 Dry spark arresters

Dry spark arresters may be either:

a) of the collection type,

b) of the quenching type.

The collection type works on the principle of removing by Vortex action hot particulates from the exhaust gas stream. This type may be tested in accordance with the procedures given in 6.4.1 or 6.4.2. Where procedure according to 6.4.1 is used, the criteria in table 2 shall be met.

The quenching type works on the principle of breaking down and quenching under Vortex action, hot particulates, before they exhaust safely in the atmosphere. This type can only be tested in accordance with the procedure given in 6.4.2.

Table 2 Minimum collection efficiency of spark arrester

Grain size mm	Collection efficiency %
0,1	95
0,2	99
0,5	100

5.10.3 Water-based spark arresters

Water-based spark arresters shall be constructed from materials resistant to the seal liquid, the exhaust gases and any product of mixing. The water-based spark arresters shall be fitted with a liquid level monitoring device as specified in 5.15.

Additionally water-based flame arresters used as spark arresters shall either meet the requirements of table 2 when tested according to either 6.4.1 or be tested according to 6.4.2. The tests shall be performed with the minimum level of liquid. If the water-based spark arrester fulfils the requirements of a flame arrester in accordance with 5.9 the requirements of a spark arrester in 5.10.3 are also fulfilled.

5.11 Mechanically generated sparks

5.11.1 Metallic materials

The requirements of 6.5.4 and 7.1 in EN 1127-1:1997 shall apply.

5.11.2 Paints and coatings

Paints and coatings shall not contain more than 25 % by weight in total of the metals aluminium, magnesium and titanium and more than 6 % in total of magnesium and titanium.

5.11.3 Fans and other rotating components

The fan shroud shall be earthed to the engine.

Fans and similar rotating components which contain light alloy shall comply with 6.5.4 of EN 1127-1:1997.

Fans, fan shroudings, coverings for ventilation apertures, etc. shall be constructed and fitted such that under running conditions defined in 5.1 no spark generating contact occurs between fixed and moving parts.

5.11.4 Mechanical engine starters

Starter motors shall be selected such that they do not produce a hot surface, sparks or otherwise comprise an ignition source and shall be of the pre-engaged type.

5.12 Electrical apparatus

The engine's electrical equipment shall fulfil the requirements given in 6.15 of EN 1679-1:1998.

For category 2 engines the electrical equipment shall satisfy all the requirements of EN 50014:1997 and of one or more of EN 50015:1994, EN 50016:1995, EN 50017:1994, EN 50018:1994, EN 50019:1994, EN 50020:1994, EN 50028:1987 or EN 50039:1980. For category 3 engines the electrical equipment shall satisfy the requirements of prEN 50021:1998.

Electrical installations shall comply with prEN 50154:1993.

The electrical equipment installation for category 2 engines shall be bipolar with the exception that the electrical circuit for glow plug or other electrical start aid may use the engine cylinder block as part of the earth return circuit for the period during which the start aid circuit is in operation. If the start aid is not in use both positive and negative connections shall be isolated from the power supply.

For mobile equipment conventional electric starters may also be used provided the electrical supply is off-engine and sited such that the starter can be used only in a non-hazardous area.

5.13 Static electricity

5.13.1 Plastic materials

For category 2 G engines, plastic materials shall only be used for externally accessible parts if there is no possibility of ignition by electrostatic discharge.

This is achieved if:

- the surface resistance does not exceed 10^9 Ω measured in accordance with 23.4.7.8 of EN 50014:1997;

or

- the electrostatically chargeable surface area is limited to the value given in table 3 below;

or

- the thickness of the non-conducting material over the conducting layers or metal gauze is not greater than 2 mm for class IIA and IIB and 0,2 mm for class IIC. Where metal gauze is used for the conducting layer, the mesh width shall not exceed the value given in table 4 below;

or

- by plastic materials which are connected with metal plates having a measured breakdown voltage equal or less than 4 kV in accordance with IEC 60243-1:1996.

Table 3: Maximum areas of plastic materials

Maximum areas of plastic materials cm^2			
Category	Group IIA	Group IIB	Group IIC
2 G	100	100	20

Table 4: Maximum mesh width

Maximum mesh width cm			
Category	Group IIA	Group IIB	Group IIC
2 G	3	3	2

5.13.2 Electrical bonding

All external and accessible parts surfaces (see 6.15 of EN 1679-1:1998) shall be electrically bonded to the engine cylinder block in order to reach potential equalization. It is not necessary to connect parts by means of separate conductors if these parts are firmly secured and are in metallic contact with the cylinder block.

5.13.3 Drive belts

Drive belts shall satisfy the electrical resistance requirements of ISO 1813:1979 or ISO 9563:1990.

5.14 Compressed air systems

It is not recommended that compressors are installed on the engine. If in exceptional circumstances, such a device is provided the precautions given below shall be taken.

- If the air is taken from the hazardous area then the compressor shall be selected such that the temperatures and pressures within the compressor do not produce ignition conditions.
- Additionally, for category 2 G engines, the compressor shall be explosion proof and be protected by flame arresters according to 5.9 on both the inlet and outlet.
- The compressor outlet flame arrester shall be tested with ignition in the compressor and at the maximum delivery temperature and pressure.

5.15 Controls

The following requirements for detection and response to engine malfunctions apply in addition to the requirements of EN 1679-1:1998.

5.15.1 Alarms and shutdowns

Automatic shut down shall be provided for engine overspeed. Automatic means shall be provided to give an alarm in accordance with table 5. Shutdown of the engine or a combination of alarms and shutdown may be provided subject to applications. When an alarm or indicator is required it can be visual or audible depending on the application.

Shut down shall be fail safe.

It shall not be possible to restart the engine until the shutdown device has been manually reset.

Table 5: Requirements for automatic alarm

Condition	Engine category 2 G or 3 G
Coolant over-temperature in a liquid cooled system	X
Low lubricating oil pressure	X
Low water level in water-based spark arresters	X
Low water level in water-based flame arrester	X
Over-temperature of the exhaust gases (see 5.3)	X
High surface temperature for air cooled engines	X
NOTE: X = shall be provided.	

5.15.2 Engine shutdown systems

The normal and emergency automatic means of stopping an engine shall be by a fuel shut off device located on the fuel injection pump or immediately adjacent to it.
For all engines an air inlet shut off valve shall be provided.

The actuation of the overspeed protection device shall automatically shut off the fuel and close the air inlet shut off valve.

It shall be possible to operate the shut off valve manually.

For an attended engine, the control shall be at the operator's position. For an unattended engine the control shall be in a prominent and accessible position outside the engine enclosure.

For large engines consideration shall be given to providing manual controls at a number of locations (see EN 1679-1:1998).

For emergency shutdown inert gas may be injected into the air inlet in conjunction with operation of the air shut off valve. No other fire extinguishing fluid is permitted in the air inlet.

5.16 Fuel intake

In order to reduce the risk of leakage, fuel intake circuits connections shall be minimized. These circuits shall be located away from engine's hot surfaces. Refuelling and draining apertures shall be fitted with positive closing devices.

6 Verification of the safety requirements and/or measures

6.1 Documentation

The manufacturer shall establish documents giving a full specification of the explosion safety aspects of the engine, including its fittings and auxiliary equipment in order to verify that in the design of the engine the requirements of this standard have been observed.

6.2 Type testing of the flameproof enclosure

The flameproof enclosure shall be tested:

a) to determine the maximum explosion pressure according to 6.2.1,
b) for overpressure according to 6.2.2,
c) for non transmission according to 6.2.3.

If tests are required on the engine these shall be done according to 6.2.4.

6.2.1 Determination of the maximum explosion pressure

The purpose of these tests is to produce and measure the most severe explosion that is expected to occur in a flameproof enclosure (e.g. in an inlet or exhaust system).

The explosion tests shall be conducted at atmospheric pressure and with the maximum gap of the flame proof enclosure defined by the manufacturer.

6.2.1.1 Test gases

The explosive test gas mixtures for determination of the maximum explosion pressure in the flameproof enclosures shall be as specified in table 6.

Table 6: Test mixture for the determination of maximum explosion pressures

Group	Test mixture
IIA	Propane 4,6 ± 0,1 % vol. in air
IIB	Ethylene 8 ± 0,5 % vol. in air
IIC	Hydrogen for first test 31 ± 1 % vol. in air Acetylene for second test 14 ± 1 % vol. in air

6.2.1.2 Test Apparatus

A - Four stroke engines

The following test apparatus is required:

a) a blanking plate to substitute for the cylinder block and to mount the fittings. This blanking plate shall be fitted with a chamber which simulates at most the cylinder volume,

If it is proven that the cylinder head has no influence on the result, it may be substituted by an appropriate volume.

NOTE: Tests have shown that cylinder volume has no influence on the test results.

b) a low energy ignition source, fitted to the blanking plate in the chamber which simulates the cylinder volume. The design of the blanking plate shall allow the source to be fitted at each port position,

c) gas input valves fitted to the blanking plate in the chamber which simulates the cylinder volume,

d) pressure transducers and a pressure recording system. At least three transducers shall be fitted to the blanking plate, close to and remote from the point of ignition, and in or close to the flame arrester. A frequency limit of 5 kHz $\pm$ 10 % shall be adopted for the measurement system in order to smooth the measured pressure,

e) a supply of the appropriate test gas mixture,

f) a space to contain the gas, comprising:

1) a gas tight test-cell for the flameproof enclosure (inlet and/or exhaust) e.g. transparent plastic or steel container or a combination of both or

2) separate transparent plastic bags to enclose the end of the system remote from the manifold and each joint.

No part of the gas containment material shall be within 300 mm of any gas outlet or joint in the flameproof enclosure.

B - Two stroke engines - Exhaust system

The apparatus shall be as defined in 6.2.1.2 A.

C - Two stroke engines - Intake system

The following test apparatus is required:

a) a means to seal the air intake ports at the inside diameter of the engine cylinders,

b) a low energy ignition source. The design of the apparatus shall enable this to be fitted within 30 mm of the intake port entry to each cylinder in turn,

c) a gas input valve to introduce the test mixture into the engine intake air box,

d) pressure transducers and pressure recording system. A minimum of two shall be incorporated; one in the intake air box and one immediately adjacent to the engine side of the intake flame trap. A frequency limit of 5 kHz ± 10 % shall be adopted for the measurement system in order to smooth the measured pressure,

e) a supply of the appropriate test gas mixture,

f) A space to contain the gas, comprising:

1) a gas tight test-cell for the flameproof enclosure (inlet and/or exhaust) e.g. transparent plastic or steel container or a combination of both or

2) separate transparent plastic bags to enclose the end of the system remote from the manifold and each joint.

No part of the gas containment material shall be within 300 mm of any gas outlet or joint in the flameproof enclosure.

D - Special case for four stroke or two stroke engines

If for special engine designs the test apparatus cannot be as described above, the test apparatus shall be set up as far as possible exactly as per 6.2.1.2 A, B or C in all respects based on the principle that the point of test gas ignition shall be within 30 mm of the relevant intake or exhaust port to the chamber in which ignition takes place in the operating engine.

6.2.1.3 Test procedures

a) assemble the flameproof enclosure under test inclusive of the cylinder head (if applicable) and all engine system parts from the interface between the intake or exhaust ports at the engine cylinder/combustion chamber to the flame arrester (see figures 1B to 1D) or to the limit of the hazardous area (see figure 1D). Also include the components immediately adjacent to the flame arrester. The appropriate valves shall be secured in the open position,

b) fit and seal the test cell or plastics bags to provide the gas containment,

c) flush the systems under test with a minimum of six volumes of the test gas. Check the gas conditions, which for the test shall be:

- ambient temperature (0 - 40 °C);
- ambient pressure;

d) after finishing the flush, initiate an explosion using the low energy ignition source and record the maximum pressure attained,

e) re-establish the correct gas mixture and connections in the system and repeat the explosion.

Carry out two tests with the ignition source located at each port position ignition point in turn for inlet and exhaust. Perform a minimum of five tests at the port that develops the maximum pressure.

Record as the explosion pressure, the maximum pressure registered during any of the tests.

For the test on water-based flame arresters the level of liquid before the test is the maximum level defined by the manufacturer and the explosions shall be made in static conditions (no gas flow).

NOTE: Explosions are dangerous. Precautions should be taken.

6.2.2 Overpressure test

6.2.2.1 Principle

The purpose of this test is to apply a controlled pressure in excess of the greatest pressure that will be experienced under the most severe explosion and to show that under these circumstances the flameproof enclosure retains its integrity.

6.2.2.2 Apparatus for hydrostatic test

The following apparatus is required:

a) blanking plates, to substitute for the cylinder block and to seal the opening to atmosphere,

b) fittings, for filling and pressurizing,

c) a pressure gauge, to register the hydraulic test pressure.

6.2.2.3 Test procedure for hydrostatic test

a) assemble the system under test, the blanking plates and the filling system,

b) pressurize the system to the test pressure equal to:

- 1,5 times the maximum explosion pressure measured in 6.2.1.3 for inlet times the pressure boost ratio with a maximum of 15 bars;

- 1,5 times the maximum explosion pressure measured in 6.2.1.3 at outlet, with a maximum of 10 bars;

c) i the pressurizing system.

6.2.2.4 Acceptance criteria

The system components shall be considered satisfactory if the hydraulic pressure is held without loss for not less than 1 min. No visible permanent deformation impairing the flameproof enclosure integrity shall be observed.

6.2.2.5 Alternative test

An alternative, dynamic over pressure test according to 15.1.3.2 of EN 50018:1994 may be used.

6.2.3 Non-transmission tests

The purpose of these tests is to produce the most severe explosion that is expected to occur in an inlet or exhaust system and to verify that, under these conditions, the explosion is contained within the flameproof enclosure and not transmitted to the surrounding atmosphere by assemblies and/or flame arresters.

The non-transmission test shall be conducted with the maximum gap of the flame proof enclosure defined by the manufacturer.

The non-transmission test shall be performed with the gas mixture at atmospheric pressure for atmospheric systems and non-pressurized parts of the air inlet boosting device, and at atmospheric pressure times pressure ratio for pressurized parts of the air inlet boosting device.

6.2.3.1 Non-transmission test gas mixtures

The explosive gas mixtures for the non-transmission tests of the inlet flameproof enclosure system shall be as specified in table 7.

Table 7: Non-transmission test mixtures

Group	Number of tests	Test mixture
IIA	10	Propane 4,2 ± 0,1 % vol. in air
IIB	10	Hydrogen 45 ± 0,5 % vol. in air
IIC	10 10	Hydrogen for first test 28 ± 1 % vol. in air Acetylene for second test 7,5± 1 % vol. in air

The explosive gas mixture for the non-transmission tests of the exhaust flame proof enclosure system shall be Propane with a concentration of 4,2 ± 0,1 % vol. in air at atmospheric pressure

6.2.3.2 Apparatus

As defined in 6.2.1.2.

The exhaust flame arrester shall be tested at ambient temperature for engines of temperature class T4, T5 and T6 or with maximum temperature up to 135 °C.

For engines of temperature, class T1 to T3 or maximum temperature over 135 °C, the exhaust flame arrester shall be at operating temperature.

6.2.3.3 Test procedure

As defined in 6.2.1.3, however the explosive gas mixture shall be outside and inside the flameproof enclosure. The flame proof enclosure shall be placed in a test chamber.
A minimum of 10 explosions shall be made at the port giving the maximum explosion pressure.

For the tests on water-based flame arresters non-transmission tests shall be made under the following conditions:

- the liquid level before the test shall be the minimum level defined by the manufacturer;

- transversal and longitudinal inclinations of the device shall be at the maximum values defined by the manufacturer;

- during the tests, test explosive mixture shall be introduced into the system with a flow equal to the maximum flow of exhaust gases. This maximum flow shall be defined by the manufacturer.

6.2.3.4 Acceptance criteria

The system shall be considered satisfactory if the test mixture external to the flameproof enclosure is not ignited in any of the tests.

6.2.4 Tests on crankcase

This test applies to engines designed to contain crankcase explosions (see 5.8.5).

For this test the engine shall undergo a test for flameproofing when subjected to crankcase explosions. This test may be carried out without the air intake and exhaust system.

6.2.4.1 Apparatus

The following apparatus is required:

a) the engine oil shall be drained off completely,

b) seals on which flameproofing depends, not comprising metal or non combustible metal-coated sealants or equivalent seals, shall be removed,

c) a low ignition source, fitted to the crankcase. The ignition points are underneath the first cylinder, as far away from the first cylinder as possible and inside the cylinder head,

d) gas inlet and outlet valves fitted to the crankcase and the cylinder head cover,

e) pressure transducers and a pressure recording system. The transducers shall be fitted:

1 - to the crankcase as far away from the ignition point as possible

2 - to the timing gear, and

3 - to the cylinder head cover as far away from the ignition point as possible.

The frequency limit of 5 kHz ± 10 % shall be used for the measurement system in order to smooth the measured pressure.

f) a supply of the appropriate test gas mixture.

g) a suitable chamber to cover up the engine.

6.2.4.2 Test procedure

a) the test shall be carried out at:

- ambient temperature (0 °C - 40 °C);

- ambient pressure;

- maximum gap defined by the manufacturer,

b) flush the test systems with a minimum of six volumes of the test gas according table 7. Check the gas mixture concentration.

c) after finishing the flush initiate an explosion using the low energy ignition source and record the maximum pressure attained.

A minimum of 3 ignitions per ignition point shall be made.

Record as the explosion pressure the maximum pressure registered during any of the tests.

6.2.4.3 Acceptance criteria

The engine shall be considered satisfactory if the test mixture external to the flameproof enclosure is not ignited in any of the tests and no visible permanent deformation impairing the flameproofing is observed.

6.3 Type testing of the engine installation and auxiliary fittings including alarms and shutdown

The purpose of these tests is to verify that the safety requirements detailed in this standard are fulfilled.

6.3.1 Engine operation

Operation is required at maximum engine surface temperature, or in accordance with a specific duty cycle for the engine and its application. Loading may be achieved by connection to the normal driven equipment, by dynamometer or other convenient means, provided that the enclosure and ventilation arrangements accurately represent the service configuration.

6.3.2 Measuring instruments

Measuring apparatus and instruments used during the test shall meet the requirements of accuracy specified in ISO 3046-3:1989. Before readings are taken the engine shall be operated at the specified speed and conditions for sufficient time to stabilize temperature etc., according to engine manufacturer's instructions.

6.3.3 Procedure

With the engine in operation and ingesting ambient air, determine and record the following data:

a) ambient air temperature (0 °C - 40 °C),

b) the maximum surface temperature. Maximum surface temperature is determined by measuring the temperature at the points expected to be the hottest and by verification that the maximum is reached. Temperature measurements shall be continued after stopping the engine until the temperature recordings show a fall in temperature,

c) the performance of the safety device and alarms fitted in accordance with 5.15.1, 5.15.2,

d) the rate of consumption of any expendable constituent of the spark arresting or cooling system,

e) the maximum engine coolant temperature and the maximum flameproof equipment coolant temperature if a separate circuit is employed. The circuit thermostat(s) shall be functioning in accordance with the manufacturer's specifications,

f) the maximum temperature of the exhaust gas measured immediately downstream of the exhaust flame arrester with a low inertia temperature measurement device e.g. bare thermocouple,

g) with the engine not loaded, increase the engine speed until either the air inlet shut-off valve or the fuel shut-off valve operates. Record the maximum engine speed. For this test it may be necessary to over-ride the engine governor,

6.4 Spark arrester test

The spark arrester may be tested according either to 6.4.1 or 6.4.2.

6.4.1 Collection efficiency test

The collection efficiency of the spark arrester shall be determined with a test equipment which consists of:

- a blower
- a particle injector
- the test spark arrester
- filters for collecting particles which have passed through the spark arrester
- a device for measuring the gas flow through the spark arrester.

When the spark arrester is to be tested on an engine, the engine exhaust shall be used in place of the blower air supply. The measurement of gas exhaust flow is not required.

For determination of the collection efficiency, test particles shall be injected into the air of the blower or engine exhaust gas stream. The collection efficiency is the ratio of the mass of particles collected on the filter and the mass of injected particles.

The test particles shall be non-flammable, have an apparent density less than 0,9 g/cm^3 and the test shall be carried out with particle size classes of 0,1 mm, 0,2 mm and 0,5 mm.

The test shall be carried out at intermediate flow rate steps between points representing the exhaust flow range for which the spark arrester is designed.

When the spark arrester is to be tested on an engine, the test shall be carried out at least at no load idle speed, 50 % rated power and intermediate speed and at 100 % rated power and at rated speed.

The collection efficiency of the spark arrester shall be determined at each flow rate and each particle size class by at least one measurement. The particle/air or particle/exhaust gas mass ratio shall be about 1/100.

The test particles shall be injected into the air of the blower or engine exhaust gas stream at a uniform rate over a period of about 1 min.

NOTE: When the test is performed on an engine corrections should be made to take account of water, burned and unburned particles.

6.4.2 Visual test

The spark arrester may be tested installed on the engine under test or type tested on an engine of similar exhaust gas flow. When type testing, the spark arrester shall be positioned as close as possible to the engine exhaust manifold.

Charcoal shall be freshly ground and the fraction between 0,5 mm and 1 mm retained for the test.

The engine shall be brought to operating temperature with air filter and flame arrester at the engine inlet removed. The exhaust flame arrester shall be left in place.

Feed in the powdered charcoal at a uniform rate of (L / 4) g/s at the inlet during 30 s. (L = engine swept volume in litres).

The test shall be done under dark room conditions and shall be observed and recorded photographically.

The test is conducted at the following engine conditions:

1) at maximum power
2) at no load at high idle speed
3) accelerating from low idle to high idle over the period of 30 s but with no load.

If any spark is seen to issue from the spark arrester, the device is deemed to have failed the test.

6.5 Leak test for ducts

Under an overpressure test of 20 kPa the duct shall have no visible permanent deformation and the air test overpressure shall not fall by more than 4 kPa in 3 min after removing the compressed air supply.

6.6 Test report

The following general information shall be included in test reports:

a) the engine type (including engine serial number);

b) the engine swept volume;

c) the engine manufacturer's full build specification for the engine including the power and speed setting relevant to the approval;

d) the flame and explosion protection equipment manufacturer's full specification for the equipment installed;

e) the approval test conditions (e.g. whether test bed full load/full speed or specific application/test cycle);

f) engine gas group;

g) temperature class or other specified temperature;

h) engine category;

i) limiting ambient temperature condition;

j) reference to this standard;

k) identification of the test laboratory (for engines category 2 G only).

7 Information for use

The specifications in 5 of EN 292-2:1991/A1:1995, apply and in addition, the following requirements in particular shall be met:

7.1 Accompanying documents

In addition to requirements of 5.5 of EN 292-2:1991/A1:1995 the manufacturer shall provide documents detailing all maintenance requirements of the equipment covered by this standard and identifying any conditions which impose a limitation on the usage of the equipment.

Depending on the application residual risks may exist which may require additional safety measures. The designer of the installation shall take them into account.

In particular the documents shall indicate that the ignition temperature of the explosive atmosphere shall exceed the temperatures given in 5.3 for the hot surfaces and gases and that externally accessible components exposed to the risks of impact or friction shall comply with 6.5.4 of EN 1127-1:1997.

7.2 Inspection check list

The documents shall specify the intervals for checking at least the following, taking into account the environment and the duty of the engine:

a) general maintenance conditions and external cleanliness of the engine and leakage of fluids;

b) flame arresters: for cleanliness, dimensions, condition and additionally for corrosion damage;

c) exhaust system including spark arresters: for carbon accumulation, corrosion and damage;

d) rotating mechanical equipment: for security and freedom from contact with stationary parts;

e) fan belt: for condition and tightness;

f) electrical equipment: for damage and deterioration;

g) sensors in shutdown systems: for function at set limits;

h) inlet air stop valve and fuel over-speed shut-off: for its setting and operation;

i) relief valves and breathers: for cleanliness and setting;

j) fasteners and joints: for tightness;

k) electrical connections to starter and battery: for tightness;

l) flexible pipes and hoses: for damages.

NOTE: The user is recommended to keep a maintenance log to record details of these checks.

7.3 The manufacturer shall state any conditions which impose a limit upon any fixed connections and any flameproof joints and provide clear instructions for the manner in which the connections or joints are to be serviced at each service interval or at any intervening time when the joints have been disturbed. The manufacturer shall provide guide-lines on how to disassemble, assemble and lock joints.

8 Marking

Each engine shall be marked with a clearly legible, permanent nameplate, showing:

- manufacturer's name or identification mark;

- name or identification mark of notified body (for engine category 2 G);

- type designation;

- serial number;

- category (2 G or 3 G);

- gas group (IIA, IIB or IIC) (if group IIC is included the marking shall indicate that CS_2 is excluded);

- temperature class or maximum temperature;

- type of application and rating;

- year of manufacture;

- the reference to this standard.

Annex A (informative)

Engine conditions and ignition sources

In order to guide the designer the following information on non flame proof engines is given as an informative annex.

A.1 Engine conditions

A.1.1 Normal operating conditions

Normal operating conditions include:

- maximum sustainable load and speed conditions for the engine application,

- ambient temperature range of -20 °C to 40 °C,

- flame emission from exhaust manifold, with increased flame length when hazardous gas is ingested,

- spark emission from the exhaust (e.g. due to load variation),

- flame emission from the inlet when hazardous gas is ingested,

- development of static potentials,

- electrical sparks and arcs from any source,

- potential for ignition due to the temperature of compression in auxiliary components,

- overspeed due to ingestion of hazardous gas.

A.1.2 Reasonably foreseeable malfunctions

Reasonably foreseeable malfunctions include:

- internal defects causing increased flame length and sparks at the exhaust outlet,

- mechanical sparks due to impact from foreign objects or from friction between moving and stationary parts,

- malfunction of cooling system,

- increased probability of flame in the inlet.

A.1.3 Rare malfunctions

Rare malfunctions include:

- fuel leakage from high pressure circuits,

- failure of pressure boosting devices,

- seizure of the engine due to lubrication failure,

- big and small end connecting rod bearing failure,

- failure of camshaft drive,

- failure of piston rings, causing excessive blow-by of combustion gases into crankcase,

- failure of cylinder head gasket resulting in water in combustion cylinder and/or exhaust gas in cooling water circuit,

- overspeed due to failure of governor.

A.1.4 Catastrophic failures

Catastrophic failures include:

- crankshaft breakage,

- crankcase explosion (for negative pressure).

A.2 Ignition sources

A.2.1 Hot surfaces

Hot surfaces accessible to explosive air-gas mixtures may include:

- internal surfaces of the combustion cylinders, accessible only to the inlet air,

- temperature, in particular of exhaust valves, may under normal operating conditions be above the ignition temperature of all flammable gases,

- outside surfaces of the exhaust system, accessible to the surrounding air. Temperature to be determined under conditions of full load, foreseeable and rare malfunctions,

- outside surfaces of turbo-charger, accessible to surrounding air. Temperature to be determined under conditions of full load, foreseeable and rare malfunctions,

- outside surfaces of accessories which are permanently fixed to the engine, such as pumps or compressors. Temperatures to be determined under conditions of full load, foreseeable and rare malfunctions.

A.2.2 Flame and hot gases

a) hot exhaust gas emission

Temperature to be determined under conditions of full load, foreseeable and rare malfunctions.

b) flame emission from exhaust

Any flame is capable of igniting any explosive mixture. This should be taken into consideration only as a foreseeable or rare malfunction.

A.2.3 Sparks

Sparks capable of igniting flammable mixtures may be emitted from the exhaust as a result of foreseeable or rare malfunctions. This should be considered bearing in mind the characteristics of the relevant explosive mixtures.

Mechanical sparks may be generated when foreign objects hit or fall on stationary parts of the engine or when such objects are ingested by the fan. This should be taken into consideration as a foreseeable or rare malfunction.

A.2.4 Electrical apparatus

A.2.5 Static electricity

A.2.6 Adiabatic compression

This may be encountered in turbo-chargers and compressors driven by the engine as auxiliaries.

This should be considered under the conditions applicable and with respect to the ignition characteristics of the relevant flammable mixtures.

Annex B (informative)

Exhaust flame arrester elimination test procedure

B.1 Equipment

a) test engines selected as representative of the range used taking account of

for example:

- combustion cycle (2 stroke, 4 stroke);
- method of air aspiration (naturally aspirated, turbocharged);
- power (kW),

b) test gases input valves from groups IIA, IIB and IIC (propane, ethylène, hydrogen, acetylene (see table 6).

B.2 Tests

B.2.1 Engine behaviour tests

a) vary the engine speed from 0 % to 100 %;

b) vary the engine load from 0 % to 100 %;

c) ingest gases in concentrations varying from lower explosion limit to upper explosion limit;

d) monitor:

1) Firing behaviour;

2) Tendency to overspeed;

3) Changes in exhaust flame pattern or length;

4) Exhaust explosion.

e) engine stop/start tests.

During the speed and load variation trials the engine shall be stopped and restarted and any explosions observed. The presence of gases in the exhaust prior to starting shall be determined.

B.2.2 Test result

The engine fails to pass the test if d) 3) and/or d) 4) occur.

B.2.3 Flame arrester tests

These tests are carried out only if the engine behaviour tests have confirmed the need for flame arresters.

a) Select plate type flame arresters which, based on the flame transmission tests given in 6.2.3, pass the IIA group test but fail the IIB group test.

b) Fit the test engine with exhaust cooling to limit exhaust temperature to 225 °C at the rated conditions.

c) Run test engine at:

i) low idle no load ;
ii) maximum torque speed no load;
iii) maximum torque speed 50 % load;
iv) maximum torque speed 100 % load;
v) rated speed no load;
vi) rated speed 50 % load;
vii) rated speed 100 % load.

d) During each test introduce ethylene into the intake of the engine at gradually increasing volumes. Record the following:

i) temperature of the exhaust gas at the outlet from the cylinder head;
ii) temperature of the exhaust gas into the exhaust flame arrester;
iii) existence of flame at 50 mm beyond the exhaust gas outlet.

e) Repeat the tests with a ‘wet’ type exhaust heat exchanger (exhaust gas at the engine rated conditions to be 70 °C to 100 °C).

f) Repeat tests with crimped ribbon type exhaust flame arresters.

B.2.4 Test result

The test fails if d) iii) occurs and/or maximum temperature is exceeded.

Annex C (informative)

Relation between zones and engines categories

Table C.1: Relation between zones and categories

Categories of engines group II	Zones for gases and vapours
2 G	Zone 1
3 G	Zone 2

Annex ZA (informative)

Clauses of this European Standard addressing essential requirements or other provisions of EU Directives

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association and supports essential requirements of EU Directives.

ATEX 94/9/ECC dated 1994/03/23.

"Machinery" 98/37/EEC dated 1998/06/22.

WARNING: other requirements and other EU Directives may be applicable to the products falling within the scope of this standard.

The clauses of this standard are likely to support requirements of Machinery and ATEX Directives.

Compliance with the clauses of this standard provides one means of conforming with the specific essential requirements of the Directive concerned and associated EFTA regulations.

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