

Lighting for buildings —

Part 1: Code of practice for artificial lighting —

(Formerly CP 3:Chapter I-2)

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Foreword

This Part of BS 8206 has been prepared under the direction of the Basic Data and Performance Criteria for Civil Engineering and Building Structures Standards Committee and is a revision of CP 3:Chapter I-2:1973 which is now withdrawn. DD 67 and DD 73, which detail the effects of sunlight and daylight, respectively, on building design, are both in the process of being converted into a Part or Parts of BS 8206.

Detailed recommendations are given in BS 5266 for emergency lighting and in CP 1007 for maintained lighting in cinemas.

Where relevant, reference is made to publications by Government Departments and other bodies such as the Chartered Institution of Building Services Engineers (CIBSE).

This revision takes into account present day thinking and practice and is intended to be a basic guide for the practising architect.

Since CP 3:Chapter I-2 was published in 1973 an important change has taken place in the cost of energy. Fortunately, coincident with the increase in cost of energy, new lamps have been developed which in some applications enable standards of illumination to be maintained with reduced running costs. Generally speaking, the cost of energy is now a much more important factor in all considerations of lighting design and necessitates a reappraisal of past practices. Consequently, new sections giving guidance on energy considerations and control of lighting have been included in this revision, to supplement the general principles set out in BS 8207.

This Part of BS 8206 sets out basic principles, and more detailed information and guidance on good practice and lighting design is to be found in other publications listed in the bibliography (see Appendix A) and in particular the CIBS Code for interior lighting (1984)¹⁾, with which this revision is compatible.

Appendix B gives a list of essential information that the manufacturer should supply when replying to an enquiry or order.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 42, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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

Section 1. General principles

1 Scope

This Part of BS 8206 gives recommendations for the design, installation and maintenance of artificial lighting systems in buildings.

The first section describes in general terms the aims of and processes concerned with artificial lighting design, including energy considerations. Section 2 deals with the characteristics of various lamps and their control gear. In section 3, luminaires and other means of controlling the distribution of light are described, together with some aspects of installation. Section 4 considers the particular lighting requirements in various types of buildings and recommends methods of meeting them and section 5 refers to economics and maintenance.

A bibliography and a list of essential information that the manufacturer should supply when replying to an enquiry or order, are included as Appendix A and Appendix B, respectively.

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this Part of BS 8206, the definitions given in BS 4727-4, BS 5266-1, BS 6100-3.4 and CP 1007 apply.

3 Materials

The materials and components used in lighting installations should comply with the appropriate British Standard. A list of relevant British Standards is given in Appendix A.

4 Purpose and relationship with daylight

4.1 Purpose

The main functions of artificial lighting, whether used alone or in combination with daylight, applicable to the buildings and circumstances described in this code are as follows.

- a) To enable the occupants to work and move about the building easily and safely.
- b) To enable the occupants of the building to see the visual task with ease and accuracy.
- c) To enhance the appearance of the interior through the appropriate lighting of surfaces, colour and detail.

4.2 Relationship with daylight

The potentials of daylighting and artificial lighting should be considered from the early stages in the design of a building. Decisions on the form of a building will have an important bearing on the roles of natural and artificial lighting. For instance, in deep buildings without roof lights, artificial lighting will be required continuously during occupation. Even in buildings with rooms designed to be lit primarily by daylight, there will be times when artificial lighting has to be used to supplement the daylight. This possibility should be borne in mind when deciding on the switching arrangement and the appropriate colour appearance and colour rendering properties of lamps. Where it is desired that the artificial light should be similar in colour to the daylight, lamps with an intermediate or cold colour appearance will be suitable.

The consequences for the overall energy requirement of a building of natural and artificial light sources are not easily evaluated. The energy conserving potential of windows is largely dependent upon the magnitude and usefulness of the solar gains and the extent to which the provision of artificial light is controlled in the presence of adequate natural light. In deep and compact plan forms, the fabric losses are decreased but the need for artificial lighting is increased and the nett energy demand will depend not only upon illuminance and lamp efficiency but also on the extent to which the heat from the lamps can be utilized or has to be dissipated by other energy consuming processes.

5 Visual environment

The visual environment created in any space should be appropriate for that space. To be appropriate, a suitable emphasis has to be given to the three functions of lighting, i.e. safety, task performance and appearance (see 4.1). Since different spaces have different functions, there is no single set of lighting recommendations which is universally applicable. Each type of application has its own set of lighting recommendations.

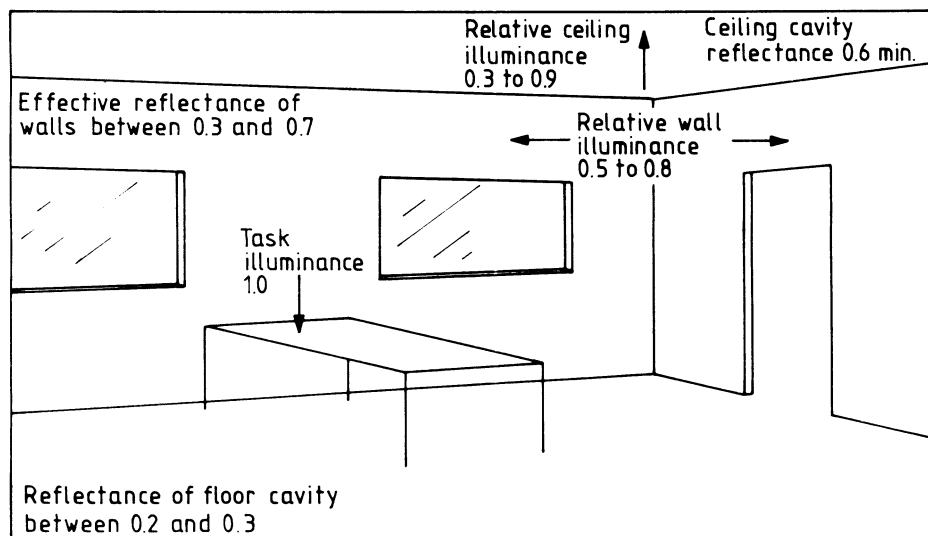


Figure 1 — Recommended ranges of reflectance and relative illuminance for room surfaces

The most widely used lighting criterion is the illuminance provided on an appropriate plane (see Table 1). Frequently this plane is horizontal but tasks in planes in other orientations do occur. The recommended illuminances apply to the appropriate plane and are standard service illuminances. The term “standard” refers to the fact that the recommended illuminances assume typical conditions for the applications being considered. The term “service” refers to the fact that the illuminances recommended are averaged over the relevant area and over the life of the installation. Thus the standard service illuminance is an average illuminance produced by the lighting installation on an appropriate plane in an area typical of the application. When the situation is not typical, then the standard service illuminances can be modified according to the flow chart (see Table 2) to provide a design service illuminance.

The illuminance provided across a space may vary. To avoid complaints about such variation, a uniformity criterion in terms of the ratio of minimum illuminance to maximum illuminance is valuable. An appropriate uniformity criterion is 0.7. (This is equivalent to a minimum/average of 0.8). This uniformity applies to the working area. This may be, for example, the whole of an office at desk height, or just a small part of it. Another criterion applies to the uniformity of illuminance desirable when working and non-working areas are adjacent. This can occur when working areas are next to storage areas or when local lighting is used. In such situations, the illuminance on the surround area should not be less than one-third of that of the working area.

The illuminances considered above have been concerned with the working plane. Although this is important, illuminances on other planes are also of concern to the designer. The illuminances on other room surfaces and the reflectances of those surfaces strongly influence the appearance of the room and the comfort of the viewer as well as the ease of performance of the visual task. Figure 1 shows the recommended ranges of room surface reflectances and illuminance ratios relative to the illuminance on the working area. Combinations of reflectance and illuminance ratios within the ranges given can produce a variety of appearances in an interior without creating discomfort. Advice on the appearance likely to be created by using different luminaires in rooms with varying combinations of surface reflectance can be obtained from the CIBS Code for interior lighting (1984).

A possible cause of discomfort in interiors is glare from the luminaires. This occurs when the range of luminances within the field of view is too large. After dark, the highest luminance in the interior is usually a luminaire. When this is seen against a dark background then discomfort glare may occur. The factors influencing the extent of discomfort glare are:

- a) the luminance of the glare source;
- b) the luminance of the background;
- c) the size of the glare source;
- d) the position of the glare source relative to the line of sight.

Table 1 — Examples of activities/interiors appropriate for each standard service illuminance

Standard service illuminance	Characteristics of the activity/interior	Representative activities/interiors
lx 50	Interiors visited rarely with visual tasks confined to movement and casual seeing without perception of detail	Walkways, cable tunnels
100	Interiors visited occasionally with visual tasks confined to movement and casual seeing calling for only limited perception of detail	Bulk stores, corridors
150	Interiors visited occasionally with visual tasks requiring some perception of detail Interiors visited occasionally but involving some risk to people, plant or product	Churches Loading bays
200	Continuously occupied interiors, visual tasks not requiring any perception of detail	Monitoring automatic processes in manufacture, turbine halls
300	Continuously occupied interiors, visual tasks moderately easy, i.e. details to be seen are large and/or of high contrast	Lecture theatres, packing goods, rough sawing
500	Visual tasks moderately difficult, i.e. details to be seen are of moderate size and may be of low contrast. Also colour judgement may be required	General offices, kitchens, laboratories
750	Visual tasks difficult, i.e. details to be seen are small and of low contrast. Also good colour judgement may be required	Drawing offices, ceramic decoration
1 000	Visual tasks very difficult, i.e. details to be seen are very small and may be of very low contrast. Also accurate colour judgements may be required	Electronic component assembly, gauge and tool rooms, retouching paintwork
1 500	Visual tasks extremely difficult, i.e. details to be seen extremely small and of low contrast. Visual aids may be of advantage	Inspection of graphic reproduction, hand tailoring
2 000	Visual tasks exceptionally difficult, i.e. details to be seen exceptionally small and of very low contrast. Visual aids will be of advantage	Assembly of minute mechanisms, finished fabric inspection

The effect of all these factors has been combined in a system developed by the IES (Illuminating Engineering Society, now the CIBSE) to form a glare index. If discomfort glare is to be avoided, then the limiting glare index recommendations given in section 4 should be complied with. The glare index scale is such that higher values mean greater discomfort, although the level of precision is not great. A difference in glare index of at least 3 is necessary before any lighting installation can be considered as producing significantly less discomfort glare than another. Glare index can be evaluated from data produced by most manufacturers for their luminaires of various types, or can be calculated by methods published by the CIBSE²⁾

Another form of glare is disability glare. This occurs when there is a high luminous flux close to the line of sight; most common sources of high luminous flux being windows and luminaires and their reflections. It is called disability glare because it may cause a reduction in visibility of detail.

²⁾ See CIBS Technical Report No.10 (1967) "Evaluation of discomfort glare — the IES Glare Index system for artificial lighting installations (and supplement, Jan. 1972)". Available from the Chartered Institution of Building Services Engineers, Delta House, 222 Balham High Road, London SW12 9BS.

Table 2 — Flow chart for obtaining the design service illuminance from the standard service illuminance

Standard service illuminance (lx)	Are the task details unusually difficult to see? ^a	Are the task details unusually easy to see? ^{ab}	Is the task done for an unusually long time? ^a	Is the task done for an unusually short time? ^{ab}	Is visual impairment widespread among those doing the work? ^c	Do errors have unusually serious consequences for people, plant or product?	Design service illuminance (lx) ^{de}
50	NO YES	50 100	50 100	50 100	50 100	50 100	50 100
100	NO YES	100 150	100 150	100 150	100 150	100 150	100 150
150	NO YES	150 200	150 200	150 200	150 200	150 200	150 200
200	NO YES	200 300	200 300	200 300	200 300	200 300	200 300
300	NO YES	300 500	300 500	300 500	300 500	300 500	300 500
500	NO YES	500 750	500 750	500 750	500 750	500 750	500 750
750	NO YES	750 1000	750 1000	750 1000	750 1000	750 1000	750 1000
1000	NO YES	1000 1500	1000 1500	1000 1500	1000 1500	1000 1500	1000 1500
1500	NO YES	1500 2000	1500 2000	1500 2000	1500 2000	1500 2000	1500 2000
2000	NO YES	2000	2000	2000	2000	2000	2000

^a The standard service illuminances recommended in the schedule are based on tasks which are representative of their type in the detail that has to be seen and the time for which the task has to be done. These steps in the flow chart allow for departures from these assumed conditions.

^b The standard service illuminance of 200 lx is provided as an amenity for continuously occupied interiors, even when perception of task detail is not required.

^c If the cause of visual impairment is dirty or scratched spectacles, safety glasses, safety screens, etc., it may be more effective to clean and/or replace these items rather than change the lighting. If safety screens are acting as a source of veiling reflections, then the lighting/task/worker geometry should be rearranged.

^d If the design service illuminance is more than two steps on the illuminance scale above the standard service illuminance, consideration should be given to whether changes in the task details, the organization of the work or the people doing the work are more appropriate than changing the lighting.

^e For the design service illuminance of 1 500 lx or 2 000 lx, local lighting supplemented by optical aids should be considered.

The colour of the light emitted by a near white source can be indicated by its correlated colour temperature (CCT). Each lamp type has a specific CCT but for practical use they have been grouped into three classes (see Table 3).

Table 3 — Correlated colour temperature classes used in this Part of BS 8206

Correlated colour temperature (CCT)	CCT class
$\text{CCT} \leq 3\,300$	Warm
$3\,300 < \text{CCT} \leq 5\,300$	Intermediate ^a
$5\,300 < \text{CCT}$	Cold
^a This class covers a large range of CCTs. Experience in the UK suggests that light sources with CCTs approaching the 5 300 K end of the range will usually be considered to have a cool colour appearance.	

The choice of an appropriate apparent colour of light source for a room is largely determined by the function of the room and the impression it is required to create. The only general rules to help with the selection of apparent colour are:

- 1) for rooms lit to an illuminance of 300 lx or less, a warm or intermediate apparent colour is preferred; cold apparent colour lamps tending to give rooms a gloomy appearance at such illuminances;
- 2) different apparent colour lamps should not be used haphazardly in the same room.

The ability of a light source to render colours of surfaces accurately can be conveniently quantified by the CIE general colour rendering index³⁾. This index is based on the accuracy with which a set of test colours are reproduced by the lamp of interest relative to how they are reproduced by an appropriate standard light source, identical agreement being given a value of 100. Each lamp type has a specific CIE general colour rendering index but for practical use they can be divided into a number of groups (see Table 4).

Where work involving accurate colour judgement is to be done, light sources from groups 1A or 1B are necessary. Where exact colour matching is to be done, lamps of colour rendering group 1A should be used and the recommendations of BS 950 should be followed. Light sources with good colour rendering properties (groups 1A and 1B) make surfaces of objects appear more colourful than light sources with moderate or poor colour rendering properties (groups 2, 3 and 4). In addition, light sources with poor colour rendering properties may distort some colours to a marked extent. Thus, where a colourful appearance is desirable, lamps with good colour rendering properties are appropriate. These are very general rules. The quality of colour rendering desirable in any particular circumstance remains a matter of individual judgement. The CIE general colour rendering index is no substitute for actually seeing the effect of different light sources when assessing their contribution to the appearance of an interior.

Two features of artificial lighting which can give rise to complaints but which are not quantified by simple criteria are veiling reflections and visible flicker. Veiling reflections occur when high luminances are reflected from a specular surface towards the observer, e.g. from the pages of a glossy magazine. The common solutions to this problem are either to use matt surfaces where possible, e.g. on desks, or to change the angle of viewing and/or the surface from where the reflection occurs so that there is no longer a high luminance object at the mirror angle to the observer. This phenomenon can still occur to some extent, even when the task material is not particularly glossy, e.g. even with matt paper, therefore it is essential that similar care is taken over the incidence and viewing angle with most materials.

Cyclic light fluctuations are inherent in all light sources operated on an a.c. supply. They are usually so small as to be unnoticeable as flicker. Sometimes the light fluctuations from discharge lamps, usually towards the end of the lamp life, do become noticeable as flicker and they can create considerable discomfort. Lamps which are producing visible flicker should be changed. Even if these cyclic light fluctuations are not themselves visible as flicker, they can produce a stroboscopic effect and give a false impression of the speed and direction of rotating objects. Guidance on minimization of the effects is given in 11.1.

³⁾ See CIE Publication No. 13.2 (1974) "Method of measuring and specifying colour rendering of light sources". Available from the Commission Internationale de l'Eclairage (CIE), 52 Boulevard Malesherbes 75008, Paris, France.

Table 4 — Colour rendering groups used in this Part of BS 8206

Colour rendering groups	CIE general colour rendering index (R_a)	Typical application
1A	$R_a \geq 90$	Wherever accurate colour matching is required, e.g. colour printing inspection
1B	$80 \leq R_a < 90$	Wherever accurate colour judgements are necessary and/or good colour rendering is required for reasons of appearance, e.g. shops and other commercial premises
2	$60 \leq R_a < 80$	Wherever moderate colour rendering is required
3	$40 \leq R_a < 60$	Wherever colour rendering is of little significance but marked distortion of colour is unacceptable
4	$20 \leq R_a < 40$	Wherever colour rendering is of no importance at all and marked distortion of colour is acceptable

6 Energy considerations

Following the recommendations of this standard will result in the effective use of energy for artificial lighting but the designer should be alert to the possible interaction with other environmental factors and the consequences for the overall energy demand of the building.

A fundamental aim of the lighting designer should be to use the available energy wisely. This aim is not achieved simply by reducing lighting standards. Careful design is required to provide the recommended lighting conditions at minimum energy cost but being mindful that an installation can be expensive in terms of first cost and running costs. The designer has to consider both the details of the lighting installation and the contribution of that installation to the overall energy balance of the building. Reduction of lighting standards may have adverse consequences on the effectiveness of the building for its function.

There are two factors which control the energy consumption of an artificial lighting installation, namely the power required to provide the lighting and the time for which that power is used. The former is determined by the designer, the latter is determined by the user within the limits set by the designer.

The power required to provide the desired lighting conditions is influenced by a number of decisions. The first is the type of lighting system used. The most common form is general lighting in which the same illuminance is provided over a large area. Two other forms are localized lighting, which is used when a large area can be conveniently split into a number of smaller areas requiring different lighting conditions, and local lighting, where there may be two lighting installations, one providing general lighting as a background and another providing local lighting on the task. As a general rule, the installed load for local lighting is less than for localized lighting, which in turn is less than for general lighting. The choice between these different lighting systems is not simply a matter of installed power. Rather, it is governed by organizational, technical and financial factors which determine the suitability of local and localized lighting to particular circumstances.

Regardless of the type of lighting system chosen, the choice of light source is an important factor determining the power used to provide the artificial lighting. Different light sources convert electricity to light with different efficiencies. This efficiency is called luminous efficacy and is expressed in lumens per watt (see Table 5). It should be noted that the discharge light sources, which include fluorescent lamps, require a control circuit which increases the power requirements which will vary according to the type of circuit selected. For any specific application, the light source with the highest luminous efficacy and which is consistent with the other requirements of the application should be chosen.

Having selected the light source, the designer's next decision is the choice of luminaire. Factors affecting the choice of luminaire are:

- the light distribution they provide;
- the way they control glare;

- c) the environmental conditions encountered; or
- d) their appearance.

For the purpose of minimizing installed power, the only important characteristic is the utilization factor of the luminaire. This is the total proportion of the lamp light output which reaches the working plane. This is not a unique property of the luminaire itself, as it is also governed by the room in which the luminaire is placed. A luminaire in a large room with high surface reflectances, will generally have a higher utilization factor than when placed in a small room with low surface reflectances. Provided it complies with the other requirements, the luminaire with the highest utilization factor for the interior under consideration should be selected. It would also be an aid to minimizing energy consumption if the reflectances in the room were near the maximum recommended in clause 5.

NOTE In order to give some guidance on the power required for a typical installation, recommended ranges of installed efficacies in lumen per watt are given in the CIBS Code for interior lighting (1984). These recommended installed efficacies are not exact. They are intended as guidance to what can be achieved using modern, commercially available equipment suitable for the application.

Having chosen the type of installation, the light source and the luminaire, the designer should consider the other aspect of minimizing energy consumption, which is controlling the hours of use of the installation. This aspect is dealt with in clause 8.

While the energy consumption of the lighting installation is of concern to the lighting designer, the building designer or his specialist advisor is concerned with the overall energy balance of the building. To assess this, he has to examine the interaction between the pattern of building use, the building structure, the natural lighting, the artificial lighting, and the heating, cooling and ventilating system. None of these aspects should be considered in isolation. Guidance on assessing the energy balance of these aspects of a building are given in the CIBS Building energy code⁴⁾.

7 Design process

Decisions about methods of lighting need to be taken early and the building designer should consult the lighting designer, and others concerned, at the conceptual stage.

The first task is to establish the visual tasks to be carried out in the building. The possibility of future changes in the use of the building should also be considered.

The artificial lighting should be considered as part of the design of the interior environment as a whole. In addition to its relationship to daylighting, it may need to be related to the thermal and acoustic requirements.

The details of the lighting design to be discussed may be considered under the following headings.

- a) The roles of natural and artificial lighting in the design and the extent to which artificial lighting will be required to supplement daylight or provide the only source of light.
- b) The illuminances required for lighting the specific visual tasks and for general lighting of the building interior.
- c) The requirements of statutory regulations, if any, for the lighting, including emergency lighting, of the activity/building type concerned.
- d) The distribution and directional characteristics of the lighting required to give the desired emphasis and modelling effects and to reveal form and texture.
- e) The apparent colour appearance and colour rendering properties of the lamps in relation to the presence of daylight, the colour scheme of the building interior in terms of hue, value and chroma, or the special requirements of the visual tasks.
- f) The switching/dimming arrangements for daytime and night-time use.
- g) A review of appropriate artificial lighting systems and the choice of luminaires of suitable construction, appearance and light distribution.
- h) The integration of artificial lighting into the building fabric.
- i) The provisions for the maintenance of the installation.
- j) An evaluation of glare. (Discomfort glare from supplementary lighting systems combined with daylight is considered in DD 73.)
- k) the provision of escape lighting and other auxiliary (standby) lighting systems. Early consultation with the appropriate authorities is desirable.
- l) The provision of lighting for the security of people and property. This may be achieved by an additional lighting system or by switching out part of the existing system.
- m) The provision of adequate lighting of the external areas immediately adjacent to building entrances and exits, particularly where steps or other potential hazards occur.

⁴⁾ Available from the Chartered Institution of Building Services Engineers, Delta House, 222 Balham High Road, London SW12 9BS.

n) An evaluation of the energy demands of the lighting system, the interaction with other environmental services, and the opportunities for energy conservation.

o) The determination of cost targets for the artificial lighting installation and review of the balance between initial costs and operating costs.

On the completion of the building, the building owner or tenant should be given drawings showing the layout of the artificial lighting installation and clear instructions for its operation and maintenance (including a reminder of the need to replace lamps by those of the type originally specified). Guidance on the measurement of illuminance using a photometer is given in the CIBS Code for interior lighting (1984).

8 Control of lighting

8.1 General

Lighting controls should be arranged so that the lighting load can be reduced in parts of buildings when no one, or perhaps very few people are in occupation, and also at times when daylight is providing a high illuminance over at least some of the working area⁵⁾.

The over-use of lighting arises in several different ways. The main way is by not switching off the lighting when no longer required, rather than by switching on unnecessarily. If too large an area of lighting is controlled by one switch, the requirement for light by one individual may lead to large numbers of luminaires being switched on when only one or two are really required. Such a requirement might arise from working in a position which is particularly poorly daylit in relation to the rest of the room, or even from working in a large room when no one else is present. In selecting switching and control methods it has to be borne in mind that some discharge lamps have a prolonged restriking and run-up time.

Control technology is continually developing; the systems detailed in 8.2 to 8.6 are examples of those available at this time.

8.2 Manual controls

Controls in rooms where there is more than one luminaire should at least permit individual luminaires or rows of luminaires parallel to window walls to be controlled separately. Each switch should preferably control a small group of luminaires, and even permit individual luminaires in a large installation to be switched by the occupants most affected. In spaces where there are a large number of luminaires, control by a bank of switches near the door should be avoided. Switches should be as near as possible to the luminaires which they control, mechanical control of ceiling mounted luminaires can be achieved by cords operating ceiling switches adjacent to each luminaire. Alternatively, electronic controls (ultrasonic or infra-red) can be placed on occupants' desks to give them control of one or more luminaires.

For domestic premises, it is desirable that all fixed lighting outlets in a room can be switched from the door.

8.3 Central control

A remote operation electronic master control avoids the necessity for additional wiring to switches on walls and can be used for overriding control when the room is unoccupied.

Central control by this means or by mains signalling techniques can then be arranged so that, regardless of the position of individual switches, all lights are off when the staff return after lunch break or the next morning.

8.4 Time controls

If the occupation of a building or any interior space effectively ceases at a fixed hour every working day, it may be worth installing a time control so that most of the lighting is switched off soon after this time and on non-working days. Similarly, lighting may be switched off centrally if there is sufficient unanimity about the timing of the lunch break.

Arrangements should be made for individuals working late or over the lunch time to override part or all of the switching with subsequent automatic switching-off and override cycles to avoid accidental leaving on. The building cleaning routine may also need special arrangements; sequential control of lighting may be appropriate when a cleaning gang move from floor to floor or area to area.

Arrangements should be made to ensure that no one has to enter an unlighted space or be in a space where all the lighting is out of his or her control.

⁵⁾ See BRE Digest 272:1983 "Lighting controls and daylight use". Available from the Building Research Station, Garston, Watford, Herts WD2 7JR.

Time controls also have an application to the lighting of outside spaces, whether industrial or domestic, so that outdoor lighting is not left on (apart from security requirements) after traffic or building occupation ceases.

8.5 Photoelectric controls

8.5.1 General. Photoelectric control of the lighting can ensure that the lighting cannot be switched on or remain on when the daylight provides the required illuminance by itself. The capital cost of these controls makes them usually only economic in large buildings with large daylit areas which are continually occupied during the day, e.g. offices, factories, schools and public circulation areas. An on-off control can be installed without difficulty in an existing building, but a top-up control requires special wiring and equipment which it is usually only economic to install in new buildings.

In interiors where there is a large range of daylight factors, e.g. a fairly deep interior with two or more rows of lights running parallel to the window wall (or walls), it may be advantageous to use a separate controller for each row.

8.5.2 On-off control. A photoelectric sensor may be installed outside a building and set to operate at that exterior illuminance which will provide the design illuminance at the work point. Alternatively, it may be installed inside to operate at the pre-set limits of internal design illuminance.

An on-off switch controlled by the level of daylight inevitably produces a sudden change of illuminance on the working plane of roughly two to one if it is set to switch off the artificial lighting when daylight alone could provide the same illuminance. There is considerable evidence that the occupants of a room find it unsatisfactory if large areas of lighting are controlled in this way, although it appears to be more acceptable if, for example, the outside row of luminaires close to a wall with windows admitting a reasonable amount of daylight are controlled in this manner, as the switching is likely to occur only infrequently.

8.5.3 Top-up control. Photoelectric dimming equipment can control the light output of lamps to provide sufficient illuminance to top-up daylight when it fails to reach the design level of the artificial lighting by itself. With this system, the artificial lighting is not fully on unless daylight falls to a negligible level. As daylight rises, the output of the lamps falls to keep the illuminance provided by the combination of the two sources constant until, when daylight alone is adequate, the lamps are switched off completely. Conversely, as daylight falls below the illuminance which the artificial lighting could provide, the lamps are switched on at an almost imperceptibly low output which increases progressively to maximum as the daylight illuminance falls towards zero. Such a system will use less energy than one which switches the lighting on fully for the whole time that the daylight is below the design illuminance, but it is more economic to arrange that some positive action has to be taken by the occupants to initiate the bringing-on action of the controller.

The photoelectric sensor for the top-up control needs to be mounted inside the room so that it is affected by the illuminance falling on the area the lighting of which is being controlled.

8.5.4 Savings. The savings achievable by substituting photoelectric control for normal manual switching depend partly on the amount of daylight entering the space, partly on the level of occupancy and partly on the use occupants make of the original manual switching arrangements. Energy savings so far reported vary from 15 % to 40 % for multi-occupied spaces. A control system that combines the centralized control of lighting related to overall occupancy with zoned control related to daylight and with localized switching arrangements for individual occupants, would be expected to produce optimum energy savings with maximum satisfaction to the occupants.

8.6 Occupation sensors

Controls are available which sense the presence of people in an interior. These can be used, perhaps in conjunction with other controls, to ensure that the lighting in a room is switched off when it is empty. Their cost may militate against their use in small spaces. Circulation spaces can be controlled by a common push-button time delay switch.