Building Bulletin 87, 2nd Edition Version 1 (May 2003)

This edition replaces Building Bulletin 87 (1997) as referenced in building regulations Approved Document Part L2 2002

Guidelines for Environmental Design in Schools

School Building and Design Unit
Department for Education and Skills

Produced by the Department for Department for Education and Skills

department for
education and skills
creating opportunity, releasing potential, achieving excellence

Contents

Introduction

Building Bulletin 87 is the Department for Education and Skills' Constructional Standard[Ref.1] for Environmental Conditions and the Conservation of Fuel and Power.

In addition BB87 contains further constructional standards applying to such things as water supplies and the prevention of summertime overheating, and also general design guidance on environmental design to achieve energy efficient school buildings.

The Building Regulations Part F: *Ventilation* and Part L2: *Conservation of Fuel and Power* apply to all schools since the ending of the exemption of LEA maintained schools from the Building Regulations in 2000. The Constructional Standards such as BB87 and BB93 which are mentioned in the Approved Documents are used by Building Control Bodies as the normal means of assessing compliance with the Building Regulations for schools. The Approved Documents (AD) in support of Part F 1995[Ref.2] and Part L2, 2002[Ref.3] both quote BB87 as a means of compliance with the Building Regulations.

This 2003 revision updates BB87 and brings it in line with the current Building Regulations and other legislation such as the Drinking Water Regulations. In a few respects, for schools the Constructional Standards refine the recommendations given in certain Approved Documents in support of the Building Regulations. However, it should be pointed out that only the School Premises Regulations[Ref.4], the Building Regulations and other Regulations are legally binding. In addition to the regulatory requirements, the Constructional Standards for Schools included in BB87 are often quoted as a basis of funding agreements and Building Contracts.

For ease of reference, the relevant Constructional Standards and School Premises Regulations can be found at the beginning of each section of BB87. Those Constructional Standards which are specifically mentioned in ADF 1995 or ADL2 2002 or other Approved Documents in support of the Building Regulations, or other Regulations, are listed beneath the appropriate Approved Document or Regulation.

The constructional standard for acoustics is now Building Bulletin 93[Ref.5], see **www.teachernet.gov.uk/acoustics** BB93 is quoted in ADE2003 and supersedes the acoustics section in the 1997 version of BB87.

The standards and guidance given in the 1997 edition of BB87 have been largely superseded by the requirements of Part L2 of the Building Regulations and hence, this 2003 revision of BB87 has been prepared. This 2nd. Edition of BB87, being the current Constructional Standard for schools, therefore replaces the 1st. Edition of Building Bulletin 87 published in 1997. All references to that document, for the purposes of compliance with Building Regulations Part F 1995 and Part L2 2002 and in the DfES Constructional Standards[1], should therefore be considered as references to the current version of this 2nd edition of Building Bulletin 87. The current version can be downloaded from the DfES website **http://teachernet.gov.uk/energy**

Scope of BB87 (2003)

The intention of this document is to provide advice on the environmental design of schools such that compliance with Requirements of ADL2 2002 and of ADF 1995 of the Building Regulations are achieved, and the energy and environmental performance of new and refurbished school buildings is compatible with current building standards.

The design guidance relating to Approved Document L2 2002 is formulated in a format similar to that of ADL2 2002, so that it reflects the three alternative means of compliance with the Energy Efficiency Requirements of Part L2 of the Building Regulations. However, BB87 contains some specific Constructional Standards for school buildings which refine and override the recommendations for compliance with Building Regulations given in ADL2 2002 and ADF 1995. For example the means of avoiding solar overheating given in Section 1 adds to the guidance on this topic in ADL2 2002.

Notwithstanding the obligations required under the Building Regulations it should also be borne in mind that The Education (School Premises) Regulations 1999, SI 1999 No.2[Ref. 4] are still in force and contain minimum environmental standards that apply to both new and existing school buildings. Note that ADL2 2002 also refers to requirements when undertaking work on existing buildings and this applies equally to schools.

Scope of the Building Regulations

Although Building Regulations do not apply to all alteration and refurbishment work, it is desirable that such work should consider environmental conditions and energy efficiency and incorporate upgrading of plant and controls and also the building fabric as is appropriate and cost effective. For the application of the Building Regulations see Regulations 3 and 4 of Building Regulations 2000 (as amended).

The exemption of Local Education Authority (LEA) maintained schools from the Building Regulations has ended and school Buildings are now subject to the Building Regulations and may be subject to detailed design checks and on-site inspections by the Building Control Bodies.

The Building Regulations apply in England and Wales. They apply to both LEA maintained schools and independent schools.

Temporary buildings are exempt from the Building Regulations. Temporary buildings are defined in Schedule 2 to the Building Regulations as those which are not intended to remain in place for longer than 28 days. What are commonly called temporary buildings in schools are classed as prefabricated buildings and are normally subject to the same building regulation requirements as other types of building. Additional guidance is given in Clause 0.6 of ADE, and clauses 0.25 and 0.26 of ADL2.

A building that is created by dismantling, transporting and re-erecting the sub-assemblies on the same premises, or is constructed from sub-assemblies obtained from other premises or from stock manufactured before the appropriate AD came into force, would normally be considered to meet the requirements for school if it satisfies, eg the 1995 edition of ADL.

The Building Regulations Part F 1995 and Part L2 2002 apply to most non-domestic buildings. Whereas, BB87 applies, and sets the constructional standards, for all areas of schools including nursery and adult/community education within school complexes. It does not apply to nursery schools which are not part of a primary school, sixth form colleges which have not been established as schools, and Universities or Colleges of Further and Higher Education[1]. However many of the performance requirements are desirable and BB87 can be used as a guide to the design of these buildings.

Note

1 The definition of a school is given in Section 4 of the 1996 Education Act. In the case of sixth form colleges the Section 4 of the 1996 Act should be read in conjunction with Section 2 of the same Act, in particular subsections (2), (2A) and (4) which deal with the definition of "secondary education".

If a sixth form college is established as a school under the 1998 School Standards and Framework Act then it will be classed as a school under section 4 of the 1996 Education Act and BB87 will apply. Only one sixth form college has done this to date. Therefore, most sixth form colleges are institutions in the Further Education sector and are not schools and hence BB87 will not apply.

In the case of a new sixth form college it will be necessary to contact the LEA to enquire if the sixth form college has been established as a school or as an institute of further education.

Section 1: BB87 and Approved Document Part L2 2002 requirements for schools

BB87 Constructional Standard	Building Regulations
Summertime overheating For school buildings it is accepted practice to define overheating as occurring when the internal air temperature exceeds 28°C. An allowable degree of overheating in a school is that this may occur for up to 80 occupied hours in a year. The CIBSE test Reference Years from CIBSE Guides J[Ref. 6] should be used as the basis of predicting the number of occupied hours when the temperature exceeds 28°C.	BB87 and Approved Document Part L2: Conservation of Fuel and PowerEnergy efficiency rating The designer of a school has three options in the design of a new school building. 1. To use the elemental method as described in Section 1 of ADL2 2002 of the Building Regulations, together with the advice contained in the revised BB87. 2. To use the Whole Building Method described in BB87 (2003) to estimate the total energy consumption of the building and achieve a carbon performance rating of better than 5 kgC/m^2 per year. 3. To use the carbon emission calculation method as described in ADL2 2002. This technique is advised for innovative or passive designs that will benefit from detailed whole building simulation procedures.

Approved Document L2 2002 gives three methods of compliance for the energy efficiency of a building. ADL2 also contains requirements, for example for air tightness testing, provision of commissioning logbooks and prevention of summertime overheating. This 2nd. Edition of BB87 gives specific constructional standards for schools relating to the elemental method and other requirements of ADL2.

Energy efficiency rating

In addition to the elemental method there are two further means of complying with Part L2 of the Building Regulation. These deal with the carbon emission of the school building as a complete building rather than the elements of which it is composed. The methods are as follows.

Elemental Method

For the elemental method of compliance the distinction is generally made between 'offices, industrial and storage buildings' and 'all other building types'. Specific guidance is given for offices etc, and separate information for 'all other building types' – which includes schools.

Whole Building Method

The whole building method has been developed to deal with 'offices', 'hospitals' and 'schools'. Targets have been set for 'whole-office carbon performance ratings', whilst for schools it is stated that:

> *For schools a way of complying with the requirements would be to show that the proposed building conforms with the DfEE guidance note.' The guidance note being BB87 (1997).*[1]

The Whole Building Method estimates the total annual energy consumption of the school taking into account the building fabric, services installed and operating conditions (including weather).

The calculation procedure is available from the Schools Building & Design Unit website at: **http://teachernet.gov.uk/energy** The spreadsheet contains all the data required to make calculations of the carbon rating for the school building. By following the design guidance contained within BB87 and ADL2 2002, the building should achieve a carbon performance rating of better than 5 kgC/m^2 per year.

Note

[1] The standards and guidance given in the 1997 edition of BB87 have been largely superseded by the requirements of Part L2 of the Building Regulations and hence, this 2003 revision of BB87 has been prepared. This 2nd. Edition of BB87, being the current Constructional Standard for schools, therefore replaces the 1st. Edition of Building Bulletin 87 published in 1997. All references to that document, for the purposes of compliance with Building Regulations Part F 1995 and Part L2 2002 and in the DfES Constructional Standards [Ref.1], should therefore be considered as references to the current version of this 2nd edition of Building Bulletin 87. The current version can be downloaded from the DfES website http://teachernet.gov.uk/energy.

Carbon Emission Calculation Method

The carbon emission calculation method is advised for innovative or passive designs that will benefit from detailed whole building simulation procedures. It is necessary to follow the carbon emission calculation method as described in ADL2 2002.

The designer of a school can design a new school building to comply by any of these three methods.

Interpretation of the elemental method of ADL2 2002 for schools

The following recommendations relate to the standards set by ADL2 2002 for compliance with the Regulations by the Elemental Method.

U-values

U-values of the building envelope's constructional elements shall meet the requirements of ADL2 2002 paragraphs 1.7 to 1.16 inclusive, and will provide energy efficient school building envelopes. Note that these are minimum standards and higher standards are desirable for energy efficiency and carbon emission reduction. Although 'trade-offs' between fabric performance and heating plant are allowable under the elemental means of compliance it is recommended that any change is restricted to a trade-off in fabric performance to achieve a more environmentally sensitive design.

Note that ADL2 2002 also refers to requirements when undertaking work on existing buildings and this applies equally to schools.

Lighting Efficacy

To provide energy efficient lighting suggests that a higher lighting efficacy can be specified for school buildings. A minimum of 65 lamp lumens/circuit watt should be adopted and therefore the light sources in table 8 of ADL2 2002 would be appropriate with the exception of "Other; any type and rating with an efficacy of greater than 50 lumens per circuit watt." All the advice on controls should be adopted.

Glazing

The maximum glazed area of 40%, which is adopted for heat loss purposes, should be accepted and will allow for an element of passive design and good daylight design. If a larger glass area is required it will be necessary to trade-off any heat loss by increasing the thermal performance of the building fabric.

External Lighting

External lighting is not explicitly mentioned in the ADL2 2002 but is being increasingly used on school premises for safety and security. It is recommended that all external lighting is provided with lamps having an efficacy of at least 65 lumens per circuit watt that are fitted with both time control and daylight level photocell control.

Summertime overheating requirements for schools relating to Part L2

Schools and their periods of occupancy are different to other building types and the conventional means of establishing overheating can be relaxed. For school buildings it is accepted practice to define overheating as occurring when the internal air temperature exceeds 28°C. An allowable degree of overheating in a school is that this may occur for up to 80 occupied hours in a year, normally non-heating periods are May to September excluding August. Simulation has shown that this can be achieved with conventional natural ventilation designs using medium to high thermal mass in the fabric for normal occupancy levels and up to five desktop PCs in a classroom. The glazing distribution as given in Table 4 of ADL2 2002 is a useful guide to avoiding overheating problems.

Appropriate use of shading device and good facade design, together with use of thermal mass, helps to limit summertime overheating.

Designers wishing to use more than the suggested glazing to achieve a passive environmentally sensitive design are advised to adopt the Carbon Emission Calculation Method for compliance. Passive designs using this amount of glazing need careful consideration to avoid overheating and would probably require an appropriate design tool.

Currently, it should be assumed that natural ventilation will be used for standard teaching zones with limited computer equipment. For guidance it is suggested that up to five desktop PCs with CRT screens, a laser printer and an OHP/computer projector will constitute the ICT equipment in a 'typical' classroom. Above this threshold, additional ICT equipment should be considered as a process load and treated as such in interpretation of the Approved Document.

These internal gains, which provide useful heat in the heating season, can lead to overheating in the summer and therefore should be reduced as much as possible by selection of efficient appliances with low heat rejection. Energy labelling schemes for domestic equipment, such as personal computers, cookers and other kitchen equipment, fridges, and washing machines, indicate bands of energy efficiency. Selecting band A and B rated equipment will reduce energy consumption. If less efficient equipment is used then other elements of the building must be improved to compensate for the increased equipment loads. In particular, summertime overheating may result from excessive heat gains from inefficient equipment. Additional information on the efficiencies of equipment can be found from the following websites:

www.ukepic.co.uk
UK Environmental Product Information Consortium

www.mtprog.co.uk
Market Transformation Programme

www.sedbuk.com
Boiler efficiency database

When predictions of overheating suggest that ACMV is required then the existing specific fan powers are adopted. That is 2 W/l/s is allowed for mechanical ventilation in new buildings and 3 W/l/s for refurbishment. Note: 2 W/l/s is a minimum standard for mechanical ventilation and current good practice is 1 W/l/s for new build installations.

In areas with high levels of ICT – ie above the basic provision of five PCs and a laser printer and OHP/computer projector – then mechanical ventilation and comfort cooling may be provided as indicated by ADL2 2002 paragraph 1.60d. In this case provision should also be made to record the energy consumption of this equipment as indicated in paragraph 3.4 of ADL2 2002.

Building Logbooks

As indicated in Section 3 of ADL2 2002 log-books and manuals for the user should be available, and a user guide should tell school staff how to operate those parts of the heating system over which they can and should exercise control.

Section 2 : Heating and Thermal Performance

School Premises Regulations

(1) Each room or other space in a school building shall have such system of heating, if any, as is appropriate to its normal use.

(2) Any such heating system shall be capable of maintaining the air temperature, at a height of 0.5m above floor level, at the specified level, in the areas set out in the Table below, when the external air temperature is –1°C:

Area	Temperature °C
Areas where there is the normal level of physical activity associated with teaching, private study or examinations	18
Areas where there is a lower than normal level of physical activity because of sickness or physical disability including sick rooms and isolation rooms but not other sleeping accommodation	21
Areas where there is a higher than normal level of physical activity (for example arising out of physical education) and washrooms, sleeping accommodation and circulation spaces	15

(3) Each room or other space which has a heating system shall, if the temperature during any period during which it is occupied would otherwise be below that appropriate to its normal use, be heated to a temperature which is so appropriate.

(4) In a special school, nursery school or teaching accommodation used by a nursery class in a school the surface temperature of any radiator, including exposed pipework, which is in a position where it may be touched by a pupil shall not exceed 43°C.

Constructional Standards

The heating system should be capable of maintaining the minimum air temperatures quoted in the School Premises Regulations. The heating system should be provided with frost protection.

Vertical glazed areas (including clerestory or monitor lights) should not normally exceed an average of 40% of the internal elevation of the external wall. However, where a passive or daylight design strategy has been adopted the percentage glazing may exceed 40%, provided the insulation of the building fabric is increased to compensate for the increased heat loss through the glazing or the heating plant carbon intensity is traded up accordingly.

Horizontal or near horizontal glazing should not normally exceed 20% of the roof area.

Building Regulations

Central heating systems should have appropriate controls complying with the requirements in ADL2 2002, in support of the Building Regulations.

The air supply to and discharge of products of combustion from heat producing appliances and the protection of the building from the appliances and their flue pipes and chimneys should comply with Building Regulations, Part J, 2002.

The fabric insulation should comply with the recommended maximum values given in the 'Elemental Method' in Table 1 of section 1 of ADL2 2002 in support of the Building Regulations, 2002.

Thermal conditions

The thermal conditions within educational buildings should be appropriate to the activities and clothing of the occupants. Thermal comfort is achieved when a balance is maintained between the heat produced by the body and the loss of heat to the surroundings. The rate of heat loss is dependent upon the amount of clothing worn and the temperature of the air and surrounding surfaces. In a normal school environment the hourly rate of heat production by the children varies with activity. This heat is lost to the surroundings by the normal processes of convection, conduction, radiation and evaporation. It is therefore necessary for the designer to take account of the functions of spaces and the activities that they contain, and the type of clothing likely to be worn.

Temperatures in the heating season

The air temperatures quoted in The School Premises Regulations are the minimum temperatures that should be maintained during normal hours of occupation throughout the heating season, assuming an external temperature of -1ºC. These room temperatures and this external temperature are not intended for use in the design of the heating plant. For sizing of the heating system, reference should be made to CIBSE Guide B[Ref. 7].

Higher air temperatures are often needed in schools to maintain comfort conditions and for those children with special educational needs, or those who may be more sensitive to the cold.

Excessive vertical temperature gradients should be avoided and the temperature at 2.0 m should not exceed that at floor level by more than 3ºC. In school buildings with spaces higher than 3 m temperatures greater than normal will occur at ceiling level. In these cases increased roof insulation should be considered. Recirculation of warm air to low level using ‘punka’ or ducted fans may be worthwhile in the heating season.

Multi-purpose spaces should have heating capable of adjustment, so that the space is kept at the temperature required for the activity and not at a higher or lower level than is needed. This is particularly so with sports and assembly halls, which may be used for both strenuous activities and sedentary occupations eg. during examinations.

In some establishments like nursery schools and those for the severely handicapped, it is necessary to prevent children from touching heated surfaces above 43ºC by the use of suitable screens or guards.

Summertime temperatures

An undesirable rise in temperature during warm weather can be caused by uncontrolled incidental and solar heat gains, or by high densities of occupation, eg in lecture rooms. In these circumstances sufficient natural ventilation is particularly important. Mechanical ventilation may be necessary in some instances to help to control air temperature.

Reflective, white or very light roof surfaces reduce the solar heat gain through the roof as well as reducing the thermal stress in the weatherproof covering, but will tend to become less effective without adequate maintenance. Insulation in the roof and walls also helps to reduce this solar gain, but will also reduce the ability of the excess heat to escape from the space. Increased thermal mass in the conditioned space controls the degree of temperature swing.

Excessive solar heat gain through windows can be minimised by appropriate orientation and by the use of brise soleil structural shading, louvres, blinds and curtains. Shading the glass from the outside is the most effective method of control. However, this calls for careful design of sun shading devices to avoid impairing the daylighting of a classroom.

Storage temperatures for food, including lunch boxes need to be considered.

Thermal insulation

Compliance with the current Building Regulations ADL2 2002 is considered as a minimum requirement that must be met and attempts should always be made to adopt more energy efficient techniques when appropriate.

Adequate thermal insulation of roof and walls is necessary not only to reduce heat loss, but also to make the internal surfaces of the building warmer and to reduce the risk of condensation. The provisions in ADL2 2002 will be adequate to ensure this in all normal circumstances.

In addition to insulating the building fabric it is important also to insulate adequately all heating mains including valves and hot water storage tanks. Thermal insulation of vessels, pipes and ducts according to ADL2 2002 is sufficient.

Heat gains

Incidental heat gains (eg solar, teaching equipment and light fittings) will also contribute heat to the space. Allowing for these and designing suitably responsive controls and heating systems will help to reduce fuel consumption. With the increasing use of Information Communication Technology (ICT) in schools these incidental gains become increasingly significant and may require special consideration.

Solar gains can be beneficial if careful consideration is given to the design and orientation of the building, but excessive solar gains may lead to overheating. Windows on a south-east facing facade will allow entry of sunlight early in the morning but will avoid direct sunlight during midday and early afternoon when the solar radiation is more intense. West and south-west facing glazing leads to the greatest risk of overheating.

Heating system design

The heating installation should be capable of achieving the temperatures recommended in The School Premises Regulations. Occupancy and solar gains may provide additional heat. However, the heating system must be responsive enough to adjust to these gains. Good control of the heating system is essential not only to maintain comfortable conditions but also to eliminate waste of fuel.

Consequently, the choice of heating system and heat emitter is an important design decision. Among other factors, it will depend on the thermal mass of the construction, the use of solar heat gain, the type of ventilation and the level of fabric insulation.

Radiators are generally the most suitable heat emitters for teaching spaces. In some primary schools where extensive use is made of the floor hot water underfloor heating is preferred. This is not appropriate where the floor area is likely to be covered, eg with insulating mats or bleacher seating and should not be the only form of heating in spaces such as nurseries, where doors are often opened for outside activities even during the heating season.

Large infrequently used spaces such as halls can benefit from a faster response and fan convectors or low temperature radiant panels are often used. Low temperature radiant panels can be fixed to ceilings rather than taking up valuable wall space. However, they can produce thermal stratification and this should be considered at the design stage.

Underfloor heating is sometimes used in halls to keep walls clear and to avoid background noise but its thermal response is slower than for other systems.

Wall space is often a priority in schools and fan convectors can then be used in preference to radiators. However, it should be remembered that fan convectors have a high maintenance cost. The background noise level of the fan convectors across the frequency spectrum should not be too high for the planned activities, see Building Bulletin 93.

To achieve an effective and efficient heat-up, optimum start controls should generally be provided. This is the case particularly in buildings with intermittent occupancy such as schools. Similarly, an optimum-off facility should be provided to minimise the heating overrun at the end of the school day.

Careful design of the number and size of boilers to match load variations is required to ensure optimum efficiency throughout the heating season and to have a reasonable standby capacity when implementing major boiler maintenance.

It should be remembered that plant sized for steady-state design conditions always has excess capacity when outside conditions are less severe than design conditions. Plant over-sizing in excess of 25% of steady-state design requirements is unlikely to be justified unless very substantial deviations in flow temperatures are required. Reference should be made to Sections A2, A3, and A9 of the CIBSE Guide[Ref.8] when calculating the heat losses and designing the heating system. Design loads should take into account the considerable incidental heat gains that are available in occupied schools. This is particularly important in determining ventilation heat loads, the majority of which will only occur during occupied periods when there are high heat gains to offset part of the heat loss.

Pupils in a classroom will compensate for all fabric losses and a major part of ventilation heat losses. Equipment and solar gains further reduce the heating demand. During pre-heat the ventilation loss will be minimal.

Where multiple boiler installations are being designed, condensing boilers should be considered for the lead boilers to take advantage of hot water loads and the long run time for the base load of the space heating. Small stand-alone gas-fired boilers or direct gas-fired heaters used in remote classrooms can allow more flexible use of the buildings than large central boiler plant.

Heat pumps may be a viable option for the heating, particularly in rural schools away from gas main networks. Heat pumps can be air to air, air to water, or water to water. Supplementary heating is normally required when external temperatures fall below approximately 3 ºC. This can be by use of a heat store and off-peak electric heating.

Choice of fuel and heating system

The choice of fuel and heating system should be based on calculations of the carbon efficiency of the system and its net present value, taking into account capital, maintenance and running costs. In practice the selection procedure is complicated by the unpredictability of fuel price trends and fuel availability.

In the choice of heating systems the option should be kept open where possible to change from one type of fuel to another during the life of a building. Systems where heat is delivered by hot water or warm air can possibly be converted to coal, gas, oil or electricity. Dual fuel burners for oil and gas are readily available and allow the site manager to choose the cheaper fuel. (Where oil tanks already exist the extra cost is small.)

Modular boilers (perhaps using a condensing lead boiler) should be considered. Smaller installations can economically use condensing boilers with underfloor heating systems.

Hot water generation should be on a separate circuit or a separate system to the main heating. Point of use systems can be the most energy efficient option.

Electric off-peak storage heater installations cannot be adapted to any other fuel use, and electric storage heaters are also unresponsive to changing heat gains.

Electricity that is derived from renewable sources, but supplied from the grid (such as 'green tariff' electricity) is not considered as an appropriate way of meeting the carbon emission calculations.

One of the most effective ways of conserving energy in existing schools is to improve the efficiency and responsiveness of the heating installation so that it comes as close as possible to the performance of a well designed new installation. Before any improvements are considered the operation of existing plant and controls should be checked. Simple re-commissioning of systems often leads to large fuel savings, for little or no cost. Improvements that may be worthwhile range from the re-design and renewal of plant to the re-assessment of its operating pattern. Fuller details are given in Building Bulletin 73[Ref.9].

When designing new buildings to improve energy efficiency it is important to consider the inclusion of systems based upon renewable energy and other innovative technologies eg micro CHP (Combined Heat and Power) systems. For further information see the following websites:

- DTI Photovoltaic Demonstration programme www.solarpvgrants.co.uk
- Renewable energy capital grants www.dti.gov.uk/renew/eoi.htm
- Community and household renewable energy grants www.clear-skies.org

The EU Directive on Environmental Performance of buildings[1] which will be included in the Building Regulations by 2006 asks member states to ensure that technical, environmental and economic feasibility studies of alternative systems are carried out.

Heating Plant Carbon Intensity

The level of carbon (C) produced by different fuels varies according to the initial proportion of carbon in the fossil fuel. ADL2 2002 refers to the 'Carbon Emission Factor' of the fuel. They are provided in Table 6 of the Approved Document and included in a table in the BB87 calculation spreadsheet. As can be seen for each unit (kWh) of electricity delivered more than twice the amount of carbon is produced as for natural gas.

However, the conversion of the fossil fuel delivered to the school takes place at less than 100% efficiency and this has to be taken into account. This is achieved by calculating the heating plant carbon intensity, in kgC/kWh of useful heat. The elemental method sets an overall maximum value for the carbon intensity of the heating plant. It is this value that can be traded-off against fabric insulation levels, although this is not recommended for schools other than to achieve a more environmentally sensitive design.

(Note: for conversion from kg of carbon to kg of CO_2 multiply the carbon figure by 44/12.)

Heating control

ADL2 2002, paragraph 1.33 recommends space heating controls such that the required temperature is only maintained when required in areas in use. The type of space heating control and the way in which it is operated have a significant influence on fuel consumption. Investing in control equipment can produce a relatively quick pay-back, and zone control of buildings can help with lettings, out of hours use and catering contracts.

Note

1 EU Directive on the Energy Performance of Buildings adopted in January 2003 *http://europa.eu.int/eur-lex/en/com/pdf/2001/en_501PC0226.pdf*

Space heating controls should be user-friendly, reliable and as far as possible automatic. Simple and inexpensive controls are now available which provide variable time control with optimum start. It is preferable if a member of the school staff can easily change heating periods, set holidays, change temperatures according to use, and extend heating periods. These controls are economic even in the smallest of schools.

Adjustable components (such as temperature sensors) should be tamper-proof. For the most accurate control, and improved energy efficiency, electronic thermostats (rather than bi-metallic strip devices) should be specified. Similarly, tamper-proof thermostatic radiator valves (TRVs) have been shown to give good local control of heat emitters to minimise overheating and underheating of areas with different thermal mass and incidental heat gains.

Good design of heating controls alone is not sufficient to ensure fuel economy. It is also necessary for the controls to be properly commissioned and maintained in good working order.

Zoning and individual temperature sensors should be provided to account for orientation and pattern of use. Heating zones should be chosen to suit the solar and incidental heat gains and to allow out of hours use of selected zones.

Large secondary schools require careful design of the control system to take account of the greater range of operating hours and diversity of use including possible out of hours use by the local community. Care should be taken to ensure that the heat load required in these areas can be provided from the heating system efficiently by avoiding long distribution runs and ensuring the boiler plant can operate efficiently at part load.

A number of zones may be provided to allow only the areas that are in use to be heated. A particular problem is offices that may be the only part of the building occupied during the holidays. Here, electric heating can be used as an alternative to the main heating system.

Building Energy Management Systems

Depending on diversity and out of hours use a building energy management system may be considered. Building energy management systems (BEMS) are becoming increasingly common and can significantly improve both the performance of the building and its controllability. Within the BEMS, optimum start/stop controls and automatic frost protection will normally be provided. Occupancy sensors and manual override to allow occasional use out of hours should also be considered. Weather compensation should be used where the boiler plant capacity exceeds 100 kW and may also be usefully applied to smaller heating zones, eg to allow for aspect zoning. Weather compensation may be of the central plant or the local zones. It is not advised on circuits serving fan convectors.

The use of BEMS will only be successful where a member of staff is available who is fully conversant with its operation and ensures the system is running correctly. There should be provision of training for the site staff and a back-up advice service should be provided if required.

Where a building energy management system is provided it can be used to monitor electrical and thermal energy as well as water consumption. Remote meter reading is likely to provide quick paybacks as it allows staff to identify waste by real-time monitoring of consumption. It can also help to monitor running costs.

Meter reading software is available at low cost where there is no control BMS and some of this software has been designed for curriculum use, eg mathematics.

An economic assessment of cost savings and payback periods should be made before installing complex control systems.

The calculations should include predicted maintenance costs of the control equipment and its anticipated life expectancy.

Frost protection

When unoccupied, a building should be heated only for frost protection or during the pre-occupation heat-up period. Frost protection is for the hot and cold water services and the heating system only, unless there is a need to preserve the structure, as with wooden panels in ancient buildings.

A three-stage frost protection is recommended for larger heating systems. Designs often omit stage 2 or 3 but the cost saving is small. The set points quoted are for bimetallic thermostats. Electronic temperature sensors have much smaller switching differentials allowing set points to be lower which saves energy.

Stage 1. An outside thermostat located in a position, which cannot be affected by sunlight, to bring on all pumps both heating and hot water service. This should be set to 2 °C (just above freezing).

Stage 2. An immersion/strap-on thermostat should be fitted in the common return from the heating and hot water service which will bring into operation the boiler plant. This should be set at 5 °C. Conventional optimisers often provide this function. The water temperature should rise high enough to prevent freezing of remote pipework due to very low outside temperatures and to prevent back-end corrosion of oil boilers. This can be achieved by providing a timer to ensure that the plant runs for 30-60 minutes dependent on the size of the system.

Stage 3. A standard low temperature thermostat installed in a normally heated room with maximum exposure should be set to bring the boiler plant into operation when the internal temperature drops below 5 °C. This temperature should be adequate for most buildings where condensation is not a problem.

Where pipework runs externally or the boiler house has a poorer level of insulation than the heated spaces, the stage 1 and 2 thermostats may need to be set to higher temperatures.

Suitable indicators should be provided to show on the boiler control panel that the various stages of frost protection are working.

An outside air temperature sensor should not be used to directly bring on the boiler plant.

This method of protection assumes that domestic hot water and cold water services are within the insulated building envelope. If they are not, additional frost protection for these services may be needed.

Single stage frost protection, omitting stages 1 and 2 is adequate for smaller gas fired heating systems.

In a building with high thermal storage, the use of night setback operation should be considered for unoccupied hours during term time. This would top up heating as required but rely mainly on stored heat in the fabric to avoid frost damage. This could use less energy than the frost thermostat protection and reduce boost heating requirements on start up for this type of building.

In some highly vulnerable areas, consideration should be given to using self-regulating tracer cable as a last resort. This should be switched on and off by a thermostat set at 2 °C.

Where air, via fresh air inlets, is heated by hot water heater batteries, provision of frost temperature sensors to protect them is essential. When the plant is not operational, the control valve should be open to the coil and the associated dampers closed.

Cold water tanks and pipework need to be insulated to prevent freezing as well as to prevent overheating in summer. (see Section 5).

Section 3 : Ventilation and Indoor Air Quality

School Premises Regulations	Constructional Standards
(1) All occupied areas in a school building shall have controllable ventilation at a minimum rate of 3 litres of fresh air per second for each of the maximum number of persons the area will accommodate.	It is recommended that in all teaching accommodation, medical examination or treatment rooms, sick rooms, isolation rooms, sleeping and living accommodation, ventilation systems, whether natural or mechanical, are capable of providing a minimum of 8 litres per second of fresh air for each of the **usual number of people** in those areas when such areas are occupied.
(2) All teaching accommodation, medical examination or treatment rooms, sick rooms, isolation rooms, sleeping and living accommodation shall also be capable of being ventilated at a minimum rate of 8 litres of fresh air per second for each of the usual number of people in those areas when such areas are occupied.	All other areas, such as corridors, halls and circulation spaces, shall be capable of being ventilated to a minimum of 3 litres per second of fresh air for each of **the maximum number** of persons the area will accommodate. Natural ventilation is the preferred method of ventilation in schools and it should be easily and readily controlled by the occupants. Spaces where noxious fumes or dust are generated may need additional ventilation. Laboratories may require the use of fume cupboards, which should be designed in accordance with DfES Building Bulletin 88[Ref.10]. Design technology areas may require local exhaust ventilation.
(3) All washrooms shall also be capable of being ventilated at a rate of at least six air changes an hour.	All washrooms in which at least 6 air changes per hour cannot be achieved on average by natural means should be mechanically ventilated and the air expelled from the building. Heat recovery fans can be used.
(4) Adequate measures shall be taken to prevent condensation in, and remove noxious fumes from, every kitchen and other room in which there may be steam or fumes.	During the summer, when the heating system is not in operation, the recommended design temperature for all spaces should be 24 °C with a swing of not more than +/- 4 °C. It is undesirable for peak air temperatures to exceed 28 °C during normal working hours but a higher temperature for 80 hours during the summer term is acceptable.

Purpose of Ventilation

It should be remembered that the primary purpose of ventilation is to provide good indoor air quality in both winter and summer. The supply of fresh external air, at a level required to meet the need for odour control and adequate indoor air quality, suggests that 8 litre per second per person (l/s/p) are provided. In the summer it may be desirable to provide more than this to remove unwanted heat gains that may lead to overheating. In winter lower ventilation rates are usual. This together with incidental heat gains limits the wintertime heat demand.

Indoor Air Quality (IAQ)

There are many factors which influence IAQ in schools, such as damp conditions, allergens from dust mites in carpets, volatile organic compounds, dirt or mould in mechanical ventilation systems due to poor maintenance and external pollution. Increasing numbers of children are reported to be asthmatic and/or sensitive to some of these contaminants.

Much research has recently been done on IAQ in school classrooms, which usually have high occupancies. It has been found that the concentration of carbon dioxide in the air in a classroom is a good indicator of the IAQ. For this reason limiting carbon dioxide concentrations are increasingly being used in design. For example, in Finland, design guidelines recommend that in classrooms, natural ventilation systems should achieve a concentration of carbon dioxide of less than 1500 parts per million (ppm) under design conditions and mechanical ventilation systems achieve a concentration of less than 1000 ppm. In normal classroom occupancy, a concentration of 1000 ppm corresponds to a ventilation rate of approximately 8 litres per second per person of fresh air whereas a concentration of 1500 ppm corresponds to 4.5 l/s/p.

Carbon dioxide concentrations of 2000 to 3000 ppm are often found in school classrooms and levels of up to 3500 ppm are considered perfectly safe. (Note: The threshold limit value for an adult for continuous eight hour exposure to carbon dioxide is 5000 ppm.) Exposure to this level is not dangerous but may affect performance.

A simple cost effective measure is to provide visual CO_2 indicators and to give guidance to teachers that high CO_2 levels are likely to lead to a fall off in the concentration of pupils.

Natural ventilation

Generally it is assumed that school classrooms can be ventilated to 8 l/s/p by natural means alone and natural ventilation is taken to be the default design solution for the ventilation of school classrooms. Some supplementary mechanical ventilation will be required in most schools, for example, in toilets, changing rooms and spaces with high functional heat gains, such as kitchens and home economics rooms, and also in some laboratories, and areas producing water vapour or fumes.

Given that natural ventilation is driven by the combined wind and stack effect, the rates of natural ventilation provided should be calculated to give good indoor air quality in the typical conditions of wind speed and inside to outside air temperature difference. The minimum design requirement of 3 l/s /p, for spaces other than those defined as teaching accommodation, offices, medical examination or treatment rooms, sick rooms, isolation rooms, sleeping and living accommodation, is based on the assumption that these will be either: used intermittently; large volume spaces providing a dilution effect; or have high levels of ventilation occuring between teaching periods, eg in circulation spaces by opening of external windows and doors.

As it is difficult to predict the actual rates required, the emphasis should be on the provision of easily adjustable openings whether they are windows, slot ventilators or adjustable grilles. The ventilation system should be designed to ensure that air movement at the occupants' level is at such a temperature and velocity as to ensure comfort; window design is important for this. Ventilation suitable for the occupancy level is required whenever spaces are occupied. Window-vents and extract grilles to ventilation stacks, controlled by the occupants are an effective way of providing natural ventilation. In practice, adequate ventilation rates may be higher or lower than the rates quoted.

In classrooms designed to be ventlated by opening windows trickle vents should also be fitted. This is particularly important with modern airtight construction.

Mechanical Ventilation

In a well insulated building, ventilation heat losses account for a major part of the energy consumed and any mechanically ventilated part of the building should include, wherever possible, heat recovery, as this can reduce ventilation heat losses by up to 80%. The potential savings from heat recovery systems will only be realised if a building is very airtight, therefore where heat recovery is used there is increased need for airtightness. Infiltration through joints in the external envelope, around door and window openings and service penetrations can represent a large part of these losses and should be reduced as far as possible[Ref.11]. Draught lobbies, auto-closing doors and internal fire doors can all play their part in reducing infiltration.

Although internal gains may provide for heat losses the incoming air will still need to be tempered to avoid draughts, for this the heat recovery can be beneficial. Small input/extract fan units including heat recovery are now available for use in toilets and smaller rooms, these are economical and give good energy savings. However, there will be additional electricity used particularly in larger heat recovery systems, by the fans and filters, ductwork and grilles. Also, these items all need maintenance. One hundred percent fresh air mechanical ventilation systems with heat recovery by thermal wheels minimise the potential for IAQ problems associated with recirculation systems and can have heat recovery efficiencies of 80%.

Ventilation systems must be designed together with any fume cupboards and local exhaust ventilation systems so that they do not disturb the operation of the fume cupboards or exhaust ventilation.[Ref.10]

Whichever ventilation system is selected it is important to note that IAQ is highly dependent on the cleanliness of the spaces and ductwork for a mechanical system. Therefore, cleaning of carpets and room surfaces such as bookshelves to limit the contaminants is as important for good IAQ as adequate fresh air ventilation rates.

Controlling summertime overheating

One of the main design problems faced by the designers of modern schools is the prevention of overheating. Classrooms can be subject to substantial heat gains from electrical equipment, the pupils and from solar gain. Electronic white board projectors and overhead projectors are in use for a large part of the school day in some schools. When in use, blinds are usually drawn to provide easier vision of the board and this again increases the heat load from the electric lights.

In addition to ensuring that all internal gains are reduced to a minimum it is necessary to control solar gains.
For those sensitive areas that cannot be oriented to the north, some form of solar shading may be required - either using special glass or blinds or a combination of the two.

The first means of removing the unwanted heat is by natural ventilation. The ventilation rate for cooling in summer is significantly more than that required for the hygiene of the occupants. Therefore, particular consideration should be given to the design of the building so that natural ventilation can achieve these supply rates.

Deep plan spaces should be avoided and classrooms should have the provision for cross-ventilation. As the worst situation is likely to be at times of high solar radiation it may be possible for the ventilation to be driven by a solar induced stack effect - solar chimneys are one way to utilise this effect. This will encourage ventilation on days with little or no wind. It may be useful to supplement the natural ventilation with fan assistance in a hybrid system for those times when the design requirements (either for fresh air for IAQ or reduction of internal temperatures) are not being met.

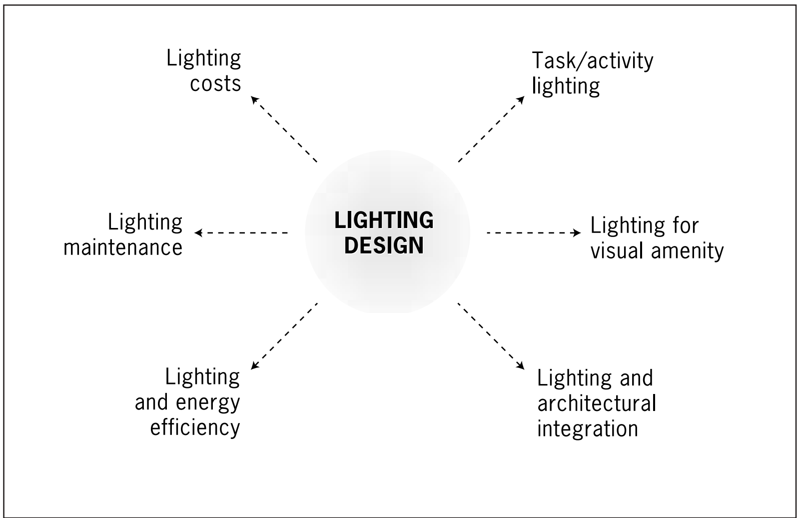
Simple methods can be used to calculate the size of opening vents in classrooms. In the case of deep plan spaces more complex design methods are required to predict the ventilation rates [Refs.12 & 13].

Section 4 : Lighting

The School Premises Regulations	Constructional Standards
(1) Each room or other space in a school building - (a) shall have lighting appropriate to its normal use; and (b) shall satisfy the requirements of paragraphs (2) to (4) (2) Subject to paragraph (3), the maintained illuminance of teaching accommodation shall be not less than 300 lux on the working plane. (3) In teaching accommodation where visually demanding tasks are carried out provision shall be made for a maintained illuminance of not less than 500 lux on the working plane. (4) The glare index shall be limited to no more than 19. **Note:** Recommended illuminance is described as maintained illuminance, and is defined in the CIBSE Code for Lighting, 2002[Ref. 14] as: *'The average illuminance over the reference surface at the time maintenance has to be carried out by replacing lamps and/or cleaning the equipment and room surfaces'.*	Where possible, priority should be given to design for daylight as the main source of light in working areas. The uniformity ratio (minimum/average daylight factor) of the daylight should be in the range 0.3 to 0.4 for side-lit rooms. Where spaces are top-lit, eg, atria, then higher uniformities should be expected of the order of 0.7. The uniformity ratio (minimum/average maintained illuminance) of the electric lighting in teaching areas should be not less than 0.8 over the task area[Ref.14]. Teaching spaces should have views out except in special circumstances. A minimum glazed area of 20% of the internal elevation of the exterior wall is recommended to provide adequate views out. A maintained illuminance at floor level in the range 80 - 120 lux is recommended for stairs and corridors. Entrance halls, lobbies and waiting rooms require a higher illuminance in the range 175 - 250 lux on the appropriate plane. The type of luminaires should be chosen to give an average initial circuit luminous efficacy of 65 lumens/circuit watt for the fixed lighting equipment within the building, excluding track-mounted luminaires and emergency lighting. In all other respects the lighting efficiency and controls should comply with Approved Document Part L2, in support of the Building Regulations. External lighting is not explicitly mentioned in the ADL2 2002 but is being increasingly used on school premises for safety and security. It is recommended that all external lighting is provided with lamps having an efficacy of at least 65 lumens per circuit watt that are fitted with both time controls and daylight level photocell control.

Design framework

This section of BB87 is based on the more detailed design advice given in Building Bulletin 90, *Lighting Design for Schools* [Ref.15]. A successful lighting installation is one that satisfies a number of different criteria shown in the lighting design framework. The criteria will not have equal weight but all should be considered to arrive at the best solution.



Task/activity lighting

Here the designer needs to examine the functional requirements of the particular space. It is necessary to consider the amount of light and the type of lighting required to ensure that the users of the space can carry out their particular tasks without visual difficulty and in a comfortable visual environment. Hence the first consideration here is to analyse the activity requirements for particular spaces.

It may be necessary to provide flexibility in the lighting to allow for a variety of activities. Local task lighting can be very useful for specific tasks. Safety should be considered in choosing the type of local task light, eg surface temperature of the fitting.

An increase in the size or contrast of the task detail, eg typeface may be an alternative to higher levels of illuminance particularly for the visually impaired.

Lighting for visual amenity

This aspect of lighting addresses the appearance of the lit scene, the aim being to create a 'light' environment that is visually interesting and pleasant. This means creating a light pattern that has luminance variation and a sensitive use of surface colour.

Lighting and architectural integration

It is important that a lighting installation, both natural and electric, appears an integrated part of the architecture. This will apply both to the lighting elements (windows and luminaires) and the light patterns they produce.

Lighting and energy efficiency

This will mean making the maximum use of daylight, using electric light to complement daylight, and using energy efficient electric lighting that only operates when it is required. This last point can be covered by the positions of the control switches, by the organisation of the lighting circuits to relate to the daylight distribution and to the use of the space. Automatic controls can provide useful energy savings but it is essential that any controls are user friendly, ie they do not hinder the use of the space.[Ref.16]

The type of luminaires should be chosen to give an average initial circuit luminous efficacy of 65 lumens/circuit watt for the fixed lighting equipment within the building. Both emergency lighting systems and equipment which is not fixed, eg track-mounted luminaires are excluded from this figure.

Lighting maintenance

All lighting will deteriorate with time due to dirt build-up on the lamps and luminaires, on the windows, on the reflecting surfaces of the space and also due to lamp light output depreciation. The designer will need to consider these matters in making decisions to ensure that the lit environment is satisfactory over the whole maintenance cycle. This will mean liaising with the client to plan a suitable maintenance programme.
It is worth remembering that use of a wide range of different lamp types makes subsequent replacement more complicated.

All lighting elements including windows should be easy to clean and maintain.

Lighting costs

Both capital costs and running costs will need to be considered to ensure a cost effective design. This is particularly important if the two costs are to be met by different budgets.

Design criteria

Daylighting

Natural light should be the prime means of lighting during daylight hours. A space is likely to be considered well lit if there is an average daylight factor of 4-5%. For the daylight illuminance to be adequate for the task, it will be necessary to achieve a level of not less than 300 lux, and for particularly demanding tasks not less than 500 lux. When this cannot be achieved, the daylight will need to be supplemented by electric light. Light exterior surfaces can sometimes be used to increase reflected light. Light shelves and special refractive glazing can be used to redirect light from perimeter windows deeper into spaces to increase the uniformity of the daylight [Ref. 17].

The design of the fenestration should relate to the layout and activities planned for the internal space, eg, to avoid silhouetting effects and excessive contrasts in brightness.

Discomfort and disability glare are possible from daylight, and in particular from direct sunlight. This potential problem can often be solved by careful design of the fenestration to minimise glare. Alternatively, adjustable blinds can be provided to screen the glare source when necessary. Blinds can also improve the thermal environment by reducing heat gains. Although they are more expensive than internal blinds, external blinds are more effective in preventing solar heat gain. Internal blinds are often difficult to maintain and are a source of noise when windows are open.

A low maintenance solution is a tripled glazed window with an internal double glazed unit and an interstitial blind located between this and the external single glazed element. This gives a very low U-value of around 1.6 $W/m^2\,^0C$ without using specialised double glazed units and also enables the outer pane to be easily replaced in the event of breakage. The external cavity can also be ventilated to dissipate heat gains.

Windows are important as they provide natural variation of light through the day and external visual interest. For the window area to be adequate for this purpose, it is recommended that a minimum glazed area of 20% of the internal elevation of the exterior wall is provided.

Windows, in addition to being treated as a lighting source and providing a view out, need to be considered in terms of other environmental factors, eg, the thermal and acoustic performance together with the energy efficiency of the building.

Where windows are used for ventilation, the openings need to be controlled to provide the necessary ventilation without draughts.

Electric lighting

The electric lighting installation will need to meet all the requirements shown in the design framework.

In terms of task lighting, for most school tasks, a maintained illuminance of 300 lux will be appropriate. If the task is particularly demanding, eg, the task detail content is small or it has a low contrast, then a value of not less than 500 lux will be necessary: in some situations, this can be provided by a local supplement to the general lighting.

A maintained illuminance at floor level in the range 80 - 120 lux is recommended for stairs and corridors. Entrance halls, lobbies and waiting rooms require a higher illuminance in the range 175 - 250 lux at an appropriate level. Reception areas should be lit to a level in the range 250 - 350 lux on the working plane.

In terms of avoiding discomfort glare, where a regular array of luminaires is used, the Glare Index shall be limited to no more than 19. It will also be important to avoid visual discomfort from individual luminaires and from reflected images, particularly on computer screens.

An additional consideration on visual comfort is the avoidance of subliminal lamp flicker. This can be important as it can induce epileptic fits in susceptible pupils. It can be minimised by the use of high frequency control gear or using more than one phase of a three phase supply in a lead-lag arrangement. The stroboscopic effect of lamp flicker must be addressed in areas with rotating machinery, eg lathes, cnc machines, band saws and circular saws.

Colour appreciation is an important part of learning, and hence it is necessary to use electric light sources that present colours accurately, particularly in art and design rooms. Good colour rendering is now not very expensive to achieve. In this respect, lamps with a CIE Colour Rendering Index (R_a) of not less than 80 are recommended. With regard to colour appearance, lamps with a Warm to Intermediate classification (Correlated Colour Temperature 2800ºK - 4000ºK should be used).

Switching arrangements should facilitate shared use of spaces and changes to the layout of spaces, where appropriate.

Combined daylighting and electric lighting

A specially designed supplement of electric lighting should be provided when the daylighting recommendations cannot be achieved throughout a space. In addition to providing a combined illuminance for the task or activities being undertaken, a satisfactory appearance should be obtained by a balance of brightness throughout the space to cope with relatively bright windows. This can be achieved by preferential lighting, and particularly wall lighting in areas remote from the window.

In these spaces, it is recommended that the colour appearance of the lamps used should be in the Intermediate classification with a Correlated Colour Temperature of about 4000ºK.

Lighting quality

In terms of the appearance of the lighting, both natural and electric, it will be necessary to consider the overall light pattern in terms of 'apparent lightness', ie the overall lightness of the space and 'visual interest', a term relating to the degree of non-uniformity in the light pattern. The bright parts can frequently be the highlight areas used for display purposes.

Another aspect that is important is the integration of the lighting (equipment and light pattern) with the the surface colours and textures and the overall architecture.

These are attributes which recent research has shown are important for the users of a space, but because they are subjective, they cannot easily be quantified.

However, for the space to have an acceptable 'apparent lightness', it will be necessary to use relatively high surface reflectances, which requires a wall finish reflectance not less than 0.6 with a ceiling finish reflectance not less than 0.7 and a floor reflectance as high as is practicable. Glossy finishes to ceilings and walls should be avoided to minimise confusing reflections and glare[1].

The choice of surface colours is important as it affects not only the surface reflectances but also the overall visual impression.

Note

1 Since it is common practice for teachers to use the wall surfaces for display, a lower average wall reflectance value of 0.3 - 0.5 will need to be used for calculations, depending on the wall finish and the amount of display material.

External lighting

Exterior lighting may be needed for:

- roadway/pathway lighting;
- floodlighting of the building at night;
- floodlighting of outdoor sports.

External lighting is not explicitly mentioned in the ADL2 2002 but is being increasingly used on school premises for safety and security. It is recommended that all external lighting is provided with lamps having an efficacy of at least 65 lumens per circuit watt that are fitted with both time control and daylight level photocell control.

Attention is needed to avoid light trespass which can cause a nuisance to people and dwellings in the neighbourhood. Light pollution which affects the local environment and atmosphere should be avoided.

Light trespass can be controlled by suitable selection of the light distribution of luminaires to avoid 'spill light' and by careful aiming of floodlights with the use of shields if necessary.

Generally the intensity of a floodlight beam diminishes away from the centre. In order to control glare from light it is often necessary to refer to the beam angle within which the intensity of the light falls to one tenth of the peak intensity of the beam.

To prevent light pollution, the light defined by this beam angle must fall within an angle of 70° from the downward vertical. These are called full-cut lanterns and usually require flat glasses.

To achieve the correct uniformity in car parks or playing fields higher columns or closer spacing may be required.
While there is no legislation concerning light pollution it has become a major planning issue with Local Authorities especially concerning effects on local residents[Ref.18]. Planning Departments often turn down proposals which would introduce major new light sources into areas with only low to moderate levels of illumination and which would create substantial sky glow.

External lighting without automatic control is not energy efficient. Some form of automatic control should be provided. Control can be by photocells and timeswitches or passive infra-red detectors.

Emergency lighting

The purpose of emergency lighting is to provide sufficient illumination, in the event of a failure of the electricity supply to the normal electric lighting, to enable the building to be evacuated quickly and safely and to control processes, machinery, etc, securely.

In schools, emergency lighting is only usually provided in areas accessible to the general public during the evenings. These include halls and drama spaces used for performances. Emergency lighting is not usually provided on escape routes, except from public areas, as the children are generally familiar with the buildings and there is only a relatively small part of the school year during the hours of darkness.

Exceptions where emergency lighting might be considered are upstairs escape corridors, escape stairways, corridors without any windows and areas with dangerous machinery.

It is recommended that for halls, gymnasia and other areas used by the public during the hours of darkness the emergency lighting should be of the maintained type. Where part of the premises is licensed it will be necessary to seek the advice and guidance of the Local Fire Authority.

Emergency Lighting should reveal safe passageways out of the building together with the fire alarm call points, the fire fighting equipment, escape signs and any permanent hazards along the escape routes such as changes of direction or stairs. Further detail is given in Building Bulletin 90, *Lighting Design for Schools*.[Ref.15]

Lighting for pupils with visual and hearing impairments

Lighting and acoustic criteria are very important both to the hearing impaired and to the visually impaired. If one sensory channel is impaired more reliance is placed on the unimpaired sensory channel. For example, the use of aural cues by the visually impaired and lip-reading by the hearing impaired. See also the advice on acoustics in Section 6 of Building Bulletin 93.[Ref.5]

The design of specialist accommodation for the visually impaired is beyond the scope of this document and specialist advice should be sought.[Refs.19 & 20] However, there are design choices that should be considered for all schools. Many of the low cost or no cost measures can be applied to existing buildings such as the choice of decor, tactile surfaces and types of luminaires. For a detailed description of possible measures see *Building Sight* published by the RNIB[Ref.21].

Other measures, such as providing or facilitating the use of visual aids can be considered as necessary. There is no single solution and what may assist one person may well not assist another. The following notes are offered as a general guide and should help in the majority of cases.

Visual impairment can be put into two broad classifications.

Field defects

Firstly, there are conditions where what is seen is seen clearly but the visual field is restricted. It may be that only the central part of the field is seen (tunnel vision). In this case mobility would be impaired although reading and the ability to do fine work would be largely unaffected. The converse, loss of central vision, would mean that movement could be made in safety but the ability to perform detailed tasks such as reading or sewing would be extremely difficult if not impossible.

In all types of field defect the quantity of task illumination is generally unimportant providing normal recommendations are followed. Glare should be avoided (see section on loss of acuity below) and decor can help rapid orientation (see section on use of colour below).

Loss of acuity

The other main condition is a loss of acuity or a blurring of vision. The extent of the blurring varies widely and some pupils may have to bring objects and print extremely close to their eyes to see best. There may also be an associated loss of colour vision.

Large print will, and higher illuminance may, be of assistance depending upon the cause of the loss of acuity. Many schools now have the facility to produce their own reading material and the use of a san serif font of at least 14pt size can be a useful aid.

The effects of low acuity can be aggravated by glare, and this should be avoided. A ‘white’ board on a dark coloured wall can be a glare source whereas a traditional ‘blackboard’ would not. Similarly, a view of a daylit scene through a window can be a disabling glare source.

Both loss of field and loss of acuity can occur together and, the particular difficulties which people with visual impairment experience, and their responses to light and other environmental features, can vary widely.

The use of higher than normal task illuminances can be of help to those whose acuity can be improved by the contraction of the iris, producing a greater depth of field. In some cases, however, such as those with central cornea opacities, the iris needs to be dilated so that the student sees ‘around’ the opacity. In such a case more light will aggravate, not relieve, the condition.

Positioning

Students with visual impairment should be seated where they can best see the work in progress. This may mean a position outside the normal arrangement, eg immediately in front of the teacher or board.

It is also important that any visual aids are readily available for use. These may range from hand-held or stand mounted optical magnifiers to CCTV magnifiers. Local task lighting may also be used as an aid. It may be necessary to allow the student to change position within the teaching space to accommodate access to an electrical supply, cope with excess daylight or use any other aid that is available.

Use of colour

Colour and contrast are particulary important to the visually impaired and the hearing impaired[Ref.21]. For example, downlighters in reception or teaching areas produce harsh shadows which obstruct lip reading.

Careful use of the colour scheme can help pupils recognise and identify a location. It can be more important than an elaborate lighting installation.

Some visual impairments involve a degree of colour blindness and it is important that contrast should be introduced in luminance and not just colour. For example, pale green and pale cream may be clearly distinguished by the normally sighted but be seen as a single shade of grey even by some pupils where an impairment has not been identified.

Contrast in the decor should be used to aid orientation within a space. For instance, using a darker colour for the architrave around a door will aid location of the door and a handle which clearly contrasts with the surface of the door will indicate which way it swings.

While in some spaces orientation may be established by the furniture arrangement or by windows during daylight hours, in others it can be aided by making one wall distinctly different, perhaps by the addition of a large clock or a change in colour. Whatever method is used, it is best adhered to throughout the building, ie, the different wall is always to the same side of the main exit from the space.

High gloss finishes should be used with care as they can appear as glare sources when they reflect bright lights such as sunlight. In general, eggshell finishes are to be preferred as some directional reflection is desirable rather than dead matt surfaces which may be difficult to place precisely.

Changes in the tactile qualities of surfaces can also be useful to reinforce visual contrasts. They are most important in schools for the blind.

ICT and display equipment

The use of ICT by the visually impaired can be made easier or more difficult by the choice of font and background colours, screen brightness, font size and style, the type and level of room lighting, and the control of solar glare [Ref. 22].

Individual display screens also provide the opportunity to set up a work space and display screen to cater for an individual’s particular needs. It can take a considerable amount of effort to set up a display screen but research is going on into ways of automating at least part of the set up process for example the choice of font and background colour.

Daylight

Generally schools should be designed with daylight as the principal light source. The window wall should be light in colour, to reduce contrast with the outdoor scene, and window reveals may be splayed to increase the apparent size of the glazing.

Sunlight can be either a help or a hindrance, depending on the type of visual impairment, and some means of controlling the quantity should be provided. Traditionally this has been by means of blinds. The design of fenestration in circulation spaces should minimise glare hazards.

Large areas of glazing can be hazardous to the visually impaired unless they can be clearly seen. To avoid accidents they can be marked with a contrasting feature at eye level. This should be visible in low light levels.

In the UK the greatest problems, both visual and thermal, are caused by low altitude sunlight at either end of the school day. Any solar shading devices, including those for rooflights must, therefore, be readily adjustable to cater for a range of conditions. Adjustment of solar shading should preferably be at the discretion of the students and not the teaching staff who may not fully appreciate the visual difficulties of the students.

Electric light

The control of glare from overhead lighting is particularly important to students with a visual impairment.

High frequency electronic ballasts for fluorescent lamps are to be preferred as they avoid subliminal flicker and also the annoying visible flicker that conventionally ballasted lamps can demostrate at the end of their life. If high frequency ballasts are used, consideration should be given to using a regulated version which can be dimmed to allow the illuminance level to be adjusted to suit the individual as well as to save energy. The additional cost for this is usually modest.

It is not normally economic to install more than the recommended illuminances on the off-chance that they will be useful some day to a hypothetical visually impaired student. Additional illuminance can often be readily supplied when the need arises from local task lights.

Escape routes should be clearly identified and alarm systems (visual and acoustic) should be adequate.

Summary of main points on lighting for pupils with visual impairments

- Provide contrast in the decor to aid the location of doors and their handles, switches and socket outlets, changes in direction in corridors, changes in floor level, stairs and steps.
- Avoid glare from windows, rooflights and luminaires; either distant or immediately overhead.
- Provide facilities for the use of any visual aids, eg magnifiers, telescopes, display screens, etc.
- Provide additional illumination by adjustable local task lighting as needed.

Section 5 : Hot and cold water supplies

The School Premises Regulations

Water Supplies

(1) A school shall have a wholesome supply of water for domestic purposes including a supply of drinking water.

(2) Water closets and urinals shall have an adequate supply of cold water and washbasins, sinks, baths and showers shall have an adequate supply of hot and cold water.

(3) The temperature of hot water supplies to baths and showers shall not exceed 43ºC. Note 1

Drainage

(1) A school shall be provided with an adequate drainage system for hygienic purposes and the general disposal of waste water and surface water.

Main summary of standards and regulations

Water storage is not a mandatory requirement of schools and need not be incorporated where mains pressures can normally be maintained throughout the occupied period sufficient to supply all outlets. However, where storage is not installed the School Authorities should be reminded that the affected building should cease to operate in periods of mains failure unless satisfactory sanitary facilities can be provided in adjacent buildings.

Cold water storage capacity in day schools should not exceed 25 litres per occupant.

All water fittings and installations should comply with The Water Supply (Water Fittings) Regulations 1999.[Ref: 23]

Where a temperature regime is used to reduce the risk of legionellosis hot water storage temperatures should not be lower than 60ºC. However for occupant safety, to reduce the risk of scalding, The School Premises Regulations require that the temperature at point of use should not be above 43ºC for baths and showers and where occupants are severely disabled. This may be achieved by thermostatic mixing at the point of use. It is also recommended that hot water supplies to washbasins in nursery and primary schools are limited to 43ºC. Particular attention should be given to the provision of facilities to ensure the effective maintenance of systems.[Ref: 24&25]

Unvented hot water storage systems should comply with Building Regulation Approved Document G3, 1992.

Drainage and waste disposal should comply with Building Regulation Approved Document H, 2000 (2002 Edition).[Note 2]

Cold water storage

If water is stored, the cold water storage cistern capacity should be designed with consideration towards providing the minimum amount of storage sufficient to enable the school to function during an interruption to the water supply. In day schools it should not be necessary to exceed 25 litres per pupil. The minimum recommended[Ref. 26 & 27] storage capacities per pupil for 24 hour storage for different types of school are shown in Table 3.

Notes

1 In the TMV2 scheme 46ºC is appropriate for showers and baths.

2 In Scotland and Northern Ireland other regulations apply.

Table 3

Day schools	
Nursery and primary	15 litres per pupil
Secondary and technical	20 litres per pupil
Boarding school	90 litres per pupil
Reference BS 6700: 1998[Ref. 26]	

These figures assume that meals are provided on site. In many schools this is not the case. In practice 8 hours storage is more realistic and 4 hours should be sufficient in most cases. The water supplier should be consulted before finalising cold water storage cistern capacities.

In mainland Europe it is normal practice not to provide any water storage in schools. This is often possible in English schools. The installation will depend on the supply pressure available from the water supply company. Where the supply pressure is low, a storage vessel with a booster pump may be required. Water supply pressures vary with location, however water supply companies must provide a minimum level of service of 1 bar (10 metres head) at 12 litres/ minute. Generally a pressure of 1.5 bar is set as a minimum standard with a normal operational pressure of 2 bar (20 metres head).[Note 3]

The size of water meter should be as small as possible, as typically standing charges increase with the meter size. As a rule of thumb it should be possible to down size existing older type meters to one size smaller than the diameter of the supply pipe to the premises. However, although water for fire fighting purposes is supplied free of charge, some schools may have a fire hose reel fed by the metered supply. In these cases, or if in doubt, the local fire officer should be consulted if a reduction in the water meter size is considered.

Remote metering allowing easy, possibly real-time monitoring of water consumption is now a cost effective possibility. Sub-metering can be included as appropriate, for example for independent facilities such as, kitchens run by outside caterers, swimming pools, sports facilities and nurseries.

By monitoring actual consumption on site, storage cistern and meter sizes can often be further reduced. Observations of the meter readings can be made over a period of time or electronic dataloggers can be used but note that consumption is usually less in winter. Water companies may help to conduct a water audit and establish peak demand flows for accurate sizing.

Drinking Water

Health and safety legislation and the School Premises Regulations require that adequate supplies of wholesome drinking water are accessible to staff and pupils throughout the school day.[Ref: 28] All water outlets should be labelled as ‘Drinking’ or ‘Not for drinking’.[Note 4]

Water fountains are quite often used to supply drinking water but can be prone to vandalism unless they are located in areas such as corridors that are easily observed by staff.

Fountains that discharge water downwards are more hygienic than those that discharge upwards. Fountains can also be fitted with in-line water filters to remove chlorine, etc and a facility for cooling water. Water coolers, including those plumbed directly to the water supply may also be considered for drinking water purposes, however consideration should be given to maintenance and the number of pupils using the facility.

Notes

3 This may fluctuate during the day due to the draw off pattern of the supply network. Compensation can usually be claimed from the water supplier if water pressure drops to 70% of the minimum level of service, ie 0.7 bar.

4 Within public buildings it is often not possible to determine whether taps are connected to the supply main or to storage cisterns and it is possible that the microbiological quality of the water in storage may deteriorate. Therefore, unless the tap is clearly labelled as suitable for drinking, it should not be assumed that the water from any tap is safe to drink. The 1998 Drinking Water Directive contained new provisions to ensure that the water supply within public buildings remains wholesome and is not adversely affected by the domestic plumbing system. The various elements of the Directive are due to be implemented before the end of 2003.

Disposable paper cups can be provided at drinking water outlets, to make them more comfortable to use, but have hygiene and maintenance consequences. Where Local Authorities remove fountains they must ensure that there is a suitable alternative source of drinking water for pupils.

Drinking water taps and fountains in toilet facilities are not recommended in new facilities but do exist in some schools and should always be clearly labelled. It is quite acceptable to supply drinking water from a "well managed" cistern supply, installed to the standards of the Water Regulations 1999; previously called a "Water Byelaw 30 tank", when the Water Byelaws were in force. This is common practice in schools and recommended by water supply companies.

However these cisterns need to be designed and maintained correctly. Key elements to ensure the preservation of water quality are:-

- cleanliness
- maintenance of cool conditions
- the regular use of water to prevent stagnation
- system design; and
- materials used in the construction of the cistern should not contaminate the stored water (eg materials listed in the Water Fittings and Materials Directory, published by the Water Regulations Advisory Scheme (WRAS)).

The water inside the cold water storage cisterns should be kept as cool as possible. To minimise the risk of proliferation of bacteria, cold water temperatures should be maintained below 20ºC. If the temperature is between 20ºC and 25ºC, then caution should be exercised. If the temperature is above 25ºC, action should be taken to lower the temperature as bacteria will multiply.

These temperatures can be achieved in practice but require all cisterns to be fully insulated and will require the ventilation of roofs or other spaces containing, cisterns, which are subject to solar gain.

Good practice requires that the water should not remain static for a long period. Automatic flushing urinals and caretaker use in holidays is usually sufficient to ensure this and preclude the need for annual draining and cleaning, which is a difficult procedure and best avoided if at all possible. If this cannot be achieved then the cistern should be cleaned, and disinfected annually as recommended. Cleaning is very important in order to remove even inorganic debris which could provide a habitat for bacteria, including legionella; and the cistern must be periodically sampled to ensure that too many bacteria are not present (depending on circumstances, between two and four times a year is normally advised).

Some Local Authorities do however routinely carry out annual draining and cleaning of their water cisterns.

The difficulty of meeting all the conditions for water quality in a school situation means that it is preferable if drinking water supplies in schools can be connected directly to the cold water main wherever possible.

An alternative is to use bottled water supplies, as are often used in offices. However the cost will usually be prohibitive for school use and bacterial counts in bottled water are often higher than in mains cold water, because bottled water is not chlorinated. Also it is possible to supply a mains fed water cooler which does not require a bottled water supply.

Water cisterns that are not up to the standard of the Water Regulations; ie, without tight-fitting lids, uninsulated or without insect screens on the vent and overflow pipes, do exist in some schools and drinking water should not be supplied from them. They should be upgraded as soon as possible even if they do not supply drinking water outlets as there is no guarantee in the school environment that children will not drink from any available cold water tap. [Note 5]

Hot water

The use of a decentralised hot water system may help to reduce energy wastage. Wherever possible a separate boiler, hot water generator or point of use water heater should be used to provide hot water. Plant sizing curves for hot water in schools are given in Section 2 of the CIBSE Guide, Public Health Engineering. [Ref : 27]

The minimum numbers of sanitary appliances for different types of schools are given in The School Premises Regulations, 1999.

Consideration should be given to the problem of build up of limescale on heat exchanger surfaces in hard water areas. This can especially be a problem for direct systems and maintenance issues need to be considered. Also, the use of water softeners has on-going consumable costs.

Legionellosis (including legionnaires' disease)

Inhalation of the *legionella* bacteria can give rise to *legionellosis*, but the risk of infection is low in children unless they are immuno-compromised or have respiratory problems, eg smoking. Aerosols produced by water services such as showers and spray taps are potential routes of infection.

Although there have been no known cases of legionnaires' disease in schools this is no reason for complacency. Schools need to be aware of the dangers and their responsibility to maintain water systems properly.

In accordance with the HSC Approved Code of Practice[Ref : 29], risk assessments are required for certain water systems. Where a reasonable foreseeable risk is assessed, management plans should be drawn up and maintained to minimise the risk by regular inspection, maintenance, cleaning and treatment procedures.

Hot and cold water services

Whilst surveys have shown legionella to be present in quite large numbers of water systems such as those found in hospitals, schools and office blocks, only rarely do these appear to give rise to infection. It is generally not possible to completely and permanently eradicate the bacteria. Therefore, in practice, the risk of infection is addressed by the application of good engineering practice to ensure the bacteria are prevented from proliferating. A considerable amount of guidance has been issued on the risks. Compliance with the HSC Approved Code of Practice[Ref :29] is a minimum requirement. Good practical guidance on procedures is also available.[Ref : 24 & 25]

Hot and cold water systems of all sizes are covered by the ACoP. Steps should be taken to minimise the opportunity for growth of *legionella*. It multiplies in warm water (approximately 20°C to 45°C) and will thrive in the presence of biofilms, scale or debris. The temperature at cold water outlets should be not more than 3°C higher than the cold water storage temperature, which can be as high as 25°C, the highest temperature at which the water companies can supply water. Consequently quick water turnover in storage tanks is crucial in preventing the proliferation of legionella. Features of cistern fed hot water systems which influence the risk of exposure to legionella include having open cisterns and larger than required cistern capacities. These risk features can be removed by replacing such hot water systems with direct feed water systems using unvented

Note

5 If lawfully installed before the 1 July 1999 water cisterns are not required to meet the Water Regulations requirements. However, such tanks should not supply drinking water outlets.

hot water storage. Other problems such as maintaining distribution temperatures throughout the system can be reduced through the installation of instantaneous hot water heaters.

Where a temperature regime is relied upon to control legionella hot water should be stored at a temperature of 60ºC or above and distributed at a minimum temperature of 50ºC. However for occupant safety, to reduce the risk of scalding, The School Premises Regulations require that the temperature at point of use should not be above 43ºC for baths and showers and where occupants are severely disabled. This may be achieved by thermostatic mixing at the point of use. It is also recommended that hot water supplies to washbasins in nursery and primary schools are limited to 43ºC. This may be achieved by installing a thermostatic mixing valve (TMV) close to the terminal fitting. Valves meeting the requirements of the Buildcert TMV scheme give assured levels of scalding protection to either TMV2 or TMV3 standards.

Because the organism thrives in warm (but not hot) water, the length of piping carrying hot and cold water (eg, after a thermostatic mixing valve) must be kept to an absolute minimum, certainly less than 2 metres where possible. Where the final pipework supplying shower heads is longer than this it should be regularly pasteurised as a precautionary measure. It is recommended that this is done every time the showers are out of use for more than 5 days. Self draining shower heads can also be fitted as a precautionary measure. Similarly, the length of pipes feeding washbasin hot taps should be minimised, especially with spray head taps which could generate an aerosol containing *legionella*; point of use water heaters may be preferable to centralised hot water systems.

Research on silver/copper ionisation water treatment has shown that this can be useful in the control of *legionellosis*.[Ref: 30] The research has also established that copper pipework is naturally biocidal particularly at slightly acid pH values. However acidic water is uncommon. Copper can inhibit the formation of biofilms which are the breeding ground for legionella and other bacteria. Copper pipework must have water passing through it in the first few months for the natural inhibition to take place. It should not be left empty for long periods.

Past outbreaks of legionnaires' disease have usually been associated with systems that have been neglected, or where the routine operation has changed. Frequent monitoring of the operation of the system and factors encouraging rapid multiplication of bacteria are therefore vital control measures. Excessive periods of stagnation (in tanks or 'dead legs') should be avoided, and storage tanks must be maintained in a clean condition. Water cisterns should comply with The Water Supply (Water Fittings) Regulations.[Ref: 23]

GRP tanks usually contain biofilms therefore annual chlorination followed by cleaning is recommended. Chlorination of copper pipework should be avoided as it strips off the natural protection of the pipe and can cause corrosion.

Chlorination of hot and cold water services should be done in accordance with the concentrations and chlorination times recommended in the ACOP.[Ref: 29]

As sampling for *legionella* will often yield positive results, it is not advocated as a routine measure because it can cause either unnecessary alarm and anxiety to all concerned, or complacency and relaxation of standards. Sampling is expensive, and since no firm conclusions can be drawn from the results, the random sampling for legionella does not

represent good value for money.
CIBSE Technical Memorandum TM 13 recommends that a thermal pasteurisation regime is the most appropriate form of legionella control for hot and cold water systems.[Ref : 24] On the other hand, monitoring general water quality can provide a fair indication of system conditions. This, together with a package of other routine measures recommended by HSE, will draw attention to potential problems as they develop.

Water Pollution

The Control of Pollution (Oil Storage) (England) Regulations 2001 administered by the Environment Agency control secondary containment of oil storage tanks dependant on a risk analysis.
Bulk storage tanks greater than 200 litres supplying a generator or "day tank" come within the scope of the Oil Storage Regulations as the oil is being stored)not used.

Lead Pipework

Lead pipework for drinking water supplies is a hazard. This is increased in areas with plumbosolvent water, ie soft water, particularly where the water is acidic.
In schools built before the early 1950s, where there is a likelihood of the presence of lead pipework, its extent should be assessed and a programme drawn up for its removal.

The European *Drinking Water Directive* came into force in December 1998.
Most of the new standards must be implemented by the end of 2003. Water within buildings is the responsibility of the owner. The new maximum lead level of 10 microgrammes/litre is expressed in terms of an average weekly consumption.

Currently, there is no practical way of measuring this except through laboratory analysis. Monitoring of water supplies at the dietetic tap will be required in schools to demonstrate compliance with the Directive. Further guidance is awaited.

Up till around 1975 lead-based solders were used on copper pipework for drinking water supplies. This can lead to breaches of the 10 microgrammes/litre level therefore testing of copper systems of this age will be necessary in some areas.

The Drinking Water Inspectorate (DWI) recommends the replacement of lead pipes however if this is not feasible DWI recommends that if water is left standing in lead pipework for an extended duration that a volume is drawn off (for a non-drinking or food preparation purpose) before consumption. Guidance can be found on the DWI website (www.dwi.gov.uk).

The School Premises Regulations Summary Sheet

These are the minimum environmental standards that apply to all school buildings, both new and existing.

Acoustics

Each room or other space in a school building shall have the acoustic conditions and the insulation against disturbance by noise appropriate to its normal use.

Lighting

(1) Each room or other space in a school building -

(a) shall have lighting appropriate to its normal use; and

(b) shall satisfy the requirements of paragraphs (2) to (4).

(2) Subject to paragraph (3), the maintained illuminance of teaching accommodation shall be not less than 300 lux on the working plane.

(3) In teaching accommodation where visually demanding tasks are carried out, provision shall be made for a maintained illuminance of not less than 500 lux on the working plane.

(4) The Glare Index shall be limited to no more than 19.

Heating

(1) Each room or other space in a school building shall have such system of heating, if any, as is appropriate to its normal use.

(2) Any such heating system shall be capable of maintaining the air temperature, at a height of 0.5 m above floor level, at the specified level, in the areas set out in the Table below, when the external air temperature is –1°C:

Area	Temperature °C
Areas where there is the normal level of physical activity associated with teaching, private study or examinations	18
Areas where there is a lower than normal level of physical activity because of sickness or physical disability including sick rooms and isolation rooms but not other sleeping accommodation	21
Areas where there is a higher than normal level of physical activity (for example arising out of physical education) and washrooms, sleeping accommodation and circulation spaces.	15

(3) Each room or other space which has a heating system shall, if the temperature during any period during which it is occupied would otherwise be below that appropriate to its normal use, be heated to a temperature which is so appropriate.

(4) In a special school, nursery school or teaching accommodation used by a nursery class in a school the surface temperature of any radiator, including exposed pipework, which is in a position where it may be touched by a pupil shall not exceed 43 °C.

Ventilation

(1) All occupied areas in a school building shall have controllable ventilation at a minimum rate of 3 litres of fresh air per second for each of the maximum number of persons the area will accommodate.

(2) All teaching accommodation, medical examination or treatment rooms, sick rooms, isolation rooms, sleeping and living accommodation shall also be capable of being ventilated at a minimum rate of 8 litre of fresh air per second for each of the usual number of people in those areas when such areas are occupied.

(3) All washrooms shall also be capable of being ventilated at a rate of at least six air changes an hour.

(4) Adequate measures shall be taken to prevent condensation in, and remove noxious fumes from, every kitchen and other room in which there may be steam or fumes.

Water supplies

(1) A school shall have a wholesome supply of water for domestic purposes including a supply of drinking water.

(2) Water closets and urinals shall have an adequate supply of cold water and washbasins, sinks, baths and showers shall have an adequate supply of hot and cold water.

(3) The temperature of hot water supplies to baths and showers shall not exceed 43°C.

Drainage

(1) A school shall be provided with an adequate drainage system for hygienic purposes and the general disposal of waste water and surface water.

Standards for environmental conditions and energy conservation for new school buildings summary sheet

The main provisions of BB87 (2003) to be used in conjunction with Approved Document Part L2, in support of the Building Regulations, or quoted by DfES as constructional standards are given below.

Conservation of Fuel and Power

Energy efficiency rating

The designer of a school has three options in the design of a new school building.

1. To use the elemental method as described in Section 1 of ADL2 2002 of the Building Regulations, together with the advice contained in the revised BB87.
2. To use the Whole Building Method described in BB87 (2003) to estimate the total energy consumption of the building and achieve a carbon performance rating of better than 5 kgC/m² per year.
3. To use the carbon emission calculation method as described in ADL2 2002. This technique is advised for innovative or passive designs that will benefit from detailed whole building simulation procedures.

Acoustics

See Building Bulletin 93 Section 1, which is quoted by Approved Document Part E in support of Building Regulations as a means of compliance for schools with Requirement E4 of the Building Regulations.

Lighting

Where possible, priority should be given to design for daylight as the main source of light in working areas.

The uniformity ratio (minimum/average daylight factor) of the daylight should be in the range 0.3 to 0.4 for side-lit rooms. Where spaces are top-lit, eg atria, then higher uniformities should be expected of the order of 0.7.

The uniformity ratio (minimum/average maintained illuminance) of the electric lighting in teaching areas should be not less than 0.8 over the task area.

Teaching spaces should have views out except in special circumstances. A minimum glazed area of 20% of the internal elevation of the exterior wall is recommended to provide adequate views out.

A maintained illuminance at floor level in the range 80 - 120 lux is recommended for stairs and corridors. Entrance halls, stairs, lobbies and waiting rooms require a higher illuminance in the range 175 - 250 lux on the appropriate plane.

The type of luminaires should be chosen to give an average initial circuit luminous efficacy of 65 lumens/circuit watt for the fixed lighting equipment within the building, excluding track-mounted luminaires and emergency lighting.

In all other respects the lighting efficiency and controls should comply with ADL2 in support of the Building Regulations.

External Lighting

It is recommended that all external lighting is provided with lamps having an efficacy of at least 65 lumens per circuit watt that are fitted with both time control and daylight level photocell control.

Heating

The heating system should be capable of maintaining the minimum air temperatures quoted in the School Premises Regulations. The heating system should be provided with frost protection.

Central heating systems should have appropriate controls complying with the requirements in ADL2 2002, in support of the Building Regulations.

The air supply to and discharge of products of combustion from heat producing appliances and the protection of the building from the appliances and their flue pipes and chimneys should comply with Building Regulations, Part J, 2002.

Thermal performance

The fabric insulation should comply with the recommended maximum values given in the 'Elemental Method' in Table 1 of section 1 of ADL2 2002 in support of the Building Regulations, 2002.

Vertical glazed areas (including clerestory or monitor lights) should not normally exceed an average of 40% of the internal elevation of the external wall. However, where a passive or daylight design strategy has been adopted the percentage glazing may exceed 40%, provided the insulation of the rest of the building fabric is increased to compensate for the increased heat loss through the glazing or the heating plant carbon intensity is traded up accordingly.

Horizontal or near horizontal glazing should not normally exceed 20% of the roof area.

Ventilation

It is recommended that in classrooms, ventilation systems, whether natural or mechanical, are capable of providing approximately 8 litres per second of fresh air per person.

Spaces where noxious fumes or dust are generated may need additional ventilation. Laboratories may require the use of fume cupboards, which should be designed in accordance with DfES Building Bulletin 88. Design technology areas may require local exhaust ventilation.

All washrooms in which at least 6 air changes per hour cannot be achieved on average by natural means should be mechanically ventilated and the air expelled from the building. Heat recovery fans can be used.

During the summer, when the heating system is not in operation, the recommended design temperature for all spaces should be 24 ºC with a swing of not more than +/- 4 ºC. It is undesirable for peak air temperatures to exceed 28 ºC during normal working hours but a higher temperature for 80 hours during the summer term is acceptable.

Hot and cold water

Cold water storage capacity in schools should not exceed 25 litres per occupant.

All water fittings should be of a type approved by a WRC (Water Research Centre), and all installations should comply with the Water Supply (Water Fittings) Regulations 1999.

Where a temperature regime is used to reduce the risk of legionellosis, hot water storage temperatures should not be lower than 60ºC. However, for occupant safety, to reduce the risk of scalding, The School Premises Regulations require that the temperature at point of use should not be above 43ºC for baths and showers and where occupants are severely disabled. This may be achieved by thermostatic mixing at the point of use. It is also recommended that hot water supplies to washbasins in nursery and primary schools are limited to 43ºC.

Particular attention should be given to the provision of facilities to ensure the effective maintenance of systems.

Unvented hot water storage systems should comply with Building Regulations Part G3, 1992.

References

1. See the Regulatory Information section of the Department for Education and Skills', Schools Buildings and Design Unit's website at **www.teachernet.gov.uk/schoolbuildings** for copies of The School Premises Regulations, and the Constructional Standards for Schools (to be revised) and guidance on their application.

2. Approved Document F (Ventilation) in support of the Building Regulations, Department of the Environment and Welsh Office, 1994, ISBN 0 11 752932 X, £4.50.

3. Approved Document L2 (Conservation of fuel and power) in support of the Building Regulations, Department of the Environment and Welsh Office, 2002, ISBN 0 11 753610 5, £15.

4. The Education (School Premises) Regulations 1999, SI 1999 No. 2, The Stationery Office, 1999, ISBN 0 11 080331 0, £3 and on website **www.legislation.hmso.gov.uk/si/si1999/19990002.htm**

5. Building Bulletin 93, Acoustic Design of Schools, DfES, The Stationery Office, ISBN 0 11 271105 7, to be published in 2003 and availble as a download from **www.teachernet.gov.uk/acoustics**

6. CIBSE Guide J : Weather, solar and illuminance data (CD-Rom), 2002, £176.25, see **www.cibse.org**

7. CIBSE Guide B18 - Installation and Equipment Data, 1988, see **www.cibse.org**

8. CIBSE Guide A - Environmental Design, 1999, see **www.cibse.org**

9. Department for Education, Building Bulletin 73, A guide to energy efficient refurbishment, HMSO, 1991, ISBN 0 11 270772 6, £8.50.

10. DfEE, Building Bulletin 88, Fume Cupboards in Schools, ISBN 0 11 271027, The Stationery Office, 1998, £14.95.

11. CIBSE Technical Memorandum 23: Testing buildings for air leakage, 2000, £30, see **www.cibse.org**

12. CIBSE Applications Manual AM10: Natural Ventilation in Non-Domestic Buildings, 1997, ISBN 0 900953 77 2, £45.

13. BS 5925: 1991 Code of Practice for Ventilation, Principles and designing for natural ventilation.

14. CIBSE Code for Lighting, 2002, ISBN 1 903287 22 7, available on CD-Rom or as printed version, see **www.cibse.org**

15. DfEE Building Bulletin 90, Lighting Design for Schools, ISBN 0 11 271041 7, The Stationery Office, 1999, £22.95.

16. BRE Information Paper IP6/96, People and lighting controls.

17. See **www.serraglaze.redbus.co.uk**

18. The Institution of Lighting Engineers, Guidance notes for the reduction of light pollution, 1994, available from ILE, Lennox House, 9 Lawford Road, Rugby, Warwickshire, CV21 2DZ.

19. RNIB/GBDA Joint Mobility Unit, 224 Great Portland Street, London, W1N 6AA, Tel: 0171 388 1266, Fax: 0171 388 3160.

20. The Partially Sighted Society, 62 Salusbury Road, London, NW6 6NS, Tel: 0171 372 1551.

21. Building Sight, Peter Barker, Jon Barrick, Rod Wilson, RNIB, ISBN 011 701 993 3, HMSO, 1995, £35.

22. The visual environmeent for display screen use, LG03: 1996 and addendum 2001, ISBN 0 900953 71 3.

23. The Water Supply (Water Fittings) Regulations 1999
Schedule 1: Fluid Categories
Schedule 2: Approved Document.

See also the Water Regulations Advisory Scheme publication, The Water Fittings and Materials Directory available from the Water Regulations Advisory Scheme, ISSN 0954-3643.

24. Chartered Institution of Building Services Engineers (CIBSE), Technical Memorandum 13, 2002, Minimising the risk of Legionnaires disease, ISBN 1 903287 23 5.

25. Guide to Legionellosis, Temperature measurements for hot and cold water services, BSRIA Application Guide AG4/94, N.L. Pavey, ISBN 0 86022 3.

26. BS 6700: 1997, British Standard Specification for Design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtillages, ISBN 0 580 26817 9.

27. CIBSE Guide Public Health Engineering, Section 2: ISBN 0 900953 87 X.

28. Workplace (Health, Safety and Welfare) Regulations 1992, Guidance for the Education Sector, Leaflet IAC(L)97, HSE Books.

29. Health and Safety Executive, HSC Approved code of practice and guidance, L8, Legionnaires' disease - The control of legionella bacteria in water systems, HSE Books, 2000.

30. Ionisation water treatment for hot and cold water services, BSRIA Technical Note TN 6/96, N.L.Pavey, ISBN 0 86022 438 4.

Legionella and Building Services, G.W.Brundrett, Buttersworth Heinemann, ISBN 0 7506 1528 1.

Bibliography – further reading

Building Bulletin 83, Schools Environmental Assessment Method (SEAM), The Stationery Office, 1996, ISBN 0 11 27099206, £14.95.

Building Bulletin 90. Lighting Design for Schools. ISBN 0 11 2710417, TSO 1999, £22.95

CIBSE Lighting Guides:

The visual environment in lecture, teaching and conference rooms, LG05:1991.

The outdoor environment, LG06: 1992, ISBN 0 900953 53 5.

Daylighting and window Design, LG10:1999, ISBN 0 900953 98 5.

Energy efficient lighting in schools, BRECSU-OPET, Building Research Establishment.

Department for Education, Building Bulletin 79, Passive Solar Schools, a design guide, HMSO 1994, ISBN 0 11 270876 5, £19.95.

Good Practice Guide 16 - Guide for installers of Condensing Boilers in Commercial Buildings - Energy Efficiency Office Best Practice Programme, 1990.

BRE IP 12/94, Thermal Bridges, Assessing condensation risk and heat loss at thermal bridges around openings, Building Research Establishment.

BS 6880: 1988 Code of practice for low temperature hot water heating systems of output greater than 45 kW.

CIBSE Applications Manual AM1:1985, Automatic controls and their implications for systems design.

BRE Digest 399 Natural Ventilation non-domestic buildings, 1994, ISBN 0 85125 645 7.

BRE Digest 457, The Carbon Performance Rating for Offices.

DfEE Building Bulletin 77, Designing for pupils with special educational needs: special schools, HMSO 1992, ISBN 0 11 270796 3, £14.95

BRE Report BR262 Thermal Insulation: Avoiding risks, Building Research Establishment, 1994, ISBN 0 11 701792 2, £16.50.

Water Regulations Advisory Scheme publications:

The Water Fittings and Materials Directory.[1]

- Reclaimed Water Systems, Information about installing, modifying or maintaining reclaimed water systems, Information and Guidance Note 9-02-04, 1999.
- Precautions against freezing of water in plumbing systems, Information and Guidance Note 9-02-02, 1998.
- Conservation of Water an IGN for Architects, Designers and Installers, Information and Guidance Note 9-02-03, 1999.

The Water Regulations Advisory Scheme,
Fern Close,
Pen-y-Fan Industrial Estate,
Oakdale,
Gwent, NP11 3EH

Tel: 01495 248454

Fax: 01495 249234

E-mail: wrcetc@wrcplc.co.uk

Website: www.wras.co.uk

Note

1 WRAS are producing a water supply industry plumbing installations guide for schools, colleges & further and higher education premises on the design and management of water supplies in schools.