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CONTENTS

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Assessment process

BREEAM assessments are carried out by independent assessors licensed by BRE. Plans can be assessed at an early stage, allowing the designer to make changes which will improve the building's environmental performance. The first step in the assessment process is taken by the building developer who approaches BRE with a formal request. BRE puts the developer in contact with an assessment agency which selects a licensed assessor to carry out the work. A written quotation is sent to the client with a questionnaire outlining further information which is required from the design team.

After receipt of confirmation that the assessment should proceed, the assessor arranges to meet the design team to discuss details of the design. The assessor carries out a provisional assessment based on the information gathered from the questionnaire and the discussion, and produces an Interim Report outlining which credits have been achieved. At this stage the client may wish to make changes to the design or specification of the building. The modified design may then be submitted, free of any extra charge, to be re-assessed, and the Final Report and a Certificate are issued.

The best time to carry out a BREEAM assessment is at the latest point at which decisions affecting the envrionmental issues embodied in the assessment have been made.

Information on how to participate in the scheme is available from:
BREEAM — MDO, Building Research Establishment, Garston, Watford, WD2 7JR
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1 Environmental assessment

INTRODUCTION TO BREEAM

Environmental issues are of fundamental importance. Public concern that environmental damage should be minimised continues to grow. Awareness is still increasing of the large impact buildings have on the environment and the contribution that good building design can make to reducing such impacts.

The BRE Environmental Assessment Method (BREEAM) for new offices (BREEAM 1/90)[1] was launched in July 1990 and has since been widely applied. It was developed with sponsorship from major developers to set criteria for good environmental performance in buildings; performance which would be recognised in the market place through an independently issued certificate. Increasing scientific knowledge and experience in operation of BREEAM has enabled the updating of the original version. This report describes the updated BREEAM/New Offices Version 1/93. Several other versions of BREEAM are now in existence or in preparation. All are voluntary and emphasise action which can be taken today. The assessment criteria will continue to be updated periodically as new information becomes available from research undertaken at BRE, for the Department of the Environment and other research organisations, and as legal requirements evolve.

BREEAM/New Offices seeks to minimise the adverse effects of new offices on the global and local environment while promoting a healthy indoor environment. The rest of this chapter describes the approach taken in assessing these points. The following chapter summarises the environmental issues concerned. Chapters 3 to 5 describe in more detail the way in which credits will be given for office designs judged to follow improved environmental practice.

OBJECTIVES

BREEAM/New Offices specifies criteria for a range of environmental issues. Its main objectives are:

- to encourage designers and specifiers to become more environmentally sensitive;
- to enable developers, designers and users to respond to a demand for buildings which are friendlier to the environment, and then to stimulate such a market;
- to raise awareness of the large impact which buildings have on the potential for global warming, acid rain and the depletion of the ozone layer;
- to set targets and standards which are independently assessed and so help to minimise false claims or distortions;
- to reduce the long-term impact buildings have on the environment;
- to reduce the use of increasingly scarce resources such as water and fossil fuels;
- to improve the quality of the indoor environment of buildings and hence the health and well-being of their occupants.

ASSESSMENT APPROACH

The assessment, which is carried out at the design stage, is based on readily available and generally accepted information. The method identifies and credits designs where specific targets are met. It is not expected that designs will meet all of the target requirements. Meeting one or more means that the building is likely to be environmentally better than buildings where the issues have not been addressed.

BREEAM/New Offices only includes items for which there is good evidence of the environmental problems they cause, for which performance criteria can be defined, and which can readily be assessed at the design stage. There are many environmental issues which have quite deliberately been omitted as they do not meet these criteria and some of these are identified in Appendix B. They will be included in future updates as evidence which will enable their objective assessment becomes available.

It is not at present practicable or justifiable to assess all the issues covered on a common scale. The costs to the environment and health of occupants could in principle be assessed, for example, in monetary terms, and it would be possible to devise a weighting scheme. However, there is insufficient information available today to carry out an objective weighting because of the difficulty in assigning an economic cost to environmental effects as diverse as, for example, the health of individuals, ozone depletion, global warming and the future value of resources such as fossil fuels.

Consequently each issue is assessed individually for each building. Credit will be given where satisfactory attention is paid to a list of items as described in the following sections of the report. Credits have been set at a level over and above those legally required. The assessment aims to reduce undesirable effects on the environment using the best available techniques while minimising additional cost. Some of the actions needed to improve an assessment will have an economic return amply justifying the action. For instance, the cost of investment in measures to achieve a reduction in carbon dioxide emission rates may be met through reduced fuel bills from heating, cooling and lighting.

To aid the communication of results the BREEAM 1/93 certificate will include a summary of performance expressed as a single rating of **FAIR, GOOD, VERY GOOD** or **EXCELLENT.** This is based on a calculation of the achievement of a minimum number of overall credits and a separate minimum level of credits in each of the three sections (Global and Resources, Local, and Indoor).

ISSUES CONSIDERED IN THE ENVIRONMENTAL ASSESSMENT

The environmental issues covered are grouped under three main headings:

- Global issues and use of resources (Chapter 3)
- Local issues (Chapter 4)
- Indoor issues (Chapter 5)

A summary of the issues is given below, and in more detail in Appendix A.

Global issues and use of resources
- CO_2 emissions resulting from energy use;
- acid rain;
- ozone depletion due to CFCs (chlorofluorocarbons), HCFCs (hydrochlorofluorocarbons) and halons;
- natural resources and recycled materials;
- storage of recyclable materials.

Local issues
- Legionnaires' disease arising from wet cooling towers;
- local wind effects;
- noise;
- overshadowing of other buildings and land;
- water economy;
- ecological value of the site;
- cyclists' facilities.

Indoor issues
- Legionnaires' disease from domestic water systems;
- ventilation, passive smoking and humidity;
- hazardous materials;
- lighting;
- thermal comfort and overheating;
- indoor noise.

2 The effect of buildings on the environment

GLOBAL ATMOSPHERE AND USE OF RESOURCES

The provision and use of buildings has a greater impact on the global environment than almost any other human activity (apart from population growth). Environmental damage arises as a result of, for example, energy used during building construction, energy used for heating, cooling and lighting[2], and the chemicals present in materials used in building services and components.

In particular, measures should be taken to maximise energy efficiency and otherwise to conserve fuel because:

- burning any fossil fuel leads to the production of carbon dioxide (CO_2) and so contributes to the potential for global warming through the greenhouse effect;
- burning fossil fuels represents the depletion of a valuable natural resource;
- oxides of nitrogen and sulphur are emitted when fossil fuels (particularly coal and oil) are burnt, thus contributing to acid rain and the problem of damage to the natural environment.

Building materials also contribute to the potential for global warming as a result of the CO_2 production which arises through energy used to win raw materials, to transport materials, to make specific products, to assemble the products, for demolition and for disposal at the end of their useful life. These issues require further research before they can be incorporated into BREEAM.

Buildings also contribute to the depletion of the ozone layer, which is due in large part to CFCs. In 1986[3], buildings accounted for some 7.5% of the annual UK use of CFCs, mainly as refrigerants in air conditioning systems and as blowing agents for the foamed insulants used in the building fabric. This figure is now thought to be around 15%, not because buildings emit more, but because other uses have been curtailed (eg use as propellants in aerosol sprays). The need for air conditioning may be avoided by appropriate design, for example the use of thermal mass or external continental-style shutters to control solar gain.

Wood is important in the global context since it is a natural, renewable material. Trees absorb CO_2 during growth and wood used in building structures provides a potential long-term store for it. Thus the use of wood as a building material has considerable potential importance as a modifier of global impact.

Buildings require a great variety of material resources such as wood, brick and stone. In many cases there is potential for re-using these materials or for obtaining them in other ways which are also less damaging to the environment. Buildings can also be designed in such a way that, when they are occupied, day-to-day consumables such as paper and glass can more easily be recycled and important resources such as water used more carefully.

LOCAL ISSUES

Much attention has been paid in the UK in the last few years to Legionnaires' disease, arising on occasion from poorly maintained wet cooling towers. This, together with local wind effects produced by the building, noise emissions and the re-use of previous building sites or derelict sites are included under local effects.

Beyond the building itself, it is possible to develop a site in such a way that effects on local wildlife and scenery are less damaging (or even enhancing). This can be achieved directly through site selection and layout, but also through consideration of transport requirements.

THE INDOOR ENVIRONMENT AND HEALTH

Many pollutants are found in the indoor environment. They include formaldehyde, wood preservatives, other volatile organic compounds, living organisms (eg bacteria, moulds, dust mites), particulates and fibres (eg man-made mineral fibres, asbestos), radon, combustion products (eg oxides of nitrogen), and lead. While there are now satisfactory procedures for dealing with many of these, others are increasingly causing concern.

THE EFFECT OF THE ENVIRONMENT ON BUILDINGS

This has been brought into sharp focus in recent years by the atypical winds (two instances of wind speeds expected only every 200 years occurring in the last 10) and changes in rainfall (the most serious drought in the south-east of England for over 100 years). Any connection between these events and the greenhouse effect is assumed, rather than proven, but the effect on public concern is real enough. Other issues are:

- the possibility of greater demand for and use of air conditioning;
- a need for better humidity control;
- increased damage to the building fabric by wind and by acid rain;
- with sufficient increase in ambient temperatures, the possibility of an increase in the threat posed by a wide range of public hygiene pests and structural pests such as house longhorn beetle;
- change in water-table levels resulting in ground heave or shrinkage and subsequent damage to foundations;
- rises in sea level resulting in increased flooding.

These issues are not considered further in this or other versions of BREEAM to date but add further impetus to the need to tackle global environmental problems.

3 Global issues and use of resources

This chapter covers the effects that buildings have on the atmosphere beyond the local region: global warming, acid rain and ozone depletion.

CARBON DIOXIDE PRODUCTION DUE TO ENERGY CONSUMPTION

Purpose

To reduce the release of CO_2 into the atmosphere and thus to reduce the potential for global warming. Related benefits will be to reduce acid rain due to oxides of nitrogen and sulphur, and to reduce depletion of fossil fuels.

Credit requirement

Credit will be given on a 10-point scale, to office designs which are predicted to produce less CO_2 per square metre of treated floor area than would be achieved by typical, new UK office buildings. The treated floor area includes all parts which are heated or air-conditioned.

∗ **1 credit for carbon dioxide production of less than 120 kg/m² per year.**

∗ **2 credits for carbon dioxide production of less than 110 kg/m² per year.**

∗ **3 credits for carbon dioxide production of less than 100 kg/m² per year.**

120–90 kg/m² per year. This includes most average energy targets for office designs including the EEO and CIBSE 'fair' energy targets for naturally ventilated offices and is very good for air-conditioned buildings.

∗ **4 credits for carbon dioxide production of less than 90 kg/m² per year.**

∗ **5 credits for carbon dioxide production of less than 80 kg/m² per year.**

90–70 kg/m² per year. This encompasses buildings designed to meet the 'good' energy targets of the EEO and CIBSE and represents an excellent air-conditioned building.

∗ **6 credits for carbon dioxide production of less than 70 kg/m² per year.**

∗ **7 credits for carbon dioxide production of less than 60 kg/m² per year.**

70–50 kg/m² per year. This represents very good design for a naturally ventilated building.

∗ **8 credits for carbon dioxide production of less than 50 kg/m² per year.**

50–40 kg/m² per year. This represents excellent low-energy design, for example the BRE low-energy office.

∗ **9 credits for carbon dioxide production of less than 40 kg/m² per year.**

∗ **10 credits for carbon dioxide production of less than 35 kg/m² per year.**

Less than 40 kg/m² per year. This will be difficult to accomplish. Nevertheless it is possible and represents an advance on the achievement of the BRE low-energy office designed some fifteen years ago.

Method of assessment

The annual energy consumption for a particular building will be predicted using a program developed by the Electricity Association, ESICHECK, to predict energy consumption for specific patterns of use and occupancy. Later, a method developed by the Chartered Institution of Building Services Engineers (CIBSE) will be usd. This is not immediately available. Appendix C lists the default values used in the model. Measurements of the treated floor area are made from the building plans and include the total area within the envelope walls ignoring partitions. Lifts and cupboards are included where these inevitably receive some direct or indirect heating or cooling. Areas which are not subject to heating or cooling are ignored. The final energy consumption figures are converted to CO_2 production in kg/m^2 per year, using the fuel multiplication factors shown in Table 1, and credits are given according to the scale shown on the previous page.

Table 1 Relationship between fuel use and carbon dioxide emission in the UK (based on the *Digest of UK energy statistics 1992*[4])

Fuel	Carbon dioxide emission (kg/kWh delivered)
Electricity	0.72
Solid fuel	0.34
Fuel oil	0.29
Gas	0.21

Background

The greenhouse effect is caused by trace gases in the atmosphere which absorb and re-emit a proportion of the infra-red radiation emitted by the earth's surface, leading to a warming of the lower atmosphere. This effect is not new and without it life on earth would not be possible. The cause for concern is the potential increase in the greenhouse effect, due to increasing levels of gases such as CO_2, methane, CFCs and nitrous oxide (N_2O). The atmospheric concentration of CO_2 alone has increased from 310 parts per million (ppm) in the 1960s to 350 ppm today[5], and is now[6] increasing at a rate of 0.5% per year.

Since BREEAM focuses on the environment it is appropriate to concentrate on the reduction of CO_2 production rather than the consumption of delivered energy. Delivered energy does not directly reflect CO_2 production because CO_2 production per unit of energy delivered depends on the fuel used (Table 1 shows the CO_2 emissions in 1992 for several types of fuel in kg/kWh delivered). The figures are based on measured CO_2 emissions from different fuels. The calculations include the energy used in extraction and refining processes (for instance solid fuel, oil and gas), but they do not include any estimate of CO_2 global warming equivalent relating to methane losses from gas pipelines or coal mines during the extraction of coal. The figure for electricity is based on the annual average mixture of fuel used for generation across the whole of Great Britain. This consists of solid fuel, oil, gas, hydroelectric and nuclear components. Most of the electricity generation arises from the combustion of solid fuel and oil. In future and on a time scale shorter than the life of the building, the mix of fuel may change and if this gives lower carbon dioxide production then an electric heating system would become a more positive option. A reduction of the current electricity CO_2 emission factor by about 15 to 20% is forecast by 1995 (Electricity Association, private communication).

The CO_2 production due to energy use in a building is therefore related to the amount and type of fuel consumed. The amount of fuel consumed is in turn related to the quality of insulation and efficiency of appliances. Generally, offices receiving the highest credit for CO_2 production will have improved insulation, no air conditioning, good use of daylighting, energy-efficient artificial lighting with effective controls, efficient appliances and gas as the predominant fuel. They also need to be well managed. It is possible to consider a quantitative scale for carbon dioxide emissions resulting from energy use because targets can be set on a quantitative basis. Ten levels have been chosen based on a review of current best practice for office design[7], as well as the Energy Efficiency Office (EEO) and CIBSE energy targets[8,9].

ACID RAIN

Purpose

To reduce the emission of the oxides of nitrogen (NO_x) into the atmosphere and so minimise their contribution to the production of acid rain.

Credit requirement

* **1 credit for specifying boilers which are fitted with reduced-NO_x emitting burners and which emit NO_x at a rate no higher than 200 mg/kWh of delivered energy.**

Method of assessment

The boiler specification will be checked for its expected rate of NO_x emission.

Background

When oxides of nitrogen (and sulphur) combine with water in the upper atmosphere, acidic compounds are formed, which are then deposited as acid rain. Acid rain is responsible for damage to plants, aquatic life and buildings. The United Kingdom is a net exporter of acid rain to countries such as Holland, Denmark and Norway which are all net importers. This section focuses on NO_x rather than SO_x because NO_x is always generated by the combustion process but SO_x is produced only where the fuel (particularly coal and oil) contains sulphur. Natural gas contains very little sulphur and so generates minimal amounts of SO_x.

Nitrogen oxides are produced during combustion, when atmospheric nitrogen combines with oxygen in the high-temperature core of a flame. Nitric oxide (NO) is produced which oxidises further to nitrogen dioxide (NO_2). The amount of NO_x created by the combustion process is dependent on the design of the burner. The damage caused by acid rain has contributed to the need to introduce European legislation to limit emissions from boilers. The new legislation is currently under development and has not yet reached the statute books. However, in some countries (such as Germany and Holland) a voluntary standard already operates and much work has already been done to develop burners which reduce NO_x emissions.

The emission of NO_x could be reduced very substantially if money were no object. However, in the absence of legislation, most manufacturers have limited emissions to levels which increase boiler prices by only 10–15%. The new generation of reduced-NO_x emitting burners (conforming to the Blue Angel standard[10]) is able to reduce the NO_x emissions from standard boilers and condensing boilers by substantial amounts. Figure 1 illustrates typical reductions of NO_x emissions which are possible for both standard and condensing boilers, based on a power output of 300 kW operating for 1200 hours per year. The standard boiler of the illustration emits 108 kg NO_x per year (300 mg NO_x per kWh), which can be reduced to 39 kg NO_x per year (110 mg NO_x per kWh); and the condensing boiler emits 88 kg NO_x per year (240 mg NO_x per kWh), which can be reduced to 32 kg NO_x per year (90 mg NO_x per kWh).

The long-term reliability and maintenance needs of a boiler are important considerations. Oil-fired boilers generally require maintenance more often than gas-fired boilers, and if fitted with reduced-NO_x burners even more frequent maintenance will be needed. The burners of modern gas boilers require very little maintenance, even when fitted with reduced-NO_x burners. However, the larger number of burners in the reduced-NO_x boiler may result in slightly increased maintenance costs. The average life of a reduced-NO_x boiler will be the same as that of a standard boiler, about 15 years or longer.

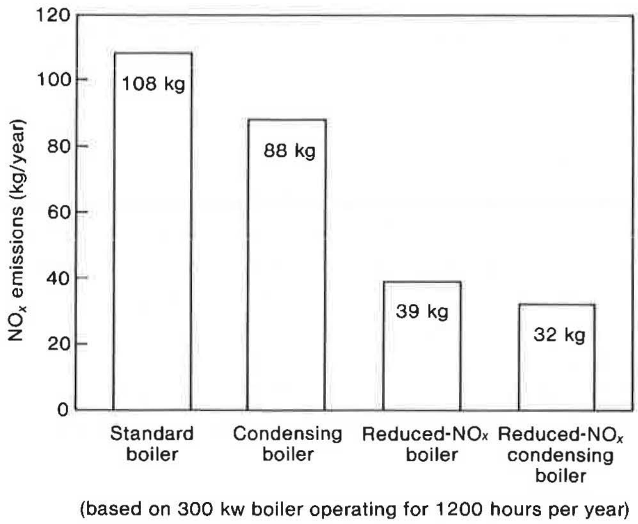

Figure 1 NO_x emissions from different boiler types, with and without reduced-NO_x burners

OZONE DEPLETION DUE TO CFCs, HCFCs AND HALONS

Purpose

To reduce the release of CFCs (chlorofluorocarbons), HCFCs (hydrochlorofluorocarbons) and halons into the atmosphere and thus to reduce the rate of depletion of the ozone layer which is expressed for halocarbons as an ozone depletion potential (ODP).

Credit requirement

(a) *Refrigerants in air conditioning*

* **1 credit for specifying refrigerants with ozone depletion potential of 0.06 or less (or no air conditioning).**

* **1 credit for specifying refrigerants with ozone depletion potential of 0.03 or less (or no air conditioning).**

* **1 credit for specifying refrigerants with ozone depletion potential of zero (or no air conditioning).**

(b) *Reduction of CFC and HCFC leakage*

* **1 credit for specifying refrigerant leak detection (or no air conditioning).**

* **1 credit for specifying provision of a suitable refrigerant recovery unit and containers (or no air conditioning).**

(c) *Avoidance of the use of halons*

* **1 credit for specifying no halons in either fixed or hand-held fire-fighting equipment.**

(d) *Insulation materials made only with agents of zero ozone depletion potential*

* **1 credit for specifying thermal insulants in building fabric and services made only from materials with zero ozone depletion potential.**

Method of assessment

(a) *Refrigerants in air conditioning*

If air conditioning is specified, the ozone depletion potential of the refrigerant will be checked. If no air conditioning is specified, a total of 5 credits will be given.

(b) *Reduction of CFC and HCFC leakage*

The specification will be checked for provision of automatic leak detection and a suitable refrigerant recovery unit and containers. A separate credit is available for each feature. Automatic leak detection systems are not suitable for use with a system which is to be sited outdoors, or an enclosed plant with condensers outdoors. In these cases, a maintenance agreement for a6-monthly manual inspection for leaks should be specified. If a reversible unitary heat-pump system (or any other system of small, sealed air conditioning units) is specified, a maintenance agreement must be drawn up covering a 6-monthly manual inspection for system leaks. The maintenance agreement should specify that full refrigerant recovery must be carried out before a unit is opened for repair. Two credits will be given where the specification is satisfactory.

(c) Avoidance of the use of halons

The specification of fixed and hand-held fire-fighting equipment will be checked.

(d) Thermal insulants made from materials with zero ozone depletion potential

A full description of all the insulation materials specified will be checked for the presence of ozone-depleting agents. If there is any doubt about the ozone depletion potential of the material, the design team must provide details from the manufacturer.

Background

(a) Refrigerants in air conditioning
Chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs) and halons are chemical compounds which cause damage to the Earth's stratospheric ozone layer. The ODP for a given substance is a calculated measure of the contribution of that substance to ozone depletion relative to that of CFC11. It is defined as the total change in ozone, per unit mass, when the substance has reached a steady state in the atmosphere. CFC11 has an ODP of 1 and is the most damaging of the CFCs. Although ODPs are widely quoted by scientists and policy-makers, they remain subject to revision. In 1987 many of the world's governments signed an agreement in Montreal (the Montreal Protocol) to reduce emissions of CFCs and halons into the atmosphere[11]. This agreement has subsequently been reviewed and the current requirement is that signatories will cease production of CFCs and halons by the year 2000. Within Europe, a European Community (EC) regulation has brought forward the phase-out date for CFCs to 1 July 1997. The Montreal Protocol is being reviewed in November 1992 and it is expected that the dates for phasing-out CFCs and halons will be brought forward to 1 January 1996. The EC is also committed to revising its Regulation to implement this date within the Community.

In 1986 air conditioning accounted for 38% of the UK demand for CFCs used for refrigeration[12]. However, without further improvements in design and maintenance it is likely that there will be increased demand for refrigerants in future. Air conditioning systems should be designed to operate on refrigerants that either pose no threat to the environment or in the short term have an ozone depletion potential of 0.06 or less. Table 2 shows alternative refrigerants and their ozone depletion potentials. HCFC22 is already in common use in air conditioning systems. As it is twenty times less damaging to the ozone layer than CFC11 and CFC12, its use has not yet been restricted under the Montreal Protocol. However, the November 1992 review of the Protocol is likely to introduce controls on transitional substances including HCFC22. The most likely replacement for CFC11 is HCFC123 which has an ODP of 0.02. However, the availability of HCFC123 is uncertain because it may be toxic in the long term. In addition to this, HCFC123, which has a low ODP, is expected to be subject to use controls, eventually being phased out. HFC134a has an ODP of zero and so does not damage ozone. It is considered to be a substitute for CFC12 and CFC500. However, it is not seen as being a 'drop-in' replacement. Existing equipment may require modification.

Other types of air conditioning system such as the lithium-bromide and the ammonia-based absorption chillers pose no threat to the ozone layer. An additional advantage to these systems is that they can be fuelled by gas rather than electricity, which has implications for overall emissions of CO_2 from the building. A disadvantage is that they are less efficient at cooling than the traditional halocarbon-based air conditioning systems, although improvements continue to be made to plant designs.

It should be noted that if no air conditioning has been specified, the design team should satisfy themselves that internal heat gains will be less than 40 W/m^2.

(b) Reduction of CFC and HCFC leakage
Poor design and maintenance of air conditioning systems is a major factor in the emission of CFCs and HCFCs. Large quantities of refrigerants are lost through leakage, during servicing and by contamination. It has been estimated that in the commercial sector 80% of the refrigerant sold is accounted for by servicing and leakage during normal use[13]. To improve this situation, greater attention needs to be paid to the design of refrigeration plant. Adequate space and access should be provided to enable maintenance of equipment. Refrigerant recovery units and containers should be provided to reduce losses during servicing. In addition, maintenance agreements should be set up which allow for manual searches for leaks on a 6-monthly basis.

It should be noted that in most cases where refrigerant is removed from equipment during servicing, maintenance or decommissioning, it becomes 'controlled' waste. Section 34[14] of the Environmental Protection Act 1990 places a duty of care on all those who handle 'controlled' wastes. Section 33[15] of the Act makes it illegal to 'treat, keep or dispose of controlled wastes in a manner likely to cause pollution to the environment or harm to human health'.

Many air conditioning systems allow the refrigerant to be pumped to the condenser of the chiller as part of the chiller's shut-down process. This is not sufficient on its own to earn a credit under BREEAM. A separate refrigerant recovery unit should be provided. This is a portable or fixed unit which contains a pump for transferring refrigerant from the chiller circuits to a storage cylinder, where it can be held until maintenance is complete. A single chiller may have more than one refrigerant circuit, but it is unlikely that two or more will fail simultaneously. The capacity of the storage container, therefore, only needs to equal that of the largest refrigerant circuit. In some situations refrigerant recovery is not appropriate, for instance small, individual room air conditioners, or heat pumps which would normally be unplugged and returned to the manufacturers for maintenance. Where such systems are specified, the design team should provide details of the maintenance agreement, including the maintenance policy to be followed. A credit can be given where maintenance documents specify that all refrigerant must be recovered or reclaimed as part of the maintenance procedure, and that all maintenance is to be carried out at the factory. Credit would also be available for the provision of appropriate automatic leak-detection equipment.

(c) Avoidance of the use of halons
Halons are extremely effective fire-fighting agents whose use is widespread[11]. They act by interfering with the free radical chain reactions occurring in flames. However, ozone is destroyed by a similar mechanism, which accounts for the

Table 2 Properties of CFCs, HCFCs, HFCs and halons

Substance	Formula	Montreal Protocol	Ozone depletion potential (CFC11=1)	Global warming potential (CO_2=1)	Atmospheric lifetime (years)	Flammability	Toxicity testing complete
CFC11	CCl_3F	Y	1.0	1500	60	No	Y
CFC12	CCl_2F_2	Y	1.0	4500	120	No	Y
HCFC22	$CHClF_2$	(N)	0.05	510	15	No	Y
HFC32	CH_2F_2	N	0	220	6	Yes	1995/6
CFC113	CCl_2FCClF_2	Y	0.8	2100	90	No	Y
CFC114	$CClF_2CClF_2$	Y	1.0	5500	200	No	Y
CFC115	$CClF_2CF_3$	Y	0.6	7400	400	No	Y
HCFC123	$CHCl_2CF_3$	(N)	0.014	29	2	No	1992/3
HCFC124	$CHClFCF_3$	(N)	0.017	150	7	No	1994/5
HFC125	CHF_2CF_3	N	0	860	28	No	1994/5
HFC134a	CF_3CH_2F	N	0	420	16	No	1992/3
HCFC141b	CH_3CCl_2F	(N)	0.08	150	8	Yes	1992/3
HCFC142b	CH_3CClF_2	(N)	0.06	540	19	Yes	Y
HFC143a	CF_3CH_3	N	0	1000	41	Yes	Not started
HFC152a	CH_3CHF_2	N	0	47	2	Yes	Y
CFC500	CFC12/ HFC152a	Y	0.74	3333	?	No	Y
CFC502	HCFC22/ CFC115	Y	0.33	4038	?	No	Y
Ammonia	NH_3	N	0	0	<1	Yes	Y
Propane	$CH_3CH_2CH_3$	N	0	3	<1	Yes	Y
Halon 1211	CF_2ClBr	Y	3.0	Not yet measured	25	No	Y
Halon 1301	CF_3Br	Y	10.0	5800	110	No	Y
Halon 2402	$C_2F_4Br_2$	Y	6.0	Not yet measured	28	No	Y

Notes

CFC500 and CFC502 are implicitly included in the Montreal Protocol because they contain the restricted refrigerants CFC12 and CFC115

Global and ozone depletion potentials are per unit mass, and values are current best available estimates which may be subject to revision. Global warming potentials relate to the long-term (500-year) warming potential.

(N) means that the substance is an HCFC and is expected to be phased out between 2020 and 2040 or earlier as alternatives are developed.

CFC chlorofluorocarbon.
HFC hydrofluorocarbon (contains no chlorine so has zero ozone depletion potential).
HCFC hydrochlorofluorocarbon or hydrogenated CFC (has a low ozone depletion potential).
HFA hydrofluoroalkane (wider chemical group for HFCs and HCFCs).
Halon halogenated hydrocarbon fire-fighting agent (all contain bromine so have high ozone depletion potentials).

very high ODPs of the halons compared with those of the CFCs.

Two halons are in common use in buildings in the UK: halon 1301 is mainly used in fixed total-flooding systems and halon 1211 is used in hand-held extinguishers. The bulk of these halons are stored in cylinders, either as part of a hand-held extinguisher or as part of the charge for a flooding system. There are now systems available whereby these stored halons can be recycled once the cylinders in which they are contained have exceeded their set lifetime There are benefits to using these systems in that such recycled halons are not proscribed under the Montreal Protocol, and an economic method of halon destruction has yet to be found.

The fire-fighting industry has adopted a number of methods to minimise unnecessary emissions of halons; these include fan pressurisation testing of enclosures in place of discharge testing, and ensuring that training in the use of hand-held extinguishers does not proceed to discharge of the halon contents. For new fire-fighting equipment, alternatives to halons should be specified. Research is under way to identify suitable functionally similar chemical replacements. In building applications, suitable alternatives such as carbon dioxide, water spray, foams and powders are available.

(d) Thermal insulants made from materials with zero ozone depletion potential

BREEAM credits the use of insulation materials for the structure, including all features such as window frames and doors, or the services (eg ventilation systems, central heating systems, pipes and water tanks), which do not use blowing agents that have a measurable potential to destroy ozone. The thermal insulation materials blown with CFCs include rigid polyurethane foams and extruded expanded polystyrene foam and phenolic foams. CFCs are used because they contribute to the thermal properties of the product, are non-flammable, stable, cost-effective, have a low toxicity and can result in closed cell structures which are resistant to water penetration. CFCs have largely been replaced by HCFCs in some insulation materials. Whilst it is important to note that HCFCs are less damaging to ozone than CFCs in the very long term (time scale of hundreds of years), it is also important to realise that HCFCs are very damaging in the short term (10 to 30 years). Figure 2[16] illustrates this point by showing the calculated time-dependent change in relative ozone column depletion which would follow a step change in the emission of CFCs or HCFCs of different composition.

In many applications, CFCs or HCFCs are being replaced by blowing agents which do not damage the ozone layer. There are also many alternative insulation materials which do not require a blowing agent, or which already use a non-CFC, non-HCFC agent as a matter of normal practice, for example:

- mineral fibre insulation (can be used for most applications, for example as quilt or as rigid board; in flooring a damp-proof membrane may be required to protect it from moisture penetration);
- cellular glass (can be used for floor, wall and some flat roof insulation);
- expanded polystyrene 'beadboard' (can be used for a similar range of applications as mineral fibre insulation, and has better water resistance than mineral fibres);
- expanded polystyrene beads (can be used as cavity wall fill);
- cork (can be used for floor and wall insulation);
- insulants blown with CO_2 or with other chemicals which have zero ODP and other suitable properties with regard to flammability, toxicity and structural performance.

These recommendations are not without problems. For example:

- there is limited user experience with some insulants blown with CFC alternatives;
- the substitution of CO_2 for CFCs and HCFCs may lead to an increase in thermal conductivity and therefore the thickness of insulation required may have to be increased to achieve the same level of insulation.

Nevertheless, ozone depletion is an issue of sufficient importance to justify immediate action.

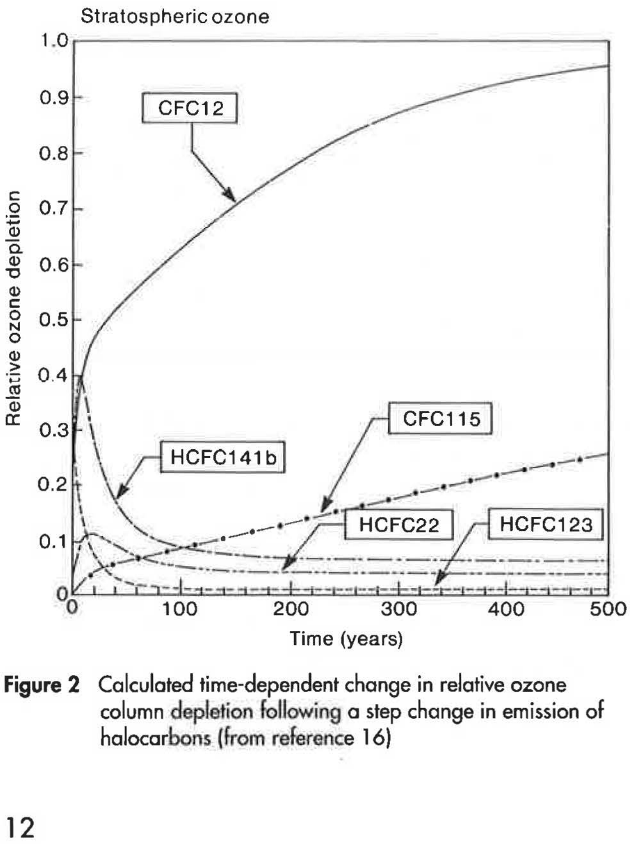

Figure 2 Calculated time-dependent change in relative ozone column depletion following a step change in emission of halocarbons (from reference 16)

NATURAL RESOURCES AND RECYCLED MATERIALS

Purpose

To maximise the use of non-renewable resources and to maximise the utility of non-renewable resources for use in the building structure and in fixed furnishings provided by the builder. Metals, minerals and oil derivatives are non-renewable materials used in many building components. In contrast to these, wood is a renewable material which comes from sources which can be sustained.

Credit requirement

* **1 credit for specifying solid timber which is entirely EITHER from well managed, regulated sources OR suitable re-used timber.**

* **1 credit for specifying timber panel products which are entirely EITHER from well managed, regulated sources OR suitable re-used timber.**

* **1 credit for specifying one or more of the following:**

  - **suitable uncontaminated demolition materials wherever appropriate in fill and hardcore and/or granular road base.**

  - **crushed concrete aggregate complying with the quality and grading requirements of British Standard BS 882[17] for use in concrete for foundations, over-site slabs, hardstanding, paths or site roads.**

* **1 credit for specifying one or more of the following:**

  - **At least 50% (by volume) of materials in the walls to contain more than 50% (by volume) of waste material or by-products such as pulverised-fuel ash or blastfurnace slag.**

  - **At least 50% (by volume) of materials in the flooring to contain more than 50% (by volume) of waste material or by-products such as pulverised-fuel ash or blastfurnace slag.**

  - **At least 50% (by volume) of any masonry material in walls (eg brick, concrete block and stone) to be made from recycled or re-used material, and guaranteed fit for its purpose.**

Method of assessment

(a) Timber

There is no internationally accepted system to indicate that wood comes from sources where the management of forests or tree plantations ensures sustainable production. In addition, it is still not possible to give specific guidance on which forests are well managed in terms of environmental, economic and social issues. However, the Timber Trade Federation and the Forests Forever Group have drawn up some environmental policies which have been adopted by many of the UK timber companies. These policies require the timber companies to seek information continually about their timber sources and the status and progress of forest management from their overseas suppliers. This information will then be made available to specifiers.

Specifications will be checked with information from manufacturers and suppliers. Softwood timbers and temperate hardwoods are assumed to be from sustainable sources. If, however, tropical hardwoods have been specified, the design team will be asked to provide the following details:

- the species and country of origin;

- the name of the concession or plantation within the country of origin which supplied the timber;

- a copy of the forestry policy being pursued for the plantation or concession;

- shipping documents confirming that the timber supplier in the UK has indeed obtained their timber from that concession.

Designers will be asked to obtain written confirmation from the suppliers regarding the composition of wood-based panel products being used on the building. Even birch-faced plywood may contain veneers of hardwood of tropical origin. If plywood does contain tropical hardwood, credit will only be given if the information listed above can be obtained, confirming its source.

(b) Use of demolition materials

Where demolition materials are to be used, the specification must be supported by evidence of fitness for purpose. Guidance should be taken from BRE Digests 276[18] (for hardcore) and 363[19] (for prevention of sulphate attack), and from British Standard BS 6543:1985 (Guide to use of industrial by-products and waste materials in building and civil engineering)[20].

(c) Use of products containing over 50% waste or by-product material

Where products such as cement or lightweight blocks are used containing waste materials or by-products such as pulverised-fuel ash (pfa) or blastfurnace slag, the developer will check with the manufacturer and provide written confirmation that the composition of the product is greater than 50% waste material by volume. One credit is available for using such material in a significant proportion (over 50%) of either the walls, or the flooring, or both.

(d) Re-use of bricks or stone

Specification of recycled materials for use in walls and flooring should be supported by evidence of their origin to demonstrate suitability for re-use. Where demolition materials are to be used, guidance should be taken from BRE Digests 276[18] (for hardcore) and 363[19] (for prevention of sulphate attack).

Background

(a) Timber
Most of the timber used in Britain (over 80%) is imported from temperate sources where forest management practices are firmly established and where the use of timber plantations with replanting programmes ensures sustainable timber production. Only a very small proportion of timber from tropical forests is sold into the international market, and of this, less than 0.1% is used in the UK[21].

There are several types of tropical forest varying from savannah woodland and montane forest, to the rain forest itself. Deforestation of the savannah woodland and montane forest arises from grazing and the local population's other needs for wood. Deforestation of the rain forest is due largely to clearance for agriculture, but commercial logging also occurs. This is selective in terms of species of trees felled but it can create conditions which make subsequent encroachment and clearance more likely. Most of the tropical wood is used locally. It is recognised that the basic causes of deforestation are poverty and human pressures on the land. But reaction to the international trade in tropical wood is seen as a route to ensuring the permanence of productive and protected forests.

Environmental groups have been very successful in raising world-wide awareness of the need to conserve forests, and world leaders made a commitment to forest conservation at the United Nations Conference on Environment and Development (UNCED) in Brazil in 1992. Guidance on the nature of timber sources is available[22,23]. In addition, it is worth noting that properly specified wood preservation, used in appropriate circumstances, would also help resource conservation in the building as well as reducing the likelihood of incurring future maintenance costs. (For details of appropriate circumstances and means of preservation of timber see references 24, 25, 26, 27 and 28.)

The UK government, with the most important countries conducting international trade in tropical timber, is committed to the Target 2000 initiative. Target 2000 is a framework for the achievement of sustainable forest management by the year 2000. It has been set up by the International Tropical Timber Organisation (ITTO) with support from many organisations including the World Bank, the Food and Agriculture Organisation and the UK Overseas Development Administration. The framework embodies the recognition that change takes time and that resources to undertake change have to be made available to tropical developing countries.

The UK government does not support bans or boycotts on imports of tropical wood because these are counter-productive and contrary to the general spirit of the General Agreement on Tariffs and Trade (GATT). Architects, designers and contractors should specify and order timber, including tropical timber, from sustainably managed sources. Because of extremes of view about what constitutes sustainability in tropical forests, it is difficult to obtain specific assurances of sustainability. For the purposes of the BREEAM assessment, specifiers should seek information on the timber from the producer countries.

(b) Use of demolition materials
On large demolition sites hardcore is conveniently produced by bringing in portable crushing plant. On smaller sites material is taken to central crushing plants. Care has to be taken to minimise the content of wood and other compressible material and to avoid contamination with soils

and industrial wastes. This rarely produces material of a quality for use in concrete unless un-reinforced concrete can be processed separately. Material available for road sub-bases complying with the Department of Transport's specification for highway works[29] is available from fixed-site recycling plants in the UK. Provision is also made in this specification for the use of (crushed concrete as aggregate in the production of pavement concrete.

(c) Use of products containing over 50% waste or by-product material
The continued growth in the aggregate industry has provoked increasing public concern about the impact of raw materials extraction from quarries and sand and gravel pits. In parallel with this, there has been growing concern about the disposal of large quantities of mineral and industrial wastes. Processed wastes such as sintered pulverised-fuel ash and pelletised blastfurnace slag can be used as aggregate in lightweight concrete blocks, and credit can be given for specifying blocks with over 50% waste material. Ground granulated blastfurnace slag (ggbs) can also be used as a substitute for up to 80% by volume of cement (dependent on the exact application). For further information on the benefits of using waste materials in concrete see BRE Digest 363 on the sulphate and acid resistance of concrete in the ground[19].

(d) Re-use of bricks or stone
Credit will be given for the use of recycled/re-used brick or stone which is suitable for its purpose. Brick from chimneys or other locations in which sulphates may have been taken up in significant quantities, must not be used. Material which has not previously been used for exterior structural purposes must be tested to British Standard BS 3921[30]. Other bodies, for example building guarantee and building control authorities, may require tests of strength and frost resistance.

STORAGE OF RECYCLABLE MATERIALS

Purpose

To encourage recycling of waste on a larger scale. This will increase the utility of both renewable and non-renewable resources.

Credit requirement

*** 1 credit for designs which incorporate separate storage space for recyclable materials.**

Method of assessment

The specification is to be as follows.

A small dedicated storage space should be provided for separate storage of recyclable materials such as paper, plastic cups, glass and aluminium cans. A reasonable guideline is that 2 square metres of storage space for each 1000 square metres of the office floor area should be provided solely for the purpose of storage, with a maximum area of 10 square metres. The space should be clearly labelled as a recycling store and have good access for removal of materials by recycling contractors or the local authority. It should also be sheltered from the weather.

Background

Offices generate computer, letterhead, photocopying and note paper, of which much could be recycled. To make recycling schemes more economic, it is beneficial for waste paper to be collected quickly and efficiently. This can be encouraged by ensuring that sufficient paper is accumulated before it is collected.

Waste paper, glass bottles and aluminium cans are the most commonly recycled materials, with many private companies and some local authorities providing collection. A convenient purpose-designed space would help building occupants to store materials for collection by the local authority or private contractors.

4 Local issues

This chapter covers those issues which affect the immediate surroundings of a building such as the use of a green field site for building, and the use of natural resources during construction and after occupation.

LEGIONNAIRES' DISEASE ARISING FROM WET COOLING TOWERS

Purpose

To eliminate the risk of Legionnaires' disease arising from wet cooling towers associated with air conditioning systems.

Credit requirement

*** 1 credit for achieving one of the following:**

- **no air conditioning; or**
- **air conditioning without wet cooling towers; or**
- **air conditioning with wet cooling towers designed to the specification described in CIBSE TM13[31].**

Method of assessment

The design should either:

- avoid specification of air conditioning;
- avoid the specification of a wet cooling tower; or
- be designed in accordance with CIBSE TM13.

Wet cooling towers designed according to the CIBSE guidelines will have the following features which should be confirmed in writing by the services engineer:

- a safe tower location in relation to fresh-air intakes and flue outlets;
- a drift eliminator designed to minimise carry-over under all operating conditions;
- water distribution designed to minimise aerosol generation;
- an accessible and cleanable filler pack;
- housing which allows full and easy access (eg quick-release fittings);
- a pond which is shielded from direct sunlight;
- the facility to know and record water make-up rates so that the system water volume can be marked on the tower or another agreed location;
- a sump design which promotes the accumulation of sludge and facilitates its removal;
- a sump drain of adequate size;

- air breaks and traps available for all drains;
- a pipework system design, fittings and components which are appropriate to the actual volume flow rates required to meet design standards; arrangements for flushing and draining to be adequate; washers, jointing materials, etc, to be selected from approved list[32];
- a water treatment programme to be integrated in all respects with water quality and to be easy to monitor regularly;
- standby pumps which can be isolated during normal operation or flushed through regularly;
- strainer/filtration arrangements which are provided in conjunction with the overall water treatment programme;
- a condenser which can be easily cleaned;
- all components provided with manufacturer's instructions for operation and maintenance, including cleaning.

Background

Attention has been focused recently upon the need for regular maintenance of wet cooling towers and proper application of water treatment systems. The lack thereof in some instances can result in Legionnaires' disease[33,34]. It is possible to limit the problem by applying dry cooling systems[35]. Although these may be less efficient than wet cooling systems and energy costs are higher, maintenance costs are less. Where wet cooling towers are used, it is important that good design procedure is followed[36]. Good design provides for effective maintenance of cooling towers and evaporative condensers as specified in CIBSE TM13[31].

LOCAL WIND EFFECTS

Purpose

To eliminate danger and nuisance to passers-by resulting from wind deflections round large, and tall, buildings.

Credit requirement

*** 1 credit for designs which satisfy one of the following conditions:**

- **the frequency of exceeding wind levels of 4 or more on the Beaufort scale is limited to 10% or less in an urban environment.**
- **the design building is surrounded by others of equal or greater height and does not itself exceed a height of 30 m.**
- **the frequency of exceeding wind levels of 4 or more on the Beaufort scale is limited to 20% or less in a rural environment.**
- **a wind-tunnel study or other suitable wind assessment demonstrates that the wind environment around the base of the building will be acceptable.**

Method of assessment

The design team will check the average wind speed of the site location (see Figure 3) or contact the local meteorological office. The average wind speed at the site will be plotted against the building height using Figure 4 or 5 depending on whether the site is urban or rural. The position of intersection will be compared with the 10% line for an urban site or the 20% line for a rural site. Where the intersection lies on or below the appropriate line, a credit will be awarded. Where it lies above, the credit will be withheld. For an urban site, the design team must provide a local plan of the area with the approximate heights of surrounding buildings marked on it.

This method assumes that the design building significantly exceeds the height of its neighbours (ie is twice the height of neighbouring buildings, or taller). Where the heights of surrounding buildings are greater than or similar to that of the design building, and similar to each other, the height of the design building may extend to a maximum of 30 m and still attract a credit.

Background

A building which is substantially taller than its surroundings presents a large obstruction to wind, deflecting it both horizontally and vertically from its original course. One effect of this deflection is to cause increased wind speeds near to ground level in the area around the building. Consideration of excessive wind speeds at ground level is an important part of the design process to ensure satisfactory conditions around the building. Further information may be found in the BRE report *Wind environment around buildings*[37].

In typical urban areas a tall building two or more times the height of the surrounding buildings will cause increased wind speeds in pedestrian areas; in such areas buildings less than 20 metres tall are unlikely to give rise to complaints. The nuisance caused depends on how often unpleasant (or dangerous) wind speeds occur in pedestrian areas. In the worst case of a wide, tall building the nuisance depends on two main factors: building height and the mean wind speed for the site (Figure 3). Figures 4 (urban site) and 5 (rural site) can be used to obtain a first, approximate, estimate of the likely wind environment around a tall building: the curves show frequencies of exceedence of a wind speed of 5.5 metres per second around the building, which equates to level 4 on the Beaufort scale, the speed at which wind starts to be a nuisance for pedestrians (Table 3).

If a proposed slab building gives a building height versus wind speed intersection which lies above the 20% curve, winds will definitely be a problem to pedestrians, and positive action will be needed to provide shelter. For buildings lying between the 10% and 20% curves, efforts should be made to provide a shelter in order to achieve a pleasant environment. Below the 10% curve, problems are only likely on unusually windy days.

The worst situation arises with tall vertical walls adjacent to pedestrian areas, with nothing to prevent deflected wind from reaching ground level. Any form of construction which impedes this wind flow will improve conditions at ground level, but it must be realised that the volume of wind deflected by a slab building is enormous. The following list indicates some preferred designs, provided they are used with care:

- a tall building set back from pedestrian areas;
- a tall building constructed on a large podium building;
- a tall building encircled by very large canopies;
- a tall building with the facade stepped back to form a pyramid shape;
- enclosed walkways for people to use on windy days.

Table 3 Wind effects on people, based on the Beaufort scale

Beaufort scale		10-minute mean speed (m/s)	Noticeable effect of wind
0	Calm	0.0 – 0.5	—
1	Light air	0.5 – 1.5	No noticeable wind
2	Light breeze	1.6 – 3.3	Wind felt on face
3	Gentle breeze	3.4 – 5.4	Wind extends a light flag Hair is disturbed Clothing flaps
4	Moderate breeze	5.5 – 7.9	Raises dust, dry soil and loose paper Hair disarranged
5	Fresh breeze	8.0 – 10.7	Force of wind felt on body Drifting snow becomes airborne Limit of agreeable wind on land
6	Strong breeze	10.8 – 13.8	Umbrellas used with difficulty Hair blown straight Difficult to walk steadily Wind noise unpleasant Wind-borne snow above head height (blizzard)
7	Near gale	13.9 – 17.1	Inconvenience felt when walking
8	Gale	17.2 – 20.7	Generally impedes progress Great difficulty with balance in gusts
9	Strong gale	20.8 – 24.4	People blown over by gusts
10	Storm	24.5 – 28.4	Trees uprooted: considerable structural damage

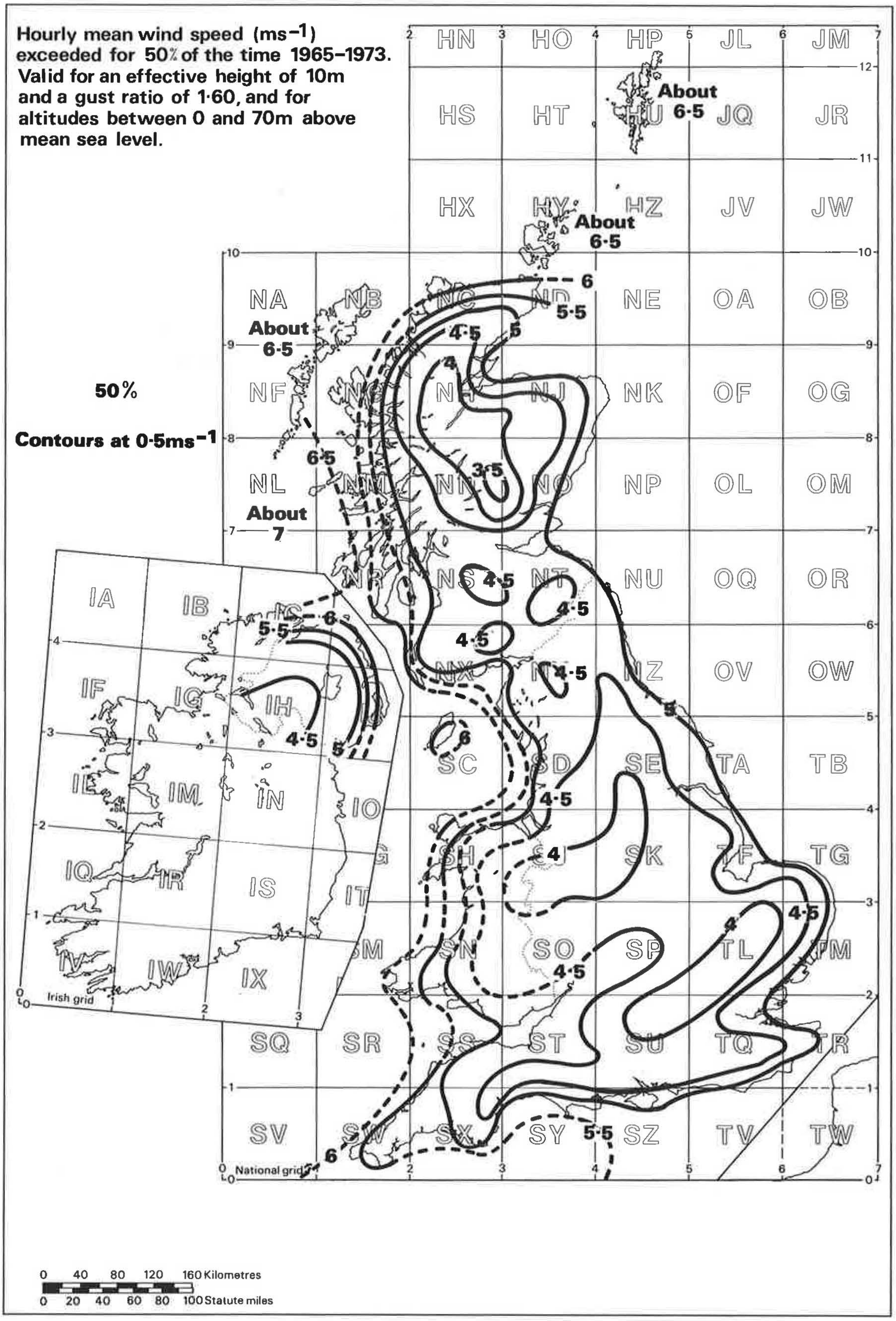

Figure 3 Contours of hourly mean wind speed for the United Kingdom

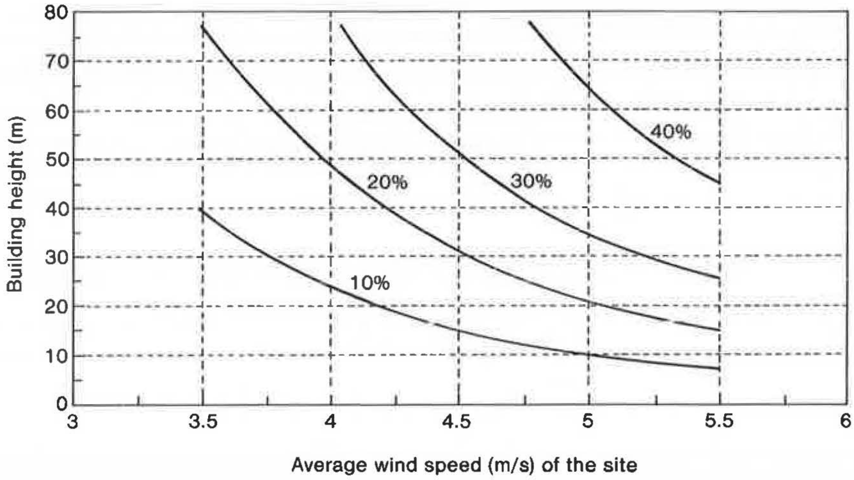

Figure 4 Frequency of exceeding level 4 on the Beaufort scale (Table 3) near a building in town

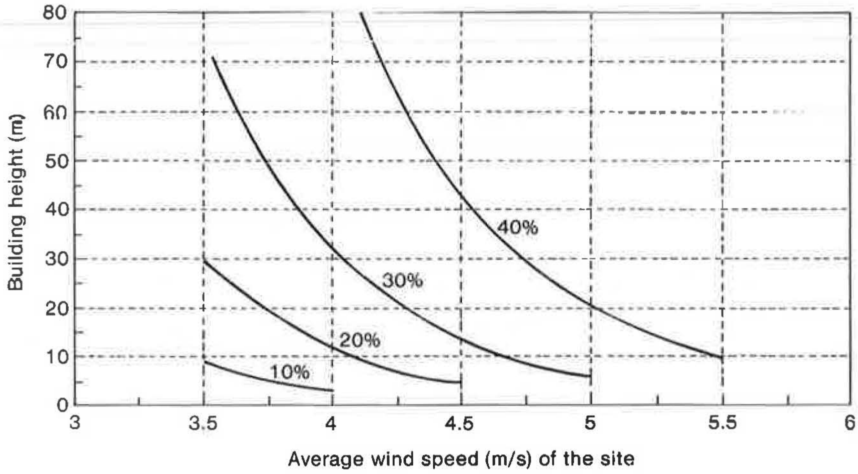

Figure 5 Frequency of exceeding level 4 on the Beaufort scale (Table 3) near a building on an open rural site

NOISE

Purpose

To reduce the nuisance caused by noise from building services disturbing neighbouring householders, particularly at night.

Credit requirement

*** 1 credit for a design for which calculations show that the rating level outside the nearest exposed residential building is not less than 5 dB below the background level during any period of the day or evening (07.00 to 23.00 h), and does not exceed the background level during any period of the night (23.00 to 07.00 h).**

Method of assessment

The noise measurements/calculations shall be carried out by the design team according to BS 4142:1990 (Method for rating noise affecting mixed residential and industrial areas)[38]. The building services shall be designed so that the rating level of the noise does not exceed the limits given above. The background noise level should be measured, not calculated.

Background

Unwanted sound from equipment on office buildings can cause serious noise pollution and consequent problems for surrounding residents. The acceptability of a noise source in a residential area can be assessed using the rating level described in British Standard BS 4142:1990[38] which takes account of undesirable characteristics of the noise. Minimal noise pollution can be achieved by ensuring that noise from fans and other plant associated with the building does not exceed the limits given above. The rating level takes account of unpleasant tonal or impulsive characteristics of the noise. The potential noise level should be assessed with respect to the residential building most exposed to the noise source (usually the nearest building unless this is screened). The requirement should not be exceeded at any time during the day or night.

OVERSHADOWING OF OTHER BUILDINGS AND LAND

Purpose

To minimise overshadowing of nearby buildings and land, particularly neighbouring houses.

Credit requirement

* **1 credit for buildings which do not cause substantial overshadowing of neighbouring properties as defined above, or which do not cause an existing situation to deteriorate.**

Method of assessment

The designers will provide a comprehensive set of calculations and drawings to demonstrate conformity with the recommendations for good site planning set out in the BRE Report *Site layout planning for daylight and sunlight: a guide to good practice*[39], with reference to existing buildings and development land (Sections 2.2, 2.3 and 3.2 of the Report).

Background

Large buildings can cause substantial overshadowing of neighbouring properties; both sunlight and light from the sky can be affected. The impact of a new building on all nearby buildings where daylight is of value should be checked; this would include homes, hospitals, hotels, schools and most offices and workshops. Adjoining land which is likely to be developed for these purposes should also be safeguarded.

In general any overshadowing should be minimised. As a rough rule, a building of large plan area is likely to cause substantial blocking of daylight if it subtends an angle in section of greater than 25° to the horizontal, measured from the centre of any window of the existing building (Figure 6). Substantial overshadowing of development land may be caused if the new building subtends an angle greater than 43° to the horizontal, measured from a point 2 m above ground at the common boundary. In both cases, if the new building is taller than the height indicated by these angular criteria, then it should be narrow enough to allow daylight (quantified by the vertical sky component on the existing building) around the side of the building. The BRE Report *Site layout planning for daylight and sunlight: a guide to good practice*[39] contains a means of checking this. The no sky line guideline in the Report is not required for BREEAM assessment purposes.

Large buildings will also block sunshine; this is especially important for adjacent homes and gardens. For homes, only living rooms facing within ±90° of due south need to be checked. The British Standard on daylighting BS 8206: Part 2[40] recommends that interiors should receive over a quarter of yearly probable sunshine hours, with at least 5% of yearly probable sunshine hours being received in the six months between 21 September and 21 March. Both of these can be checked using the BRE sunlight availability protractor[41] or the BRE Report *Site layout planning for daylight and sunlight: a guide to good practice*[39]. More stringent control of building height and proximity is good practice if adjoining properties have been specially designed to make use of solar energy.

If existing buildings are already heavily obstructed (for example in a city centre) the BRE Report *Site layout planning for daylight and sunlight: a guide to good practice*[39] shows how to carry out a 'before and after' comparison of local overshadowing, and indicates the degree of extra overshadowing (of both daylight and sunlight) which would be considered to be reasonable.

Note that rights to light may be enforceable for older buildings nearby; if they are, additional checks will then be required.

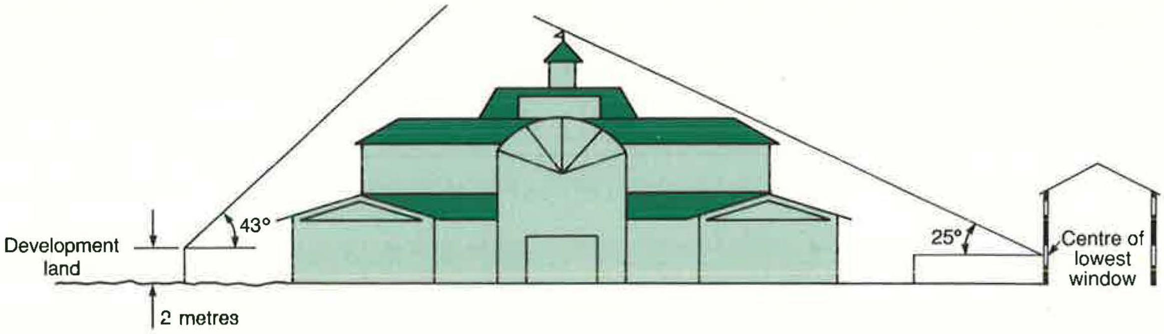

Figure 6 Angular criteria for overshadowing of nearby buildings (on right) and development land (on left)

WATER ECONOMY

Purpose

To reduce wastage of water, which is a valuable resource, and to increase awareness of its importance.

Credit requirement

* **1 credit for specifying all WCs with a maximum flushing capacity of 6 litres or less.**

Method of assessment

The specification must be as above with installation guidance included in the specification, and taken from BS 6465:Part 1[42].

Background

Water is an increasingly scarce resource with an associated increasing degree of financial and environmental cost from the development of new sources. There are several ways of decreasing the demand for publicly supplied water. UK Model Water Byelaws[43] state that from 1 January 1989 all new lavatory installations must have a maximum flushing capacity of 7.5 litres, and dual-flush WCs are to be prohibited from 1 January 1993. A well designed WC can operate effectively at a capacity as low as 3.5 litres, and 6 litres should be achievable without significant risk. Information on low-water-use WCs can be found in BRE Report *Low-water-use washdown WCs*[44].

ECOLOGICAL VALUE OF THE SITE

Purpose

To discourage building on ecologically valuable sites, and to raise awareness of, to protect and to enhance local ecology.

Credit requirement

* **1 credit for the re-use of sites which have previously been built upon or reclaimed from industrial processes or landfill.**
* **1 credit for building on land which meets defined criteria for low ecological value or, in the case of ecologically valuable land, designing in compliance with recommendations from an audit by the RSNC (Royal Society for Nature Conservation — The Wildlife Trusts Partnership) or recognised by them in order to minimise ecological damage.**
* **1 credit for designing-in features for positive enhancement of the site ecology in accordance with advice from the RSNC.**

Method of assessment

Site plans will be examined and commercial or local authority certification of safety will be required for land which is suspected to be contaminated (or to have been contaminated at some time).

The credit relating to the ecological value of the site will be assessed in two stages. First the developer will complete a checklist (Table 4) to indicate whether the site meets specified criteria for low ecological value (principally land previously used for buildings and contaminated land). If these initial criteria are not met, the developer will need to provide confirmation from the RSNC that the site is of low ecological value, if the credit is to be given. If the environmental consultancy report indicates the presence of ecologically valuable land, the developer must confirm that recommendations for minimising ecological damage will be followed, and show on plans how this will be achieved. The developer may choose to obtain an environmental consultancy certificate before submitting the design for BREEAM certification. In this case, the preliminary checklist need not be completed.

For the credit relating to ecological enhancement of the site, written recommendations will be required from the RSNC and the developer must confirm that these written recommendations will be followed, and show on plans how this will be done.

Table 4 Checklist for minimising ecological damage to a site

Type of land to be used for the new building or for access to the building site		
Land which is entirely within the floor plan(s) of existing building(s) or building(s) demolished within the past 2 years.	Yes ☐	No ☐
Land which is entirely covered by other constructions such as sporting facilities (eg hard-surface tennis courts, outdoor swimming pool), car parking or such constructions which have been demolished within the past 2 years.	Yes ☐	No ☐
Land which is contaminated by industrial or other waste to the extent that it would need decontamination before building.	Yes ☐	No ☐
Land to which one of the first three previous descriptions applies but extending to a maximum of 20% of the ground area of the building into land consisting of a mixture of single-crop arable farm land (maximum 10%) and regularly cut lawns and sports fields.	Yes ☐	No ☐
Land to which one of the first three previous descriptions applies but extending to a maximum of 10% of the ground area of the building into an area which has been used for at least 5 years for single-crop arable farming (without using any lawns or sports fields).	Yes ☐	No ☐
Land to which one of the first three previous descriptions applies but extending to a maximum of 20% of the ground area of the building into land which consists of regularly cut lawns and sports fields (without using any arable land).	Yes ☐	No ☐
Does land listed above cover ALL the land you will use?	Yes ☐	No ☐
Ecological features of the land		
Is it devoid of trees or hedges above 1 metre high?	Yes ☐	No ☐
Are ponds, streams and rivers absent?	Yes ☐	No ☐
Are marsh and other wet land absent?	Yes ☐	No ☐
Is it devoid of natural meadows?	Yes ☐	No ☐
Is it devoid of heathland such as heather?	Yes ☐	No ☐

If you have answered 'Yes' to at least one item on the **type of land to be used**, and to ALL of the questions on the **ecological features of the land**, the site meets the criteria for low ecological value.

If you have answered 'No' to any of the questions on the **ecological features of the land**, the site does not meet the initial criteria for low ecological value, and advice should be sought from the RSNC.

Background

The re-use of existing sites will help to slow down or halt the destruction of natural habitats and the wildlife they support. Wherever buildings are constructed, there is always a risk that, however environmentally friendly the building itself may be, it may present a threat to local ecology or areas of natural beauty. The principle of this Section is to give credit first for minimising damage to the local ecology, then for positively enhancing the local ecology. Damage can be minimised either by selecting a site of low ecological value or by developing a site in a way that protects the most important ecological attributes. Construction does not have to reduce the ecological value of a site — it can be used to enhance the value.

There is clearly a difficulty in specifying simple rules for doing this, rules which would apply to the whole of the UK and perhaps beyond. For example the operation of rules about trees on a site will vary considerably among local authorities across the UK, making it almost impossible for BREEAM to specify improvements on what is required by local authorities. The possibility of requiring a proportional improvement (eg 10% extra trees) was considered but thought to be impractical. Because of problems of this kind, BREEAM takes the option of third-party certification. RSNC Environmental Services collectively comprises a nation-wide network of locally based wildlife trust consultancies, offering a wide range of ecology-based services. The organisation is ideally placed to answer questions posed anywhere in the UK concerning the ecological value of individual building sites. It is also well qualified to offer advice on the ecological enhancement of sites as part of the building design process.

One option which is likely to prove favourable under this scheme is to build on and revitalise a previously derelict site. However, an apparently derelict site may have been colonised by rare, protected or locally important species if it has been derelict for some time, and therefore cannot always automatically be credited. Derelict sites may include contaminated land, provided that adequate measures have been taken to ensure the health and safety of the occupants and construction workers. The use of landfill sites which are producing gas should be avoided. Requirements for using contaminated land should be dealt with by the normal health, safety and planning procedures. For example:

- a thorough analysis of possible soil contaminants should be made as materials such as polychlorinated biphenyls (PCBs) and heavy metals could have health implications;
- if landfill gas is a potential problem, near to landfill sites, membranes used in conjunction with some form of sub-floor ventilation would be a method at some sites to prevent explosions at a later date (measures must also be taken to minimise the risk of subsidence at a later stage);
- contaminated land can be cleaned or the contaminants dealt with in a variety of ways using both on-site and off-site methods; techniques to achieve this are under development but some, for example biological techniques, are currently commercially available;
- contaminated waste can be excavated and replaced with clean fill (this method does not really solve the problem of contamination, it merely transfers it to another area).
- advice and guidance are available in DOE Circulars[45,46], the Building Regulations Approved Documents C[47] and from Guidance Notes produced by the Interdepartmental Committee on the Redevelopment of Contaminated Land[48]. Site investigation procedures are set out in a BSI Draft for Development (DD175/88)[49].

CYCLISTS' FACILITIES

Purpose

To encourage employees to reduce the pollution, traffic congestion, fuel use and noise which result from the use of private cars, by cycling to work.

Credit requirement

*** 1 credit for designing-in secure points to allow a minimum 10% of staff to lock bicycles adjacent to the building, sheltered from rain and snow. The design should allow one wheel and the frame to be secured together. In addition at least two of the following features should be provided:**

- **changing facilities for cyclists;**
- **space for drying wet clothes;**
- **showers for cyclists.**

Method of assessment

The design will be checked for the specification of a secure bicycle shelter and two or more additional features from the list above.

Background

The provision of secure, dry storage for bicycles and shower/changing facilities for their riders is likely to encourage occupants of an office building to cycle to work rather than drive their cars. The environmental benefits would include a reduction in air pollution, noise, fuel use and traffic congestion.

5 Indoor issues

Indoor issues include all those aspects of a building design which have an impact on the health, comfort or safety of the occupants, such as air quality and hazardous materials.

LEGIONNAIRES' DISEASE FROM DOMESTIC WATER SYSTEMS

Purpose

To minimise the threat of Legionnaires' disease arising from domestic hot water systems within buildings.

Credit requirement

∗ 1 credit for domestic water systems that meet the specifications listed in CIBSE TM13[31].

Method of assessment

Domestic water systems designed according to the CIBSE guidelines[31] will have the following features which should be confirmed in writing by the services engineer:

- a tight-fitting but ventilated cistern cover to prevent dirt entering the water;
- the water drawing-off point from a side tank to minimise dirt entrainment;
- a cold tank location/environment which maintains the temperature of the water at less than 20°C;
- a calorifier shell which is designed to minimise sludge accumulation, with access for easy descaling;
- a drain which is accessible and large enough for the easy removal of sludge;
- a heater which is designed to ensure uniform temperature throughout the storage vessel, and with sufficient capacity to heat water in the calorifier and the rest of the system to 70°C;
- the thermostat setting to be specified at a minimum of 55°C, and easy to check regularly;
- the pump performance (or trace heating output) and pipework installation, including thermal insulation, should be specified to ensure a minimum return water temperature of 50°C; where duplicate pumps are provided, a formal change-over procedure should be specified; thermal insulation to be easy to check regularly for integrity;
- dead-legs should be kept to a minimum; design out any draw off points which would be rarely used;
- washers, jointing materials, etc, should be specified from the *Water fittings and materials directory*[32];
- all components should be provided with manufacturer's instructions for operation and maintenance, including cleaning;
- non-return valves to prevent risk of reverse flow in buildings with occupants who are at particular risk of contracting Legionnaires' disease.

Background

The first Badenoch Inquiry report points out that the majority of outbreaks of Legionnaires' disease are associated with the domestic hot water systems of non-domestic buildings. The main professional body involved in this part of the building design is the Chartered Institution of Building Services Engineers (CIBSE). They have recommended design procedures for minimising the risk of colonisation and dispersal of water droplets containing *Legionella* bacteria in their Technical Memorandum TM13[31].

VENTILATION, PASSIVE SMOKING AND HUMIDITY

Purpose

To achieve an improved level of indoor air quality while maintaining energy efficiency.

Credit requirements

* **1 credit for the provision of openable windows, and if air conditioning or mechanical ventilation is to be used to service the inner core of a deep-plan building, this should be designed in accordance with CIBSE recommended ventilation rates[50].**
* **1 credit for designs which include separately ventilated areas for smokers, or which specify no smoking to be allowed in the building.**
* **1 credit for specifying or designing for steam-based humidifier systems, paying attention to condensation control inside the air distribution system (if humidification is required), or for specifying no humidification.**

Method of assessment

(a) Ventilation

The presence of openable windows will be checked. To achieve a credit, ventilation must be supplied by the provision of openable windows, whether or not the building is to be naturally ventilated. Where the building is of a deep-plan design, any air conditioning plant or mechanical ventilation plant must be designed to provide ventilation at rates according to CIBSE guidelines[50].

(b) Passive smoking

An area should be specified which is physically separated from the rest of the space by full-height partitions and a closed door, and which has its own ventilation system, distinct from that of the rest of the building. (This may be as simple as an openable window.) If no such space is specified, the credit may still be given if the prospective occupiers of the building undertake in writing to operate a smoking ban throughout the building.

(c) Humidity

If humidification is required, the specification should be for a steam-based system.

(a) Ventilation
It should be the basis of good design to make the building envelope airtight and then to provide controlled ventilation, ie the concept of 'build tight — ventilate right'[51]. It needs to be emphasised that a building cannot be too tight — but it can be underventilated. Rather than having to measure airtightness in each office building, BREEAM specifies individual methods of improving airtightness. It is important to note that no guarantee of airtightness can be made for a building at the design stage as the quality of building practice will determine the final level of performance. Guidance on the airtight design and construction of large buildings can be found in the forthcoming BRE Report *The buildability guide to minimising air infiltration in office buildings*[52]. The fan pressurisation test[53] is a good means of determining building tightness during and after construction.

The fresh airflow rate specified for office buildings is normally based on assumptions about smoking by the occupants. CIBSE[50] currently specifies 8 litres/second per person in the absence of smoking. Where smoking is permitted, CIBSE specifies 16 litres/second per person for light smoking and 32 litres/second per person for heavy smoking. The Government code of practice[54] suggests ventilation rates of between 24 and 32 litres/second per person. Because the increased use of fresh air has both benefits and penalties during the heating season, it is difficult to suggest figures for environmentally assessed buildings which differ from the codes widely used for building design. Buildings which rely on natural ventilation and which have openable windows are able to have greatly increased rates of ventilation out of the heating season without an energy penalty. During the heating season it is necessary to limit the use of openable windows. One way to do this is to provide trickle ventilators. Some buildings have been designed which utilise mechanical ventilation with heat recovery for the heating seasons with the windows locked shut[55], but this has been found to be unsuccessful in energy and cost terms. It was also unpopular with the occupants of the building.

(b) Passive smoking
Passive smoking is recognised both as a nuisance and a health hazard. Many people find the odour of tobacco smoke unpleasant. One possible solution to this problem is to allow smoking only in specially designated areas. Office designs which supply these areas with a ventilation system which does not feed the air extracted into the general ventilation system may provide a cheaper, more energy-efficient solution than using high rates of fresh air to cope with smoking throughout. For further guidance on design for good smoking policy, refer to the recently issued code of practice by the Department of the Environment and the Department of Health[54].

(c) Humidity
This Section is based on HSE Specialist Inspectors' Report No 11[56]. Control of work-place humidity may be necessary for a number of reasons. High humidity can cause discomfort, especially at raised temperatures, and may result in excessive condensation. Low humidity causes drying of the body's mucous membranes resulting in eye and nose discomfort and increased risk of respiratory illnesses. Static electricity can become a problem at lower humidities. CIBSE recommends a relative humidity range of 40 to 70%.

In cold weather, air which is drawn into buildings from the outside and then heated to room temperature often has a low humidity. It may be necessary to increase humidity for comfort and health. If the humidifier is allowed to become contaminated with micro-organisms and distribute water droplets, it may itself become a health hazard. Inhalation of contaminated water from humidifiers can cause various illnesses including respiratory infections and allergenic illness. Of these, humidifier fever is the most common.

Cases of humidifier fever in the UK have presented symptoms similar to those of influenza: aching limbs, fever, headache, chest tightness and breathing difficulty. Symptoms usually occur some hours after first exposure, then abate over the next day or so even if exposure continues. If exposure ceases for a period and then recurs, symptoms will reappear. Other illnesses caused by the inhalation of contaminated droplets from humidifiers include infections and allergies such as asthma and extrinsic allergic alveolitis. This is more common in the USA than the UK.

Spray humidification is sometimes used in association with air conditioning in offices. This usually involves spraying water into the air stream as fine droplets with any surplus water falling into a tray beneath the spray heads for re-circulation and re-spraying. Steam humidification, usually electrically driven, avoids the use of drip trays. Free water drops are usually not present unless condensation takes place downstream of the injection point. In general, steam humidification has not been associated with humidifier fever and there is also evidence that the sick building syndrome symptoms are sometimes reduced when steam rather than spray humidification is used. Hot-water humidifiers may also provide a safe means of increasing humidity, but there is some uncertainty about this.

The use of a stream humidifier will always be associated with an increase in energy consumption. This will be included as part of the energy prediction made using the ESICHECK model (see the Section on carbon dioxide production in Chapter 3). The associated additional CO_2 emission would be calculated and included in the total form which the total number of CO_2 credits is derived.

HAZARDOUS MATERIALS

Purpose

To eliminate minor or occasional health risks which are not at present covered by regulations and to reduce the unnecessary use of wood preservatives while maintaining essential protection of vulnerable timber.

Credit requirement

* **1 credit for achieving items (a), (b) and (c) below:**

(a) *Formaldehyde emissions*

- **no specification of urea formaldehyde foam cavity insulation (UFFI), or specification of UFFI in accordance with British Standards BS 8208, BS 5617 and BS 5681; particleboard specified should conform to British Standard BS 5669; medium-density fibreboard specified should conform to British Standard BS 1142.**

(b) *Asbestos*

- **no materials specified containing asbestos.**

(c) *Lead in paint*

- **no paints specified which contain lead.**

(d) *Wood preservatives*

* **1 credit for specifying wood preservative treatments according to the following criteria:**

- **no use of treated timber where it is not recommended in the relevant codes and standards[25,26].**
- **all preserved timber industrially pre-treated ready for finishing on site.**

Method of assessment

(a) *Formaldehyde emissions*

The materials specification must exclude the use of urea formaldehyde foam insulation, or if UFFI is to be used then British Standards BS 8208, BS 5618 and BS 5617 must be specified. If particleboard is to be specified it must conform to BS 5669 and if medium-density fibreboard is to be specified it must conform to BS 1142.

(b) *Asbestos and lead*

The materials specification must show the absence of materials containing asbestos and of paints containing lead.

(c) *Wood preservatives*

Treatment must be in accordance with the approval conditions for the preservative under the Control of Pesticides Regulations [24,27,28]. (See 'Background' for further information.) It is a prerequisite that timber treatment be restricted to the provisions made in the relevant codes and standards[25,26] which are applicable to particular building components.

(a) Formaldehyde emissions
The World Health Organisation[57] reports the threshold of irritation of airborne formaldehyde to be 0.1 mg/m^3 and that symptoms of irritation of the eye and throat occur at levels between 0.3 and 1.0 mg/m^3 in healthy subjects. The odour detection threshold of formaldehyde is 0.06 mg/m^3. Formaldehyde has been classified as possibly causing cancer in human beings by the International Agency for Research on Cancer (IARC) but the evidence available is not sufficient to enable the risk of cancer to be estimated[58].

Formaldehyde is ubiquitous in buildings. It is released from many building materials including chipboards, adhesives and urea formaldehyde foam cavity wall insulation. The concentration of formaldehyde inhaled by office occupants will depend on the rate of emission and on the fresh air ventilation rate. The emission rate cannot be established at the design stage and hence it is not possible to limit the formaldehyde problem by specifying a fresh airflow rate.

Care must be taken to ensure that urea formaldehyde foam insulation is only specified for buildings which are of double-masonry-leaf construction as specified in British Standards BS 8208:Part 1[59] and BS 5618:1985[60]. British Standard BS 5617:1985[61] specifies urea formaldehyde systems suitable for installation. There is no evidence to limit the use of other materials containing formaldehyde employed in the fabric (or furnishings) of office buildings. For example, British Standard BS 5669[62] sets a maximum level of acceptable formaldehyde content for particleboards (25 mg per 100 g of board), but a German standard[63] sets an even lower formaldehyde content (10 mg per 100 g of board). Medium-density fibreboard (MDF) is covered by British Standard BS 1142[64]. Board which satisfies any of these standards would not normally cause any irritation. In fact particleboard is available which it is claimed emits no measurable formaldehyde. Such board uses an isocyanate-based glue; it has good moisture-resistance properties but it is relatively expensive and rarely used indoors. While such advances are to be encouraged, the indoor environment consequences of the changes are not clear at present, and there are probably no substitutes of equivalent performance and economy for particleboards used in construction. It is therefore not advisable to place limits on the use of particleboard at present, but builders are encouraged to specify boards which comply with BSI or DIN Standards.

(b) Asbestos
The use of blue asbestos (crocodilite), brown asbestos (amosite), and products containing them is now prohibited in the UK. The use of white asbestos (chrysotile) and products containing it is permitted although restricted. Today most white asbestos is used in asbestos–cement products and in friction materials. Asbestos is a proven human carcinogen and exposure to high levels of airborne white asbestos fibres in the work place (in asbestos manufacturing) can cause lung cancer. The risk of lung cancer from exposure to the very low levels of airborne fibres normally found in buildings is extremely small — estimated[65] to be between 1 in 100 000 and 1 in a million. However, alternative non-asbestos-fibre reinforced materials are available[66] and their specification may be appropriate for buildings which are designed in response to environmental concerns. Care should be taken in choosing alternatives to asbestos as some other durable fibres may also be harmful. Credit will be given for designs which specify no asbestos.

(c) Lead-based paints
Lead is used in roofing, windows and paints. Under the European Directive on Marketing and Use of Dangerous Substances (EC 76/769)[67], the 8th Amendment in effect prohibits the use of lead paints in new buildings. This passed into UK law in April 1992[68] and covers the use of decorative paints such as those containing lead sulphate and lead carbonate, but does not include lead primers such as red lead and calcium plumbate. BREEAM therefore credits the use of lead-free primers.

(d) Wood preservatives
Wood preservatives are essential to the long-term integrity of some timber components for buildings and other constructions. Indeed wood preservative treatment is widely accepted as the simplest and most economic means of achieving timber durability appropriate to Building Regulations requirements for certain specific components. British Standards BS 5589[25] and BS 5268:Part 5[26] and other specific Codes of Practice give guidance on building components where preservative treatment should be considered in the interests of satisfactory performance in service.

Wood preservative use in the UK is regulated under the Control of Pesticides Regulations 1986 [24]. Under these regulations it is an offence to sell, supply, use, store or advertise wood preservative products without prior approval of Ministers through a process of scrutiny for safety and for effectiveness. This process is operated by the Pesticides Registration Section of the Health and Safety Executive and the Advisory Committee on Pesticides. A list of Approved Products is published annually in a MAFF/HSE Manual (RB500) [27] and additions and amendments are published monthly in *The pesticides register*[28]. Specifiers with particular local criteria can select from this list those products which conform with their special requirements.

Specification of preserved timber for new build should favour pre-treatment because pre-treatment is carried out under controlled conditions by trained specialists. This is preferable to on-site techniques, which are often applied by non-specialist personnel. It also reduces the potential for solvent emissions from treated timber into the building structure following completion. Timber pre-treated in controlled, industrial plants by specialist professional suppliers is readily available or can be ordered for specific construction purposes. This includes structural carcassing timber, battens and cladding boards in addition to exterior joinery components such as windows and doors.

Use of preservative fluids on site can therefore be limited to essential operations only. This would include certain protective decorative finishing and application to cut ends in accordance with published Codes and Standards and the instructions of the suppliers of the treated timber. Such on-site treatments would not prevent the credit being awarded. Contractors will be directed to adhere strictly to the guidance on handling preservative pre-treated wood provided by the treaters or suppliers.

Although wood of suitable natural durability can be specified as an alternative to preservative treatment, with some species there may be cost penalties, engineering consequences and difficulties in obtaining supplies. In particular, should the selection of naturally durable timber lead to an increase in the use of tropical hardwoods, this will present a conflict with environmental concerns for their conservation and more rational use.

LIGHTING

Purpose

To improve the level of visual comfort produced by the lighting of the office.

Credit requirement

* **1 credit for demonstrating that at least 80% of all the area used for office work meets the daylighting criteria set out in Appendix C of the BRE Report *Site layout planning for daylight and sunlight: a guide to good practice*[39] or the CIBSE window design manual[69] or British Standard BS 8206:Part 2 (Code of practice for daylighting)[40]. (The method for calculating the daylight factor can also be found in BRE Information Paper IP15/88[70]).**

* **1 credit for specifying that any fluorescent and other lamps with modulating (fluctuating) output should be fitted with high-frequency ballasts in all the areas used for office work and for ensuring that CIBSE guidelines on horizontal illuminance are followed and that luminaires appropriate to the tasks to be undertaken are used.**

Method of assessment

The design calculations will be checked against criteria set out in Appendix C of the BRE Report *Site layout planning for daylight and sunlight: a guide to good practice*[39] which are taken from the CIBSE window design manual[69], or in British Standard BS 8206:Part 2 (Code of practice for daylighting)[40].

The specification will be checked for luminaires with high-frequency ballasts to be fitted in areas to be used as offices. The horizontal design illuminance will be checked against the CIBSE code for interior lighting[71] and the CIBSE *Lighting Guide LG3: Areas for visual display terminals*[72].

Background

Credit will be given for a design which maximises the effective use of daylight, which most people prefer to artificial light. This will also reduce electricity consumption for lighting. Provision should also be made for protection from unwanted solar heat gain.

Appendix C of the BRE Report *Site layout planning for daylight and sunlight: a guide to good practice*[39], the CIBSE window design manual[69] and British Standard BS 8206:Part 2[40] give guidelines for maximising the use of daylight in buildings. The guidelines specify three criteria for achieving good daylighting indoors:

- the average daylight factor in a room (preferably 5% for a well day-lit office, but at least 2% for a partially day-lit office);
- no significant areas (20% or more) of each room, or any fixed work surfaces or tables, from which the sky cannot be seen from desk height (0.7 m);
- a room depth criterion:

  $d/w + d/h$ to be less than $2/(1-R_B)$

  where d = room depth
  w = width
  h = window head height
  R_B = average reflectance of surfaces in the back half of the room.

In offices, headaches and eyestrain have successfully been reduced when high-frequency ballasts have been substituted for conventional ballasts used in fluorescent lights[73]. Energy consumption due to lighting is covered by the Section on carbon dioxide production in Chapter 3; the credit for high-frequency ballasts is included here as a comfort issue. High-frequency ballasts reduce energy consumption by a small amount, inadequate at present to cover the initial cost in a reasonable period.

A further lighting issue with implications for energy consumption and occupant comfort is that of illuminance. CIBSE recommendations are contained in the CIBSE code for interior lighting[71] and CIBSE *Lighting Guide LG3: Areas for visual display terminals*[72]. The Code recommends 500 lux for general offices. CIBSE Lighting Guide LG3 recommends the range 300–500 lux as a compromise between the illuminance necessary for reading paper documents, often of poor quality, and the most comfortable illuminance for operating the visual display terminal (vdt). Where tasks are mainly screen-based the illuminance should be towards the bottom of the range; where tasks are mainly document-based the illuminance should be towards the top of the range. The CIBSE Lighting Guide LG3 also gives recommendations for both down-lighting and up-lighting to avoid unacceptable reflections on vdt screens. For down-lighting, three categories of luminaire are defined: categories 1, 2 and 3 have a luminance limitation above 55°, 65° and 75° respectively to the downward vertical. Category 1 luminaires should be used where there is a high density of screens in an area and screen usage is sustained over long periods or is of an intensive nature. Category 2 luminaires should be used in areas where fairly widespread use of screens is intended, eg one terminal per desk for general usage or a few terminals used continuously. Category 3 luminaires should be used where the task makes only casual use of the vdt and the density of screens within an area is relatively low.

THERMAL COMFORT AND OVERHEATING

Purpose

To minimise the risk of discomfort due to overheating of buildings.

Credit requirement

∗ 1 credit for demonstrating that a building design has been subject to an assessment consistent with the CIBSE Guide, Volume A[50].

Method of assessment

Sections A5, A8 and A9 of CIBSE Guide, Volume A[50] provide a method for calculating internal summer-time temperatures. An example of a suitable model is the BRE computer program BRE-ADMIT[74] which is based on this method. If the designer does not use BRE-ADMIT and the design includes an option for variable ventilation (eg free night-time cooling), the more comprehensive calculation outlined in Section A5 should be used. The designer must show that an assessment has been made and is consistent with the CIBSE Guide, Volume A[50].

Background

The avoidance of overheating is an important consideration in the design of a building. The use of air conditioning (and, to some extent, mechanical ventilation without cooling) can provide solutions to the problem of overheating due to excessive solar or internal gains. But the need for air conditioning may be avoided by appropriate design. For example, thermal mass may be used with night-time ventilation to control internal temperatures. External continental-style shutters or deep reveals can be used to control solar gain. High internal heat gains such as from photocopiers can be concentrated into a room with fans to extract the heat. Information concerning design methods for avoiding overheating may be found in the CIBSE Guide, Volume A[50], and the BRE *Environmental design manual*[75]. If as a result of the calculation a decision is made to reduce the glazing area of the building, the issue of daylighting provision may need to be revisited.

Thermal comfort is defined as 'that condition of mind which expresses satisfaction with the thermal environment'[76]. Twenty years of research has resulted in the development of recommendations which enable the comfort of occupants to be assessed. Further research has examined the effects of discomfort on people. The general rule is that conditions of optimal thermal comfort result in the best conditions for performance and well-being.

Various studies have shown that overheating can increase the number of sick building syndrome (SBS) type symptoms (eg headaches, lethargy, irritated eyes, itchy skin) and dissatisfaction with the indoor air quality[77]. The number of accidents in the working environment has also been shown to be related to excessive heat[78].

Many studies have shown that at adverse room temperatures (ie greater than 30°C) both mental performance and productivity are reduced but these effects are not so clear in less extreme conditions (26–30°C). The faculties affected include reading speed and comprehension, concentration span, logical thinking, and writing speed[77]. In overheated conditions the occupants may also become irritable or conversely feel drowsy with the onset of fatigue more rapid[78]. Physical as well as mental performance is affected by heat; one study[79] found that physical performance was reduced by 10% at 29°C and 22% at 32°C.

Extreme overheating causes heat stress due to the body not being able to thermo-regulate. Moreover less severe but significant problems with overheating may result. Thus at higher temperatures human beings perspire more, increasing body odour, whereas building materials may produce higher emissions of substances such as formaldehyde and benzene.

INDOOR NOISE

Purpose

To achieve a comfortable noise climate.

Credit requirement

* 1 credit for noise levels at or below the following values:
  - private offices and small conference rooms — 40 dB $L_{Aeq,T}$
  - large offices — 45 dB $L_{Aeq,T}$

Method of assessment

Calculations shall be made by the design team in terms of $L_{Aeq,T}$ (see British Standard BS 8233:1987[80]), where T is the length in hours of the normal working day. Noise from all sources which are not under the control of the occupant shall be considered, eg noise from traffic (a site measurement will be necessary) and building services (obtained from manufacturer's literature). If windows are to be used for ventilation should be assumed in the calculations that they are open. Sufficient numbers of calculations shall be made to ensure that the requirements are met in all the offices.

Background

$L_{Aeq,T}$ is the 'equivalent steady level' of a fluctuating noise, ie a logarithmic average of the A-weighted level over the period of time T. Noise is a frequent cause of complaint in office buildings and can be distracting. However, in open-plan areas low noise levels can result in a lack of acoustic privacy and a balance must be struck. The credited noise levels are based on the intrusive noise levels used for building design given in British Standard BS 8233:1987 (Sound insulation and noise reduction for buildings)[80].

Appendix A
Summary of issues to be assessed

Global issues and use of resources

Carbon dioxide production due to energy consumption

* 1 credit for carbon dioxide production of less than 120 kg/m^2 per year.

* 2 credits for carbon dioxide production of less than 110 kg/m^2 per year.

* 3 credits for carbon dioxide production of less than 100 kg/m^2 per year.

  120–90 kg/m^2 per year. This includes most average energy targets for office designs including the EEO and CIBSE 'fair' energy targets for naturally ventilated offices and is very good for air-conditioned buildings.

* 4 credits for carbon dioxide production of less than 90 kg/m^2 per year.

* 5 credits for carbon dioxide production of less than 80 kg/m^2 per year.

  90–70 kg/m^2 per year. This encompasses buildings designed to meet the 'good' energy targets of the EEO and CIBSE and represents an excellent air-conditioned building.

* 6 credits for carbon dioxide production of less than 70 kg/m^2 per year.

* 7 credits for carbon dioxide production of less than 60 kg/m^2 per year.

  70–50 kg/m^2 per year. This represents very good design for a naturally ventilated building.

* 8 credits for carbon dioxide production of less than 50 kg/m^2 per year.

  50–40 kg/m^2 per year. This represents excellent low-energy design, for example the BRE low-energy office.

* 9 credits for carbon dioxide production of less than 40 kg/m^2 per year.

* 10 credits for carbon dioxide production of less than 35 kg/m^2 per year.

  Less than 40 kg/m^2 per year. This will be difficult to accomplish. Nevertheless it is possible and represents an advance on the achievement of the BRE low-energy office designed some fifteen years ago.

Acid rain

* 1 credit for specifying boilers which are fitted with reduced-NO_x emitting burners and which emit NO_x at a rate no higher than 200 mg/kWh of delivered energy.

Ozone depletion due to CFCs, HCFCs and halons

(a) Refrigerants in air conditioning

* 1 credit for specifying refrigerants with ozone depletion potential of 0.06 or less (or no air conditioning).

* 1 credit for specifying refrigerants with ozone depletion potential of 0.03 or less (or no air conditioning).

* 1 credit for specifying refrigerants with ozone depletion potential of zero (or no air conditioning).

(b) Reduction of CFC and HCFC leakage

* 1 credit for specifying refrigerant leak detection (or no air conditioning).

* 1 credit for specifying provision of a suitable refrigerant recovery unit and containers (or no air conditioning).

(c) Avoidance of the use of halons

* 1 credit for specifying no halons in either fixed or hand-held fire-fighting equipment.

(d) Insulation materials made only with agents of zero ozone depletion potential

* 1 credit for specifying thermal insulants in building fabric and services made only from materials with zero ozone depletion potential.

Natural resources and recycled materials

* 1 credit for specifying solid timber which is entirely EITHER from well managed, regulated sources OR suitable re-used timber.

* 1 credit for specifying timber panel products which are entirely EITHER from well managed, regulated sources OR suitable re-used timber.

* 1 credit for specifying one or more of the following:

  - suitable uncontaminated demolition materials wherever appropriate in fill and hardcore and/or granular road base.

  - crushed concrete aggregate complying with the quality and grading requirements of British Standard BS 882[17] for use in concrete for foundations, over-site slabs, hardstanding, paths or site roads.

* 1 credit for specifying one or more of the following:

  - at least 50% (by volume) of materials in the walls to contain more than 50% (by volume) of waste material or by-products such as pulverised-fuel ash or blastfurnace slag.

  - at least 50% (by volume) of materials in the flooring to contain more than 50% (by volume) of waste material or by-products such as pulverised-fuel ash or blastfurnace slag.

  - at least 50% (by volume) of any masonry material in walls (eg brick, concrete block and stone) to be made from recycled or re-used material, and guaranteed fit for its purpose.

Storage of recyclable materials

* 1 credit for designs which incorporate separate storage space for recyclable materials.

Local issues

Legionnaires' disease arising from wet cooling towers

* 1 credit for achieving one of the following:

  - no air conditioning; or

  - air conditioning without wet cooling towers; or

- air conditioning with wet cooling towers designed to the specification described in CIBSE TM13[31].

Local wind effects

* 1 credit for designs which satisfy one of the following conditions:

  - the frequency of exceeding wind levels of 4 or more on the Beaufort scale is limited to 10% or less in an urban environment.
  - the design building is surrounded by others of equal or greater height and does not itself exceed a height of 30 m.
  - the frequency of exceeding wind levels of 4 or more on the Beaufort scale is limited to 20% or less in a rural environment.
  - a wind-tunnel study or other suitable wind assessment demonstrates that the wind environment around the base of the building will be acceptable.

Noise

* 1 credit for a design for which calculations show that the rating level outside the nearest exposed residential building is not less than 5 dB below the background level during any period of the day or evening (07.00 to 23.00 h), and does not exceed the background level during any period of the night (23.00 to 07.00 h).

Overshadowing of other buildings and land

* 1 credit for buildings which do not cause substantial overshadowing of neighbouring properties as defined above, or which do not cause an existing situation to deteriorate.

Water economy

* 1 credit for specifying all WCs with a maximum flushing capacity of 6 litres or less.

Ecological value of the site

* 1 credit for the re-use of sites which have previously been built upon or reclaimed from industrial processes or landfill.

* 1 credit for building on land which meets defined criteria for low ecological value or, in the case of ecologically valuable land, designing in compliance with recommendations from an audit by the RSNC (Royal Society for Nature Conservation — The Wildlife Trusts Partnership) or recognised by them in order to minimise ecological damage.

* 1 credit for designing-in features for positive enhancement of the site ecology in accordance with advice from the RSNC.

Cyclists' facilities

* 1 credit for designing-in secure points to allow for a minimum 10% of staff to lock bicycles adjacent to the building, sheltered from rain and snow. The design should allow one wheel and the frame to be secured together. In addition at least two of the following features should be provided:

  - changing facilities for cyclists;
  - space for drying wet clothes;
  - showers for cyclists.

Indoor issues

Legionnaires' disease from domestic water systems

∗ 1 credit for domestic water systems that meet the specifications listed in CIBSE TM13[31].

Ventilation, passive smoking and humidity

∗ 1 credit for the provision of openable windows, and if air conditioning or mechanical ventilation is to be used to service the inner core of a deep-plan building, this should be designed in accordance with CIBSE recommended ventilation rates[50].

∗ 1 credit for designs which include separately ventilated areas for smokers, or which specify no smoking to be allowed in the building.

∗ 1 credit for specifying or designing for steam-based humidifier systems, paying attention to condensation control inside the air distribution system (if humidification is required), or for specifying no humidification.

Hazardous materials

∗ 1 credit for achieving items (a), (b) and (c) below:

(a) Formaldehyde emissions

- no specification of urea formaldehyde foam cavity insulation (UFFI), or specification of UFFI in accordance with British Standards BS 8208, BS 5617 and BS 5681; particleboard specified should conform to British Standard BS 5669; and medium-density fibreboard specified should conform to British Standard BS 1142.

(b) Asbestos

- no materials specified containing asbestos.

(c) Lead in paint

- no paints specified which contain lead.

(d) Wood preservatives

∗ 1 credit for specifying wood preservative treatments according to the following criteria:

- no use of treated timber where it is not recommended in the relevant codes and standards[25,26].
- all preserved timber industrially pre-treated ready for finishing on site.

Lighting

∗ 1 credit for designing 80% of all the area used for office work to meet the daylighting criteria set out in Appendix C of the BRE Report *Site layout planning for daylight and sunlight: a guide to good practice*[39] or the CIBSE window design manual[69] or British Sandard BS 8206:Part 2 (Code of practice for daylighting)[40]. (The method for calculating the daylight factor can also be found in BRE IP15/88[70]).

∗ 1 credit for specifying that any fluorescent and other lamps with modulating (fluctuating) output should be fitted with high-frequency ballasts in all the areas used for office work and for ensuring that CIBSE guidelines on horizontal illuminance are followed and that luminaires appropriate to the tasks to be undertaken are used.

Thermal comfort and overheating

* 1 credit for demonstrating that a building design has been subject to an assessment consistent with the CIBSE Guide, Volume A[50].

Indoor noise

* 1 credit for noise levels at or below the following values:

- private offices and small conference rooms — 40 dB $L_{Aeq,T}$
- large offices — 45 dB $L_{Aeq,T}$

Appendix B
Issues to be considered in future versions of BREEAM/New Offices

There are many issues which are relevant to buildings and the environment which have not been included in the current version of BREEAM/New Offices. There are three main reasons for their exclusion: that no clear improvement on current regulations could be defined, that there was insufficient evidence that a problem exists or that there was no satisfactory way of dealing with a particular issue at the design stage. It is also likely that the issues currently included in BREEAM/New Offices could be addressed more rigorously in the future. The following list covers these and other issues which could be included in BREEAM/New Offices in due course.

Global issues and use of resources

- The greenhouse gases released during fuel extraction, processing and distribution, eg methane released in the ventilation air of coal mines, oil extraction and gas distribution.
- The energy (and associated carbon dioxide emission) content of building materials.
- The energy used on building sites during construction and fuel used to transport people and materials to and from the site.
- Energy used during maintenance, refurbishment and eventual demolition.
- The use of renewable energy sources.
- Development and use of a CO_2 emission factor for off-peak electricity.
- Design for air infiltration rates below 0.3 air changes per hour for the improvement of ventilation control and energy efficiency. (Need to cater for night-time free cooling.)
- The use of combined heat and power schemes (CHP) or waste heat from industrial processes.
- Design of appropriate control systems for heating and cooling, with respect to the quality of the operator.
- Design for provision of several fuel meters at different locations to aid future targeting exercises (eg catering areas, computer suites, equipment rooms, big fans, lifts, humidifiers, chilled water and condenser pumps).
- Purchase of electricity from specific sources (eg hydroelectric power in Scotland, and refuse combustion in Sheffield).
- Documentation and local tagging of all control/services settings established at commissioning which are critical to environmentally friendly operation.
- Design for manageability, and the provision of an operating manual.
- Design of building and systems for easy maintenance.
- Robustness of design, allowing the building to remain energy efficient and environmentally friendly as it is adapted/refurbished during its life.
- Use of materials from suppliers that have not breached permitted discharge consents within the previous two years.

- Environmental consequences of obtaining and processing the materials used for the building.
- Specification of alternative wood species for standard building applications.
- Choice of materials for durability.
- Design to facilitate the recycling or re-use of building components.
- Avoidance of waste in the construction process due to specifying materials unnecessarily.

Local issues

- Pollutant release during demolition.
- Sunlight reflection from the building facade.
- External appearance, aesthetics.
- Location and provision of nearby public transport.
- Localised self-contained (or efficient) sewage treatment.
- Microclimate effects provision of wind shelter, noise shielding and shading by planting.
- Interference in television/radio reception due to tall buildings in the path of transmitted signals.
- Heritage values of archaeological sites.
- Economising taps, spray taps, foot control taps.
- Encouraging the use of contaminated land for building.

Indoor issue

- Pollutant release during fire.
- Internal environmental parameters such as electromagnetic radiation, negative ions and air speed.
- Organic gases and vapour emitted from building materials.
- Ventilation effectiveness.
- Occupant-controlled ventilation systems.
- Lighting levels and other aspects of lighting, eg glare, colour and veiling reflections.
- Airborne particulates and organisms, including moulds (arising as a consequence of gross errors of design or construction) and dust mites (arising from normal use of the building), but not including Legionnaires' disease dealt with as an issue in the main text.
- Pest control.
- Indoor environmental monitoring equipment.
- Radon emissions into the building.
- Use of hot-water humidifiers — assessment of health hazards compared with energy requirements, to be carried out as part of decision to install steam-based or other types of humidifier.

- Avoidance of solvent-based paints.

- Thermal comfort — it is intended that future updates of BREEAM/New Offices will include specification of appropriate standards for achievement of thermal comfort conditions.

- Sick building syndrome (SBS) has emerged as a problem in recent years, not only in the UK but also in most western industrialised countries[80]. Many possible causes of SBS have been researched with explanations focusing on air quality in relation to heating, ventilation and air conditioning, lighting quality, noise, office layout, and personal control of the indoor environment. Much progress has been made during the last two years, but insufficient as yet to allow either a consensus to be developed on the issues to be included, or adequate assessment methods to be developed for identified issues at the design stage.

Appendix C
Default values used in the calculation of CO_2 emissions by ESICHECK

Description	Data
Percentage of floor area which is open-plan space	40% (narrow plan) 80% (deep plan)
Average building winter design temperature	19.5°C (narrow plan) 20.0°C (deep plan)
External winter design temperature	–3°C
Average building summer design temperature for the cooling load calculations	22°C (air condition) 28°C (natural ventilation)
Percentage of gross area occupied by dealers	0%
Is the ground floor carpeted? Yes or No	(Y)
Are intermediate floors carpeted? Yes or No	(Y)
Occupation period (hours per day)	9 hours
Start time of occupation period	09.00 hours GMT
Occupation days per week	5
Is the heating or cooling system continuously operated?	No
Occupation density in m^2 per person	15.0 (narrow plan) 11.25 (deep plan)
Ventilation rate	1.3 air changes per hour
If mechanically ventilated, how many hours of operation?	9 hours
Amount of small power to be used	5–6 W/m^2
Would visual display units made before 1986 be used?	No
Number of hours per day that the fans, pumps and heating system operate AFTER the normal hours of occupation	0 hours
Is the pre-heat capacity sufficient to pre-heat the building in a short period of time?	Yes No (if storage heaters are used)
Power factor	0.9

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