

Emergency lighting

Part 4. Code of practice for design, installation, maintenance and use of optical fibre systems

ICS 91.160.10; 33.180.01

Confirmed
January 2010

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- Association of British Theatre Technicians
- Association of Building Engineers
- Association of County Councils
- Association of Manufacturers of Power Generating Systems
- British Cable Makers Confederation
- British Fire Consortium
- Chartered Institution of Building Services Engineers
- Chief and Assistant Chief Fire Officers Association
- Cinema Exhibitors Association
- Department of the Environment, Transport and the Regions
(Construction Directorate)
- Department of Trade and Industry (Consumer Safety Unit, CA Division)
- District Surveyors Association
- Electrical Contractors Association
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- GAMBICA (BEAMA Ltd.)
- Home Office
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- Institute of Fire Prevention Officers
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- Institution of Lighting Engineers
- Lighting Industry Federation Ltd.
- London Transport
- National Illumination Committee of Great Britain
- National Inspection Council for Electrical Installation Contracting
- Photoluminescent Safety Products Association
- Tenpin Bowling Proprietors' Association
- Coopted members

This British Standard, having been prepared under the direction of the Electrotechnical Sector Committee, was published under the authority of the Standards Committee and comes into effect on 15 July 1999

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Amendments issued since publication

Amd. No.	Date	Comments

The following BSI references relate to the work on this standard:
Committee reference CPL/34/9
Draft for comment 93/206752

ISBN 0 580 33004 4

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Foreword

This British Standard has been prepared by Technical Committee CPL/34/9.

Optical fibre systems can provide a viable alternative solution for emergency lighting applications where the traditional electric lamp systems described in BS 5266 : Part 1 are either impractical, unsuitable, or costly, for example, in explosive atmospheres, low level applications, inaccessible positions or small systems.

In public places where vandalism could be a problem the small size of optical fibre lightguides makes them easier to protect. In industrial applications where pipes, ducts, and machine parts often impede the proper siting of emergency lighting luminaires the small size of optical fibre lightguides allows lighting positions to be sited with fewer restrictions.

However, poor system design and component part specification can lead to unsatisfactory system performance and high operating costs over the potentially long life of an optical fibre system. This Part of BS 5266 is intended to enable the user to prepare a suitable design and establish an installation specification and also provides guidance for safe and satisfactory operation of the installed system.

The only difference between emergency lighting provided by traditional electric lamp systems and optical fibre systems is the method by which light is provided at the point of utilization. In the former the lamp is operated directly at the point of utilization whilst in the latter the light is conducted along a lightguide from a lamp located some distance away from the point of utilization.

The potential advantages of an optical fibre emergency lighting system are:

- a) use of a single lamp to illuminate a greater area;
- b) improved control of distribution and uniformity of illumination;
- c) convenient placement of lamps for ease of maintenance in areas with difficult access;
- d) improved safety. Absence of electricity and less heat at the point of utilization facilitates provision of emergency lighting in high risk areas;
- e) reduced ultraviolet and infra-red transmission makes provision of emergency lighting easier in environments sensitive to these wavelengths;
- f) long life. Optical fibres are virtually ageless and in an optical fibre system only the light source is liable to deteriorate with age. Other parts can become unfashionable and require changing for aesthetic reasons.

The optical fibre systems covered by this Part of BS 5266 may be used to provide emergency lighting by overhead or low mounted arrangements or they may form part of a way-guidance system. They may also be used to illuminate signs.

This standard is complementary to BS 5266 : Part 1 which gives general guidance and recommendations on emergency lighting systems and to BS 5266 : Part 5 which specifies the component parts of an optical fibre system.

It is not the purpose of this standard to explain the mechanisms of optical fibre transmission, it has been assumed that the user has the technical expertise to appreciate these, neither does it detail the considerations and calculations necessary to design an emergency lighting system as these are covered in BS 5266 : Part 1.

As a code of practice, this Part of BS 5266 takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 22, an inside back cover and a back cover.

1 Scope

This Part of BS 5266 gives recommendations and guidance on the design, installation, maintenance and use of optical fibre emergency lighting systems.

It is applicable to optical fibre emergency lighting systems for escape route lighting, including open area lighting. It is also applicable to optical fibre systems used for standby lighting when the system is also used as part of the emergency escape route lighting.

NOTE. This Part is to be used in conjunction with BS 5266 : Part 1 and BS 5266 : Part 5.

2 References

2.1 Normative references

This Part of BS 5266 incorporates by dated or undated reference, provisions from other publications. These normative references are made at the appropriate places in the text and the cited publications are listed on the inside back cover. For dated references, only the cited edition applies; any subsequent amendments to or revisions of any of the cited publications apply to this Part of BS 5266 only when incorporated in the reference by amendment or revision. For undated references, the latest edition of the cited publication applies, together with any amendments.

2.2 Informative references

This Part of BS 5266 refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on the inside back cover, but reference should be made to the latest editions.

3 Definitions

For the purposes of this British Standard the definitions given in BS 5266 : Part 1 apply, together with the following.

3.1 cladding

Dielectric material surrounding the core of an optical fibre.

3.2 core

Central region of an optical fibre, with higher refractive index than the cladding, through which most of the optical power is transmitted.

3.3 connectors

3.3.1 plug connector (male)

Free connector attached to the end of a lightguide.

3.3.2 socket connector (receptacle or female)

Fixed connector mounted on an item of equipment.

3.3.3 adaptor connector

Double ended socket connector used for the interconnection of two lightguides.

3.4 Fresnel reflection

Reflection of a portion of the light incident on a planar interface between two homogeneous dielectric media having different refractive indices, for example silica and air.

3.5 index matching substance

Substance which has a refractive index equal or nearly equal to that of the core of an optical fibre, used to reduce Fresnel reflections from an optical interconnection.

3.6 lightguide

Assembly of optical fibres sheathed into a cable type format that is terminated with connectors.

3.7 light source

Means of producing visible light and coupling this to a lightguide.

3.8 light transmittance loss (P_{LOSS})

The total loss of light between the light source and the output of the lightguide, expressed either in decibels or as an efficiency fraction (see 3.9).

NOTE. Light transmittance loss is made up of fibre attenuation loss (see 3.9) and coupling losses (see 3.10).

3.9 fibre attenuation loss (P_F)

The ratio, at a defined wavelength, of the intensity of the light reaching the end of an optical fibre bundle or lightguide of known length to the intensity of the light entering the fibre bundle or lightguide, expressed in decibels or as an efficiency fraction.

The fibre attenuation loss, P_F , expressed in decibels, is given by the following equation:

$$P_F = 10 \log \left(\frac{P_{\text{OUT}}}{P_{\text{IN}}} \right)$$

The fibre attenuation loss, P_F , expressed as an efficiency fraction, is given by the following equation:

$$P_F = \frac{P_{\text{OUT}}}{P_{\text{IN}}}$$

where:

P_{IN} is the intensity of the light entering the fibre bundle or lightguide (in candelas);

P_{OUT} is the intensity of the light reaching the end of the fibre bundle or lightguide (in candelas).

NOTE. In the industry, the fibre attenuation loss of lightguides is normally given in decibels per unit length (dB/m or dB/km). The above equation for the value in decibels gives a negative value, but for practical purposes the negative sign is usually omitted.

3.10 coupling loss

The ratio, at a defined wavelength, of the intensity of the light passing through an interface to the intensity of the light entering that interface, expressed in decibels or as an efficiency fraction (see 3.9).

NOTE. Coupling losses occur at the connection of the light source to the lightguide, at interconnections between lightguides and at the emission end of the lightguide.

3.11 numerical aperture

The amount of light entering the end of an optical fibre expressed as a proportion of the light incident on it.

3.12 optical fibre

Filament shaped optical waveguide made of dielectric materials.

3.13 optical fibre system

Serial combination of a light source, an emission end mounting arrangement and interconnecting optical fibre lightguide complete with connectors.

3.14 refractive index

At a point in a medium and in a given direction, the ratio of the velocity of light in vacuum to the phase velocity of a sinusoidal phase wave propagating in that given direction.

4 Design of the lighting installation

4.1 General

The design of the emergency lighting installation should be in accordance with clauses 4, 5, 6, 9 and 10 of BS 5266 : Part 1 : 1988 and component parts should conform to BS 5266 : Part 5. The information given in clause 8 of this Part of BS 5266 should also be taken into account.

NOTE 1. Attention is drawn to the fact that when used in premises subject to licensing, prior discussion of the lighting system with the licensing authority may be required. All design data used, and calculations carried out, to produce an emergency lighting scheme using the components specified in BS 5266 : Part 5 and the systems described in this Part and in BS 5266 : Part 1 may be required for inspection by the enforcing authorities.

NOTE 2. Attention is also drawn to the fact that many design aspects of the system may be covered by legislation.

NOTE 3. Further guidance on design can be found in the Chartered Institution of Building Services Engineers (CIBSE) Technical Memorandum TM12 *Emergency lighting* [1].

The design should be executed by a competent person having knowledge of the application and limitations of optical fibre systems.

4.2 Environmental conditions

NOTE. The components specified in BS 5266 Part 5 are suitable for systems to be used in air. Where component parts are to be used in any other environment, for example in an explosive atmosphere, their suitability for use in that particular environment should be checked with the manufacturer.

If the system is to be used outside the following limits the manufacturer should be consulted:

- a) for indoor applications: temperatures between +5 °C and +60 °C and a relative humidity of 40 %;
- b) for outdoor applications: temperatures between –10 °C and +70 °C and a relative humidity of 80 %.

4.3 Types of system

Optical fibre emergency lighting systems may be provided as follows.

- a) *Partially designed*. These comprise items of fully designed and manufactured equipment selected by a manufacturer to give a defined optical performance requiring only final illuminance design either by calculation or by the use of space/height data provided by the manufacturer.

NOTE. The equipment may be provided in kit form or as individual items of equipment selected by the purchaser from co-ordinating data provided by the manufacturer.

These systems require minimum design input, are similar to conventional self-contained luminaire systems, and are generally suitable for straightforward applications.

- b) *Custom designed*. These are designed, and items of equipment selected or manufactured, to suit the requirements of a particular application.

These systems require considerable design input to implement and are generally suited to complex or difficult applications.

NOTE. Where the lighting design requires an innovative approach the equipment to realise that design may also require an innovative approach.

For partially designed systems manufacturers should provide design and installation advice to installers.

4.4 Category of system and operating duration

The category of system and operating duration should be chosen to suit the application (see 6.12 and 9.2 of BS 5266 : Part 1 : 1988).

NOTE. The use of optical fibre emergency lighting systems for non-emergency lighting applications is not excluded; for example, a maintained system may also be used to provide all or part of the normal lighting scheme.

4.5 Failure of normal supply

The supply to normal lighting circuits in areas where emergency lighting is provided in accordance with BS 5266 : Part 1 should be monitored for integrity and arranged such that on failure of the normal supply the appropriate light source(s) are brought into operation to provide emergency lighting.

4.6 Illuminance, uniformity, glare and colour

4.6.1 Illuminance

The illuminance achieved at the point of utilization should be calculated:

- a) *for a partially designed system*: by use of space/height data or other information provided by the manufacturer of the partially designed system;
- b) *for a custom designed system*: by considering the output from a lightguide as a plane point source and, in conjunction with the distribution pattern (polar curve), illustrated in figure 1, supplemented by data provided by the lightguide manufacturer, carrying out normal point-by-point calculations for illuminance.

NOTE. The use of a focusing arrangement or decorative/protective cover at the end of a lightguide can alter the distribution pattern.

Each application should be assessed individually to determine the most appropriate system.

The luminous intensity of a lightguide can be calculated using the optical budget detailed in annex A. Worked examples of the calculations are given in annex B.

4.6.2 Uniformity of illuminance

Light is emitted from the end of a lightguide, which is perpendicular to its axis, as a cone having a clearly defined and constant angle about the lightguide axis. This is known as the acceptance angle, θ , and is illustrated in figure 1. The size of the acceptance angle is dependent upon the fibre dimensions and construction.

This conical output produces a circular distribution on the working plane and the outputs from adjacent lightguides should be arranged to ensure that the required uniformity of illuminance is achieved.

NOTE. The use of a focusing arrangement or decorative/protective cover at the end of a lightguide can alter the distribution pattern.

4.6.3 Glare

The angles at which light is emitted from the end of an optical fibre lightguide installed pointing vertically downwards are below those at which glare normally occurs. However, care should be taken when lightguides are installed in any other orientation or where reflective surfaces are present (see 5.5 of BS 5266 : Part 1 : 1988).

4.6.4 Colour

The illuminance should be provided by lamps having an appropriate colour rendering index (Ra). A minimum colour rendering index is specified in 9.4.1 of BS 5266 : Part 5 : 1999.

The materials used to form the active core of optical fibre lightguides generally attenuate the constituent wavelengths of transmitted light differently, for example, white light input tends to shift towards green at the output. Whilst this colour shift is unlikely to be detrimental to the effectiveness of emergency lighting it could have the psychological effect of giving an eerie ambience if it became too pronounced. Colour difference between adjacent output ends could also be visually unacceptable.

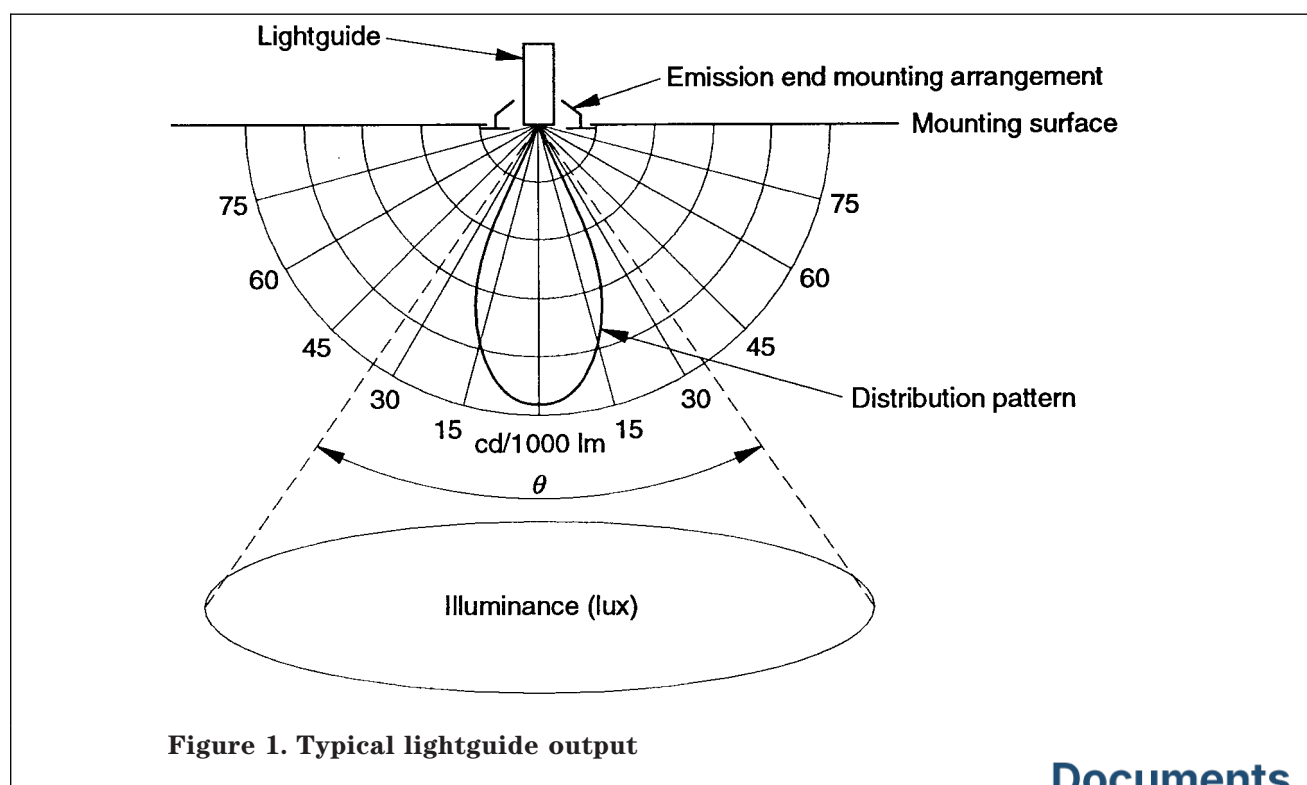


Figure 1. Typical lightguide output

It is this colour shifting effect which usually gives the practical limit for the length of a particular size of lightguide. Each application should be assessed to determine the amount of colour shift that is acceptable.

NOTE 1. The colour appearance of the emission end of a lightguide may need to be carefully considered in a maintained system.

NOTE 2. Where an optical fibre emergency lighting system is also used to provide all or part of the normal lighting, colour rendition on the working plane may be affected by the lightguide colour shift.

4.7 Spacing and mounting height of lightguide emission ends

The provision of highly reliable illumination on escape routes is essential. Whilst optical fibre lightguides can be sized to give a high power light output it is better to use a larger number of lower power output lightguides to ensure that the illumination is evenly distributed.

The mounting height of emission ends is not critical and is usually governed by the physical characteristics of the application, the illumination required and its plane of utilization, and any other use that is being made of the optical fibre system, for example, way guidance. The best compromise should be chosen to suit the application.

The descriptions and explanations given in this standard assume traditional overhead lighting. However, optical fibre technology makes the system applicable to any orientation provided the same essential illumination criteria are satisfied.

Emission ends from different light sources should be interspersed such that failure of a light source or loss of its lightguide harness would not materially affect the ability of the system to meet the objectives of the emergency lighting system design.

5 Operational assessment

In conjunction with BS 5266 : Part 1 the following aspects should be considered when designing an emergency lighting installation using an optical fibre system.

- a) *Purpose of the system.* The purpose of the system, for example whether it is to be defined escape route lighting, or undefined (open area) escape route lighting, should be established.
- b) *Type of system.* Whether a maintained or a non-maintained system is needed should be decided.
- c) *Type of emergency power supply.* Whether a central source or self-contained battery is to be used should be decided.
- d) *Lamp arrangement.* Whether a single lamp, dual lamp or lead and standby lamp arrangement is to be used (see 8.3.1) should be decided.

e) *Topology.* The location of all hazards and signage positions, etc. on escape routes should be established.

f) *Building construction.* Details of escape route widths, mounting heights, mounting surface construction and materials, fire compartmentation, etc. should be established.

g) *Routing.* Routes for lightguides, either existing or proposed, should be established.

h) *Optical budget.* The required illuminance, system losses, etc. should be established (see annexes A and B).

i) *Physical hazards.* Potential points of damage for lightguides, either during installation or subsequently, should be identified.

j) *Fire risk.* Areas of low fire risk for the location of equipment and routing of lightguides should be established (see 8.4.2). Any areas where additional precautions against fire damage to component parts of the system is required should be identified.

NOTE 1. There should be liaison between the system designer, the enforcing authority and the building occupier when establishing locations, routes and the need for additional fire precautions.

k) *Environment.* Potential environmental hazards to the light source, lightguides, or lightguide ends should be established and an assessment made of the protection required. Reference should be made to 522 of BS 7671 : 1992.

NOTE 2. Where installation in an explosive atmosphere is proposed it may be necessary for all or some of the system components to conform to the relevant Part of BS 5501. In such cases, reference should be made to the relevant Part of BS 5345 and the manufacturer(s) of the components should be consulted.

l) *Maintenance.* The access available to the building structure, and any finishes needed, for future maintenance of component parts of the system should be established.

m) *Working life.* The required working life of the system should be established to avoid over-specification. For example, some buildings are constructed with a definite useful life after which they are demolished or refurbished.

n) *Vibration.* Levels of vibration to which component parts will be subject in operation should be established so that adequate precautions against detriment can be taken. This is especially important when establishing the required performance of lightguides under fire conditions (see also item i)).

o) *Health and safety.* Particular hazards inherent in the construction of the premises or in the installation and subsequent maintenance of the equipment should be identified.

6 Technical specification

The technical specification for the system should specify the following to enable the component parts of the system to be selected (see clause 8):

- a) *physical parameters*: light source lamp type and power, lightguide size at each outlet, etc.;
- b) *constructional requirements*: armouring or weather/chemical resistant covering for lightguides, emission end mounting arrangement materials, etc.;
- c) *optical requirements*: the light output of lightguides, performance of emission end focusing systems, etc.;
- d) *fire performance requirements*.

7 Scope of works document

Once the operational assessment has been carried out, the installation design completed, and system components selected in accordance with the technical specification and clause 8 a scope of works document should be prepared by the designer for the installer to clearly:

- a) identify the location of all equipment and any special materials that may be required;
- b) identify the building/constructional works that will be required, such as lightguide route access and fire enclosure;
- c) specify the route preparation required such as mechanical protection (conduit, ductwork, traywork, etc.);
- d) provide a detailed description of how the system components are to be installed, setting out bending radii, clipping methods, etc. Any special precautions to be taken during installation of lightguides identified during the operational assessment should be detailed;
- e) to provide details of test and inspection procedures to establish that the design criteria of BS 5266 : Part 1 and the recommendations in the present standard have been met.

8 Selection of components

8.1 Elements of an optical fibre system

An optical fibre emergency lighting system is made up of four basic elements:

- a) an electrical power source;
- b) a light source;
- c) one or more optical fibre lightguides;
- d) an emission end mounting arrangement.

Each of these elements needs careful selection for a reliable and effective emergency lighting system to be provided.

8.2 Power source

8.2.1 General

The light source needs a secure power source to function correctly. This may be provided by:

- a) a self-contained battery; or
- b) one or more central batteries; or
- c) another appropriate power source (see 6.11.4 of BS 5266 : Part 1: 1988).

The battery power source chosen should take account of the user's method of operating the premises and the arrangements that the method of operating the premises allows for testing and maintenance of the emergency lighting system. Wherever possible the battery selection should be discussed with the user and the options evaluated to ensure that the most appropriate selection for the user's application is made.

When evaluating the battery arrangement the details given in 8.2.2 to 8.2.4 should be considered.

8.2.2 Self-contained battery

Where the premises are fully occupied, or have a significant occupation level, at all times, for example, continuous working factories and dealing rooms, or where the application is high risk, for example, chemical plants and hospitals, where total failure of emergency lighting under battery fault conditions would create danger, there may be benefits from the use of self-contained battery light sources in comparison to a central battery system.

For testing and maintenance, the ability to sub-divide the installation that is given by the use of self-contained battery light sources may also be of benefit. Temporary arrangements can be more easily made for small sections of the installation during testing and maintenance and the subsequent battery recharge period.

Loss of a self-contained battery light source would cause only a minimal loss of emergency lighting.

The benefits of self-contained battery light sources for testing and maintenance should however be balanced against the possibly prolonged time period required to carry out the testing and maintenance programme and the relatively shorter battery life in comparison to a central battery system.

8.2.3 Single central battery

For premises that are periodically unoccupied, for example, at weekends, or where minimal occupation levels occur for which alternative arrangements for emergency lighting can be made during testing and maintenance and the subsequent battery recharge period, a central battery system may be suitable.

The central battery should be arranged to serve all light sources comprising the installation via a distribution system in accordance with 9.2.1.

Whilst a central battery can simplify testing and maintenance, failure of the battery would result in complete loss of emergency lighting and this fact should be balanced against the testing and maintenance benefits.