BRITISH STANDARD

BS EN 60079-28:2007

Incorporating corrigendum July 2014

Explosive atmospheres —

Part 28: Protection of equipment and transmission systems using optical radiation

ICS 29.260.20

British Standards

National foreword

This British Standard is the UK implementation of EN 60079-28:2007. It is identical to IEC 60079-28:2006.

The UK participation in its preparation was entrusted to Technical Committee EXL/31, Equipment for explosive atmospheres.

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

The publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 May 2007

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TC 31/IEC 60079-28:2006, First edition/I-SH 01

Explosive atmospheres –
Part 28: Protection of equipment and transmission systems using optical radiation

INTERPRETATION SHEET

This interpretation sheet has been prepared by IEC technical committee 31: Equipment for explosive atmospheres.

The text of this interpretation sheet is based on the following documents:

ISH	Report on voting
31/1102/ISH	31/1114/RVD

Full information on the voting for the approval of this interpretation sheet can be found in the report on voting indicated in the above table.

IEC 60079-28:2006 (1st edition) *Explosive atmospheres – Protection of equipment and transmission systems using optical radiation*

Following decision No 12 of the TC 31 meeting in Melbourne in 2011, the issuing of an Interpretation Sheet for IEC 60079-28:2006 (1st edition) was requested, in order to clarify the scope of the existing standard.

Question

Does the scope of this standard cover

1) non-array divergent LEDs;
2) luminaires;
3) optical radiation sources for Mb, Gb or Gc applications which comply with Class 1 limits in accordance with IEC 60825-1;
4) single or multiple optical fibre cables not part of optical fibre equipment; or
5) enclosed equipment involving an enclosure that fully contains the optical radiation and that complies with a suitable type of protection?

Answer

This standard applies to optical fibre equipment and optical equipment, including LED and laser equipment, with the exception of the equipment detailed below:

1) Non-array divergent LEDs used for example to show equipment status or backlight function.
2) All luminaires (fixed, portable or transportable), hand lights and caplights (other than for Group I) intended to be supplied by mains (with or without galvanic isolation) or powered by batteries
   – with continuous divergent light sources (for all EPLs);
   – with LED light sources (for EPL Gc only).

3) Optical radiation sources for Mb, Gb or Gc applications which comply with Class 1 limits in accordance with IEC 60825-1.

4) Single or multiple optical fibre cables not part of optical fibre equipment if the cables

   – comply with the relevant industrial standards, along with additional protective means, e.g. robust cabling, conduit or raceway (for Gb, Mb or Gc);

   – comply with the relevant industrial standards (for Gc).

5) Enclosed equipment involving an enclosure that fully contains the optical radiation and that complies with a suitable type of protection as required by the involved EPL, with the enclosure complying with one of the following conditions:

   – an enclosure for which an ignition due to optical radiation in combination with absorbers inside the enclosure would be acceptable (such as flameproof "d" enclosures), or

   – an enclosure for which protection regarding ingress of an explosive atmosphere is provided, such as pressurized "p" enclosures, restricted breathing “nR” enclosure", or

   – an enclosure for which protection regarding ingress of absorbers is provided (such as IP 6X enclosures) and where no internal absorbers are to be expected.

NOTE For these scope exclusions it is anticipated that the enclosures are not opened in the explosive atmosphere, so that ingress is protected.

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 60079-28

March 2007

ICS 29.260.20

English version

Explosive atmospheres - Part 28: Protection of equipment and transmission systems using optical radiation (IEC 60079-28:2006)

Atmosphères explosives -
Partie 28: Protection du matériel et des systèmes de transmission utilisant le rayonnement optique
(CEI 60079-28:2006)

Explosionsfähige Atmosphäre -
Teil 28: Schutz von Einrichtungen und Übertragungssystemen, die mit optischer Strahlung arbeiten
(IEC 60079-28:2006)

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of document 31/631/FDIS, future edition 1 of IEC 60079-28, prepared by IEC TC 31, Equipment for explosive atmospheres, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60079-28 on 2006-10-01.

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2007-10-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2009-10-01

This European Standard has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association and covers essential requirements of EC Directive 94/9/EC. See Annex ZZ.

Annexes ZA and ZZ have been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60079-28:2006 was approved by CENELEC as a European Standard without any modification.

CONTENTS

INTRODUCTION

Optical equipment in the form of lamps, lasers, LEDs, optical fibers, etc. is increasingly used for communications, surveying, sensing and measurement. In material processing, optical radiation of high irradiance is used. Often the installation is inside or close to potentially explosive atmospheres, and radiation from such equipment may pass through these atmospheres. Depending on the characteristics of the radiation it might then be able to ignite a surrounding explosive atmosphere. The presence or absence of an additional absorber significantly influences the ignition.

There are four possible ignition mechanisms.

a) Optical radiation is absorbed by surfaces or particles, causing them to heat up, and, under certain circumstances, this may allow them to attain a temperature which will ignite a surrounding explosive atmosphere.
b) Thermal ignition of a gas volume, where the optical wavelength matches an absorption band of the gas.
c) Photochemical ignition due to photo dissociation of oxygen molecules by radiation in the ultraviolet wavelength range.
d) Direct laser induced breakdown of the gas at the focus of a strong beam, producing plasma and a shock wave both eventually acting as the ignition source. These processes can be supported by a solid material close to the breakdown point.

The most likely case of ignition occurring in practice with lowest radiation power of ignition capability is case a). Under some conditions for pulsed radiation, case d) also will become relevant.

Optical equipment is used in most cases in conjunction with electrical equipment, for which clear and detailed requirements and standards for use in potentially explosive atmospheres exist. One purpose of this standard is to inform industry about potential ignition hazards associated with the use of optical systems in hazardous locations as defined in IEC 60079-10 and the adequate protection methods.

This standard details the integrated system used to control the ignition hazard from equipment using optical radiation in hazardous locations.

EXPLOSIVE ATMOSPHERES –

Part 28: Protection of equipment and transmission systems using optical radiation

1 Scope

This part of IEC 60079 explains the potential ignition hazard from equipment using optical radiation intended for use in explosive gas atmospheres. It also covers equipment, which itself is located outside but its emitted optical radiation enters such atmospheres. It describes precautions and requirements to be taken when using optical radiation transmitting equipment in explosive gas atmospheres. It also outlines a test method, which can be used to verify a beam is not ignition capable under selected test conditions, if the optical limit values cannot be guaranteed by assessment or beam strength measurement.

This standard contains requirements for optical radiation in the wavelength range from 380 nm to 10 µm. It covers the following ignition mechanisms:

- optical radiation is absorbed by surfaces or particles, causing them to heat up and, under certain circumstances, this may allow them to attain a temperature which will ignite a surrounding explosive atmosphere;
- direct laser induced breakdown of the gas at the focus of a strong beam, producing plasma and a shock wave both eventually acting as the ignition source. These processes can be supported by a solid material close to the breakdown point.

NOTE 1 See items a) and d) of the introduction.

This standard does not cover ignition by ultraviolet radiation and by absorption of the radiation in the explosive mixture itself. Explosive absorbers or absorbers that contain their own oxidizer as well as catalytic absorbers are also outside the scope of this standard.

This standard specifies requirements for equipment intended for use under atmospheric conditions.

This standard supplements and modifies the general requirements of IEC 60079-0. Where a requirement of this standard conflicts with a requirement of IEC 60079-0, the requirement of this standard willll take precedence.

NOTE 2 Although one should be aware of ignition mechanism b) and c) explained in the introduction, they are not addressed in this standard due to the very special situation with ultraviolet radiation and with the absorption properties of most gases (see Annex B).

NOTE 3 Safety requirements to reduce human exposure hazards from fibre optic communication systems are found in IEC 60825-2:2000.

NOTE 4 Types of protection "op is", "op pr", and "op sh" can provide equipment protection levels (EPL) Ga, Gb, or Gc. For further information, see Annex E.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60079 (all parts), *Electrical apparatus for explosive gas atmospheres*

IEC 60079-0, *Electrical apparatus for explosive gas atmospheres – Part 0: General requirements*

IEC 60079-10, *Electrical apparatus for explosive gas atmospheres – Part 10: Classification of hazardous areas*

IEC 60079-11, *Explosive atmospheres – Part 11: Equipment protection by intrinsic safety "i"*

IEC 60825-2, *Safety of laser products – Part 2: Safety of optical fibre communication systems*

IEC 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems*

IEC 61511 (all parts), *Functional safety – Safety instrumented systems for the process industry sector*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC IEC 60079-0 and the following apply.

NOTE Additional definitions applicable to explosive atmospheres can be found in IEC 60050-426 [1][1].

3.1
absorption
in a propagation medium, the conversion of electromagnetic wave energy into another form of energy, for instance heat

[IEV 731-03-14]

3.2
beam diameter (or beam width)
the distance between two diametrically opposed points where the irradiance is a specified fraction of the beam's peak irradiance

[IEV 731-01-35]

NOTE Most commonly applied to beams that are circular or nearly circular in cross section.

3.3
beam strength
a general term used in this standard referring to an optical beam's power, irradiance, energy, or radiant exposure

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1 Figures in square brackets refer to the bibliography.

3.4
core
the central region of an optical fibre through which most of the optical power is transmitted

[IEV 731-02-04]

3.5
cladding
that dielectric material of an optical fibre surrounding the core

[IEV 731-02-05]

3.6
fibre bundle
an assembly of unbuffered optical fibres

[IEV 731-04-09]

3.7
fibre optic terminal device
an assembly including one or more opto-electronic devices which converts an electrical signal into an optical signal, and/or vice versa, which is designed to be connected to at least one optical fibre

[IEV 731-06-44]

NOTE A fibre optic terminal device always has one or more integral fibre optic connector(s) or optical fibre pigtails(s).

3.8
inherently safe optical radiation
visible or infrared radiation that is incapable of producing sufficient energy under normal or specified fault conditions to ignite a specific hazardous atmospheric mixture

NOTE This definition is analogous to the term "intrinsically safe " applied to electrical circuits.

3.9
irradiance
the radiant power incident on an element of a surface divided by the area of that element

[IEV 731-01-25]

3.10
light (or visible radiation)
any optical radiation capable of causing a visual sensation directly on a human being

[IEV 731-01-04]

NOTE 1 Nominally covering the wavelength in vacuum range of 380 nm to 800 nm.

NOTE 2 In the laser and optical communication fields, custom and practice in the English language have extended usage of the term light to include the much broader portion of the electromagnetic spectrum that can be handled by the basic optical techniques used for the visible spectrum.

3.11
minimum ignition energy
MIE
lowest electrical energy stored in a capacitor which upon discharge is sufficient to effect ignition of the most ignitable explosive atmosphere under specified test conditions

3.12
optical fibre
filament shaped optical waveguide made of dielectric materials

[IEV 731-02-01]

3.13
optical fibre cable
an assembly comprising one or more optical fibres or fibre bundles inside a common covering designed to protect them against mechanical stresses and other environmental influences while retaining the transmission qualities of the fibres

[IEV 731-04-01]

3.14
optical fibre communication system
OFCS
engineered, end-to-end assembly for the generation, transference and reception of optical radiation arising from lasers, LEDs or optical amplifiers, in which the transference is by means of optical fibre for communication and/or control purposes

3.15
free space optical communication system
FSOCS
an installed, portable, or temporarily mounted, through-the-air system typically used, intended or promoted for voice, data or multimedia communications and/or control purposes via the use of modulated optical radiation produced by a laser or IR-LED. "Free space" means indoor and outdoor optical wireless applications with both non-directed and directed transmission. Emitting and detecting assemblies may or may not be separated.

NOTE The above definitions are from IEC TC 76. This standard is not only dealing with “communication systems”, so a more general definition could be useful.

3.16
optical (or radiant) power
the time rate of flow of radiant energy with time

[IEV 731-01-22]

3.17
optical radiation
electromagnetic radiation at wavelengths in vacuum between the region of transition to X-rays and the region of transition to radio waves, that is approximately between 1 nm and 1 000 µm

[IEV 731-01-03]

NOTE In the context of this standard, the term “optical” refers to wavelengths ranging from 380 nm to 10 µm.

3.18
protected optical fibre cable
optical fibre cable protected from releasing optical radiation into the atmosphere during normal operating conditions and foreseeable malfunctions by additional armouring, conduit, cable tray or raceway

3.19
radiant energy
energy that is emitted, transmitted or received via electromagnetic waves

[IEV 731-01-21]

3.20
radiant exposure
the radiant energy incident on an element of a surface divided by the area of that element

[IEV 393-14-84, modified, and IEV 845-01-42, modified] [2)]

4 General requirements

4.1 Optical equipment

All electrical parts and circuits inside and outside optical equipment shall comply with the appropriate standards for electrical apparatus.

4.2 Risk levels

Three different equipment protection levels Ga, Gb, Gc are defined (see Annex E). Table 1 shows the relationship between the EPL and the probability of an ignition source:

Table 1 – Relationship between EPL and the probability of an ignition source

EPL	Protection required
Ga	Ignition not likely with one fault and two independent faults or in the case of rare malfunctions
Gb	Ignition not likely with one fault or in the case of expected malfunctions
Gc	Ignition not likely in normal operation

An ignition hazard assessment, as given in Annex C, has to be carried out to identify the ignition mechanisms and ignition sources caused by the specific working principle of the equipment using optical radiation.

The types of protection selected from section 5 to protect the specific equipment depend on this ignition hazard assessment considering the table of ignition probabilities given above for the different EPLs.

NOTE In IEC TC 31, the introduction of "equipment protection levels (EPL) Ga, Gb, Gc" was decided.

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2 IEC 60050-393:2003, *International Electrotechnical Vocabulary (IEV) – Part 393: Nuclear instrumentation – Physical phenomena and basic concepts*

IEC 60050-845:1987, *International Electrotechnical Vocabulary (IEV) – Chapter 845: Lighting*

5 Types of protection

5.1 General

Three types of protection can be applied to prevent ignitions by optical radiation in potentially explosive atmospheres. These types of protection encompass the entire optical system.

These types of protection are

a) inherently safe optical radiation, type of protection "op is";

b) protected optical radiation, type of protection "op pr";

c) optical system with interlock, type of protection "op sh".

5.2 Requirements for inherently safe optical radiation "op is"

5.2.1 General

Inherently safe optical radiation means visible or infrared radiation that is incapable of supplying sufficient energy under normal or specified fault conditions to ignite a specific explosive atmosphere. The concept is a beam strength limitation approach to safety. Ignition by an optically irradiated target absorber requires the least amount of energy, power, or irradiance of the identified ignition mechanisms in the visible and infrared spectrum. The inherently safe concept applies to unconfined radiation and does not require maintaining an absorber-free environment.

NOTE Research to date [17-22] has concluded the following values of visible and infrared beam strength are safe for explosive gas atmospheres. The safe values incorporate a modest safety factor on observed ignition values obtained under severe test conditions. Ignition of a carbon disulfide-air mixture has been reported recently using 24 mW optical power.

5.2.2 Continuous wave radiation

Optical powers or optical irradiance shall not exceed the values listed in Table 2, categorized by apparatus group and temperature class. The irradiance values are safe up to a maximum irradiated surface area of 400 mm^2. For irradiated surface areas above 400 mm^2, the temperature limits of the relevant temperature class apply. Table 2 contains information on combustible and on non-combustible absorbers. As an alternative to Table 2, for intermediate target surface areas where combustible solid targets can be excluded safe power values can be drawn from Figure 1.

Table 2 – Safe optical power and irradiance for hazardous locations categorized by apparatus group and temperature class

Apparatus group	**I**	**IIA**	**IIA**	**IIB**	**IIC**	
Temperature class		T3	T4	T4	T4	T6
Temperature class (°C)	<150	< 200	< 135	< 135	< 135	< 85
Power (mW)	150	150	35	35	35	15
Irradiance (mW/mm^2) (surface area not exceeding 400 mm^2)	20[a]	20[a]	5	5	5	5

[a] For irradiated areas greater than 30 mm^2 where combustible materials may intercept the beam, the 5 mW/mm^2 irradiance limit applies.

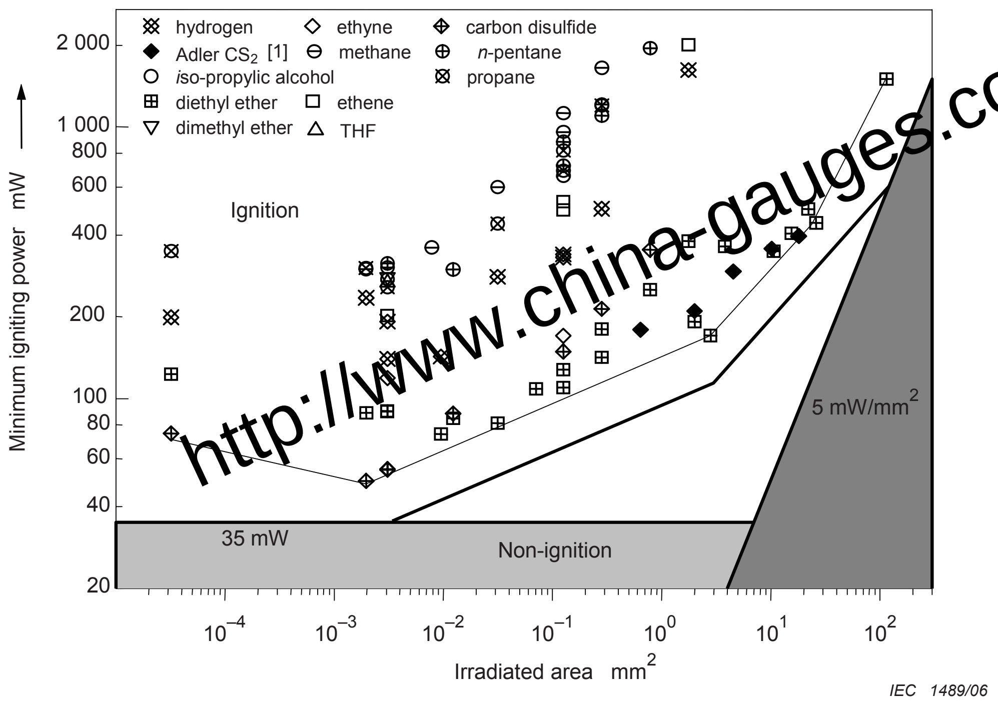

Figure 1 – Figure B.1 with limit lines for intermediate areas for non-combustible targets, T1 – T4 atmospheres, apparatus group IIA, IIB or IIC

5.2.3 Pulsed radiation

For optical pulse duration of less than 1 ms, the optical pulse energy shall not exceed the minimum spark ignition energy (MIE) of the respective explosive gas atmosphere.

For optical pulse duration between 1 ms and 1 s, an optical pulse energy equal to 10 times the MIE of the explosive gas atmosphere shall not be exceeded.

For optical pulse duration greater than 1 s, the peak power shall not exceed the safety levels for continuous wave radiation (see 5.2.2, Table 2). Such pulses are considered as continuous wave radiation.

For optical pulse trains, the single pulse criterion applies for each pulse. With repetition rates above 100 Hz, the average power shall not exceed the safety levels for continuous wave radiation. With repetition rates below 100 Hz, a higher average power may be applicable if demonstrated by tests according to Clause 6.

5.2.4 Ignition tests

Ignition tests to demonstrate inherent safety may be performed in special cases such as

– beams of intermediate dimensions or duration that may exceed the minimum optical ignition criteria but are still incapable of causing ignition;

– beams with complex time waveforms so that pulse energies and/or average power are not easily resolved;
– specific atmospheres, targets, or other specific applications that are demonstrably less severe than test conditions studied to date.

The test shall be done with 10 samples of the light source as specified in Clause 6. The test is passed if there is no ignition during the 10 tests.

5.2.5 Optical devices incorporating the inherently safe concept

Optical devices incorporating the inherently safe concept shall provide over-power/energy fault protection to prevent excessive beam strengths in potentially explosive atmospheres. The risk/hazard analysis shall determine when these additional devices are required. The failure modes of the optical source, the supply barrier, and the presence of an explosive atmosphere shall be considered during normal operation and during fault conditions to determine the requirement for additional protection.

Optical sources such as laser diodes or light-emitting diodes will fail if over-heated under over-power fault conditions. The thermal failure characteristic of certain optical sources may provide the necessary over-power fault protection (test of 10 samples).

Electrical circuits such as current and/or voltage limiters placed between the optical source and the electrical power source can provide over-power fault protection similar to intrinsically safe circuits.

Over-power fault protection shall be provided to the degree necessary for the intended EPL (see for example IEC 60079-11). For Ga equipment, for example, current and/or voltage limiters shall provide over-power fault protection after two countable faults are applied to the current and/or voltage limiter. For Gb equipment, the two-fault requirement can be reduced to one failure. For Gc equipmen,t the rated values shall be taken without assuming any fault. The thermal failure characteristic of certain low power optical sources such as light-emitting diodes is acceptable to provide adequate over-power protection for any EPL.

5.3 Requirements for protected optical radiation “op pr”

5.3.1 General

This concept requires radiation confined inside optical fibre or other transmission medium based on the assumption that there is no escape of radiation from the confinement. In this case, the performance of the confinement defines the safety level of the system.

The risk analysis provides the safety requirements based on postulated conditions (fault conditions or normal operation).

Optical fibre may be used for situations where there are no postulated conditions so that an external force may cause a break of the protective barrier. Additional protective means (e.g. robust cabling, conduit or raceway) shall be used when external forces may cause a break during normal or abnormal operations. The risk analysis will dictate the protective measures required to prevent a break and escape of radiation.

Where enclosures are used, they may allow an ignition source inside without igniting the atmosphere outside, provided they meet the requirements of the standard types of protection concerned (IEC 60079 series).

5.3.2 Radiation inside fibre, etc. (no mechanical damage to be expected)

The optical fibre protects the release of optical radiation into the atmosphere during normal operating conditions. For foreseeable malfunctions, this can be provided by additional armouring, conduit, cable tray, or raceway.

5.3.3 Radiation inside enclosures

Incendive radiation inside enclosures is acceptable if the enclosure complies with recognised types of protection for electrical apparatus where an ignition source may be present inside (flameproof "d" enclosure, pressurised "p" enclosure, restricted breathing enclosure...) according to IEC 60079 series. It shall, however, be considered, that any radiation escaping from the enclosure has to be protected according to this standard.

5.4 Optical radiation interlock with optical fibre breakage “op sh”

This type of protection is applicable when the radiation is not inherently safe with interlock cut-off if the protection by the confinement fails and the radiation becomes unconfined on time scales suitably shorter than the ignition delay time.

The interlock cut-off shall be required to perform according to the requirements defined by the risk analysis. The methods given in appropriate standards (e.g. IEC 61508, IEC 61511) may be used to analyse equipment performance to have an availability or risk reduction factor, depending on the equipment protection level, as shown in Table 3.

Table 3 – Optical interlock availability or ignition risk reduction factor by EPL

EPL	Safety availability	Ignition risk reduction factor
Ga	0,999 to 0,9999	1 000 to 10 000
Gb	0,99 to 0,999	100 to 1 000
Gc	0,9 to 0,99	10 to 100

NOTE The values listed in Table 3 were derived from recommendations of the SAFEC report (Wilday 2000).

Where it can be demonstrated by the ignition hazard assessment (see Annex C), that the conditions for ignition are not attained readily after breakage of the fibre, shut down times used for eye protection purposes may be used (see IEC 60825-2:2000). This will typically be the case for Gc equipment, but may also apply for Gb equipment.

5.5 Suitability of types of protection

Where the ignition hazard assessment given in Annex C shows that ignitions due to optical radiation are to be expected, the following principles of using the types of protection can be applied.

Table 4 – Application of types of protection for optic systems based on EPLs

Type(s) of protection	Ga	Gb	Gc
Inherently safe optical radiation "op is" (see 5.2)			
Safe with two faults	Yes	Yes	Yes
Safe with one fault	No	Yes	Yes
safe in normal operation	No	No	Yes
Protected fibre optic media with ignition capable beam "op pr" (see 5.3)			
With additional mechanical protection	No	Yes	Yes
Without additional mechanical protection	No	No	Yes
Protected fibre optic media with ignition capable beam interlocked with fibre breakage "op sh" (see 5.4)			
With additional mechanical protection	Yes	Yes	Yes
Without additional mechanical protection	No	Yes	Yes
None (unconfined, ignition capable beam)	No	No	No

6 Type verifications and tests

6.1 Test set-up for ignition tests

6.1.1 Test vessel

Diameter >150 mm, height above ignition source >200 mm.

6.1.2 Energy and power measurements

Total uncertainty of energy and power measurement shall be less than 5 % relative, including variations of light source.

6.1.3 Ignition criterion

A temperature increase of at least 100 K, measured by a 0,5 mm diameter thermocouple bead, 100 mm above the hot spot , or the appearance of a flame.

6.1.4 Mixture temperature

40 °C or the maximum temperature of the specific application.

6.1.5 Mixture pressure

Ambient pressure according to IEC 60079-0.

6.1.6 Safety factor

A safety factor of 1,5 for cw radiation and 3 for pulsed radiation shall be applied to all results (as non-ignition results) obtained by the tests according to 6.3 or 6.4 before using these data as inherently safe data.

Where no ignition can be obtained during test (e.g. because the power or energy cannot be increased further more in the test), this factor shall also be applied to the highest non incendive beam strength data obtained.

Another possibility to obtain safe beam strength data (including a safety factor) is to use a test gas that is more sensitive to ignition. For cw-equipment to be used in IIA/T3 atmospheres, this test gas can be ethene up to a size of the beam area of about 2 mm^2.

NOTE As the ignition by a small hot surface is a process containing considerable statistical deviations, a safety factor is justified. Due to the same reason, great care is to be applied when judging experiments as non-incendive because small variations in test parameters may influence the results remarkably.

6.2 Reference test

6.2.1 Reference gas

Propane-air-mixture of 5 % or 4 % by volume, see Table A.1 (for ignition tests with continuous wave radiation and pulses above 1 s duration) respectively 4 % by volume (for pulsed radiation, single pulses below 1 ms duration), quiescent mixture.

6.2.2 Reference absorber

Absorption at investigated wavelength above 80 %, to be applied on the transmission fibre tip (fibre optics), or compressed respectively applied to an inert substrate (free beam transmission).

NOTE Experiments showed that for pulses in the micro and nanosecond range, a carbon black absorber gives lowest igniting pulse energies (absorption 99 %, combustible, high decomposition temperature) [17,20,22].

6.2.3 Reference test for continuous wave radiation and pulses above 1 s duration

The irradiated reference absorber has to be physically and chemically inert for the duration of the test. The absorber is needed to have very high absorption to nearly act as a black body. The set-up should be tested with the reference gas and absorber at 40 °C. For the testing of fibre optics, the absorber should be applied to the fibre tip in a very thin layer (~ 10 µm) (as a powder in suspension and dried afterwards). The reference values are given in Annex A (Table A.1). The test setup is acceptable if the achieved ignition values are not more than 20 % above the data from Table A.1. The absorber has to be undamaged at the end of the test.

For the testing of free beam transmission the smallest diameter of the beam should hit a plane layer of the target material applied to a substrate or compressed. The reference values are to be taken from Table A.1 for the respective beam diameter. The test setup is acceptable if the achieved ignition values are not more than 20 % above the data from Table A.1. The absorber has to be undamaged at the end of the test.

6.2.4 Reference test for pulsed radiation below 1 ms pulse duration

The irradiated reference absorber should be irradiated from the front (free beam irradiation) during all pulse tests. For the testing of free beam transmission the smallest diameter of the beam should hit a plane layer of the target material applied either to a substrate or is compressed to form a pellet. The reference value for a beam diameter of 90 µm is 499 µJ pulse energy for pulses of 90 ns and 600 µJ for pulses of 30 ns. The set-up should be tested with the reference gas and absorber at 40 °C. The test setup is acceptable if the achieved ignition values are not more than 20 % above the data from Table B.1.

NOTE Background information for the reference values are given in the literature [20].

6.3 Test mixtures

6.3.1 Ignition tests with continuous wave radiation and pulses above 1 s duration

6.3.1.1 For T6/IIC atmospheres

CS_2 in air, 1,5 % by volume, and diethyl ether, 12 % by volume.

If only diethyl ether is used, the minimum ignition powers or irradiances obtained have to be divided by a factor of 4 for further use.

6.3.1.2 For T4/IIA, T4/IIB and T4/IIC atmospheres

Diethyl ether, 12 % by volume.

6.3.1.3 For T3/IIA and I atmospheres

Propane in air, 5 % by volume.

6.3.1.4 For special applications

The atmosphere under consideration.

6.3.2 Ignition tests with single pulses below 1 ms duration

6.3.2.1 For IIC atmospheres

H_2 in air, 12 % and 21 % by volume or CS_2 in air, 6,5 % by volume.

6.3.2.2 For IIB atmospheres

Ethene in air, 5,5 % by volume.

6.3.2.3 For I and IIA atmospheres

Diethyl ether, 3,4 % by volume or propane in air, 4 % by volume; divide minimum ignition energies obtained with propane by 1.2 for further use.

6.3.2.4 For special applications

The atmosphere under consideration.

6.4 Tests for pulse trains and pulses between 1 ms and 1 s duration

Apply test configuration according to 6.3.1 and then test configuration according to 6.3.2, absorbers and mixtures as specified in 6.1 to 6.3.

7 Marking

7.1 General

The apparatus using optical radiation shall be additionally marked with the following.

7.2 Marking information

The marking shall include

a) the symbol for the type of protection used:
   - “op is”: for inherently safe optical radiation,
   - “op pr”: for protected optical radiation,
   - “op sh”: for optical system with interlock;
b) the symbol of the group of the apparatus:
   - For the type of protection inherently safe optical radiation “op is”, the suffixes A, B or C shall be used;
   - For apparatus not suitable for installation in a hazardous area, but providing optical radiation, the marking for associated apparatus shall apply. If Table 2 requires a restriction of the temperature class, this shall be indicated following the type of protection. Example: [Ex op is T4 Gb] IIC;
c) equipment protection level Ga, Gb or Gc as determined by Table 4;
d) a serial number, except for:
   - connection accessories; optical fibre cables, etc.,
   - very small apparatus on which there is limited space.

7.3 Examples of marking

- Apparatus which is complying with EPL Ga:

  Ex op is IIC T6 Ga
- Apparatus which is complying with EPL Gb:

  Ex op pr II T4 Gb
- Apparatus, which is installed outside the hazardous area and providing optical radiation to the hazardous area, limit values taken from Table 2:

  [Ex op is T3 Ga] IIA

The certificate shall identify the relevant EPL of the equipment (there may be more than one EPL for the different parts of the equipment).

Annex A
(normative)

Reference test data

Table A.1 – Reference values for ignition tests with a mixture of propane in air at 40 °C mixture temperature

Fibre core diameter µm	Minimum igniting power at 1 064 nm (absorption: 83 %, 5 % propane by volume) mW	Minimum igniting power at 805 nm (absorption: 93 %, 4 % propane by volume) mW
62,5 (125 µm cladding)	250	
400	842	690
600		1 200
1 500		3 600
NOTE The absorber was attached to the end of an optical fibre and irradiated continuously.		

NOTE Other reference test data (e.g. for 8µm core diameter, 1 550 nm wavelength) are currently not available.

Annex B
(informative)

Ignition mechanisms [3]

The potential hazard associated with optics in the infrared and visible electromagnetic spectrum depends on

- laser wavelength (absorption properties),
- absorber material (inert, reactive),
- fuel,
- pressure,
- irradiated area,
- irradiation time.

There is an immense number of combinations of these factors that will influence the hazard of optics in explosive atmosphere and at least the ignition mechanism. Worst case conditions arise when an absorber is present. When the dimensions of the radiation and or the absorber fall below the quenching distance of the explosive gas, the ignition can be seen as point ignition. However, radiation from the end of a fibre optic cable diverges rapidly and the irradiated area may reach dimensions of square centimetres. The conditions for ignition can be characterised in terms of the fundamental parameters energy, area and time.

	Area tends to	Time tends to	Ignition criterion
(1)	zero	infinity	minimum power
(2)	infinity	infinity	minimum irradiance
(3)	zero	zero	minimum energy
(4)	infinity	zero	radiant exposure

Infinite time means continuous wave radiation. The research results for small and big areas are given in Table B.1, Figure B.1 and Figure B.2. In both regimes, ignition takes place via hot surface ignition when the beam hits an absorber. The smaller the surface, the higher the igniting irradiance. This means that a smaller surface has to be heated to higher temperatures to cause an ignition. No ignition was observed below 50 mW optical power for all gas/vapour mixture (excluding carbon disulfide). This supports the maximum permissible power value of 35 mW including a safety margin, which also has to consider the non-ideal grey body absorption of the inert absorber. Experiments with reactive absorbers (coal, carbon black and a toner) showed, that even though they have higher absorption, they were less effective as ignition sources. The n-alkanes do not ignite below 200 mW (150 mW including safety margin). For bigger irradiated areas, a permissible value of 5 mW/mm^2 is much more realistic than a restrictive power criterion.

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3 The information provided in this annex is taken from reference [17] of Bibliography.

In the small area short time regime, a laser pulse can create an ignition source similar to an electric spark by a breakdown in air. It is known from the literature [26] that such spark with an energy approaching the electrical minimum ignition energy (MIE) is able to ignite an explosive mixture under optimised conditions (µs and ns pulses).

The effectiveness of this ignition process depends on

– pulse length and repetition rate,
– wavelength,
– target (absorber) material,
– irradiance and radiant exposure.

Microsecond pulses and nanosecond pulses with energies close to the MIE were found to ignite explosive mixtures as shown in Table B.2. In this case, the combustible carbon black target is the most effective absorber. The properties of carbon black support this breakdown in comparison to the inert material chosen in the continuous wave experiments (very high absorption, high decomposition temperature, electron-rich structure and combustibility). For pulses in the millisecond range without a breakdown process but heating of the target, ignition energies are more than one order of magnitude higher than the electrical MIE. Here, the inert grey body is the ideal absorber. Pulses longer than 1 s should be treated as continuous wave radiation.

For pulse trains, the ignition criterion for each individual pulse is the energy criterion given above when the pulse is shorter then 1 s. With higher repetition rates, the previous pulse might have an influence on the behaviour of the irradiated area with the actual pulse. For repetition rates greater than 100 Hz, the average power should be restricted to the continuous wave limit. This limitation forces a maximum repetition rate for a defined pulse energy. The shorter the pulse, the higher the permissible peak power but the longer the duty cycle. This gives time for cooling of the target or decay of a spark or plume of hot material. Experiments showed [20] that for nanosecond pulses in the range of the MIE (up to 400 µJ), a spark lifetime of more than 100 µs is not to be expected for a beam diameter of 90 µm. For long pulse duration >1 s, the peak power should be restricted to the corresponding cw-limit.

The remaining combination of fundamental parameters, i.e. short times over infinite area, can be evaluated by the results for the other regimes.

Table B.1 – AIT (auto ignition temperature), MESG (maximum experimental safe gap) and measured ignition powers of the chosen combustibles for inert absorbers as the target material ($\alpha_{1\,064\ nm}$=83 %, $\alpha_{805\ nm}$=93)

Group according to IEC 60079-0	Combustible In brackets: increased mixture temperature	AIT °C	MESG mm	Conc. comb.[a] at min. ignition power PTB* (1064 nm) % vol.	Min. ignition power 62,5 µm fibre PTB (1064 nm) mW	Min. ignition power 400 µm fibre PTB (1064 nm) mW	Conc. comb. at min. ignition power HSL* (803 nm) % vol.	Min. ignition power 400 µm fibre HSL (803 nm) mW	Min. ignition power 600 µm fibre HSL (803 nm) mW	Min. ignition power 1500 µm fibre HSL (803 nm) mW
IIA	Methane	595	1,14	5,0	304	1125	6,0	960	1 650	5 000
	Acetone	535	1,04	-	-	-	8	830	-	-
	2-propanol	425	0,99	4,5	273	660	-	-	-	-
	N-pentane	260	0,93	3,0	315	847	3,0	720	1 100	3 590
	Butane	410 (365)	 (0,98)	-	-	-	4,6	680	-	-
	Propane	470	0,92	5,0	250	842	4,0	690	1 200	3 600
	Petrol unleaded	300 (350)	>0,9	-	-	-	4,3	720		3 650
	N-heptane (110 °C)	220	0,91	3,0	-	502	-	-	-	-
	Methane/ hydrogen	595	0,90	6,0	259	848	-	-	-	-
IIB	Diethyl ether/ n-heptane (110 °C)	200	0,90	4,0	-	658	-	-	-	-
	Tetra-hydrofuran	230	0,87	6,0	267	-	-	-	-	-
	Diethyl ether	175	0,87	12,0	89	127	23,0	110	180	380
	Propanal (110 °C)	190	0,84	2,0	-	617	-	-	-	-
	Dimethyl ether	240	0,84	8	280	-	-	-	-	-
	Ethene	425	0,65	7,0	202	494	7,5	530	-	2 007
	Methane/ hydrogen	565	0,50	7,0	163	401	-	-	-	-
IIC	Carbon disulphide	95	0,37	1,5	50/24**	149	-	-	-	-
	Ethyne	305	0,37	25,0	110	167	-	-	-	-
	Hydrogen	560	0,29	10,0	140	331	8,0	340	500	1 620

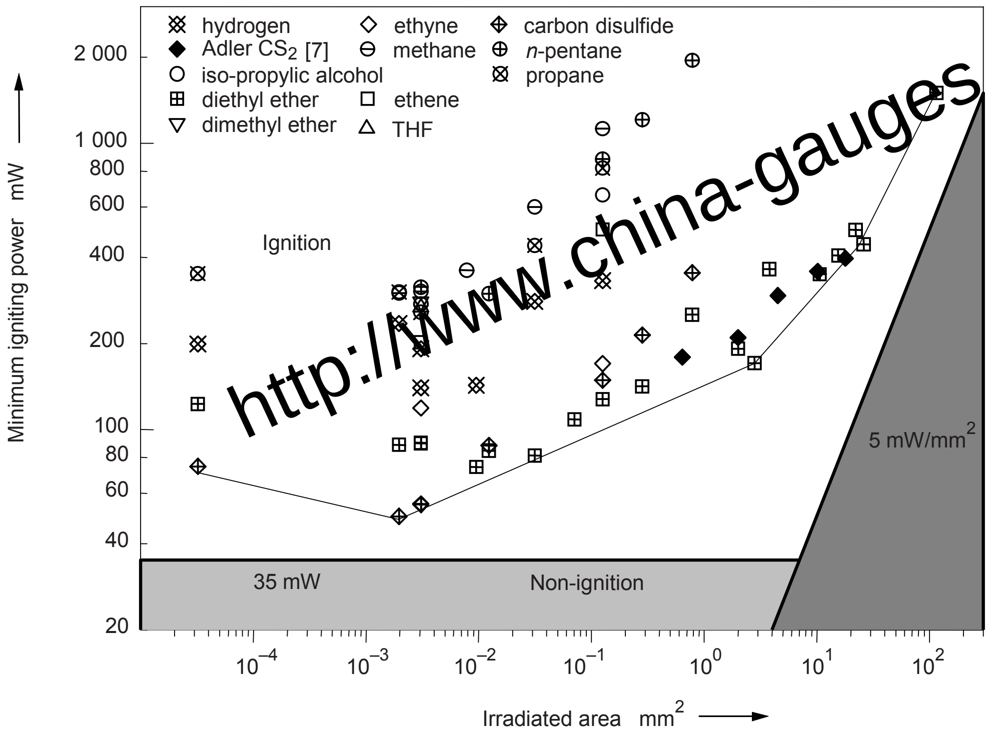
NOTE AIT and MESG were taken from reference [25] of Bibliography.

[a] Conc comb: Concentration of combustible

* HSL = Health and Safety Laboratory of the Health and Safety Executive (UK)

PTB = Physikalisch-Technische Bundesanstalt (Germany)

** 24 mW was obtained for a combustible target (coal)



NOTE 1 Data taken from [17][23].

NOTE 2 The given values are for each combustible in its most easily ignitable mixture.

Figure B.1 – Minimum radiant igniting power with inert absorber target ($\alpha_{1\,064\ nm}$=83 %, $\alpha_{805\ nm}$=93 %) and continuous wave-radiation of 1 064 nm

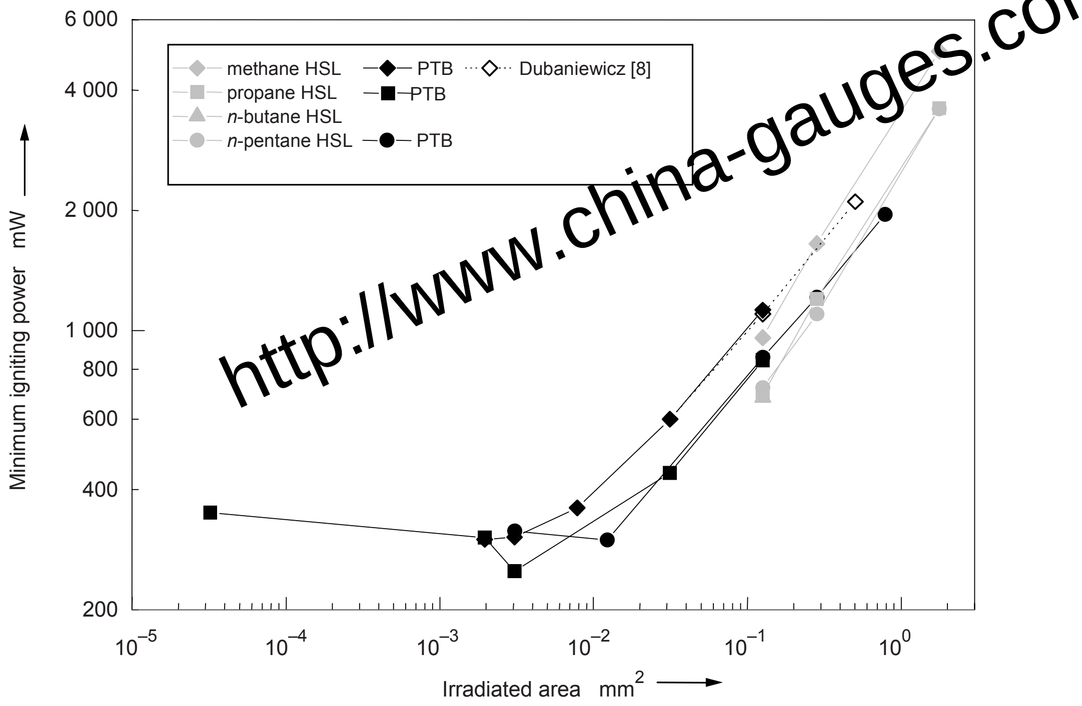


Figure B.2 – Minimum radiant igniting power with inert absorber target ($\alpha_{1\,064\ nm}$=83 %, $\alpha_{805\ nm}$=93 %) and continuous wave-radiation (PTB: 1 064 nm, HSL: 805 nm, [24]: 803 nm) for some n-alkanes

Table B.2 – Comparison of measured minimum igniting optical pulse energy ($Q_{e,p}^{i,min}$) at 90 µm beam diameter with auto ignition temperatures (AIT) and minimum ignition energies (MIE) from literature [25] at concentrations in percent by volume (φ)

Fuel	$Q_{e,p}^{i,min}$ µJ	φ %	AIT °C	MIE µJ	φ^{MIE} %	$Q_{e,p}^{i,min}$/MIE
70 µs spiked pulse						
N-Pentane	669	3	260	280	3,3	2,4
	>55 000	6,4				
Propane	784	5,5	470	240	5,2	3,3
Diethyl ether	661	3,4	175	190	5,2	3,5
	1 285	5,2				6,8
Ethene	218	5,5	425	82	6,5	2,7
Hydrogen	88	21	560	17	28	5,2
Carbon disulfide	79	6,5	95	9	8,5	9,3
Nanosecond pulses (20 ns to 200 ns)						
Propane	499	4,0	470	240	5,2	2,1
Ethene	179	5,5	425	82	6,5	2,2
Hydrogen	44	12	560	17	28	2,6
	46	21				2,7
NOTE The target material was carbon black.						

Annex C
(normative)

Ignition hazard assessment

An explosive combustible air atmosphere can be ignited by optical radiation provided that the beam strength exceeds an inherently safe level and an absorbing solid exists in the beam that can cause a hot spot and an ignition source accordingly, or the conditions for a breakdown apply (threshold irradiance exceeded). See Figure C.1.

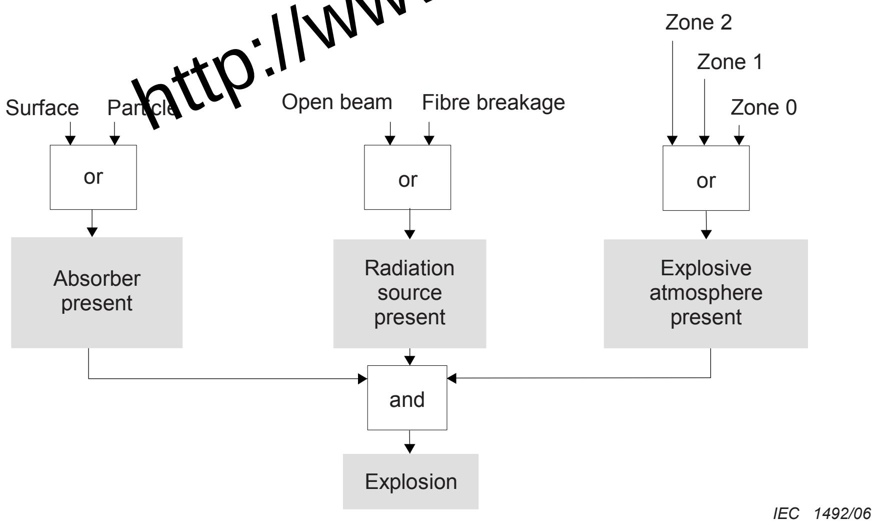


Figure C.1 – Ignition hazard assessment

If these conditions apply, the types of protection b) and c) given in 5.1 shall be used.

Where these conditions do not apply, an ignition hazard may not exist. A further assessment considering all conditions necessary for ignition

– for the specific case or equipment,

– and considering the requirements for the different EPLs according to 4.2

shall be performed and measures necessary derived accordingly.

NOTE 1 Although not covered by this standard, all possible ways to ignite an explosive mixture by optical radiation (see Introduction and this Annex C) must be checked before excluding this ignition source.

It is important to understand that even in the case of open radiation, exceeding the inherently safe level does not readily lead to ignition, as additional provisions (different from the electrical spark ignition) are necessary to start an ignition process.

NOTE 2 As an example, a gas analysis system where in the beam there is no absorbing target that can be heated up to be an ignition source may not create an ignition hazard with respect to the optical radiation. In this specific case, there will be absorption of optical energy in the mixture itself, but it can be easily demonstrated in most cases that there is no heating of the mixture to such an extent that it will be ignited.

This assessment applies also to the use of the protections concepts themselves. Where an enclosure for the beam is used that does not allow solid materials to enter it (although it allows the explosive atmosphere to enter), an ignition source is prevented inside this enclosure, provided there exists no other target inside.

If a fibre breakage is assumed, where the concept of interlock with the breakage detection is used, it may be safe to use the shut down times allowed for eye protection (IEC 60825-2: 2000), if it is improbable that the beam will hit a target with an incendive intensity.

Annex D
(informative)

Typical optical fibre cable design

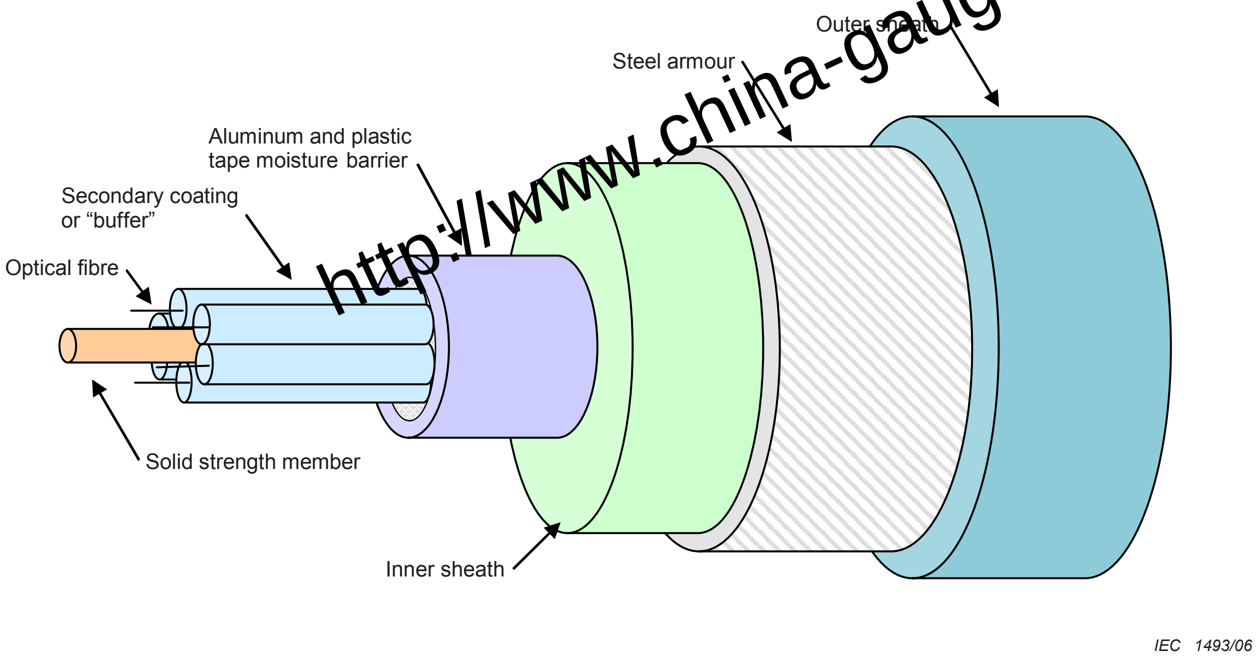


Figure D.1 – Example multi-fibre optical cable design for heavy duty applications

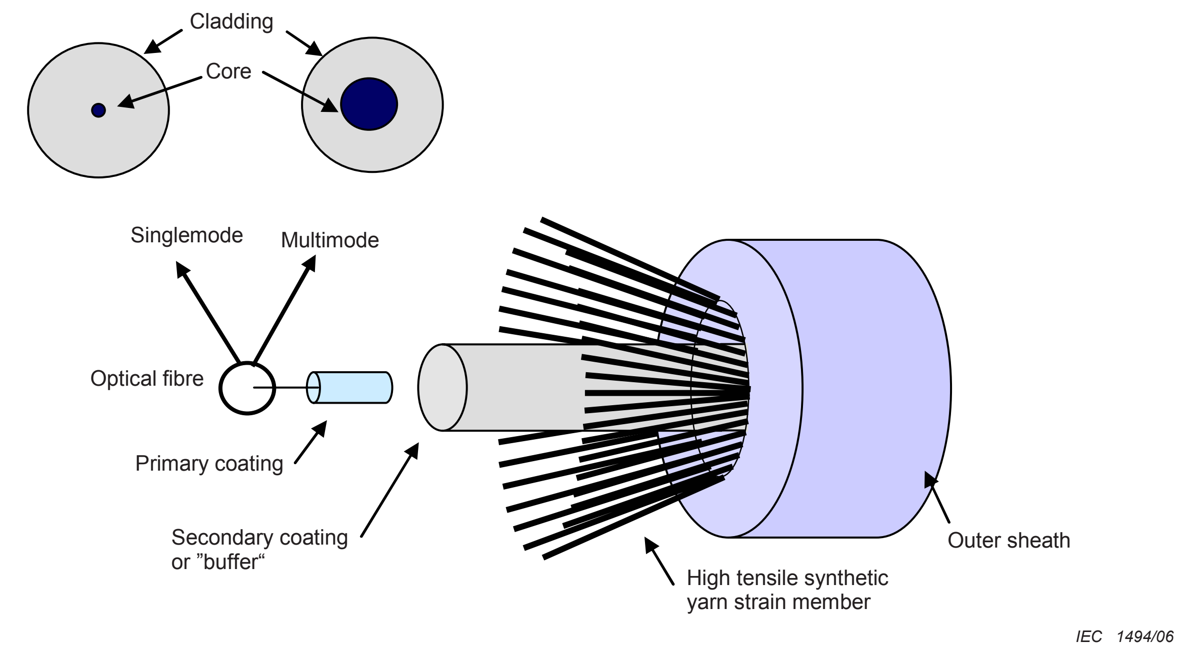


Figure D.2 – Typical single optical fibre cable design

Annex E
(informative)

Introduction of an alternative risk assessment method encompassing "equipment protection levels" for Ex equipment

E.0 Introduction

This annex provides an explanation of the concept of a risk assessment method encompassing equipment protection levels (EPLs). These EPLs are introduced to enable an alternative approach to current methods of selecting Ex equipment.

E.1 Historical background

Historically, it has been acknowledged that not all types of protection provide the same level of assurance against the possibility of an incendive condition occurring. The installation standard IEC 60079-14 [8] allocates specific types of protection to specific zones, on the statistical basis that the more likely or frequent the occurrence of an explosive atmosphere, the greater the level of security required against the possibility of an ignition source being active.

Hazardous areas (with the normal exception of coal mining) are divided into zones, according to the degree of hazard. The degree of hazard is defined according to the probability of the occurrence of explosive atmospheres. Generally, no account is taken of the potential consequences of an explosion, nor of other factors such as the toxicity of materials. A true risk assessment would consider all factors.

Acceptance of equipment into each zone is historically based on the type protection. In some cases, the type of protection may be divided into different levels of protection which again historically correlate to zones. For example, intrinsic safety is divided into levels of protection ia and ib. The encapsulation "m" standard includes two levels of protection "ma" and "mb".

In the past, the equipment selection standard has provided a solid link between the type of protection for the equipment and the zone in which the equipment can be used. As noted earlier, nowhere in the IEC system of explosion protection is there any account taken of the potential consequences of an explosion, should it occur.

However, plant operators often make intuitive decisions on extending (or restricting) their zones in order to compensate for this omission. A typical example is the installation of "zone 1 Type" navigation equipment in zone 2 areas of offshore oil production platforms, so that the navigation equipment can remain functional even in the presence of a totally unexpected prolonged gas release. In the other direction, it is reasonable for the owner of a remote, well secured, small pumping station to drive the pump with a "zone 2 Type" motor, even in zone 1, if the total amount of gas available to explode is small and the risk to life and property from such an explosion can be discounted.

The situation became more complex with the publication of the first edition of IEC 60079-26 which introduced additional requirements to be applied for equipment intended to be used in zone 0. Prior to this, Ex ia was considered to be the only technique acceptable in zone 0.

It has been recognized that it is beneficial to identify and mark all products according to their inherent ignition risk. This would make equipment selection easier and provide the ability to better apply a risk assessment approach, where appropriate.

E.2 General

A risk assessment approach for the acceptance of Ex equipment has been introduced as an alternative method to the current prescriptive and relatively inflexible approach linking equipment to zones. To facilitate this, a system of equipment protection levels has been introduced to clearly indicate the inherent ignition risk of equipment, no matter what type of protection is used.

The system of designating these equipment protection levels is as follows.

E.2.1 Coal mining (group I)

E.2.1.1 EPL Ma

Equipment for installation in a coalmine, having a "very high" level of protection, which has sufficient security that it is unlikely to become an ignition source, even when left energised in the presence of an outbreak of gas.

NOTE Typically, communications circuits and gas detection equipment will be constructed to meet the Ma requirements – for example an Ex ia telephone circuit.

E.2.1.2 EPL Mb

Equipment for installation in a coal mine, having a "high" level of protection, which has sufficient security that it is unlikely to become a source of ignition in the time span between there being an outbreak of gas and the equipment being de-energised.

NOTE Typically, all the coal winning equipment will be constructed to meet the Mb requirements – for example Ex d motors and switchgear.

E.2.2 Gases (group II)

E.2.2.1 EPL Ga

Equipment for explosive gas atmospheres, having a "very high" level of protection, which is not a source of ignition in normal operation, expected faults or when subject to rare faults.

E.2.2.2 EPL Gb

Equipment for explosive gas atmospheres, having a "high" level of protection, which is not a source of ignition in normal operation or when subject to faults that may be expected, though not necessarily on a regular basis.

NOTE The majority of the standard protection concepts bring equipment within this equipment protection level.

E.2.2.3 EPL Gc

Equipment for explosive gas atmospheres, having an "enhanced" level of protection, which is not a source of ignition in normal operation and which may have some additional protection to ensure that it remains inactive as an ignition source in the case of regular expected occurrences (for example failure of a lamp).

NOTE Typically, this will be Ex n equipment.

E.2.3 Dusts (group III)

E.2.3.1 EPL Da

Equipment for combustible dust atmospheres, having a "very high" level of protection, which is not a source of ignition in normal operation or when subject to rare faults.

E.2.3.2 EPL Db

Equipment for combustible dust atmospheres, having a "high" level of protection, which is not a source of ignition in normal operation or when subject to faults that may be expected, though not necessarily on a regular basis.

E.2.3.3 EPL Dc

Equipment for combustible dust atmospheres, having an "enhanced" level of protection, which is not a source of ignition in normal operation and which may have some additional protection to ensure that it remains inactive as an ignition source in the case of regular expected occurrences.

For the majority of situations, with typical potential consequences from a resultant explosion, it is intended that the following would apply for use of the equipment in zones. (This is not directly applicable for coal mining, as the zone concept does not generally apply.) See Table E.1.

Table E.1 – Traditional relationship of EPLs to zones (no additional risk assessment)

Equipment protection level	Zone
Ga	0
Gb	1
Gc	2
Da	20
Db	21
Dc	22

E.3 Risk of ignition protection afforded

The various levels of protection of equipment must be capable of functioning in conformity with the operational parameters established by the manufacturer to that level of protection.

Table E.2 – Description of risk of ignition protection provided

Protection afforded	Equipment protection level	Group	Performance of protection	Conditions of operation
Very High	Ma	Group I	Two independent means of protection or safe even when two faults occur independently of each other	Equipment remains functioning when explosive atmosphere present
Very High	Ga	Group II	Two independent means of protection or safe even when two faults occur independently of each other	Equipment remains functioning in zones 0,1 and 2
Very High	Da	Group III	Two independent means of protection or safe even when two faults occur independently of each other	Equipment remains functioning in zones 20, 21 and 22
High	Mb	Group I	Suitable for normal operation and severe operating conditions	Equipment de-energised when explosive atmosphere present
High	Gb	Group II	Suitable for normal operation and frequently occurring disturbances or equipment where faults are normally taken into account	Equipment remains functioning in zones 1 and 2
High	Db	Group III	Suitable for normal operation and frequently occurring disturbances or equipment where faults are normally taken into account	Equipment remains functioning in zones 21 and 22
Enhanced	Gc	Group II	Suitable for normal operation	Equipment remains functioning in zone 2
Enhanced	Dc	Group III	Suitable for normal operation	Equipment remains functioning in zone 22

E.4 Implementation

The 4th edition of IEC 60079-14 (encompassing the former requirements of IEC 61241-14) will introduce the EPLs to allow a system of “risk assessment" as an alternative method for the selection of equipment (see Table E.2). Reference will also be included in the classification standards IEC 60079-10 and IEC 61241-10 [14].

The additional marking and the correlation of the existing types of protection are being introduced into the revisions to the following IEC standards [3-7], [9-11]:

- IEC 60079-0 (encompassing the former requirements of IEC 61241-0 [12])
- IEC 60079-1
- IEC 60079-2 (encompassing the former requirements of IEC 61241-4 [13])

- IEC 60079-5
- IEC 60079-6
- IEC 60079-7
- IEC 60079-11 (encompassing the former requirements of IEC 61241-11 [15])
- IEC 60079-15
- IEC 60079-18 (encompassing the former requirements of IEC 61241-18 [16])
- IEC 60079-26
- IEC 60079-28

For the types of protection for explosive gas atmospheres the EPLs require additional marking. For explosive dust atmospheres, the present system of marking the zones on equipment is being replaced by marking the EPLs.

Bibliography

[1] IEC 60050-426:1990, *International Electrotechnical Vocabulary (IEV) – Chapter 426: Electrical apparatus for explosive atmospheres*

[2] IEC 60050-731:1991, *International Electrotechnical Vocabulary (IEV) – Chapter 731: Optical fibre communication*

[3] IEC 60079-1, *Electrical apparatus for explosive gas atmospheres – Part 1: Flameproof enclosures "d"*

NOTE Harmonized as EN 60079-1:2004 (not modified).

[4] IEC 60079-2, *Electrical apparatus for explosive gas atmospheres – Part 2: Pressurized enclosures "p"*

NOTE Harmonized as EN 60079-2:2004 (not modified).

[5] IEC 60079-5, *Electrical apparatus for explosive gas atmospheres – Part 5: Powder filling "q"*

[6] IEC 60079-6, *Electrical apparatus for explosive gas atmospheres – Part 6: Oil immersion "o"*

[7] IEC 60079-7, *Explosive atmospheres – Part 7: Equipment protection by increased safety "e"*

NOTE Harmonized as EN 60079-7:2007 (not modified).

[8] IEC 60079-14, *Electrical apparatus for explosive gas atmospheres – Part 14: Electrical installations in hazardous areas (other than mines)*

NOTE Harmonized as EN 60079-14:2003 (not modified).

[9] IEC 60079-15, *Electrical apparatus for explosive gas atmospheres – Part 15: Construction, test and marking of type of protection "n" electrical apparatus*

NOTE Harmonized as EN 60079-15:2005 (not modified).

[10] IEC 60079-18, *Explosive atmospheres – Part 18: Electrical equipment – Requirements for encapsulation "m"*

[11] IEC 60079-26:2004, *Electrical apparatus for explosive gas atmospheres – Part 26: Construction, test and marking of Group II Zone 0 electrical apparatus*

NOTE Harmonized as EN 60079-26:2004 (not modified).

[12] IEC 61241-0, *Electrical apparatus for use in the presence of combustible dust – Part 0: General requirements*

NOTE Harmonized as EN 61241-0:2006 (modified).

[13] IEC 61241-4, *Electrical apparatus for use in the presence of combustible dust – Part 4: Type of protection "pD"*

NOTE Harmonized as EN 61241-4:2006 (not modified).

[14] IEC 61241-10, *Electrical apparatus for use in the presence of combustible dust – Part 10: Classification of areas where combustible dusts are or may be present*

NOTE Harmonized as EN 61241-10:2004 (not modified).

[15] IEC 61241-11, *Electrical apparatus for use in the presence of combustible dust – Part 11: Protection by intrinsic safety 'iD'*

NOTE Harmonized as EN 61241-11:2006 (not modified).

[16] IEC 61241-18, *Electrical apparatus for use in the presence of combustible dust – Part 18: Protection by encapsulation 'mD'*

NOTE Harmonized as EN 61241-18:2004 (not modified).

[17] CARLETON, F.B., BOTHE, H., PROUST, C., and HAWKSWORTH, S., *Prenormative Research on the Use of Optics in Potentially Explosive Atmospheres*, European Commission Report EUR 19617 EN, 2000

[18] McGEEHIN, P., *Optical Techniques in Industrial Measurements: Safety in Hazardous Environments*, European Commission Report EC 16011 EN, 1995

[19] WELZEL, M.M., *Entzündung von explosionsfähigen Dampf/Luft- und Gas/Luft-Gemischen durch kontinuierliche optische Strahlung*, PTB-Report W-67, ISBN 3-89429-812-X , 1996

[20] SCHENK, S., Entzündung explosionsfähiger Atmosphäre durch gepulste optische Strahlung, PTB-Report Th-Ex 17, ISBN 3-89701-667-2, 2001

[21] WELZEL, M.M., SCHENK, S., HAU, M., CAMMENGA, H.K., and BOTHE, H*., J. Hazard. Mater.* A72:1 (2000)

[22] SCHENK, S., BOTHE, H., and CAMMENGA, H.K., in BRADLEY, D., *Proc. Third International Seminar on Fire and Explosions Hazards 2000,* 2001, p. 495

[23] ADLER, J., CARLETON, F.B. and WEINBERG, F.J., Proc. R. Soc. Lond. A (1993) 440, 443-460

[24] DUBANIEWICZ, T.H., CASHDOLLAR, K.L., GREEN, G.M. and CHAIKEN, R.F*., J. Loss Prevent. Proc.* 13: 349-359 (2000)

[25] DECHEMA, PTB, BAM: ChemSafe: Sicherheitstechnische Datenbank, Karlsruhe. STN Datenbank, 1995

[26] SYAGE, J.A., FOURNIER, E.W., RIANDA, R. and COHEN, R.B., J. Appl. Phys. 64:1499

[27] WILDAY, A.J., WRAY, A.M., EICKHOFF, F., UNRUH, M., HALAMA, S., FAE, E., CONDE LAZARO, E., REINA PERBAL, P

[28] Determination of Safety Categories of Electrical Devices Used in Potentially Explosive Atmospheres (SAFEC) Contract SMT4-CT98-2255, http://www.prosicht.com/EC-Projects/SAFEC/finalrp4.pdf (Safetynet, Prosicht, Germany, 2000).

[29] ANSI/ISA-TR12.21.01-2004, Use of Fiber Optic Systems in Class I Hazardous (Classified) Locations. ISA, Research Triangle Park, North Carolina, USA, 2004.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60079	Series	Electrical apparatus for explosive gas atmospheres	EN 60079	Series
IEC 60079-0 (mod)	-[1]	Electrical apparatus for explosive gas atmospheres - Part 0: General requirements	EN 60079-0	2006[2]
IEC 60079-10	-[1]	Electrical apparatus for explosive gas atmospheres - Part 10: Classification of hazardous areas	EN 60079-10	2003[2]
IEC 60079-11	-[1]	Explosive atmospheres - Part 11: Equipment protection by intrinsic safety "i"	EN 60079-11	2007[2]
IEC 60825-2	-[1]	Safety of laser products - Part 2: Safety of optical fibre communication systems (OFCS)	EN 60825-2	2004[2]
IEC 61508	Series	Functional safety of electrical/electronic/programmable electronic safety-related systems	EN 61508	Series
IEC 61511	Series	Functional safety - Safety instrumented systems for the process industry sector	EN 61511	Series

[1] Undated reference.

[2] Valid edition at date of issue.

Annex ZZ
(informative)

Coverage of Essential Requirements of EC Directives

This European Standard has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association and within its scope the standard covers only the following essential requirements out of those given in Annex II of the EC Directive 94/9/EC:

- ER 1.0.1 to ER 1.0.4, ER 1.0.5 (partly)
- ER 1.2.1, ER 1.2.6, ER 1.2.8 to ER 1.2.9
- ER 1.3.1
- ER 1.5.1
- ER 2.1.1 (partly)
- ER 2.2.1 (partly)
- ER 2.3.1 (partly)

Compliance with this standard provides one means of conformity with the specified essential requirements of the Directive concerned.

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

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