BRITISH STANDARD

BS 5266 : Part 4 : 1999

Emergency lighting

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

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Committees responsible for this British Standard

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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
Electricity Association
Engineering Industries Association
GAMBICA (BEAMA Ltd.)
Home Office
Industry Committee For Emergency Lighting Ltd. (ICEL)
Institute of Fire Prevention Officers
Institute of Fire Safety
Institution of Electrical Engineers
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

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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:

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

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

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

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.

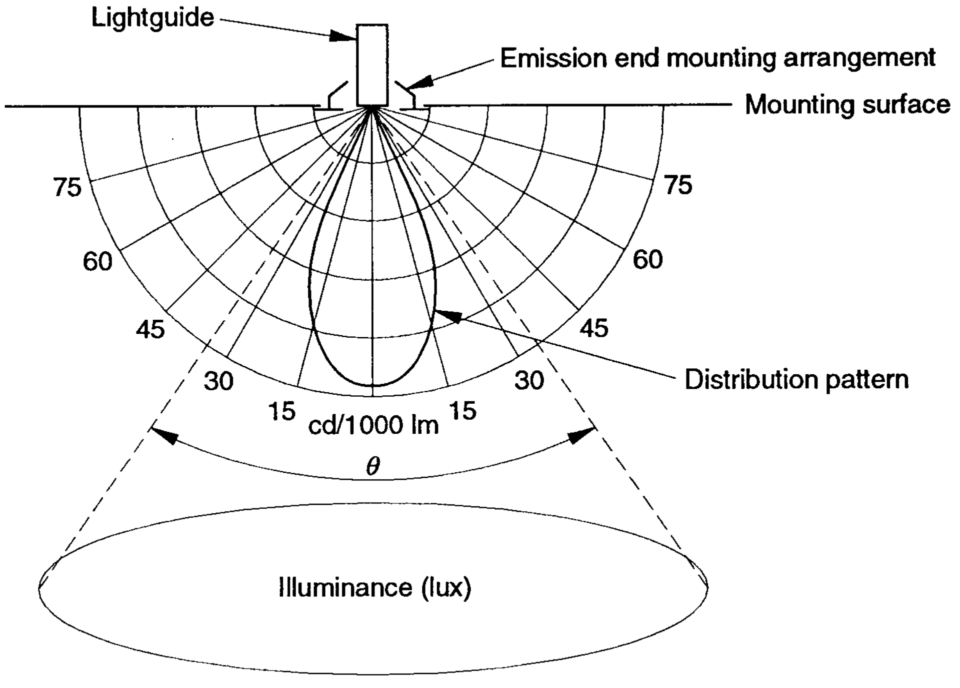

Figure 1. Typical lightguide output

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.

8.2.4 ***Multiple central batteries***

This arrangement has the benefits of a central battery system together with the ability to provide coarse sub-division of the system. It may be useful in premises which can be divided, for example, on a floor by floor basis.

The central batteries should be arranged to serve all light sources comprising the part of the installation they serve via a distribution system in accordance with **9.2.1**.

Failure of one of a number of central battery units would cause a smaller loss of emergency lighting in comparison to failure of a single central battery system, although the loss would be greater than that on failure of a battery in a self-contained battery light source system.

8.3 Light source

8.3.1 ***General***

The light source is the only active element in an optical fibre emergency lighting system, all other parts being passive.

Light sources may be located within the fire compartment they serve or at some other location; for example, they may be located at a point central to several fire compartments. When a light source is not located in the fire compartment which it serves it may be necessary to take additional measures to protect against loss in the event of fire.

The location should be readily accessible for maintenance and well ventilated to ensure that waste heat is removed to prevent detriment to equipment life. Light sources should be located in areas of low fire risk (see annex C which also gives guidance on ventilation.)

Each fire compartment should be served by more than one light source. The light sources should be served by different electrical circuits to ensure that at least one will remain operational in the event of circuit failure.

Three possible forms of lamp arrangement in a light source are specified in BS 5266 : Part 5 as follows:

a) single lamp (see **8.3.3**);

b) dual lamp (see **8.3.4**);

c) lead and standby lamp (see **8.3.5**).

Each lamp arrangement has its own advantages and disadvantages which should be carefully considered by the designer when carrying out the operational assessment outlined in clause **5**.

The light source is the element that will have the highest maintenance requirement. For all lamp arrangements, the type of lamp used is vitally important in the provision of a reliable and effective emergency lighting system and will determine the level of maintenance required.

Care should be exercised when locating light sources as the number of lightguides they can serve, and hence emergency lighting points, can be quite large. The potential for loss of emergency lighting with the loss of a light source is considerably greater than that on the loss of a single lamp in an electrical system.

8.3.2 ***Lamp and light source selection***

Planning a programme of lamp maintenance and replacement may suggest the use one type of lamp in preference to another. Whether the system is maintained or non-maintained also has a bearing on the type of lamp selected.

In a maintained system, planned maintenance of the light source and programmed lamp replacement ensures that the emergency lighting system is kept at optimum performance. In a non-maintained system, the random nature of lamp failure, particularly where single lamp light sources are used, may result in increased maintenance requirements over other systems.

As part of the light source selection procedure the designer should consider maintenance of the system. The skill levels required to carry out the necessary maintenance, including lamp replacement, should be evaluated against those which the user has available where these are known. Adequate skilled personnel in-house may lead to a completely different lamp or light source selection to that in a situation where all skills are obtained from an external supplier. The facilities available for reactive lamp replacement or light source repair should be carefully considered.

Physical constraints of the application may influence the choice of light source. For example, the availability of fire compartments or areas of low fire risk to locate equipment may suggest the use of a light source with one particular lamp arrangement in preference to another.

8.3.3 ***Single lamp arrangement***

This is a simple arrangement comprising only one lamp and its control gear (see **9.4.2.2** of BS 5266 : Part 5 : 1999). Consequently the number of light sources required for a given application may be higher than with other lamp arrangements to ensure system integrity in the event of lamp failure.

Loss of the lamp would result in the loss of all emergency lighting provided by the lightguides served by the light source concerned.

This lamp arrangement is likely to produce a light source with the smallest physical dimensions.

8.3.4 ***Dual lamp arrangement***

In this arrangement the output from two lamps is optically combined (see **9.4.2.3** of BS 5266 : Part 5 : 1999). As both lamps are unlikely to fail simultaneously system reliability is better than with a single lamp arrangement and consequently fewer light sources will be required for a given application.

However, the possibility of failure of one lamp affecting the other lamp exists and this should be taken into consideration during the selection of equipment.

A light source with this lamp arrangement is physically larger than a single lamp light source as it contains two lamps together with their controlgear and possibly an optical mirror system.

Provision of emergency lighting would not be affected by loss of a single lamp.

Where optical combination by bifurcation of lightguides is used, two single lamp light sources can be considered equivalent to a dual lamp light source. This arrangement may produce some additional system reliability as the component parts are in separate enclosures and thus less likely to affect one another should failure occur.

8.3.5 *Lead and standby lamp arrangement*

This arrangement is a hybrid of the single and dual lamp types (see **9.4.2.4** of BS 5266 : Part 5 : 1998). It contains two lamps, only one of which operates at any time. The outputs from the lamps are optically combined either by means of a mirror system or by bifurcation of lightguides. A sensor monitors the integrity of the lead lamp and automatically switches the standby lamp into circuit upon failure of the lead lamp. The light source may also be specified with circuitry to alternate the lead and standby lamps, for example, each time the lamp is energized, to even out lamp wear.

For a given lamp type this arrangement is likely to require the smallest number of light sources but the potential for failure introduced by the sensing and changeover circuits should be carefully considered.

Provision of emergency lighting would not be affected by loss of a single lamp.

A light source with this lamp arrangement is physically larger than a single lamp light source as it contains two lamps together with their controlgear and possibly an optical mirror system.

Where optical combination by bifurcation of lightguides is used two single lamp light sources controlled by a suitable sensing and changeover circuit may be used to form a lead and standby lamp arrangement.

8.3.6 *Protection against environmental hazards*

Protection against environmental hazards identified in the operational assessment (see clause **5j**) should be provided, for example protection against ingress of sprinkler water. Preferably such protection should be inherent in the design of the light source but where this cannot be achieved external protection should be considered after careful examination of the potential problems for waste heat removal and maintenance. Guidance on ventilation is given in annex C.

8.4 Lightguides

8.4.1 *Optical performance*

Lightguides transmit the light produced in the light source to the point of utilization. The material from which the fibres forming the lightguide are made determines the light losses sustained in transmission and the colour shift incurred. In general the purer the material the lower the light losses and the less the colour shift. However, there is a point beyond which increased purity achieves little improvement in performance for considerable increase in cost. This limiting point changes with time as the technology used for the production of fibres improves.

In practical terms the purity of the fibre material selected is a compromise between cost and the light losses acceptable in a particular application. For each application, and particularly where a custom designed system is proposed, it is advisable for the designer to investigate the specifications of available fibre materials to ensure that the most appropriate is chosen.

Light is captured and emitted by an optical fibre lightguide in the form of a cone. The dimensions of the individual fibres and the refractive indices of the active core and cladding determine the amounts of light entering and leaving the lightguide and the angle over which it is captured and emitted. This angle is the acceptance angle explained in **4.6.2**.

Optical fibres used in lightguides transmitting visible light typically have an acceptance angle of 60° to 80° although other angles are often used. Generally the acceptance angle increases as the fibre diameter increases. The acceptance angle in most cases is a practical compromise between optical performance and material properties including ductility. If fibres are too large they become stiff and are liable to break during formation into a lightguide and subsequently when the lightguide is installed. For some short straight lightguide applications stiff fibres may be an advantage and each installation should be assessed to determine the most suitable fibre dimensions.

In general, the larger the acceptance angle the greater the amount of light captured by a lightguide and the larger the cone of emitted light. Large output cones allow large areas to be illuminated with the minimum number of emission ends although the illuminance achieved is reduced. Typically for a given mounting height and luminous output every 10° increase in acceptance angle reduces illuminance by 30 %. Conversely, every decrease of 10° increases illuminance by 30 %.

Wide angle outputs can be useful for illuminating large areas as they can reduce the number of emission ends required. Narrow angle outputs can also be useful to highlight features, for example fire alarm contacts and signs, where a concentrated high intensity beam may be desirable. See also **4.7**.

In practice a partially designed system usually uses lightguides which all have the same acceptance angle. Custom designed systems can have lightguides with acceptance angles appropriate to the application, i.e. more than one acceptance angle can be used in an installation to achieve the required lighting effect.

Where the required lighting effect cannot be achieved by lightguide acceptance angle alone, or where it is desirable to use a single acceptance angle throughout an installation, beam modifiers should be considered. These may take the form of a focusing or dispersive system of lenses or mirrors. A cover for decorative or protective purposes may also be provided or incorporated with the beam modifier.

Where the use of beam modifiers is considered appropriate, devices having fixed optical characteristics are recommended wherever possible to ensure that the designed performance cannot be altered subsequent to commissioning of the emergency lighting system. If adjustable beam modifiers are used then these should have a means of locking the adjustment setting after commissioning. Where the mounting surface is subject to vibration it may be necessary to use additional measures to prevent alteration of the adjustment setting.

8.4.2 *Fire performance*

In an electrical emergency lighting system it is essential for cables to have inherent resistance against damage by fire to prevent short-circuit and loss of all luminaires attached to the particular circuit. Inherent fire resistance is not always necessary with optical fibre systems as destruction of a single lightguide cannot affect the operation of any other lightguide attached to the light source.

Where a light source and all of the lightguides that it serves are located within the same fire compartment then inherent resistance is not necessary. The light source and lightguides should however be located and routed in areas of lowest fire risk within the compartment.

NOTE. The use of equipment having inherent resistance to damage by fire is not precluded for this application.

Where a light source is used to serve more than one fire compartment, or where light sources are located in a central position and lightguides pass through more than one fire compartment en route to the one they serve, then fire resistance may be necessary where lightguide routes having low fire risk are not available. Such fire resistance may be inherent to the lightguide or equivalent protection may be applied externally. The routing of lightguides is discussed more fully in annex D.

The fire resistance required for lightguides is against melting of the fibres due to the heat generated in a fire. The glass material typically used for optical fibres begins to soften around 400 °C and ceases to be an effective conductor of light around 450 °C. The temperatures relevant to the lightguide to be used should be checked in every case.

It is essential to ensure therefore that lightguides are kept below the temperature at which the fibre material softens for the operating duration of the system determined in accordance with **4.4**.

This may be achieved by the use of category 2 lightguides conforming to BS 5266 : Part 5 : 1999, or by use of category 1 lightguides conforming to BS 5266 : Part 5 : 1999 together with the application of external protection. The most appropriate approach should be evaluated for each application.

8.4.3 *Moisture resistance*

Water has the potential for causing long term detriment to optical fibres. Where water is likely to have a significant presence during the working life of an installation, lightguides which have a moisture barrier incorporated in their construction should be used.

NOTE. In areas where standing or running water is expected to occur additional protection against water ingress should be provided when the lightguide is installed (see **9.4.1.1**b).

8.5 Emission end mounting arrangement

8.5.1 *Purpose*

The emission end mounting arrangement is similar in function to a luminaire body and its purpose is to:

a) securely anchor the lightguide end to the mounting surface;

b) ensure that light is consistently distributed according to the original design;

c) provide the lightguide end with protection against physical hazards;

d) protect the lightguide end against environmental contamination;

e) offer an aesthetically acceptable means of achieving the above functions.

The mounting arrangement for a particular function should be chosen to ensure that these objectives are satisfied.

8.5.2 *Mounting surfaces*

An installation may need to comprise many different forms of mounting arrangement to suit various mounting surfaces. The mounting arrangement may be designed for installation below the mounting surface, i.e. surface or pendant installation, or for installation flush with the mounting surface.

NOTE. It may be necessary for the mounting arrangement to achieve a fire resistance rating to satisfy the enforcing authority, for example, when the mounting surface forms part of a fire barrier.

8.5.3 ***Anchoring***

The methods of anchoring mounting arrangements may be many and varied to suit a diverse range of mounting surfaces. For common mounting surfaces, for example ceiling tiles, there may be many competing methods to choose from and it is necessary to make a careful evaluation of the operational assessment carried out in accordance with clause **5** to determine the most appropriate method for the application.

The anchoring method chosen should not be adversely affected by infrequent or light vibration of the mounting surface. Where periodic or continual vibration is severe it may be necessary to consider additional anchoring security.

NOTE. Light vibration does not usually adversely affect the lightguide emission end but severe vibration can affect some forms of potting. The manufacturer's advice should be sought and where necessary either a different potting method used or an anti-vibration mounting arrangement selected.

Where the operational assessment carried out in accordance with clause **5** indicates that the mounting arrangement could be disturbed after commissioning, for example where it is located along a common services route, the use of additional anchoring security should be considered.

In situations where the lightguide emission end or the mounting arrangement could be subjected to accidental impact, for example in a workshop, or where vandalism can be expected, additional or strengthened anchoring should be considered together with methods of deflecting impact forces.

8.5.4 ***Light distribution***

The mounting arrangement should be selected to ensure that the designed optical performance is maintained throughout the life of the installation, and the selection should take into account any known or foreseeable adverse environmental conditions and the possibility of mechanical damage, vandalism, etc.

The use of a protective cover over the lightguide emission end should be considered where there is the likelihood of contamination or damage. Where the protective cover itself may become damaged or defaced sufficiently to affect optical performance the use of a replaceable cover should be considered. In this case it should not be possible to remove the cover without the use of a tool.

Where adjustable beam modifying arrangements are used the means of locking the beam modifier after commissioning should be selected taking into account the risk of accidental or deliberate adjustment. The long term effects of mounting surface vibration on beam modifier adjustment should also be considered when selecting the locking method.

8.5.5 ***Physical and environmental hazards***

An important function of the mounting arrangement is to protect the emission end against physical and environmental hazards.

The physical hazards that should be protected against are those identified by the operational assessment carried out in accordance with clause **5** which would reduce or eliminate light output, or distort light output such that the distribution of light is permanently altered. Such hazards include mechanical damage, chemical attack and painting over.

The environmental hazards that should be protected against are those giving rise to surface deposits which would reduce light output by obscuration and could also alter the distribution of light. Such deposits include dust, oil and grease.

8.5.6 ***Aesthetics***

As the mounting arrangement is normally the only part of an optical fibre emergency lighting system on display it is important that it is as aesthetically pleasing as possible.

In some cases, for example industrial applications, functionality may take precedence over aesthetics, but generally appearance should be an important factor in the selection of a mounting arrangement.

There is no requirement for the mounting arrangement to be made from any particular material or be any particular shape, size or colour but those parts of it responsible for its optical performance dictate the general appearance.

Partially designed systems offer a range of mounting arrangements but inevitably these are not suitable for all applications. Custom designed systems generally have greater scope for innovation in the design of the mounting arrangement to ensure that it fully complements the ambience of its surroundings. Size, shape, surface finish, colour and anchoring method can all be designed and specified to ensure that the particular requirements of the application are satisfied. Particular hazards identified in the operational assessment carried out in accordance with clause **5** can be taken into consideration in the design.

The aesthetics of the mounting arrangement need careful evaluation at the outset of system design as these can have an impact upon the optical budget especially where a custom designed system is being considered. All aspects need to be carefully evaluated to ensure that the correct selection is made.

8.6 Remote fault indicators

The light source internal audible fault indicator specified in **9.7.1.2** of BS 5266 : Part 5 : 1999 has been made deliberately loud to ensure that it is not ignored. It can be expected to promote a response from people in the vicinity. However there can be situations where even this is not heard, for example, where the light source is sited in a sealed room or located in a noisy environment.

The internal audible fault indicator may be provided with facilities which allow it to be muted by competent persons such as maintenance staff after investigating the fault (see **9.7.3** of BS 5266 : Part 5 : 1999). Where these staff are not readily available, a noise nuisance could be created, for example in health care establishments or old people's homes. There can be instances where danger would arise if the audible indicator activated unexpectedly, for example in operating theatres or laboratories.

Care should therefore be exercised when locating light sources to avoid these potential problems. However, when they cannot be overcome by suitable siting of the light source then the use of remote fault indicators should be considered. If remote fault indicators are used, a full duplicate set of indicators should be provided. In this case, the internal audible fault indicator may be set to any one of the following states.

a) *Permanently operational*. The fault indicator is left permanently connected in the circuit. This option should be used in, for example, a noisy environment.

b) *Permanently disconnected*. This option should only be chosen where the remote fault indicators are located at a permanently staffed position such as a control room, security desk, or warden's office.

c) *Temporarily muted*. This option should be chosen for locations such as offices, museums, shops or other noise sensitive areas to temporarily silence the alarm whilst maintenance personnel are summoned to investigate the fault.

The muting facility is self-cancelling by loss of the mains supply and by a timer integral to the light source (see **9.7.3**b of BS 5266 : Part 5 : 1999). The period between cancellations can be set at any time interval between 1 h and 4 h to suit the application. The most appropriate time interval should be chosen taking into account the need on the one hand to minimize disturbance, and on the other hand to provide a regular reminder that a fault condition exists. Staff breaks, shift changes, etc. should be evaluated to determine the most appropriate time to provide the reminder.

This option may have application, for example, in rented or other similar premises where the user has no obligation for maintenance and could mute the audible indicator and ignore the fault.

d) *Temporarily disabled*. This option should only be chosen where the alarm conditions are monitored by a central system, for example, a building management system or a central station. In this case the internal audible indicator can be disabled by a device that permanently monitors the control system or communications link for integrity. Loss of the control system or link returns the indicator to the permanently operational condition. (See **9.7.3**c of BS 5266 : Part 5 : 1999.)

An individual remote fault indicator may be provided for each light source, or a number of fault indicators may be grouped together, for example, a group for each floor of a building. Alternatively they may all be concentrated at a permanently manned position, for example, a reception desk, warden's office, or security office. Where permanently manned positions are not available then the remote fault indicators should be placed on frequently used routes, for example, corridors, stairs, or entrance lobbies.

Remote fault indicators may be grouped together on a common facia in which case it is acceptable for a common audible indicator with local muting to be used. Each new fault condition should over-ride any muting and re-activate the audible indicator. A separate visual indicator should be provided for each light source and should show clearly and unambiguously which light source has triggered the alarm.

NOTE 1. The remote audible and visual fault indicators should have the same sound, light output and pulse rate as the light source internal fault indicators.

NOTE 2. Where the test switch recommended in **8.3.3** of BS 5266 : Part 1 : 1988 is provided for self-contained light sources it is acceptable for the remote fault indicators to be located on a common facia provided electrical segregation is provided where different voltages are present.

8.7 Automatic control system connection

Where an optical fibre emergency lighting system is to be used in an installation having central control by, for example, a building management system (BMS), then it is acceptable for the light source to be controlled by that system to:

a) operate a switching device in the lamp circuit in accordance with **8.8**;

b) monitor the fault indicators. In this case the internal audible fault indicator may be temporarily disabled as described in **8.6**d.

The control system connection is permanently monitored for integrity by the light source and in the event of loss the lamp circuit and audible fault indicator are returned to the permanently operational condition.

8.8 Lamp circuit switch

The light source may be specified with a lamp circuit switching device to prevent operation, for example when the building is unoccupied, which could leave the battery unable to provide power for the rated operating duration when the premises are occupied (see **9.8**. of BS 5266 : Part 5 : 1999).

The switching device contained within the light source may be operated by a manually operated switch, for example, at a final exit position, or by an automatic signal, for example, by a building management system (BMS). In this case great care should be taken to ensure that the BMS cannot disable the emergency lighting whilst the premises are occupied.

Alternatively, where a central battery is used the output may be isolated to remove the supply to all the light sources that it serves.

9 Installation

9.1 General

9.1.1 *Initial checks*

Upon delivery component parts should be checked for conformity to the technical specification and examined to ensure they are undamaged. In particular lightguides should be examined to ensure that:

a) they have not been exposed to bending, pressure, sharp edges, etc. by packaging or transport, resulting in physical damage;

b) connectors are undamaged, and the polished faces have a protective transit cover and are not scratched, chipped, or otherwise damaged;

NOTE. Protective covers should be replaced after inspection until installation is complete and lightguides are ready for connection.

c) they are of correct length and size and, where specified, they have been identified.

Mounting arrangements should be examined to ensure they are the correct type, complete, undamaged and that they conform to the technical specification in all respects.

After examination component parts should be stored in a clean, dry area at or above the manufacturer's minimum recommended storage temperature until required for installation.

The installer should ensure that the manufacturer's instructions for correct handling and installation of all component parts are available.

9.1.2 *Handling and installation*

Handling and installation of all component parts of the system should be carried out in accordance with the manufacturer's instructions.

9.2 Power sources

9.2.1 *Wiring systems*

The power supply to battery chargers for self-contained batteries and central battery units, and the wiring and power distribution system from central battery units to individual light sources, should be in accordance with clause **8** of BS 5266 : Part 1 : 1988 and should conform to BS 7671.

9.2.2 *Central batteries*

Central battery units should be located in areas having low fire risk. The location should be discussed with the enforcing authority. Guidance on areas of low fire risk is given in annex C.

9.3 Light source location

The light source is equivalent to a central battery in an electrical system and its loss would have a similar effect. Its location, fire protection, and ventilation should therefore receive the same consideration as given to a central battery unit.

The following precautions should be taken with regard to the light source enclosure.

a) The enclosure should be sited in an area of low risk of fire and mechanical damage and which has appropriate fire integrity (see **8.4.2**). Guidance on areas of low fire risk is given in annex C.

NOTE. The enforcing authority may require a specific fire integrity to be achieved.

b) Preferably the enclosure should not be used for any other purpose, for example, for storage, or for electrical switchgear. Services necessary for operation of the light source such as an isolator, a distribution board, and a ventilation fan. may be located adjacent to the enclosure but should not restrict access to the enclosure or operation of the light source.

Where it is not possible to locate the light source enclosure away from other equipment sufficient separation should be provided to prevent interference with operation or maintenance and prevent danger to the light source in the event of failure of that equipment. Physical barriers with fire integrity should be provided where necessary to protect the light source from other equipment.

c) A smoke or heat operated fire detector should be located adjacent to the enclosure and arranged to generate an alarm condition in a manner acceptable to the enforcing authority.

d) There should be ready and unimpeded access to the enclosure. Preferably, this should not require the use of access plant such as ladders or scaffold, but these may be used where they do not compromise rapid reaction time and safe maintenance operations.

e) There should be adequate space and illumination available in and/or around the enclosure for maintenance operations to be carried out safely.

f) The enclosure should have adequate ventilation to keep the light source and any other component parts and equipment such as switchgear operating within their design temperature range (see **9.3.2** of BS 5266 : Part 5 : 1999).

The light source should have an adjacent means of isolating the electrical supply for maintenance.

9.4 Lightguide installation

9.4.1 *General*

9.4.1.1 For the purposes of installation lightguides can be considered equivalent to electric cables. However, owing to their different construction and method of operation there are factors which need special consideration during handling and installation. These factors are as follows.

a) *Robustness*. Unless they have a form of mechanical protection incorporated into their construction lightguides are less robust than electric cables.

They should not be walked on during installation or be drawn tight over sharp edges which could cut through the covering and fibres so reducing light output and/or admitting moisture which could cause long term deterioration.

All conduits, trunking, ducting, channels, traywork or ladders should be fully erected before lightguides are installed. Additionally conduits, trunking, ducting, and channels should be proven free of burrs, standing water and debris or other obstruction. Traywork and ladders should be proven free of sharp edges.

b) *Water damage*. Optical fibres are vulnerable to long term detriment by water (see **8.4.3**). It should be considered good practice in areas where standing or running water is expected to occur to provide means to protect against ingress of water into lightguides, such as spacing off the mounting surface or provision of drain points.

c) *Light output*. A reduction in light output can occur due to bending losses in fibres if lightguides are bent too tightly. Care should be taken to ensure that the internal bending radius is not less than eight times the outside diameter of the lightguide.

d) *Earthing*. Lightguides are electrically non-conducting and, unless metallic armouring is incorporated in the construction or external metallic mechanical protection is provided, there are no requirements for earthing. Where earthing is required it should be carried out in accordance with BS 7671.

e) *Calculations*. Electrical circuit calculations should be replaced by those for the optical budget given in annex A.

f) *Electromagnetic interference*. Lightguides neither generate nor suffer from electromagnetic interference. Their location and orientation in relation to power circuits is therefore not critical except as recommended in **9.4.4**.

g) *Thermal movement*. Contraction and expansion of structural parts could cause stretching of lightguides and breakage of fibres. The manufacturer's installation recommendations should be followed to prevent fibre damage. The effect of contraction and expansion on bending radius should not be overlooked.

h) *Heat*. lightguides do not emit significant heat. Such heat that is emitted does not de-rate lightguides and a space factor is not required in conduit, trunking, ducting, or channel for this effect but adequate space should be allowed for easy withdrawal of lightguides for maintenance or alteration and for future additional lightguides to be installed.

NOTE. Recommendations for the safe handling of optical fibre lightguides are given in annex E.

9.4.1.2 Lightguides should be installed generally as Category 3 circuits in accordance with BS 7671 : 1992. The guidance given in clause **8** of BS 5266 : Part 1 : 1988 should also be followed. Lightguides may be installed:

a) in an exclusive conduit, trunking, ducting or channel system or on an exclusive tray or ladder;

b) in an exclusive compartment within a multi-compartment trunking, ducting or channel system;

c) in accordance with recommendations given in **9.4.4** for mixed installation with electric cables in common ducts or channels or on common traywork or ladders.

9.4.2 *Route identification*

Trunking systems, including compartments in multi-compartment systems, ducts and channels reserved for optical fibre emergency lighting lightguides should be marked to indicate this reservation. Lightguides installed in or on a reserved part of a common traywork or ladder system with electric cables should be similarly marked to aid identification and prevent subsequent reduction of separation distances.

9.4.3 *Route fire integrity*

In all cases, temporary or permanent, where lightguides pass through a fire resisting enclosure any opening around the lightguides should be sealed to prevent the passage of heat, smoke and flame and maintain the full integrity of the enclosure.

NOTE. The Building Regulations [2] require that where there is any piercing of a fire barrier it has to be made good such that the fire integrity of the barrier is maintained.

9.4.4 *Separation*

Where lightguides share a common traywork, ladder, trunking, ducting or channel with, or are clipped or otherwise supported in close proximity to electric cables then a separation distance of at least 300 mm should be ensured at all points to ensure ready identification and assist with protection against subsequent damage when work is carried out on the electric cables. Where the potential for future damage can be foreseen, for example, at cross-overs, then additional mechanical protection should be provided. Further guidance on lightguide routing is given in annex D.

9.4.5 *Support*

It is important to ensure that the method of installation chosen for lightguides provides adequate support to prevent sagging, especially under fire conditions, to avoid reduction or complete loss of light at the point of utilization due to bending losses along the route. For this reason the use of cable hangers and cable ladders should be carefully considered as appreciable sagging can occur in the free space between supports. Additional support may be necessary.

The distance between supports should be in accordance with the manufacturer's recommendations but as a guide it should not exceed 400 mm on straight horizontal or vertical runs, and 150 mm before a change of direction. The use of pin racks and stress relief at the top of vertical runs should be in accordance with the lightguide manufacturer's recommendations.

Care should be taken to ensure that supports do not grip lightguides too tightly and that free movement is available along the route to allow thermal expansion to occur.

For long runs, or where structural expansion joints are crossed, the inclusion of a loop in the lightguide may be necessary to allow free movement. The loop should be such that the internal bending radius is always greater than eight times the outside diameter of the lightguide.

9.4.6 *Protection*

Mechanical protection should be provided to ensure, as far as is practicable, that maintenance or alterations carried out to structural parts or other services adjacent to installed lightguides do not allow them to be crushed or bent tighter than the limiting internal bending radius (i.e. eight times the outside diameter of the lightguide).

NOTE 1. Consideration should also be given to the crushing and bending damage that could occur under fire conditions when structural parts or parts of decorative finishes could collapse onto lightguides. Where only individual utilization points would be affected their loss may be acceptable but where several would be involved additional protection should be considered. A risk analysis should be carried out to determine whether additional protection is required and, if so, the most appropriate type.

NOTE 2. For applications in premises where rodents can reasonably be expected, for example food manufacturing or storage premises, the use of lightguides having an inherent deterrent or a suitable form of mechanical protection is recommended to protect the fibres from damage.

9.5 Emission end mounting arrangement

It is essential that the emission end mounting arrangement is able to retain the lightguide end in position on the mounting surface for the full fire integrity period of the lightguide or of the mounting surface, whichever is the lower, as determined in the operational assessment detailed in clause **5**.

The emission end mounting arrangement should be installed in accordance with the manufacturer's instructions.

Wherever the emission end mounting arrangement is to be secured into or onto a removable structural part or decorative finish it is preferable that this be permanently retained to prevent it becoming dislodged, being removed, or being placed in a different position thereby impairing the emergency lighting. For example, if the mounting arrangement is secured to a ceiling tile, the tile should be secured to its supporting grid.

9.6 Remote fault indicators

Remote fault indicators should be sited where they are readily accessible for operation but where they cannot be subjected to damage, tampering or vandalism.

Wiring between the light source and remote fault indicators should be at least Category B to BS 6387 : 1994.

9.7 Lamp circuit switch

Where the lamp circuit is to be de-activated by a manually operated switch this should be of the key operated type. The location for the switch should be chosen with care to ensure that emergency lighting is available until the premises are fully vacated. A position adjacent to the final exit is recommended wherever possible. Where the premises are closed in sections, for example, floor by floor then it may be more convenient to use more than one lamp circuit switch i.e. one for each section.

The wiring between the light source and the switch should be at least Category B to BS 6387 : 1994. The switch should be encased in metal.

Where the output of a central battery is to be isolated, the switch-disconnector should be mounted on or adjacent to the central battery unit and should conform to BS EN 60947-3. Alternatively it may be a circuit-breaker conforming to either BS EN 60947-2 or BS EN 60898. Both line and neutral conductors should be isolated.

10 Records

When the installation is complete the installer should provide the purchaser with a manual containing the following:

a) *drawings*: a complete 'as fitted' set of drawings showing the location of all equipment;

b) *certificates*: completion certificates in accordance with BS 7671 and BS 5266 : Part 1 (see **11.1**);

c) *equipment details*: full details of all equipment used together with any information provided by manufacturers (catalogues, instruction manuals, etc.);

d) *operation instructions*: full details of how to operate the installation. For large installations the use of supplementary sectionalized instruction cards placed in readily visible positions around the installation should be considered;

e) *maintenance schedule*: a schedule, log book (see **11.3**), and full instructions for the periodic maintenance of the installation including any manufacturer's recommendations. A full list of spare parts should be included.

11 Certificates and log book

11.1 Completion certificates

When the installation of an optical fibre emergency lighting system or a major alteration to an existing installation is complete, completion certificates in accordance with BS 7671 and BS 5266 : Part 1 should be supplied to the purchaser. A copy of these certificates may be required by the enforcing authority.

Certificates should be based on the model certificates given in appendix 6 of BS 7671 : 1992 and appendix B of BS 5266 : Part 1 : 1988. Recommendations on the measuring of illuminance of emergency lighting are given in appendix A of BS 5266 : Part 1 : 1988.

11.2 Periodic inspection and test certificate

On completion of a three-yearly inspection and test as recommended in clause **12** a periodic inspection and test certificate should be supplied to the person instructing the inspection and test. The certificate should be based on the models given in appendix 6 of BS 7671 : 1992 and appendix C of BS 5266 : Part 1 : 1988. These certificates should be supplied at intervals not exceeding 3 years or on the completion of major alteration or addition to an existing installation, or at such other times as may be required by the enforcing authority. A copy of these certificates may be required by the enforcing authority.

11.3 Log book

A log book should be kept on the premises in the care of a responsible person appointed by the owner/occupier and should be readily available for examination by the enforcing authority or any other authorized person.

The log book should be used to record the following information:

a) date of any completion certificate including any certificate relating to alterations;

b) date of each periodic inspection and test certificate;

c) date and brief details of each service, inspection or test carried out;

d) date and brief details of any defects and of remedial action taken;

e) date and brief details of any alteration to the emergency lighting installation.

NOTE. The log book may also include pages relating to other safety records, for example, fire alarm tests. Details of replacement components of light sources such as lamp type, battery, and circuit protective device may also be recorded in the log book.

12 Servicing

12.1 Supervision

Regular servicing is essential. The occupier/owner of the premises should appoint a competent person to supervise servicing of the system. This person should be given sufficient authority to ensure the carrying out of any work necessary to maintain the system in correct operation. All servicing should be carried out by suitably qualified and competent persons who have an understanding of, and specialist training in, work with optical fibre systems.

12.2 Batteries

In all cases the manufacturer's instructions should be followed. It is particularly important for sealed batteries to ensure that:

a) the batteries and their terminals are kept clean and unobstructed and that the battery cases are periodically checked for leaks;

b) any replacement battery is compatible with the battery charger;

c) any replacement battery charger is compatible with the battery.

12.3 Routine inspections and tests

12.3.1 *General*

Because of the possibility of a failure of the supply occurring shortly after a period of testing of the emergency lighting system or during the subsequent recharge period, all tests should wherever possible be undertaken at a time of minimum risk. Alternative suitable temporary arrangements should be made until the batteries have been recharged.

Inspections and tests should be carried out at the intervals recommended in **12.3.2** to **12.3.6**.

12.3.2 *Daily*

An inspection should be made every day to ensure that:

a) any fault recorded in the log book has been given urgent attention and the action noted;

b) every light source in a maintained system is producing light and no lamps have failed;

c) the main control or indicating panel of each central battery system indicates normal operation;

d) the audible/visual fault alarms in light sources or at remote positions are not operating to indicate a fault;

e) any fault found is recorded in the log book and the action taken noted.

12.3.3 *Monthly*

An inspection should be made at monthly intervals in accordance with a systematic schedule which should be based on the model schedule illustrated in appendix C of BS 5266 : Part 1 : 1988. Tests should be carried out as follows.

Each light source should be energized from its self-contained or central battery by simulation of failure of the normal supply for a period sufficient only to ensure that each lamp is illuminated. The light source visual and audible fault indicators should operate on loss of the normal supply.

A period of 5 min is usually sufficient to carry out this check but in any event the period of simulated failure should not exceed one quarter of the rated duration of the system. During this period all light sources should be examined visually to ensure that they are functioning correctly.

At the end of the test period the supply should be restored and the light source or central battery charger visual fault indicator checked to ensure that it is showing that the supply has been restored. The light source audible fault indicator should cease to operate. Cancellation of any muting should be checked.

The charging arrangements should be checked for proper functioning

If it is not possible to examine visually all light sources in this period, further tests should be made after the battery has been fully recharged.

12.3.4 ***Six-monthly***

The monthly inspection should be carried out and the following additional tests made.

Each light source with a 3 h self-contained or central battery should be energized from its battery for a continuous period of 1 h by simulation of a failure of the normal supply. If the self-contained battery or central battery has a rated duration of 1 h then the period of simulated failure should be 15 min.

During this period all light sources should be examined visually to ensure that they are functioning correctly. Lightguide ends should be inspected to ensure that they are not contaminated by dust, dirt, etc.

At the end of the test period the supply should be restored and the light source or central battery charger visual fault indicator checked to ensure that it is showing that the supply has been restored. The light source audible fault indicator should cease to operate. Cancellation of any muting should be checked.

The charging arrangements should be checked for proper functioning.

Ventilation fans, if fitted to the light source, should be checked for correct operation and any filters checked for contamination or blockage.

12.3.5 ***Three-yearly***

The monthly inspection should be carried out and the following additional tests made.

a) Each emergency lighting installation should be tested and inspected to ascertain that its performance has not been impaired by mechanical damage, alterations to the building etc.

b) Each self-contained light source and central battery system should be tested for its full rated duration.

At the end of the test period the supply should be restored and the light source or central battery charger visual fault indicator checked to ensure that it is showing that supply has been restored. The light source audible fault indicator should cease to operate. Cancellation of any muting should be checked.

The charging arrangements should be checked for proper functioning.

c) Lightguide ends should be cleaned to remove any surface contamination and inspected for damage (this should include lightguide ends at adaptor connectors unless they are sealed or contain an index matching substance which does not require replacement).

d) Emission end mounting arrangements should be cleaned if necessary to remove surface contamination and examined for damage.

e) Light sources should be examined for damage or deterioration, inspected and tested for electrical safety in accordance with BS 7671 and the manufacturer's specific recommendations, and cleaned if necessary.

12.3.6 ***Subsequent annual inspections and tests***

For self-contained light sources with sealed batteries, after the first three-yearly inspection and test, items a), b), and e) of the three-yearly inspection and tests (see **12.3.5**) should be carried out annually.

Annexes

Annex A (normative)
Optical budget

A.1 Budget construction

To calculate the light output from a light source required to achieve the desired level of illuminance at the point of utilization or to calculate the illuminance at the point of utilization using a light source of known output, it is necessary to know the luminous intensity of the lightguide emission end which is calculated using an optical budget.

The optical budget enables the output of the light source to be expressed in terms of the level of illuminance at the point of utilization, or vice versa, taking into account the light transmittance loss of the system.

It is prudent to include a safety margin in the optical budget (see **A.4**) to take into account such factors as:

a) lamp ageing;

b) minor fibre breakages occurring during handling and installation of lightguides;

c) dust, dirt, and other environmental factors (a maintenance factor).

The terms used in an optical budget are illustrated in figure A.1 and the optical budget is given by the following equation:

$$P_{OUT} = P_{IN} \times P_{LOSS} \times P_{SM} \qquad (A.1)$$

where:

P_{OUT} is the intensity of the light reaching the emission end of the lightguide (in candelas);

P_{IN} is the intensity of the light entering the lightguide (see **A.2**) (in candelas);

P_{LOSS} is the light transmittance loss (see **3.8**) expressed as an efficiency fraction;

P_{SM} is an extra efficiency fraction included to allow for the safety margin (see **A.4**).

In this equation P_{LOSS} and P_{SM} are expressed as efficiency fractions but can be converted to decibels for the purposes of calculation (see **A.3**).

P_{LOSS} in decibels would be a negative value and P_{SM} in decibels would be a positive value, but for the purposes of calculation these signs can be ignored.

Worked examples of the optical budget are given in annex B.

A.2 Input luminous intensity, P_{IN}

This represents the light actually launched into the lightguide by the light source and is measured as the luminous intensity produced at the emission end of a short (< 1 m) lightguide.

A coupling efficiency factor P_C is involved in launching light into the lightguide. Thus, P_{IN}, in candelas, is calculated using the following equation:

$$P_{IN} = P_{LAMP} \times P_C \qquad (A.2)$$

where:

P_{LAMP} is the on-axis luminous intensity of the lamp (in candelas);

P_C is the coupling efficiency factor.

The coupling efficiency gives the purchaser a clear indication of the efficiency with which the light source converts the available light from the lamp to useful light launched into the lightguide.

As in **A.1**, P_C is expressed as an efficiency fraction but can be converted to decibels for the purposes of calculation.

Values of P_C vary considerably with lamp type and manufacturer, and light source construction. Only values specific to the particular type and manufacturer of lamp and light source should be used for an optical budget calculation.

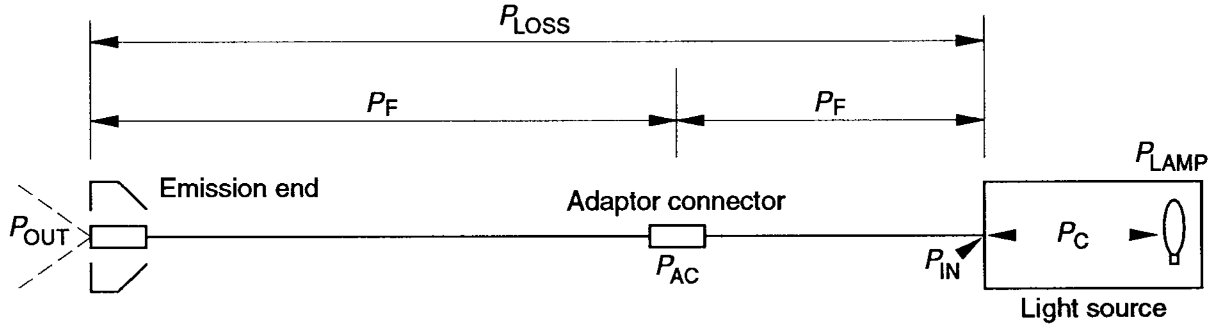

Figure A.1 Terms used in an optical budget

A.3 Light transmittance losses, P_{LOSS}

These are the losses incurred in transmitting light from the light source to the point of utilization i.e. losses that occur along the lightguide. They include the following:

a) fibre attenuation loss, P_F (usually expressed in decibels);

b) losses at adaptor connectors, P_{AC}, due to:

1) lightguide end spacing (longitudinal misalignment), P_{ES};

2) lateral misalignment of fibres in the lightguide, P_{LA};

3) lightguide end alignment (angular misalignment), P_{EA};

4) Fresnel reflection, P_{FR};

5) acceptance angle differences, P_A.

P_{AC} is normally expressed in decibels. P_{AC}, in decibels, is given by the following equation:

$$P_{AC} = P_{ES} + P_{LA} + P_{EA} + P_{FR} + P_A \qquad \text{(A.3)}$$

From this:

$$P_{LOSS} = P_F + P_{AC} \text{ if losses are expressed in decibels} \qquad \text{(A.4)}$$

or

$$P_{LOSS} = P_F \times P_{AC} \text{ if losses are expressed as efficiency fractions} \qquad \text{(A.5)}$$

NOTE. The use of adaptor connectors is not recommended due to the considerable losses that they introduce. They are included here to provide a complete treatment of the optical budget and in annex B to illustrate the magnitude of these losses.

A.4 Safety margin, P_{SM}

The magnitude of the safety margin which needs to be allowed depends upon the parameters relating to the particular installation, which may include, but are not limited to, the following:

a) *lamp ageing*;

b) *lamp output*: which can be affected, for example, by variations in the electrical supply, or by temperature changes;

c) *installation difficulties*: which can create a greater than normal number of broken fibres in lightguides;

d) *maintenance factor*: associated with lightguide ends (input, output, and at adaptor connectors);

e) *other environmental factors*: for example atmospheric pollution, and condensation, dust or other extraneous material on the emission end.

Each application should be assessed by a competent person and an appropriate allowance made.

As a guide the safety margin should be not less than 2 dB (decibel value) or ×1.5 (efficiency fraction value).

Annex B (informative)
Optical budget worked examples

B.1 Arrangement

As a means of illustrating the theory and calculations presented in annex A consider the system shown in figure B.1.

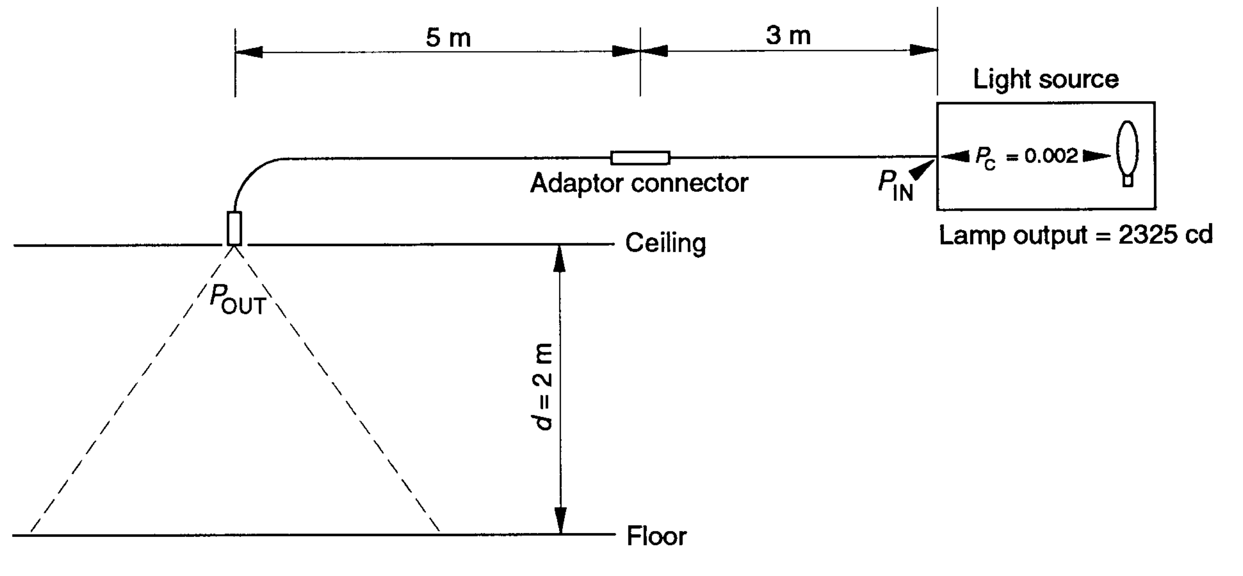

Figure B.1 Example of an optical fibre system for use in the worked example

B.2 Calculation of P_{IN}

The lamp in the light source has an on-axis luminous intensity of 2 325 cd.

The lightguide used is Size 1. The light source manufacturer's advised coupling efficiency factor, P_C, is 0.002. Hence, using equation A.2, P_{IN}, in candelas, is given by:

$$P_{IN} = P_{LAMP} \times P_C$$
$$= 2\,325 \times 0.002$$
$$= 4.6 \text{ cd}$$

B.3 Calculation of light transmittance loss

NOTE. The number and diameter of fibres in a lightguide with a particular size number can vary between manufacturers.

The fibre attenuation loss, P_F, is calculated using the values for attenuation of white light by a Size 1 lightguide which is given by the lightguide manufacturer as 0.4 dB/m.

Hence:

P_F for a 3 m lightguide = 3 × 0.4 = 1.2 dB

P_F for a 5 m lightguide = 5 × 0.4 = 2.0 dB

The adaptor connector loss should be that specified by its manufacturer. Where this is not available a value of 3 dB should be assumed. This value has been used in the present example.

Thus, using equation A.4, the light transmittance loss, P_{LOSS}, in decibels, is given by:

$$P_{LOSS} = P_F + P_{AC}$$
$$= 1.2 + 2.0 + 3.0$$
$$= 6.2 \text{ dB (which equates to a 76 \% loss of light)}$$

B.4 Safety margin, P_{SM}

For the purposes of this example a competent person has assessed that a value of 2 dB is applicable.

B.5 Conversion of decibels to efficiency values

It is necessary to convert the value of P_{LOSS} calculated in **B.3** and the value of P_{SM} given in **B.4** from decibels to efficiency values for use in equation A.1. This is carried out as follows:

$$P_{LOSS} = 6.2 \text{ dB}$$
$$= \text{antilog } \frac{6.2}{10}$$
$$= 0.24 \text{ (efficiency value).}$$

Similarly:

$$P_{SM} = 2 \text{ dB}$$
$$= \text{antilog } \frac{2}{10}$$
$$= 0.63 \text{ (efficiency value)}$$

B.6 Complete system calculation

Using the values calculated in **B.2**, **B.3** and **B.5** it is now possible to calculate P_{OUT}, in candelas, for the system illustrated as follows:

$$P_{OUT} = P_{IN} \times P_{LOSS} \times P_{SM}$$
$$= 4.6 \times 0.24 \times 0.63$$
$$= 0.695 \text{ cd}$$

Using this value, illuminance on the working plane can be calculated by conventional methods.

B.7 Illuminance example

Usually the illuminance required on the working plane is the starting point for calculations. This approach is illustrated in the following example.

Consider again the system shown in figure B.1. The distance, d, between the lightguide emission end and the working plane, in this case the floor, is 2 m. The illuminance required (E) is 1 lx. For simplicity assume that the values for P_{LOSS} and P_{SM} used in **B.6** apply and that the same light source is used.

Using the inverse square law the required luminous intensity, I, in candelas at the lightguide end can be calculated as follows:

$$I = d^2E$$
$$= (2)^2 \times 1$$
$$= 4 \text{ cd}$$

Note that use of the inverse square law is valid as the source is small in comparison to d and total darkness is assumed, i.e. no reflections, in accordance with BS 5266 : Part 1. Therefore, using equation A.1:

$$P_{OUT} = P_{IN} \times P_{LOSS} \times P_{SM}$$

Therefore:

$$P_{IN} = \frac{P_{OUT}}{P_{LOSS} \times P_{SM}}$$
$$= \frac{4}{0.24 \times 0.64}$$
$$= 26.455 \text{ cd}$$

The coupling efficiency P_C, for the light source using a Size 1 lightguide gives a value of P_{IN} of 4.6 cd (see **B.2**). This is inadequate for the task and the size of lightguide therefore needs to be increased proportionately.

$$\text{Size} = \frac{26.455}{4.6} = 5.75$$

The nearest standard lightguide is, therefore, Size 7.

Annex C (informative)
Guidance on areas of low fire risk

An area of low fire risk cannot be defined absolutely but indicators to areas that are likely to be suitable for locating light sources, central battery units for light sources, and for routing lightguides can be identified.

Generally an area of low fire risk:

a) should contain little or no combustible material and have no ignition sources. For example, the area should not contain furniture or fittings or be used for storage;

b) should ideally be enclosed by parts of the structure, i.e. walls (including doors), ceilings (including suspended ceilings) and floors, which are of fire resisting construction;

NOTE. Standards of fire resistance in such areas are normally enforced under the Building Regulations [2] by the local authority or under fire safety legislation by the fire authorities and should, where necessary, be the subject of discussion with these authorities.

c) should have surface finishes on walls and ceilings which have a low surface spread of flame (see BS 476);

d) should ideally not contain any other equipment which could endanger light sources or their central battery units. For example, electrical switchrooms would be unsuitable. Similarly other plant rooms would be unsuitable unless the plant contained could not cause a fire or otherwise endanger the emergency lighting equipment. For example, a pipe chamber or pneumatic valve chamber could present minimal risk.

Where light sources are located in a ceiling void the criteria listed in items a) to d) should be satisfied as well as the need for accessibility. The potential that other services, such as electric cables and heating pipes, have for causing fire in the event of malfunction should not be overlooked.

The recommendations for separation of services given in **9.4.4** should be used to ascertain whether additional protection is required to protect the emergency lighting equipment.

Where a suitable area is not available and special construction is required the criteria set out in items a) to d) should be applied to the general construction of the enclosure and ventilation of the enclosure should also be considered.

Ventilation should preferably be by natural convection and radiation but where satisfactory conditions cannot be achieved by these means then mechanical assistance should be used. Forced air fans may be contained within the light source or be part of the external installation. Ducting may be from the light source where this is specified, designed and manufactured to accept ducting (see **9.3.2** of BS 5266 : Part 5 : 1999), or from the enclosure. Ducted forced air ventilation schemes should be designed by a specialist.

Ventilation schemes should not impair the fire integrity of the light source surroundings. Additional fire protection should be provided as required.

A dual fan system is preferred arranged in a lead and standby format with the lagging fan automatically taking over on failure of the lead fan. Fan duty cycling is recommended to ensure even wear of mechanical parts, prevent seizure, and check that the changeover circuit operates.

A fault alarm to indicate fan failure is recommended. This should be independent of the light source fault indicators as failure of a fan does not automatically imply unsatisfactory operating conditions for the light source. The two sets of indicators may however be grouped together for convenience of reference.

Annex D (informative)
Routing of lightguides

D.1 General

Where lightguides are not entirely routed through the fire compartment that they serve they should be routed through areas of low fire risk.

Areas of low fire risk cannot be absolutely defined but guidance applicable to lightguides is given in annex C. Some additional methods of reducing risks to lightguides are illustrated in **D.2** to **D.4**.

D.2 Low fire risk route

Corridors are usually part of the escape route and can be considered areas of low fire risk. They are often separate fire compartments. Figure D.1 illustrates how lightguides may be routed in a corridor.

In figure D.1 lightguides are shown routed from different light sources along each side of the corridor. Such routing would minimize the loss of emergency lighting in the application areas should either lightguide route be destroyed by fire, mechanical damage, etc. Loss of any of the lightguides in the application areas would not affect the operation of any of the other lightguides and therefore in this situation category 1 lightguides (see **6.1** of BS 5266 : Part 5 : 1999) are suitable as the structural fire resistance and the separation between lightguide routes together with the low fire loading offered by the escape route provide adequate protection.

D.3 High fire risk route

Where lightguides cannot be routed along a low fire risk route then other measures need to be taken to prevent loss of emergency lighting in the event of fire. Figure D.2 illustrates some possible solutions.

In figure D.2 the lightguides for application areas 1 and 2 may be category 1 or they may need additional protection or need to be category 2 lightguides according to whether fire compartment 1 is low fire risk or not. Here it is taken to be low fire risk.

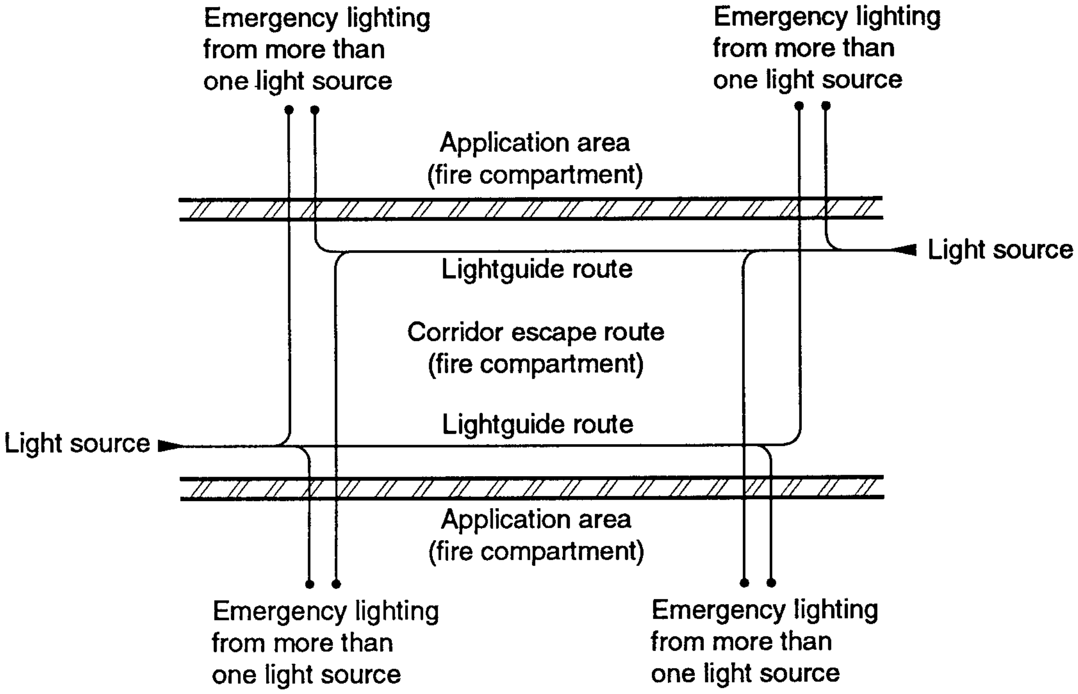

Figure D.1 Low fire risk route in a corridor

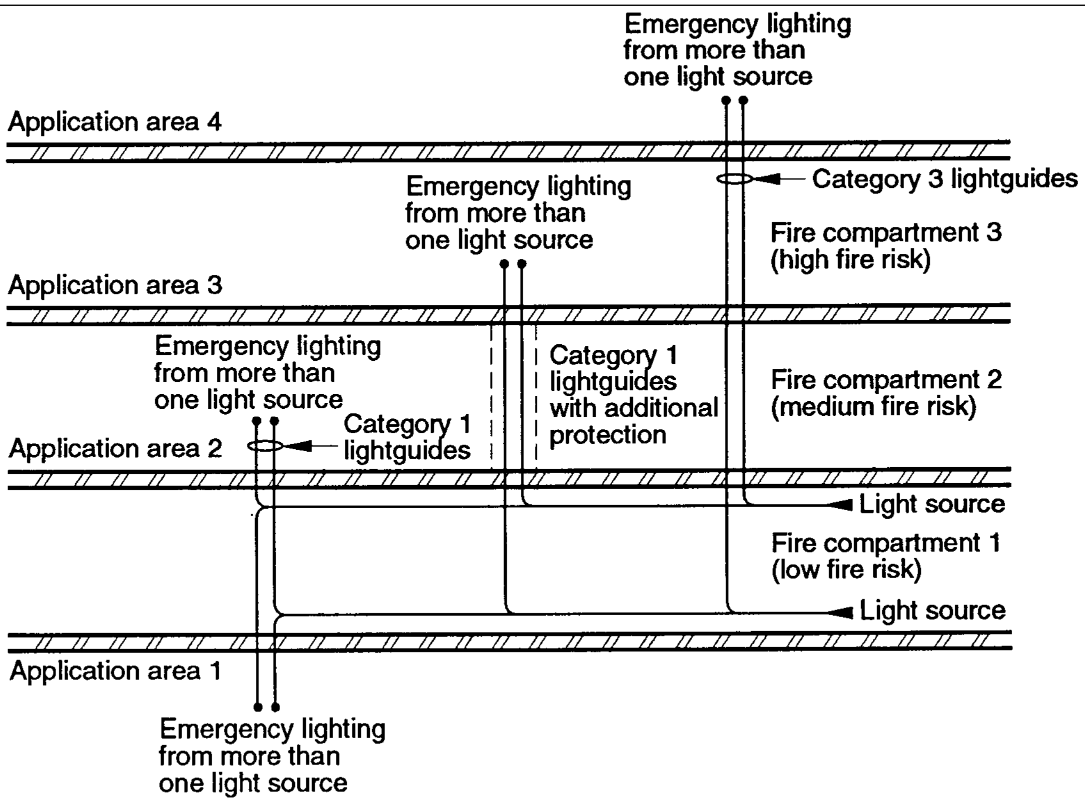

Figure D.2 High fire risk route

The lightguides for application area 3 cross fire compartment 2. If this is low fire risk then category 1 lightguides may be suitable. A risk assessment should be carried out to determine whether additional protection is required or whether category 2 lightguides would be more suitable. Here the area is taken as being of medium fire risk and the use of category 1 lightguides with additional protection is indicated.

The lightguides for application area 4 cross two fire compartments. It is unlikely that both would be low fire risk but it is possible, in which case category 1 lightguides may be suitable but the need for additional protection needs to be seriously considered and a risk analysis carried out to ensure that any possible risk of loss is eliminated by the use of additional protection or category 2 lightguides. Here area 3 is taken as high fire risk and the use of category 2 lightguides indicated.

Where additional protection is applied it should generally be provided by materials conforming to BS 476 but where other materials or methods can provide equal or better protection they are not excluded.

D.4 Separation

Where lightguides cross fire compartments, improved protection against loss of emergency lighting can be obtained by separating lightguides by as great a distance as is practical. A separation distance of 2 m or more is recommended where this can be achieved.

Where lightguides are routed in an area of low fire risk, for example the escape corridor described in **D.2** and a 2 m separation distance is not available then in this case a lesser distance can be accepted but the greatest separation distance possible should be achieved.

Where the light source and all lightguides that it serves are located within the same fire compartment then the risk to lightguides should be assessed. For example, some areas within the fire compartment may present a higher fire risk than others. Lightguides should be routed to avoid such areas and generally should separate as soon as possible after leaving the light source to minimize risk of loss due to fire or mechanical damage adjacent to the light source.

Annex E (informative)

Safety recommendations for handling of optical fibre lightguides

NOTE 1. Persons working on or handling bare optical fibres and associated chemicals are required under the Control of Substances Hazardous to Health (COSHH) Regulations, 1994 [3] to follow documented procedures. Guidance on good practice is given in the COSHH Regulations Guidance Notes [4].

NOTE 2. Further general guidance on safety when handling optical fibre lightguides is given in BS 7718.

E.1 General

The primary safety issues relating to optical fibres are those concerning physical hazards and those concerning hazards due to fumes and chemicals.

E.2 Physical hazards

There is a risk of optical fibre fragments piercing the skin (and eyes) which can lead to infection and complications due to the difficulty in their removal. Optical fibres are only of the order of 50 μm in diameter and nearly crystal clear which makes them virtually invisible.

This risk is normally only encountered when lightguides are broken or damaged exposing the fibres, or when assemblies are produced on-site.

Good housekeeping practices should be adopted to minimize the risk and installation staff should be trained in safety procedures. Exposed optical fibre ends should be kept away from the skin and eyes.

E.3 Hazards due to fumes and chemicals

There is a risk of operatives inhaling fumes from, or developing allergic reactions to, chemicals used to prepare and process optical fibres.

Again this hazard is normally encountered when site-made assemblies are used, but adverse reactions can also be encountered with adaptor connectors when an index matching material is used.

Certain chemicals used to prepare and clean optical fibres can be hazardous when inhaled or ingested by mouth. Others, such as epoxide resins used to attach fibres to connectors, can cause allergic reactions if handled in the uncured state.

Generally work should be carried out in a well ventilated area and prolonged and repeated breathing of vapour or fumes should be avoided.

Precautions should be taken to avoid contact with skin and eyes.

Specific safety recommendations from manufacturers of the substances involved should be obtained and followed.

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List of references (see clause **2**)

Normative references

BSI publications

BRITISH STANDARDS INSTITUTION, London

BS 476 :	*Fire tests on building materials and structures*
BS 5266 :	*Emergency lighting*
BS 5266 : Part 1 : 1988	*Code of practice for the emergency lighting of premises other than cinemas and certain other specified premises used for entertainment*
BS 5266 : Part 5 : 1999	*Specification for component parts of optical fibre systems*
BS 5345 :	*Code of practice for selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres (other than mining applications or explosive processing and manufacture)*
BS 5501 :	*Electrical apparatus for potentially explosive atmospheres*
BS 6387 : 1994	*Specification for performance requirements for cables required to maintain circuit integrity under fire conditions*
BS 7671 : 1992	*Requirements for electrical installations. IEE Wiring Regulations. Sixteenth Edition*
BS EN 60898 : 1991	*Specification for circuit-breakers for overcurrent protection for household and similar installations*
BS EN 60947 :	*Specification for low-voltage switchgear and controlgear*
BS EN 60947-2 : 1996	*Circuit-breakers*
BS EN 60947-3 : 1992	*Switches, disconnectors, switch-disconnectors, and fuse-combination units*

Informative references

BSI publications

BRITISH STANDARDS INSTITUTION, London

BS 7718 : 1996	*Code of practice for installation of fibre optic cabling*

Other publications

[1] CHARTERED INSTITUTION OF BUILDING SERVICES ENGINEERS. Technical Memorandum TM 12 *Emergency Lighting*, 1986[1).

[2] GREAT BRITAIN. The Building Regulations 1991, London, The Stationery Office.

[3] GREAT BRITAIN The Control of Substances Hazardous to Health Regulations 1994, London, The Stationery Office.

[4] HEALTH AND SAFETY EXECUTIVE. COSHH Regulations Guidance Notes HS(G)97, London, The Stationery Office.

[1) Available from: Chartered Institution of Building Services Engineers, Delta House, 222 Balham High Road, London SW12 9BS.

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