HM Government

Non-Domestic Building Services Compliance Guide

2010 Edition

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Section 1

Introduction

> **Note:**
> Any reference to building regulations in this guide is to building regulations in England,Wales, Scotland and Northern Ireland.

1.1 Scope

This guide provides detailed guidance for persons installing fixed building services in new and existing non-domestic buildings to help them comply with building regulations. It covers work on both new systems and replacement systems, identifying the differing requirements where these exist.

This edition of the guide covers conventional means of providing primary space heating, domestic hot water, mechanical ventilation, comfort cooling and interior lighting. In addition, it covers low carbon generation of heat by heat pumps and combined heat and power systems.

The guide also refers to publications which include information on good practice for design and installation over and above the recommended minimum standards in this guide.

1.2 Innovative systems

It is important to note that this guide covers a range of frequently occurring situations. It deals with the most commonly used fixed building services technologies. In doing so it neither endorses these methods and technologies nor excludes other more innovative technologies.

Innovative technologies are not excluded from the compliance process and alternative means of achieving compliance with the functional requirements of building regulations may be possible. Where the technology has been the subject of a recognised testing procedure that assesses its energy performance, this may be used to indicate that the system is adequately efficient.

In the event that there is no recognised testing standard, suitable calculations or modelling methods may be used to show the carbon performance of the system.

1.3 European Directives

Fixed building services products such as boilers, circulators and heat pumps shall at the appropriate time comply with all relevant requirements of EU Directives, including the Eco-design of Energy Using Products (EuP) Framework Directive 2005/32/EC and Directive 2009/28/EC on the Promotion of the Use of Energy from Renewable Sources (Renewable Energy Directive).

1.4 Status of guide

Building regulations contain functional requirements (called standards in Scotland), such as requirements that buildings must be structurally stable, must be constructed and fitted to ensure reasonable levels of fire protection, and must be reasonably energy efficient. These functional requirements are often drafted in broad terms, and so it may not always be immediately clear to a person carrying out work how to comply with the relevant requirements. Consequently, documents are often issued which provide practical guidance on ways of complying with specific aspects of building regulations in some of the more common building situations. Those documents are called Approved Documents in England and Wales, Technical Handbooks in Scotland and Technical Booklets in Northern Ireland.

Approved Documents, Technical Handbooks and Technical Booklets are intended to provide practical guidance but they are not intended to be comprehensive. Consequently, they may contain references to other documents which will provide more detailed information and assistance on parts of the guidance. This guide is one of those documents. It provides more detailed information on the guidance contained in Approved Documents L2A and L2B, Section 6 of the Non-Domestic Technical Handbook, and Technical Booklet F2 about compliance with the energy efficiency requirements which apply when installing fixed building services in new and existing buildings.

Note: Following guidance in an Approved Document, Technical Handbook or Technical Booklet does not guarantee compliance with building regulations. If you follow the relevant guidance in an Approved Document, Technical Handbook or Technical Booklet and in any document referred to (such as this guide) which provides additional information to help you follow that guidance, there is a legal presumption that you have complied with building regulations. However, in every case it is for the building control body to decide whether work complies with building regulations. So, you should always check with the building control body before you start work what they consider it is necessary for you to do to comply with building regulations.

1.5 How to use the guide

The guide is divided into the following sections:

- Section 1: Introduction and summary of requirements
- Section 2: Gas, oil and biomass-fired heating
- Section 3: Heat pumps
- Section 4: Gas and oil-fired warm air heating
- Section 5: Gas and oil-fired radiant heating
- Section 6: Combined heat and power and community heating
- Section 7: Direct electric heating
- Section 8: Domestic hot water
- Section 9: Comfort cooling
- Section 10: Air distribution systems
- Section 11: Pipework and duct insulation
- Section 12: Interior lighting
- Section 13: Heating and cooling system glandless circulators and water pumps

For each building service, the guide sets out recommended minimum energy efficiency standards for compliance with building regulations. Table 1 below presents a summary of the requirements.

The guide identifies building services parameters needed by National Calculation Methodology (NCM)[1] tools such as SBEM[2] to calculate carbon dioxide emissions from new buildings.

In relevant sections, the guide identifies additional non-prescriptive measures that can be used to improve plant efficiency, and thus gain "heating efficiency credits" to help meet minimum recommended efficiency standards or the carbon dioxide emission targets.

[1] The National Calculation Methodology modelling guide can be downloaded from www.communities.gov.uk/publications/planningandbuilding/ncmmodellingguide.

[2] The Simplified Building Energy Model (SBEM) tool can be downloaded from www.2010ncm.bre.co.uk.

"Supplementary information" that may help with interpreting the minimum energy efficiency provisions needed to comply with the Building Regulations is in *italic font with a grey background*. In some cases there are links to best practice guidance that goes beyond the recommended minimum requirements.

Key terms are defined at appropriate points throughout the guide. In the text they are shown in ***italic bold font***.

1.6 Key terms for space heating and domestic hot water systems

The following general definitions are applicable to the sections that deal with space heating and hot water. Further definitions are included in later sections as appropriate.

Heat generator means a device for converting fuel or electricity into heat, e.g. a boiler or radiant heater.

Heat generator efficiency means the ratio of useful heat output to energy input in the fuel (based on gross calorific value) or electricity delivered to the ***heat generator***, as determined by the appropriate test methods for that type of ***heat generator***.

Heat generator seasonal efficiency means the estimated seasonal ratio of heat output from the ***heat generator*** to heat input. This will depend on the ***heat generator efficiency*** and the operating mode of the ***heat generator*** over the heating season. For example, in the case of boilers it is a "weighted" average of the efficiencies of the boiler at 30 and 100 per cent of the boiler output. For other technologies the ***heat generator seasonal efficiency*** may be the same as the ***heat generator efficiency***.

Minimum controls package means a package of controls specific to each technology that represents the recommended minimum provision necessary to meet building regulation energy efficiency requirements.

Additional measures means additional controls or other measures that go beyond the recommended ***minimum controls package*** and for which ***heating efficiency credits*** are available.

Heating efficiency credits are awarded for the provision of ***additional measures***, such as additional controls, that raise the energy efficiency of the system and go beyond recommended minimum standards. Different credits apply to the different measures that are available for heating and hot water technologies.

Effective heat generator seasonal efficiency is obtained by adding ***heating efficiency credits***, where applicable, to the ***heat generator seasonal efficiency***:

Effective heat generator seasonal efficiency =
Heat generator seasonal efficiency + heating efficiency credits **Equation 1**

Where relevant, this guide sets standards for ***effective heat generator seasonal efficiency*** so that a ***heat generator*** with an inherently low efficiency may be used in combination with ***additional measures***.

Space heating system means the complete system that is installed to provide heating to the space. It includes the heating plant and the distribution system by which heating is delivered to zones. Heat losses from the distribution system can be addressed by reference to guidance by TIMSA on HVAC insulation[3].

Domestic hot water system means a local or central system for providing hot water for use by building occupants.

1.7 Energy efficiency standards for compliance with building regulations – summary table

To assist compliance with the relevant energy efficiency requirements in building regulations, this guide sets out recommended minimum energy efficiency standards for space heating, domestic hot water, cooling, ventilation, lighting and microgeneration systems. They are summarised in Table 1 below.

The sections that follow Table 1 give guidance on how to meet these standards.

It is important to note that many of these recommended minimum standards will need to be exceeded if the building regulations target carbon dioxide emission rate (TER) for new buildings is to be met.

[3] TIMSA *HVAC guidance for achieving compliance with Part L of the Building Regulations* at www.timsa.org.uk.

Table 1: Summary of recommended minimum energy efficiency standards for building services

Building service		**Standard[4]**
Gas, oil and biomass-fired boilers (a) New buildings		**Boiler seasonal efficiency (gross[5])**
Natural gas	Single boiler system	86%
	Multiple-boiler system	82% for any individual boiler 86% for the overall multi-boiler system
LPG	Single boiler system	87%
	Multiple-boiler system	82% for any individual boiler 87% for the overall multi-boiler system
Oil	Single boiler system	84%
	Multiple-boiler system	82% for any individual boiler 84% for the overall multi-boiler system
Biomass – independent automatic pellet/ woodchip		75%
Gas, oil and biomass-fired boilers (b) Existing buildings		**Effective boiler seasonal efficiency (gross)**
Natural gas		84%
LPG		85%
Oil		86%
Biomass – independent automatic pellet/ woodchip		75%
Heat pump systems		**CoP (Heat generator efficiency)**
All types (except absorption heat pumps and gas-engine heat pumps) for space heating		2.2 (220%) when operating at the rating conditions[6]
All types (except absorption heat pumps and gas-engine heat pumps) for domestic hot water heating		2.0 (200%) when operating at the rating conditions
Absorption heat pumps		0.5 (50%) when operating at the rating conditions
Gas-engine heat pumps		1.0 (100%) when operating at the rating conditions

[4] All values are minimum values and apply to new and existing buildings, except where stated.

[5] Efficiency is heat output divided by calorific value of fuel. The net calorific value of a fuel excludes the latent heat of water vapour in the exhaust, and so is lower than the gross calorific value. Efficiency test results and European standards normally use net calorific values. SAP 2009 (at www.bre.co.uk/sap2009), which uses gross values, gives factors in Table E4 for converting net efficiency to gross efficiency (e.g. 0.901 for natural gas, 0.921 for LPG, 0.937 for oil).

[6] Rating conditions – standardised conditions provided for the determination of data presented in BS EN 14511:2007 *Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling*.

Table 1: Summary of recommended minimum energy efficiency standards for building services *(continued)*

Building service		**Standard**[4]	
Heat pump systems (BS EN 15450:2007 Tables C1 & C2)		**Seasonal performance factor**	
		New build	**Retrofit**
Air/water		2.7	2.5
Ground/water		3.5	3.3
Water/water		3.8	3.5
Gas and oil-fired warm air systems		**Thermal efficiency (net)**	
Gas-fired forced convection (natural gas)		91%	
Gas-fired forced convection (LPG)		91%	
Direct gas-fired forced convection		100%	
Oil-fired forced convection		91%	
Radiant heaters		**Efficiency (net)**	
		Thermal	**Radiant**
Luminous radiant heater (unflued)		86%	55%
Non-luminous radiant heater (unflued)		86%	55%
Non-luminous radiant heater (flued)		86%	55%
Multi-burner radiant heater		91%	N/A
CHP		**CHPQA quality index**	**Power efficiency**
All types		105	20%
Electric (primary) heating		**Seasonal efficiency**	
Boiler		N/A	
Warm air		N/A	
Domestic hot water systems		**Thermal efficiency (gross)**	
Direct-fired	Natural gas	73%	
	LPG-fired	74%	
	Oil-fired	75%	
Indirect-fired (dedicated hot water boiler)	Natural gas	80%	
	LPG-fired	81%	
	Oil-fired	82%	
Electric DHW heaters	Electricity	100%	

Table 1: Summary of recommended minimum energy efficiency standards for building services *(continued)*

Building service	Standard[4]
Comfort cooling systems	**Energy efficiency ratio (EER)**
Packaged air conditioners – single duct types	2.5
Packaged air conditioners – other types	2.5
Split and multi-split air conditioners	2.5
Variable refrigerant flow systems	2.5
Vapour compression cycle chillers, water cooled <750 kW	3.85
Vapour compression cycle chillers, water cooled >750 kW	4.65
Vapour compression cycle chillers, air cooled <750 kW	2.5
Vapour compression cycle chillers, air cooled >750 kW	2.6
Water loop heat pump	3.2
Absorption cycle chillers	0.7
Gas engine driven variable refrigerant flow	1.0
Air distribution systems (a) New buildings	**Specific fan power (max)[7]**
Central mechanical ventilation system including heating and cooling	1.8 W/(l/s)
Central mechanical ventilation system including heating only	1.6 W/(l/s)
All other central mechanical ventilation systems	1.4 W/(l/s)
Zonal supply system where the fan is remote from the zone, such as ceiling void or roof mounted units	1.2 W/(l/s)
Zonal extract system where the fan is remote from the zone	0.6 W/(l/s)
Zonal supply and extract ventilation units such as ceiling void or roof units serving a single room or zone with heating and heat recovery	2.0 W/(l/s)
Local supply and extract ventilation system such as wall/roof units serving a single area with heating and heat recovery	1.8 W/(l/s)

7 Maximum pressure drop is not specified.

Table 1: Summary of recommended minimum energy efficiency standards for building services *(continued)*

Building service	Standard[4]
Local supply or extract ventilation units such as window/wall/roof units serving a single area (e.g. toilet extract)	0.4 W/(l/s)
Other local ventilation units	0.6 W/(l/s)
Fan-assisted terminal VAV unit	1.2 W/(l/s)
Fan coil units (rating weighted average)	0.6 W/(l/s)
Air distribution systems (b) Existing buildings	**Specific fan power (max)**
Central balanced mechanical ventilation system including heating and cooling	2.2 W/(l/s)
Central balanced mechanical ventilation system including heating only	1.6 W/(l/s)
All other central balanced mechanical ventilation systems	1.8 W/(l/s)
Zonal supply system where the fan is remote from the zone, such as ceiling void or roof mounted units	1.5 W/(l/s)
Zonal extract system where the fan is remote from the zone	0.6 W/(l/s)
Zonal supply and extract ventilation units such as ceiling void or roof units serving a single room or zone with heating and heat recovery	2.0 W/(l/s)
Local balanced supply and extract ventilation system such as wall/roof units serving a single area with heating and heat recovery	1.8 W/(l/s)
Local supply or extract ventilation units such as window/wall/roof units serving a single area (e.g. toilet extract)	0.5 W/(l/s)
Other local ventilation supply and/or extract units	0.6 W/(l/s)
Fan-assisted terminal VAV unit	1.2 W/(l/s)
Fan coil units (rating weighted average)	0.6 W/(l/s)
Air distribution systems	**Dry heat recovery efficiency**
Plate heat exchanger	50%
Heat pipes	60%
Thermal wheel	65%
Run around coil	45%

Table 1: Summary of recommended minimum energy efficiency standards for building services *(continued)*

Building service	Standard[4]
Internal lighting	**Lighting efficacy**
General lighting in office, storage and industrial areas	55 luminaire lumens per circuit-watt
General lighting in other types of space other than office areas	55 lamp lumens per circuit-watt
Display lighting	22 lamp lumens per circuit-watt

Section 2

Gas, oil and biomass-fired boilers

2.1 Introduction

This section provides guidance on specifying gas, oil and biomass-fired space heating systems for new and existing buildings to meet relevant energy efficiency requirements in building regulations. It covers relevant boiler types, and describes measures – such as the use of better controls – to gain ***heating efficiency credits*** to improve the ***effective heat generator seasonal efficiency***.

2.2 Scope of guidance

The guidance applies to wet central heating systems using commercial boilers fired by:

- natural gas
- liquid petroleum gas (LPG)
- oil, and
- biomass.

The guidance in this section does not cover:

- steam boilers (these are used primarily for processes, rather than provision of space heating), or
- electric boilers (for which see Section 7).

2.3 Key terms

The terminology used to describe efficiencies for boiler systems is detailed below. In this section the ***heat generator*** is a boiler.

Biomass means all material of biological origin, excluding material embedded in geological formations and transformed to fossil fuel.

Boiler efficiency means the energy delivered by the water as it leaves the boiler (or boilers in multi-boiler installations) to supply the heat emitters, divided by the energy (based on gross calorific value) in the fuel delivered to the boiler, expressed as a percentage. It is an expression of the boiler's performance and excludes energy used by boiler auxiliary controls, pumps, boiler room ventilation fans, mechanical flue extraction fans and fan dilution systems. The ***boiler efficiency*** is measured according to the standards that are used to demonstrate compliance with the Boiler Efficiency Directive[8].

Effective boiler seasonal efficiency is the ***boiler seasonal efficiency*** (as calculated by Equation 2 below for individual boilers, or by Equation 3.1 for multiple boilers) plus any applicable ***heating efficiency credits***.

Economiser means a device, including a secondary heat exchanger fitted on or near to a boiler, which provides additional heat transfer capacity. For the purpose of this guide, any boiler which will be supplied with an ***economiser*** should have the ***economiser*** fitted when the ***boiler efficiency*** is tested according to the standards that are used to demonstrate compliance with the Boiler Efficiency Directive. The effect of this on the ***boiler efficiency*** at 30 per cent and 100 per cent of the boiler output may be taken into account in the values used for the calculation of the ***boiler seasonal efficiency*** using Equations 2 or 3.1 or the three-step method and Equations 3.2 and 3.3, as appropriate.

Condensing boiler means a boiler that offers a higher energy efficiency by recovering heat from the flue gases. This is achieved by increasing the heat exchanger surface area, which recovers extra sensible heat whenever the boiler fires. The boiler becomes even more efficient when system water temperatures are low because the larger heat exchanger area promotes condensation, allowing much of the latent heat to be recaptured. Standing losses (when the boiler is not firing) are low and part load performance is very good. In multiple-boiler systems, condensing boilers can be used as the lead boiler.

Standard boiler means, in the context of this document, a non-condensing boiler.

Zone control means independent control of rooms or areas within buildings that need to be heated to different temperatures at different times. Where several rooms or areas of a building behave in a similar manner, they can be grouped together as a "zone" and put on the same circuit and controller.

Sequence control enables two or more heating boilers to be switched on or off in sequence when the heating load changes. This maximises the efficiency of the boilers, so reducing fuel consumption, and reduces wear and tear on the boilers.

8 Council Directive 92/42/EEC (the Boiler Efficiency Directive) relates to the efficiency requirements for new hot water boilers fired with liquid or gaseous fuels. The associated UK legislation is the Boiler (Efficiency) Regulations 1993 (SI 1993/3083), amended by the Boiler (Efficiency) (Amendment) Regulations 1994 (SI 1994/3083).

Direct acting weather compensation is a type of control that enables a ***heat generator*** to work at its optimum efficiency. The control allows the boiler to vary its operating flow temperature to suit weather conditions and the temperatures inside the building. Weather compensation relies on communication between an external sensor and one inside the boiler. The boiler's water flow temperature is varied accordingly, so that energy is not wasted by the boiler turning on and off.

Weather compensation via a mixing valve is similar to ***direct acting weather compensation*** except that the temperature of water supplied to the heat emitters is controlled by mixing the boiler flow and return rather than by altering the boiler temperature.

Optimum start is a control system or algorithm which starts plant operation at the latest time possible to achieve specified conditions at the start of the occupancy period.

Optimiser is a control system employing an ***optimum start*** algorithm.

Optimum stop is a control system or algorithm which stops plant operation at the earliest possible time such that internal conditions will not deteriorate beyond preset limits by the end of the occupancy period.

Two-stage burner control is a type of control that offers two distinct boiler firing rates.

Multi-stage burner control is a type of control that offers more than two distinct firing rates, but without continuous adjustment between firing rates.

Modulating burner control is a type of control that provides a continuously variable firing rate, which is altered to match the boiler load over the whole turndown ratio.

Decentralisation means the replacement of centralised boiler plant and its associated distribution pipework with several smaller, more accurately sized boiler plants, installed within or adjacent to the buildings or systems they serve. This eliminates long pipe runs between buildings or through unheated areas, so reducing heat losses.

Building management system (BMS) means a building wide network which allows communication with and control of items of HVAC plant (and other building systems) from a single control centre, which may be local or remote. More advanced ("full") building management systems offer a wide range of functions, including ***sequential control***, ***zone control***, ***weather compensation***, frost protection and night set-back, as well as monitoring and targeting.

2.4 Determining boiler seasonal efficiency

(a) Single-boiler systems and multiple-boiler systems using identical boilers

For boilers the relevant ***heat generator seasonal efficiency*** is the ***boiler seasonal efficiency***. The ***boiler seasonal efficiency*** is a "weighted" average of the efficiencies of the boiler at 15, 30 and 100 per cent of the boiler output (the efficiency at 15 per cent being taken to be the same as that at 30 per cent). This is usually quoted by the boiler manufacturer. Note that the efficiencies based on net calorific value should be converted to efficiencies based on gross calorific value using the appropriate conversion factor in SAP 2009 Table E4.

The ***boiler efficiencies***, measured at 100 per cent load and at 30 per cent load, are used in Equation 2 to calculate the ***boiler seasonal efficiency***. The weighting factors in Equation 2 reflect typical seasonal operating conditions for a boiler.

$$\text{Boiler seasonal efficiency} = 0.81\eta_{30\%} + 0.19\,\eta_{100\%}$$ **Equation 2**[9]

where:

$\eta_{30\%}$ is the gross boiler efficiency measured at 30% load, and

$\eta_{100\%}$ is the gross boiler efficiency measured at 100% load.

Equation 2 applies to:

- single-boiler systems where the boiler output is ≤ 400 kW and the boiler will operate on a low temperature system
- multiple-boiler systems where all individual boilers have identical efficiencies and where the output of each boiler is ≤ 400 kW operating on low temperature systems.

For boilers with an output > 400 kW, the manufacturer's declared efficiencies should be used.

(b) Multiple-boiler systems with non-identical boilers replacing existing systems

Where more than one boiler is installed on the same heating system and the efficiencies of the boilers are not all identical, Equation 3.1 should be used to calculate the overall ***boiler seasonal efficiency***. All boilers should be included in the calculation, even when some are identical.

9 This equation assumes that the efficiency at 15% load is the same as that at 30% (and therefore the equation has been simplified accordingly).

The ***boiler seasonal efficiency*** for multiple-boiler systems with non-identical boilers is:

$$\eta_{OSBE} = \frac{\Sigma(\eta_{SBE}.R)}{\Sigma R}$$ **Equation 3.1**

where:

η_{OSBE} is the gross overall ***boiler seasonal efficiency***, being an average weighted by boiler output of the individual seasonal boiler efficiencies

η_{SBE} is the gross ***boiler seasonal efficiency*** of each individual boiler calculated using Equation 2

R is the rated output in kW of each individual boiler (at 80°C/60°C).

(c) Multiple-boiler systems in new buildings

In the case of multiple boilers in new buildings, the more accurate three-step method described below should be used to calculate the overall ***seasonal boiler efficiency***. These steps can readily be programmed into a spreadsheet to automate the calculation.

Step 1

Determine the load on each boiler for each of the three system part-load conditions of 15, 30 and 100 per cent. For example, if the total system output is made up of three equally sized boilers, at 15 per cent of system output the lead boiler will be operating at 45 per cent of its rated output, with the other two boilers switched off.

Step 2

Determine the efficiency of each boiler for the above operating conditions. In the above example, the efficiency of the boiler operating at 45 per cent can be determined by linear interpolation between its efficiencies at 30 per cent and 100 per cent of rated output. Where it is necessary to determine the efficiency of an individual boiler at 15 per cent of rated output, this should be taken as the same as the efficiency at 30 per cent of rated output. (Note that the efficiency at 15 per cent of rated output will only be needed if a single boiler meets the full design output.)

Step 3

Calculate the overall operating efficiency at each of the system part load conditions using:

$$\eta_p = \frac{Q_p}{\Sigma \frac{q_{b,p}}{\eta_{b,p}}}$$ **Equation 3.2**

where:

η_p is the system efficiency at part load condition p, i.e. 15%, 30% and 100% of system rated output

Q_p is the system heat output at part load condition p

$q_{b,p}$ is the individual boiler heat output at system part load condition p

$\eta_{b,p}$ is the individual boiler efficiency at system part load condition p.

Calculate the overall ***boiler seasonal efficiency*** as the weighted average of the efficiencies at the three load conditions using:

$$\eta_{OSBE} = 0.36\eta_{15\%} + 0.45\eta_{30\%} + 0.19\eta_{100\%} \qquad \textbf{Equation 3.3}$$

Table 2 is a worksheet for following through these calculations (using manufacturer data for boiler efficiency at 100 per cent and 30 per cent output). Table 3 shows a completed example calculation using this worksheet, for the case where a system with a rated output of 625 kW is served by three boilers, each rated at 250 kW. The first two boilers are ***condensing boilers***, with the third being a ***standard boiler***. Because the installation is oversized (750 kW compared to 625 kW), at full system output the final boiler is only operating at 50 per cent output (125/250).

The notes at the foot of the table illustrate how the various values are calculated.

Table 2: Worksheet for calculating the overall boiler seasonal efficiency of a multiple-boiler system using the alternative three-step method

		Boiler % efficiency at boiler outputs of		Boiler % output at system outputs of			Boiler % efficiency at system outputs of		
Boiler no	**Rating kW**	**100%**	**30%**	**15%**	**30%**	**100%**	**15%**	**30%**	**100%**
1									
2									
3									
4									
5									
6									
7									
8									
System efficiency at part load									
Weighting factor							0.36	0.45	0.19
Overall seasonal boiler efficiency									

Table 3: Example calculation of the overall boiler seasonal efficiency of a multiple-boiler system in a new building

		Boiler % efficiency at boiler outputs of		Boiler % output at system output of			Boiler % efficiency at system output		
Boiler no	**Rating kW**	**30%**	**100%**	**15%**	**30%**	**100%**	**15%**	**30%**	**100%**
1	250	90%	86%	38.0%	75.0%	100.0%	89.6%[1]	87.4%	86.0%
2	250	90%	86%	not firing	not firing	100.0%	not firing	not firing	86.0%
3	250	85%	82%	not firing	not firing	50.0%	not firing	not firing	84.1%
System efficiency at part load							89.6%	87.4%	85.6%[2]
Weighting factor							0.36	0.45	0.19
Overall seasonal boiler efficiency							87.9%[3]		

Notes

1: Calculated by linear interpolation $\eta_{b,p} = \eta_{30\%} - (\eta_{30\%} - \eta_{100\%})*\frac{(q_{b,p} - 30\%)}{(100\% - 30\%)}$

$$\eta_{1,15\%} = \eta_{30\%} - (\eta_{30\%} - \eta_{100\%})*\frac{(38\% - 30\%)}{(100\% - 30\%)}$$

2: Calculated by dividing the thermal output of the system (625 kW) by the rate of fuel consumption, which is given by the sum of the boiler outputs divided by their individual operating efficiency, i.e.

$$\eta_{100\%} = \frac{625}{\frac{250*100\%}{86\%} + \frac{250*100\%}{86\%} + \frac{250*50\%}{84.1\%}} = 85.6\%$$

3: Calculated as the weighted average, i.e.

$89.6\%*0.36 + 87.4\%*0.45 + 85.6\%*0.19 = 87.9\%$

2.5 Boilers in new buildings

Background

New buildings should be provided with high efficiency ***condensing*** or non-condensing boilers that meet the recommended minimum standards for ***heat generator seasonal efficiency*** in this guide.

Commercial heating systems are inherently more complicated than domestic systems with a wider range of temperatures and heat emitters. The selection of ***condensing*** or non-condensing boilers will be determined by application and physical constraints.

Condensing boilers will meet projected efficiencies only when they operate with a system return temperature between 30°C and 40°C for 80 per cent of the annual operating hours. With a return temperature of 55°C and above, ***condensing boilers*** will not produce condensate and will have similar efficiencies to non-condensing high efficiency boilers. Some systems are suitable for outside compensator control, which allows return temperatures to fall into the condensing range for some periods of the heating season, and they may be best served by a mixture of ***condensing*** and non-condensing boilers.

The efficiency value that should be entered into accredited NCM tools to calculate the carbon dioxide emission rate is the ***effective heat generator seasonal efficiency***. For boilers in new buildings, no ***heating efficiency credits*** can be gained and the ***effective heat generator seasonal efficiency*** is therefore the same as the ***heat generator seasonal efficiency***.

Recommended minimum standards

To meet relevant energy efficiency requirements in building regulations when installing boiler plant in new buildings:

a. where a single boiler is used to meet the heat demand, its ***boiler seasonal efficiency*** (gross calorific value) calculated using Equation 2 should be not less than the value in Table 4; or

b. for multiple-boiler systems, the ***boiler seasonal efficiency*** of each boiler should be not less than 82 per cent (gross calorific value), as calculated using Equation 2; and the overall ***boiler seasonal efficiency*** of the multiple-boiler system, as defined by the 3-step method and calculated using Equations 3.2 and 3.3, should be not less than the value in Table 4; and

c. the relevant minimum controls package in Table 5 should be adopted.

Table 4: Recommended minimum heat generator seasonal efficiency for boiler systems in new buildings

Fuel type	Boiler seasonal efficiency (gross calorific value)
Natural gas	86%
LPG	87%
Oil	84%

Table 5: Recommended minimum controls package for new boilers and multiple boiler systems

Boiler plant output	Package	Minimum controls
<100 kW	A	a. Timing and temperature demand control, which should be zone specific where the building floor area is greater than 150 m^2. b. Weather compensation except where a constant temperature supply is required.
100 kW to 500 kW	B	a. Controls package A above; and b. optimal start/stop control with either night set-back or frost protection outside occupied periods; and c. two stage high/low firing facility in boiler, or multiple boilers with sequence control to provide efficient part-load performance. Note: The heat loss from non-firing boiler modules should be limited by design or application. For boilers that do not have low standing losses, it may be necessary to install isolation valves or dampers.
>500 kW individual boilers	C	a. Controls package A and Controls package B; and b. for gas-fired boilers and multi-stage oil-fired boilers, fully modulating burner controls.

2.6 Boilers in existing buildings

Background

Boiler efficiencies have improved markedly over recent years. A modern boiler meeting the minimum requirements of the Boiler Efficiency Directive has a ***boiler seasonal efficiency*** of approximately 78.5 per cent (based on gross calorific value).

This guidance recognises that in many cases using ***condensing boiler*** technology in existing buildings would be either technically impractical (due to flueing constraints) or economically unviable. For this reason non-condensing boilers may be used provided that they meet the recommended minimum efficiency standards given in this section.

Replacement boilers

To meet relevant energy efficiency requirements in building regulations when installing boiler plant in existing buildings:

a. the ***boiler seasonal efficiency*** of each boiler (in a single-boiler system or a multiple-boiler system with identical boilers) calculated using Equation 2 should be not less than the value in Table 6

b. for multiple-boiler systems using non-identical boilers, the overall ***boiler seasonal efficiency*** calculated using Equation 3.1 should be not less than the value in Table 6

c. the ***controls package*** in Table 7 should be adopted – i.e. ***zone control***, demand control and time control

d. the ***effective boiler seasonal efficiency*** should be not less than the value in Table 6. To meet the standard, it may be necessary to adopt ***additional measures*** from Table 8 in order to gain ***heating efficiency credits*** (see below).

Table 6: Recommended minimum boiler seasonal efficiency for boiler systems in existing buildings

Fuel type	Effective boiler seasonal efficiency (gross calorific value)	Boiler seasonal efficiency (gross calorific value)
Natural gas	84%	82%
LPG	85%	81%
Oil	86%	84%

Table 7: Recommended minimum controls package for replacement boilers in existing buildings

Minimum controls package	Suitable controls
a. Zone control; and	Zone control is required only for buildings where the floor area is greater than 150 m^2. As a minimum, on/off control (e.g. through an isolation valve for unoccupied zones) should be provided. This is achieved by default for a building with a floor area of 150 m^2 or less.
b. demand control; and	Room thermostat which controls through a diverter valve with constant boiler flow water temperature. This method of control is not suitable for condensing boilers.
c. time control.	Time clock controls.

2.7 Heating efficiency credits for replacement boilers

Where the ***boiler seasonal efficiency*** is less than the minimum ***effective boiler seasonal efficiency*** for that type of boiler, ***additional measures*** will need to be adopted to achieve the minimum ***effective heat generator seasonal efficiency*** in Table 6.

Table 8 indicates the measures that may be adopted and the relevant ***heating efficiency credits*** that are applicable. It should be noted that the maximum number of ***heating efficiency credits*** that can be claimed is 4 percentage points.

Table 8: Heating efficiency credits for measures applicable to boiler replacement in existing buildings

Measure		Heating efficiency credits % points[10]	Comments
A	Boiler oversize ≤20%	2	Boiler oversize is defined as the amount by which the maximum boiler heat output exceeds the system heat output at design conditions, expressed as a percentage of that system heat output. For multiple-boiler systems the maximum boiler heat output is the sum of the maximum outputs of all the boilers in the system.
B	Multiple boilers	1	Where more than one boiler is used to meet the heat load.
C	Sequential control of multiple boiler systems	1	Applies only to multiple-boiler/module arrangements. It is recommended that the most efficient boiler should act as the lead in a multi-boiler system.
D	Monitoring & targeting	1	Means of identifying changes in operation or onset of faults. The credit can only be claimed if metering is included and a scheme for data collection is provided and available for inspection.
E	i. Thermostatic radiator valves (TRVs) alone. Would also apply to fanned convector systems	1	TRVs enable the building temperature to be controlled and therefore reduce waste of energy.
	ii. Weather (inside/ outside temperature) compensation system using a mixing valve	1.5	Provides more accurate prediction of load and hence control.
	iii. Addition of TRV or temperature zone control to (ii) above to ensure full building temperature control	1	This credit is additional to Eii. above.

[10] The maximum that can be claimed is 4 percentage points.

Table 8: Heating efficiency credits for measures applicable to boiler replacement in existing buildings *(continued)*

Measure		Heating efficiency credits % points[10]	Comments
F	i. A "room" thermostat or sensor that controls boiler water temperature in relation to heat load	0.5	
	ii. Weather (inside/ outside temperature) compensation system that is direct acting	2	Provides more accurate prediction of load and hence control.
	iii. Addition of TRV or temperature zone control to i. or ii. above to ensure full building temperature control	1	This credit is additional to Fi. or Fii. above. Note Fi. and Fii. are not used together.
G	i. Optimised start	1.5	A control system which starts plant operation at the latest time possible to achieve specified conditions at the start of the occupancy period.
	ii. Optimised stop	0.5	A control system which stops plant operation at the earliest possible time such that internal conditions will not deteriorate beyond preset limits by the end of the occupancy period.
	iii. Optimised start/stop	2	A control system which starts plant operation at the latest time possible to achieve specified conditions at the start of the occupancy period and stops plant operation at the earliest possible time such that internal conditions will not deteriorate beyond preset limits by the end of the occupancy period. Note that if optimised start/stop systems are installed, credits Gi. and Gii. cannot also be claimed.

Table 8: Heating efficiency credits for measures applicable to boiler replacement in existing buildings *(continued)*

Measure		Heating efficiency credits % points[10]	Comments
H	Full zoned time control	1	Allowing each zone to operate independently in terms of start/stop time. Only applicable where operational conditions change in different zones. Does not include local temperature control.
I	Full building management system (BMS)	4	A full BMS linked to the heating plant will provide: sequential control of multiple boilers, full zoned time control and weather compensation where applicable; frost protection or night set back; optimisation and monitoring and targeting. Note that if a full BMS is installed, no further heating efficiency credits can be claimed.
J	De-centralised heating system	1	Elimination of long pipe runs between buildings or through unheated areas in buildings in order to reduce excessive heat losses.

Example: Using ***heating efficiency credits*** to achieve the minimum ***effective heat generator seasonal efficiency*** for a boiler system in an existing building

An existing boiler is to be replaced with a gas boiler with a ***boiler seasonal efficiency*** of 82 per cent, the minimum allowed by Table 6.

The boiler's ***effective boiler seasonal efficiency*** needs to be at least 84 per cent according to Table 6, which means that 2 percentage points of ***heating efficiency credits*** are needed.

The following approach would achieve this:

a. restrict boiler oversizing to 15 per cent (after a detailed assessment of load)

b. fit room thermostat to control boiler water temperature in relation to heat load

c. use two equally sized boilers to meet the heat load in place of the existing single boiler

d. fit TRVs to control the temperature in areas other than where the room thermostat is fitted.

Table 9 below shows how credits would be awarded in this example.

Table 9: Example to illustrate allocation of heating efficiency credits for a replacement boiler in an existing building

Plant description	Heating efficiency credits (% points)
Boiler efficiency 82%	
Boiler oversizing is less than 20%	2
System controlled by room thermostat which controls boiler water temperature	0.5
System uses TRVs to ensure full building temperature control	1
Multiple boilers	1
Total credits	**4.5**

Effective boiler seasonal efficiency

= boiler seasonal efficiency + maximum of 4 heating efficiency credits

= 82% + 4.0% = 86.0%

In this example the minimum required ***effective boiler seasonal efficiency*** of 84 per cent is exceeded by 2.0 per cent.

2.8 Biomass boilers

Background

The method in Section 2.4 for calculating the seasonal efficiency of single and multiple-boilers fired by gas, LPG and oil is not appropriate for biomass boilers.

For biomass boilers, requirements and test methods are covered by EN 12809:2001 *Residential independent boilers fired by solid fuel – nominal output up to 50 kW – requirements and test methods.*

Recommended minimum standards

To meet relevant energy efficiency requirements in building regulations:

a. the efficiency of biomass boilers at their nominal load should be at least:
   i. 65 per cent for independent gravity-fed boilers < 20.5 kW
   ii. 75 per cent for independent automatic pellet/woodchip boilers.
b. controls as for gas, LPG and oil boilers in Table 5 should be provided, where technically feasible.

Section 3

Heat pumps

3.1 Introduction

This section gives guidance on specifying heat pumps to provide space heating and domestic hot water in new and existing buildings to meet relevant energy efficiency requirements in building regulations.

The heat pumps covered in this section take heat energy from a low temperature source and upgrade it to a higher temperature at which it can be usefully employed for heating.

The guidance covers measures, such as the use of improved controls, that can be taken to gain ***heating efficiency credits*** to improve the ***effective coefficient of performance*** of heat pumps.

For guidance on reverse cycle heat pumps that also provide cooling, see Section 9 of this guide.

3.2 Scope of guidance

The guidance in this section applies to the commercial heat pump systems identified in Table 10, which categorises the different types of heat pump according to:

- the source of the heat
- the medium by which it is delivered, and
- the technology.

Table 10: Heat pump types and associated test standards

Heat pump type	Technology	Sub-technology	Test standard
Electrically driven warm air	Ground-to-air	Single package + variable refrigerant flow warm air systems	ISO 13256-1[11]
		Energy transfer systems (matching heating/cooling demands in buildings)	
	Water-to-air	Single package + variable refrigerant flow warm air systems	BS EN 14511[12]
		Energy transfer systems (matching heating/cooling demands in buildings)	
	Air-to-air	Single package	BS EN 14511
		Split system	
		Multi-split system	
		Variable refrigerant flow systems	
Electrically driven warm water	Ground-to-water	Single package + variable refrigerant flow warm air systems	ISO 13256-2[13]
		Split package	
	Water-to-water	Single package + variable refrigerant flow warm air systems	BS EN 14511
		Split package	
	Air-to-water	Single package	BS EN 14511
		Split package + variable refrigerant flow warm air systems	
Gas engine-driven	Available as variable refrigerant flow warm air systems		Generally to BS EN 14511

11 ISO 13256-1 *Water-source heat pumps – Testing and rating for performance – Part 1: Water-to-air and brine-to-air heat pumps.*

12 BS EN 14511-3:2007 *Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling. Test methods.*

13 13256-2 *Water-source heat pumps -Testing and rating for performance – Part 2: Water-to-water and brine-to-water heat pumps.*

3.3 Key terms

Seasonal performance factor (SPF) is the operating performance of an electric heat pump over the season. It is the ratio of the heat delivered and the total energy supplied over the season.

Coefficient of performance (CoP) is a measure of the efficiency of heat pumps.

Heating CoP = heat output/power input **Equation 4**

% CoP (***CoP*** x 100) is the ***heat generator efficiency***.

Effective % CoP is the ***% CoP*** with ***heating efficiency credits***.

The ***CoP*** of a heat pump should be tested in accordance with the standard identified in Table 10. The input power items to be included in the calculation are defined in the standard.

There are currently no European test standards for part load testing of heat pumps, so a single minimum figure should be used, obtained at the heating system rating conditions.

3.4 Heat pumps in new and existing buildings

Heat pump systems in new and existing buildings should:

a. have a ***seasonal performance factor*** not worse than the minimum required by BS EN 15450 Table C1 for new build and Table C2 for existing build;

b. have a ***coefficient of performance*** which is no worse than the value in Table 11; and

c. feature as a minimum the ***controls package*** in Table 12 for systems in new buildings and the ***controls package*** in Table 13 for systems in existing buildings.

Table 11: Recommended minimum CoP for heat pump systems in new and existing buildings

Heat pump type	Minimum CoP at the rating conditions[14]
All types (except absorption heat pumps and gas-engine heat pumps) for space heating	2.2
All types (except absorption heat pumps and gas-engine heat pumps) for domestic hot water heating	2.0
Absorption heat pumps	0.5
Gas engine heat pumps	1.0

[14] Rating conditions – standardised conditions provided for the determination of performance data presented in BS EN 14511:2007 *Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling*.

For non-residential buildings, the heat pump system can be sized to meet either the full heating and hot water demand or part of it. Economically viable installations provide at least 50 per cent of the heating and hot water demand for the building.

Table 12: Recommended minimum controls package for heat pump systems in new and existing buildings

Heat source/sink	Technology	Minimum controls package	
All types	All technologies	A	a. On/off zone control. If the unit serves a single zone, and for buildings with a floor area of 150 m² or less, the minimum requirement is achieved by default. b. Time control.
Air-to-air	Single package Split system Multi-split system Variable refrigerant flow system	B	a. Controls package A above; and b. heat pump unit controls for: i. control of room air temperature (if not provided externally); ii. control of outdoor fan operation; iii. defrost control of external airside heat exchanger; iv. control for secondary heating (if fitted); a. external room thermostat (if not provided in the heat pump unit) to regulate the space temperature and interlocked with the heat pump unit operation.
Water-to-air Ground-to-air	Single package energy transfer systems (matching heating/cooling demand in buildings)	D	a. Controls package A above; and b. heat pump unit controls for: i. control of room air temperature (if not provided externally); ii. control of outdoor fan operation for cooling tower or dry cooler (energy transfer systems); iii. control for secondary heating (if fitted) on air to air systems; iv. control of external water pump operation; c. external room thermostat (if not provided in the heat pump unit) to regulate the space temperature and interlocked with the heat pump unit operation.

Table 12: Recommended minimum controls package for heat pump systems in new and existing buildings *(continued)*

Heat source/sink	Technology	Minimum controls package	
Air-to-water Water-to-water Ground-to-water	Single package Split package	E	a. Controls package A above; and b. heat pump unit controls for: i. control of water pump operation (internal and external as appropriate); ii. control of water temperature for the distribution system; iii. control of outdoor fan operation for air to water units; iv. defrost control of external airside heat exchanger for air to water systems c. external room thermostat (if not provided in the heat pump unit) to regulate the space temperature and interlocked with the heat pump unit operation.
Gas engine-driven heat pumps are currently available only as variable refrigerant flow warm air systems	Multi-split Variable refrigerant flow	F	a. Controls package A above; and b. heat pump unit controls for: i. control of room air temperature (if not provided externally); ii. control of outdoor fan operation; iii. defrost control of external airside heat exchanger; iv. control for secondary heating (if fitted); c. external room thermostat (if not provided in the heat pump unit) to regulate the space temperature and interlocked with the heat pump unit operation.

3.5 Heating efficiency credits for heat pump systems in existing buildings

Heating efficiency credits can be gained for heat pump systems installed in existing buildings by adopting the measures in Table 13, which exceed the minimum standards in Tables 11 and 12. These credits are added to the ***% CoP*** to produce the ***effective % CoP***.

Table 13: Heating efficiency credits for measures applicable to heat pump systems in existing buildings

Measure	Heating efficiency credits (% points)	Comments
< 20% oversizing	2	The amount by which the maximum heat pump output exceeds the system heat output at design conditions, expressed as a percentage of that system heat output.
Optimized stop	2	A control system which stops plant operation at the earliest possible time such that internal conditions will not deteriorate beyond preset limits by the end of the occupancy period.
Full zone control	2	Allows each zone to operate independently in terms of start/stop time. Only appropriate where operational conditions change in different zones.
Monitoring and targeting	2	Means of identifying changes in operation or onset of faults.

Example: Using ***heating efficiency credits*** to achieve the recommended standard for ***effective % CoP*** for a heat pump installation

A proposed system has an air-to-water, electrically-driven heat pump supplying heat to an underfloor heating system. The ***CoP*** of the heat pump tested to EN 14511 is 2.16, which is below the minimum standard recommended by Table 11 for space heating.

The ***minimum controls package*** recommended by Table 12 is package E, comprising:

a. zone control and time control;

b. heat pump unit controls for:

   i. control of outdoor fan operation for cooling tower or dry cooler (energy transfer systems)

   ii. control for secondary heating (if fitted) on air to air systems

   iii. control of external water pump operation and water temperature for the distribution system.

c. room thermostat to regulate the space temperature and interlocked with the heat pump unit operation.

By adding optimised stop control and full zone control, the heating efficiency credits shown in Table 14 can be gained.

Table 14: Example to illustrate the allocation of heating efficiency credits to a new heat pump system in an existing building	
Measure	**Heating efficiency credits (% points)**
% CoP of single duct air-to-water heat pump is 216 in this example (the manufacturer's rating)	
Measures specified in controls package A	0 (as minimum requirement)
Measures specified in controls package B	0 (as minimum requirement)
Optimised stop	2
Full zone control	2
Total credits	**4**

Effective % CoP = % CoP + heating efficiency credits = 216 + 4 = 220

The ***effective CoP*** is therefore 2.20, which meets the minimum required by Table 11.

3.6 Supplementary information on heat pumps

Table 15 contains further guidance on good practice, but which is not required to meet relevant energy performance requirements in building regulations.

Table 15: Supplementary information on heat pumps		
Heat source/ sink	**Technology**	**Comments**
Air-to-air	*Single package*	*Units may be ducted on one or other of the supply and return air sides or ducted on both sides. Ducting needs to be designed to take into account the maximum specific fan power allowable (see Section 10 of this guide) and to maintain the minimum allowable coefficient of performance.*
	Split system *Multi-split system* *Variable refrigerant flow system* *Gas engine-driven*	*A split system will comprise a single outdoor unit and a single indoor unit as a package. Multi-split and VRF systems will comprise a single outdoor unit and two or more indoor units as a package. Several packages may be used to satisfy the requirements of the building.* *In order for efficiencies to be maintained, all connecting pipework must be installed in accordance with manufacturers' recommendations (diameter, length, insulation and riser height). Any ducting needs to be designed to take into account the maximum specific fan power allowable and to maintain the minimum allowable coefficient of performance.*

Table 15: Supplementary information on heat pumps

Heat source/sink	Technology	Comments
Water-to-air *Ground-to-air*	*Single package* *Energy transfer systems (matching heating/cooling demand in buildings)*	*Energy transfer systems generally consist of multiple water-source heat pumps connected in parallel to a common closed water loop. They are installed to offset the simultaneous heating and cooling demand in a building due to the different loads present on the aspects of the building. Water circulation pumps for the closed loop need to be taken into consideration along with the fan power required for the cooling tower or dry cooler or energy for water pumps for the ground loop if this method is utilised for heat injection and rejection. Any ducting needs to be designed to take into account the maximum specific fan power allowable and to maintain the minimum allowable coefficient of performance.*
Air-to-water *Water-to-ground* *Water-to-water*	*Single package* *Split package*	*Water circulation pumps for the delivery of heated water to the building need to be taken into consideration in the calculation. Additionally the energy of water pumps used for the heat source (water or ground) need to be considered in the calculation. Any ducting needs to be designed to take into account the maximum specific fan power allowable and to maintain the minimum allowable coefficient of performance.*
Additional guidance on design criteria for heating systems with integrated heat pumps is given in BS EN 15450:2007[15]*.*		

[15] BS EN 15450:2007 *Heating systems in buildings – Design of heat pump heating systems*.

Section 4

Gas and oil-fired warm air heaters

4.1 Introduction

This section gives guidance on specifying gas and oil-fired warm air heaters for space heating in new and existing buildings to meet relevant energy efficiency requirements in building regulations. It includes guidance on measures, such as the use of better controls, to gain ***heating efficiency credits*** to improve the ***effective heat generator seasonal efficiency***.

4.2 Scope of guidance

The guidance in this section covers the warm air heaters listed in Table 16. The guidance also covers indirect gas or oil-fired heat exchangers (as used in large ducted systems for office blocks, shopping and leisure complexes, etc) to provide heating and fresh or conditioned air. Warm air central heating systems are not within the scope of this section but are covered in the relevant heat generator section and Section 10 *Air distribution systems*.

Table 16: Warm air heaters and test methods

Type of warm air heater		Product standard
Type 1	Gas-fired forced convection without a fan to assist transportation of combustion air and/or combustion products	BS EN 621:1998[16]
Type 2	Gas-fired forced convection incorporating a fan to assist transportation of combustion air or combustion products	BS EN 1020:1998[17]
Type 3	Direct gas-fired forced convection	BS EN 525:1998[18]
Type 4	Oil-fired forced convection	BS EN 13842:2004[19]

[16] BS EN 621:1998 *Non-domestic gas-fired forced convection air heaters for space heating not exceeding a net heat input of 300kW, without a fan to assist transportation of combustion air.*

[17] BS EN 1020:1998 *Non-domestic gas-fired convection air heaters for space heating not exceeding a net heat input of 300kW, incorporating a fan to assist transportation of combustion air and/or combustion products.*

[18] BS EN 525:1998 *Non-domestic direct gas-fired forced convection air heaters for space heating not exceeding a net heat input of 300kW.*

[19] BS EN 13842:2004 *Oil-fired convection air heaters – stationary and transportable for space heating.*

4.3 Key terms

Heat generator seasonal efficiency of air heaters, since they operate under the same conditions at all times, is equivalent to their measured steady state ***thermal efficiency*** (net calorific value). ***Thermal efficiency*** (net calorific value) will be obtained from the heater manufacturer's data, and can be converted to efficiency (gross calorific value) using the conversion factors in SAP 2009 Table E4.

For indirect-fired heaters, data values for heat output and net heat input are measured using the efficiency test methods described in EN 1020, EN 621 or EN 13824 as appropriate.

For direct-fired heaters the efficiency should be calculated using the method described in EN 525.

The calculation of the net thermal efficiency should:

- take account of the heater and the exhaust chimney within the building envelope
- exclude fans.

4.4 Warm air heaters in new and existing buildings

Warm air systems in new and existing buildings should have:

a. an ***effective heat generator seasonal efficiency*** which is no worse than in Table 17; and

b. a controls package featuring, as a minimum, time control, space temperature control, and, where appropriate for buildings with a floor area greater than 150 m^2, zone control.

The ***effective heat generator seasonal efficiency*** is the ***heat generator seasonal efficiency*** with added ***heating efficiency credits*** (see below).

Table 17: Recommended minimum effective heat generator seasonal efficiency	
Warm air heater type (see Table 16)	**Effective heat generating seasonal efficiency (net calorific value)**
Types 1, 2 natural gas	91%
Types 1, 2 LPG	91%
Type 3*	100%
Type 4	91%

*Note: For Type 3 air heaters 100% of the net heat input is delivered to the space. Specific ventilation requirements as defined in EN 525 must be met.

4.5 Heating efficiency credits for warm air heaters in new and existing buildings

Heating efficiency credits can be gained by adopting the optional measures listed in Table 18. They are added to the ***heat generator seasonal efficiency*** to give the ***effective heat generator seasonal efficiency***.

The ***effective heat generator seasonal efficiency*** is the value entered into NCM tools such as SBEM to calculate a proposed building's carbon dioxide emission rate (BER).

Table 18: Heating efficiency credits for measures applicable to warm air heaters		
Measure	**Heating efficiency credits (% points)**	**Comments**
Optimised shut down	1	A control system which stops plant operation at the earliest possible time such that internal conditions will not deteriorate beyond preset limits by the end of the occupancy period.
Hi/Lo burners	2	Two stage burners which enable two distinct firing rates.
Modulating burners	3	Burner controls which allow continuous adjustment of the firing rate.

Destratification fans and air-induction schemes

It is recognised that destratification fans and air-induction schemes may improve the efficiency of a warm air system and significantly reduce the carbon emissions associated with the heating system. The benefits of these measures are already taken into account by the NCM so no ***heating efficiency credits*** can be gained by using them. Note that warm air systems with air induction schemes or destratification fans should not be confused with central heating systems that have air distribution.

Example: Using ***heating efficiency credits*** to exceed the minimum ***effective heat generator seasonal efficiency*** for a warm air heater

A proposed building has a gas-fired forced-convection warm air heater without a fan to assist transportation of combustion air or combustion products. When tested to BS EN 621:1998 the ***thermal efficiency*** (net calorific value) is found to be 91 per cent, which meets the minimum ***effective heat generating efficiency*** recommended for this type of system in Table 17.

The ***minimum controls package*** specified in 4.4 b. comprises zone, space temperature and time controls by adding optimum start/stop control, modulating burners and destratification fans providing seven volume changes per hour.

Table 19 shows how credits are awarded.

Table 19: Example to illustrate the allocation of heating efficiency credits to a warm air heater system

Measure	Heating efficiency credits (% points)
Thermal efficiency of warm air heater 91%	
Zone, space and temperature controls	0 (as minimum requirement)
Modulating burners	3
Optimised shut down	1
Destratification fans	0 (as benefits already recognised by NCM)
Total credits	**4**

Effective heat generator seasonal efficiency = thermal efficiency (net) + heating efficiency credits

= 91% +4% = 95%

The ***effective heat generator seasonal efficiency*** is therefore 95 per cent, exceeding the minimum standard by four percentage points. The value that should be entered into the accredited NCM tool to calculate the carbon dioxide emission rate is 95 per cent.

Section 5

Gas and oil-fired radiant technology

5.1 Introduction

This section gives guidance on specifying radiant heaters for space heating in new and existing buildings to meet relevant energy efficiency requirements in building regulations. It includes guidance on measures, such as the use of better controls, to gain ***heating efficiency credits*** to improve the ***effective heat generator seasonal efficiency***.

5.2 Scope of guidance

The guidance in this section covers the types of radiant heater listed in Table 20.

Table 20: Types of radiant heater and associated product standards

Radiant heater type	Product standard
Luminous radiant heater	BS EN 419:2000[20]
Non-luminous radiant heater	BS EN 416-1:1999[21]
Multi-burner radiant heater	BS EN 777 series[22]
Oil-fired radiant heater	N/A

5.3 Key terms

Radiant heater seasonal efficiency (***heat generator seasonal efficiency***) is equivalent to ***thermal efficiency*** (net calorific value).

For flued appliances, the manufacturer of the radiant heater should declare a ***thermal efficiency*** measured to the test standards EN 1020[23] or EN 13842[24] as applicable.

[20] BS EN 419-1:2000 *Non-domestic gas-fired overhead luminous radiant heaters. Safety.*

[21] BS EN 416-1:1999 *Single-burner gas-fired overhead radiant tube heaters. Safety.*

[22] BS EN 777-1:1999 *Multi-burner gas-fired overhead radiant tube heater systems for non-domestic use. System D, safety.*
BS EN 777-2:1999 *Multi-burner gas-fired overhead radiant tube heater systems for non-domestic use. System E, safety.*
BS EN 777-3:2000 *Multi-burner gas-fired overhead radiant tube heater systems for non-domestic use. System F, safety.*
BS EN 777-4:1999 *Multi-burner gas-fired overhead radiant tube heater systems for non-domestic use. System H, safety.*

[23] BS EN 1020 *Non-domestic gas-fired convection air heaters for space heating not exceeding a net heat input of 300kW, incorporating a fan to assist transportation of combustion air and/or combustion products* (AMD 13525).

[24] BS EN 13842:2004 *Oil-fired convection air heaters – stationary and transportable for space heating.*

The calculation of the ***thermal efficiency*** (net calorific value) should:

a. take account of the radiant heater and associated flue pipe/tailpipe within the building envelope;

b. exclude fans.

For unflued heaters the minimum ***thermal efficiency*** levels given in Table 21 should be used.

5.4 Radiant heaters

Radiant heaters in new and existing buildings should have:

a. an ***effective heat generator seasonal efficiency*** not worse than in Table 21; and

b. a controls package consisting of, as a minimum, time control and space temperature control with black bulb sensors.

Table 21: Recommended minimum performance standards for radiant heaters

Appliance type	Effective heat generator seasonal efficiency (%)	
	Thermal	**Radiant**
Luminous radiant heater – unflued	86	55
Non-luminous radiant heater – unflued	86	55
Non-luminous radiant heater – flued	86	55
Multi-burner radiant heater	91	N/A

5.5 Heating efficiency credits for radiant heaters in existing buildings

Heating efficiency credits can be gained by adopting the optional measures listed in Table 22. They are added to the ***heat generator seasonal efficiency*** (the thermal efficiency – net calorific value) to give the ***effective heat generator seasonal efficiency***.

Table 22: Heating efficiency credits for measures applicable to radiant heaters

Measure		Heating efficiency credits (% points)	Comments
Controls (additional to the minimum package)	Optimum stop	1	A control system which stops plant operation at the earliest possible time such that internal conditions will not deteriorate beyond preset limits by the end of the occupancy period.
	Optimum start	0.5	A control system which starts plant operation at the latest possible time such that internal conditions will be up to required limits at the start of the occupancy period.
	Zone control	1	A control system in which each zone operates independently in terms of start/stop time. It is only appropriate where operational conditions change in different zones.

Example: Using ***heating efficiency credits*** to achieve the minimum ***effective heat generator seasonal efficiency*** for a radiant heater system

A proposed building will have a flued non-luminous radiant heater system with a thermal efficiency (***heat generator seasonal efficiency***) of 84 per cent. A black bulb sensor and an optimiser will be fitted.

The ***heating efficiency credits*** associated with these measures are added to the appliance thermal efficiency to obtain the ***effective heat generator seasonal efficiency***.

Table 23 shows how credits are awarded for this example.

Table 23: Example to illustrate the allocation of heating efficiency credits to a radiant heater system

Measure	**Heating efficiency credits (% points)**
Thermal efficiency of radiant heater	84%
Black bulb sensor	0 (as minimum requirement)
Optimised shut down	1
Zone control	1
Total credits	**2**

Effective heat generator seasonal efficiency = thermal efficiency + heating efficiency credits

= 84% + 2% = 86%

In this example, the application of ***additional measures*** to gain ***heating efficiency credits*** has brought the radiant heater's ***effective heat generator seasonal efficiency*** up to the minimum recommended value.

Section 6

Combined heat and power and community heating

6.1 Introduction

This section gives guidance on specifying combined heat and power (CHP) systems for space heating, hot water and chilled water (via absorption chillers) in new and existing buildings to meet relevant energy efficiency requirements in building regulations. It includes guidance on measures, such as the use of improved controls, to gain ***heating efficiency credits*** to improve the ***effective heat generator seasonal efficiency*** of the heat generator. Guidance on the design of community heating systems can be found in Section 6 of the *Domestic building services compl iance guide*.

CHP units are normally used in conjunction with boilers. The majority of the annual heat demand is usually provided by the CHP plant, while the boilers are used to meet peak demand and in periods when the CHP unit is not operating (for example at night or when undergoing maintenance).

CHP units may on a relatively small scale supply single buildings, or on a larger scale supply a number of buildings through a community heating system. The most common fuel is natural gas, which can be used in spark-ignition gas engines, micro-turbines, or gas turbines in open cycle or combined cycle.

6.2 Scope of guidance

The guidance in this section covers CHP systems with a total power capacity less than 5 MWe used in commercial applications. The CHP units may or may not supply community heating.

Guidance on community heating systems with micro-CHP (having a total power capacity less than 5 kWe) and other heat generators is available in the *Domestic building services compliance guide*.

6.3 Key terms

Combined heat and power (CHP) means the simultaneous generation of heat and power in a single process. The power output is usually electricity, but may include mechanical power. Heat outputs can include steam, hot water or hot air for process heating, space heating or absorption cooling.

Combined heat and power quality assurance (CHPQA) is a scheme[25] under which registration and certification of CHP systems is carried out according to defined quality criteria.

CHPQA quality index is an indicator of the energy efficiency and environmental performance of a CHP scheme relative to generation of the same amounts of heat and power by alternative means.

Power efficiency is the total annual power output divided by the total annual fuel input of a CHP unit.

6.4 CHP in new and existing buildings

CHP plant in new and existing buildings should have:

a. a minimum ***CHPQA Quality Index*** (QI) of 105 and ***power efficiency*** greater than 20 per cent, both under annual operation;

b. a control system that, as a minimum, ensures that the CHP unit operates as the lead heat generator; and

c. metering to measure hours run, electricity generated and fuel supplied to the ***CHP*** unit.

The CHP plant should be sized to supply not less than 45 per cent of the annual total heating demand (i.e. space heating, domestic hot water heating and process heating) unless there are overriding practical or economic constraints.

[25] Further information about the CHPQA programme is available at www.chpqa.com.

Calculating the CO_2 emissions from a CHP heating system

CHP may be used as a main or supplementary heat source in community heating systems. To calculate the CO_2 emission rate for a new building for the purposes of showing compliance with building regulations, the following data will need to be entered into an accredited NCM tool such as SBEM:

a. the proportion of the annual heat demand (H MWh) to be supplied by the CHP plant (P %), calculated from heating only requirement. This is needed as the CHP unit is normally sized below the peak heat demand of the building and will also be out of service for maintenance purposes

b. the overall efficiency ratio of the CHP plant (E) as defined by Equation 5 and taking account of part-load operation and all heat rejection predicted by an operating model:

   E = annual useful heat supplied + annual electricity generated (net of parasitic electricity use) divided by the annual energy of the fuel supplied (in gross calorific value terms) **Equation 5**

c. the heat to power ratio of the CHP plant (R), calculated for the annual operation according to Equation 6:

   R = annual useful heat supplied ÷ annual electricity generated (net of parasitic electricity use) **Equation 6**

From these parameters, the NCM tool will calculate the CO_2 emissions in the heat supplied from the CHP plant using an emissions factor for the electricity generated by the CHP of X g/kWh applied to the annual total of electricity generation.

The figure for annual CO_2 emissions for the heat supplied by the CHP plant (assuming it is gas-fired) is then:

$$= ((H \times P)/E)+(H \times P)/(R \times E)) \times 198 - ((H \times P)/R) \times X \text{ kg}$$ **Equation 7**

The CO_2 emissions for the balance of heat supplied by the boilers is then calculated by the NCM tool as for a boiler only system.

6.5 Supplementary information on community heating

Community heating systems may include other low and zero carbon sources of energy such as biomass heating. Emission factors should be determined based on the particular details of the scheme, but should take account of the annual average performance of the whole system – that is, of the distribution circuits and all the heat generating plant, including any CHP, and any waste heat recovery or heat dumping. The calculation of the building CO_2 emission rate should be carried out by a suitably qualified person, who should explain how the emission factors were derived.

The design of the community heating connection and the building's heating control system should take account of the requirements of the community heating organisation with respect to maintaining low return temperatures at part-load and limiting the maximum flow rate to be supplied by the community heating system to the agreed level. A heat meter should be installed to measure the heat energy supplied and to monitor the maximum heat demand, the maximum community heating flow rate and the return temperatures into the community heating network.

Further guidance can be found in the following documents:

- *Carbon Trust GPG 234 "Community heating and CHP"*
- *CIBSE AM12 "Small-scale CHP for buildings"*
- *HVCA TR/30 "Guide to good practice – Heat pumps".*

Section 7

Direct electric space heating

7.1 Introduction

This section gives guidance on specifying direct electric heaters for space heating in new and existing buildings. It addresses the relevant electric heater types and the minimum provision of controls.

7.2 Scope of guidance

The guidance given in this section covers the following types of electric heating systems which may be used to provide primary or secondary space heating:

- electric boilers
- electric warm air systems
- electric panel heaters
- electric storage systems including integrated storage/direct systems
- electric fan heaters and fan convector heaters
- electric radiant heaters including quartz and ceramic types.

The guidance does not cover electric heat pumps or portable electric heating devices.

7.3 Electric space heating in new and existing buildings

It is assumed that electric heating devices convert electricity to heat within a building with an efficiency of 100 per cent. A minimum ***heat generator seasonal efficiency*** is therefore not specified.

Electric space heating systems in new and existing buildings should meet the minimum standards for:

a. controls for electric boilers in Table 24; or

b. controls for electric heating systems other than boilers in Table 25.

Table 24: Recommended minimum standards for control of electric boiler systems

Type of control	Standard	Comments
Boiler temperature control	a. The boiler should be fitted with a flow temperature control and be capable of modulating the power input to the primary water depending on space heating conditions.	
Zoning	a. Buildings with a total usable floor area up to 150 m^2 should be divided into at least two zones with independent temperature control. b. For buildings with a total usable floor area greater than 150 m^2, at least two space heating zones should be provided, each having separate timing and temperature controls, either by: i. multiple heating zone programmers, or ii. a single multi-channel programmer.	If the building floor area is less than 150 m^2 sub-zoning of temperature control is not appropriate.
Temperature control of space heating	a. Separate temperature control of zones within the building, using either: i. room thermostats or programmable room thermostats in all zones; or ii. a room thermostat or programmable room thermostat in the main zone and individual radiator controls such as thermostatic radiator valves (TRVs) on all radiators in the other zones; or iii. a combination of (i) and (ii) above.	
Time control of space and water heating	a. Time control of space and water heating should be provided by either: i. a full programmer with separate timing to each circuit; ii. two or more separate timers providing timing control to each circuit; or iii. programmable room thermostat(s) to the heating circuit(s), with separate timing of each circuit.	

Note: An acceptable alternative to the above controls is any boiler management control system that meets the specified zoning, timing and temperature requirements.

Table 25: Recommended minimum standards for control of primary and secondary electric heating systems (other than electric boilers)

Type of electric heating system	Type of control	Standard	Comments
Warm air	Time and temperature control, either integral to the heater or external	a. A time switch/programmer and room thermostat; or b. a programmable room thermostat.	
	Zone control	a. For buildings with a total usable floor area greater than 150 m^2, more than one space heating circuit should be provided, each having separate timing and temperature controls. b. Control should be by: i. multiple heating zone programmers; or ii. a single multi-channel programmer.	
Radiant heaters	Zone or occupancy control	a. Connection to a passive infra-red detector.	Electric radiant heaters can provide zone heating or be used for a full heating scheme. Common electric radiant heaters include the quartz or ceramic type.
Panel/skirting heaters	Local time and temperature control	a. Time control provided by: iii. a programmable time switch integrated into the appliance; or iv. a separate time switch. b. Individual temperature control provided by: v. integral thermostats; or vi. separate room thermostats.	Panel heater systems provide instantaneous heat.

Table 25: Recommended minimum standards for control of primary and secondary electric heating systems (other than electric boilers) *(continued)*

Type of electric heating system	Type of control	Standard	Comments
Storage heaters	Charge control	a. Automatic control of input charge (based on an ability to detect the internal temperature and adjust the charging of the heater accordingly).	
	Temperature control	b. Manual controls for adjusting the rate of heat release from the appliance, such as adjustable damper or some other thermostatically-controlled means.	
Fan/fan convector heaters	Local fan control	a. A switch integrated into the appliance; or b. a separate remote switch.	
	Individual temperature control	c. Integral switches; or d. separate remote switching.	

Section 8

Domestic hot water

8.1 Introduction

This section gives guidance on specifying domestic hot water (DHW) systems for new and existing buildings to meet relevant energy efficiency requirements in building regulations. It includes guidance on measures, such as the use of better controls, to gain ***heating efficiency credits*** to improve the ***effective heat generator seasonal efficiency***.

As well as building regulations, other regulations apply to the provision of domestic hot water. Energy-saving measures should not compromise the safety of people or the ability of the system to achieve approved regimes for the control of legionella.

Domestic hot water systems are referred as hot water service systems in SBEM.

8.2 Scope of guidance

The guidance in this section covers the conventional gas, electric and oil-fired domestic hot water systems shown in Table 26.

The recommended minimum standards of this section apply only to dedicated water heaters. Central heating boilers which provide space heating and domestic hot water should meet the minimum standards in Section 2.

Section 3 contains guidance on the use of heat pumps to heat domestic hot water.

This section does not cover solar thermal hot water systems – for this see the *Domestic building services compliance guide*. However, the guidance in this section does apply to back-up gas or electric systems used with solar thermal hot water systems.

Table 26: Types of hot water system

DHW system type	Definition
Indirect natural gas, LPG and oil-fired systems	A system in which the water is supplied to the draw-off points from a device in which water is heated by means of an element, through which the heating medium is circulated in such a manner that it does not mix with the hot water supply. In practice these are likely to be boilers dedicated to the supply of DHW that meet the minimum requirements of the Boiler Efficiency Directive.
Direct-fired storage water heater system (natural gas, LPG and oil-fired)	A system in which the water is supplied to the draw-off points from a hot water vessel in which water is heated by combustion gases from a primary energy source.
Point of use electrically-heated water heater systems	A system in which the water is supplied to the draw-off points from a device in which water is heated by an electric element or elements immersed in the stored water. The water heater is situated in close proximity to the draw-off points (points of use) and should have a storage capacity no greater than 100 litres.
Instantaneous electrically-heated water heater systems	A system in which the water is supplied to the draw-off points from a device in which the water is heated by an electric element or elements that heat the cold water as it flows through the water heater. The water heater is situated in close proximity to the draw-off points. The unit has no storage volume as water is instantaneously heated as it flows through the device.
Local, electrically-heated water heater systems	A system in which the water is supplied to the draw-off points from a device in which water is heated by an electric element or elements immersed in the stored water. The water heater is situated in the locality of the draw-off points and should have a storage capacity of between 100 and 300 litres. Bulk heating of the water heater should be arranged to occur using off-peak electricity supplies.
Centralised electrically-heated water heater systems	A system in which the water is supplied to the draw-off points from a device in which water is heated by an electric element or elements immersed in the stored water. The water heater is situated centrally with a distribution system to supply water to the draw off-points and should have a capacity greater than 300 litres. Bulk heating of the water heater should be arranged to occur using off-peak electricity supplies.

8.3 Key terms

The ***heat generator seasonal efficiency*** is defined for each system type in Table 27.

The ***effective heat generator seasonal efficiency*** is the ***heat generator seasonal efficiency*** plus ***heating efficiency credits*** gained by adopting ***additional measures*** from Table 30.

Table 27: Definition of heat generator seasonal efficiency for DHW systems

DHW system type	Heat generator seasonal efficiency	Components to include in calculation of heat generator seasonal efficiency *
Direct-fired systems (gas and oil-fired)	Equals the ***thermal efficiency*** of the heater (gross calorific value) when tested using the procedures in BS EN 89:2000[26]. Gross thermal efficiency = heater output ÷ gross input **Equation 8** where: Heater output = recovery rate of heater in litres/second x specific heat capacity of water x temperature rise of the water **Equation 9**	For direct systems include the water heater and insulation of the allied storage vessel only. Exclude: a. secondary pipework; b. fans and pumps; c. diverter valves, solenoids, actuators; d. supplementary storage vessels.
Indirect-fired systems (gas and oil-fired)	The ***heat generator seasonal efficiency*** of the heat generator (boiler) allied to an indirect storage cylinder should be calculated using Equation 2, 3.1, or 3.2 and 3.3 (as appropriate) in Section 2. If ***boiler seasonal efficiency*** values are obtained as net values the conversion factors in SAP 2009 Table E4 should be used to convert to a gross value.	For indirect cylinder systems include the heat generator only.

[26] BS EN 89:2000 *Gas fired water heaters for the production of domestic hot water.*

Table 27: Definition of heat generator seasonal efficiency for DHW systems *(continued)*		
DHW system type	**Heat generator seasonal efficiency**	**Components to include in calculation of heat generator seasonal efficiency ***
Point of use electrically-heated water heater systems	These are assumed 100% thermally efficient in terms of conversion to heat within the building.	
Local electrically-heated water heater systems		
Centralised electrically-heated water heater systems		

* Note: For hot water systems in new buildings, standing losses are calculated in the accredited NCM tool.

8.4 Domestic hot water systems in new and existing buildings

Domestic hot water systems in new and existing buildings should meet the recommended minimum standards for:

a. heat losses from DHW storage vessels in Table 28

b. thermal efficiency (gross calorific value) in Table 29

c. controls in Table 30.

Table 28: Recommended maximum heat losses from DHW storage vessels

Nominal volume (litres)	**Heat loss** (kWh/24h)	**Nominal volume** (litres)	**Heat loss** (kWh/24h)
200	2.1	900	4.5
300	2.6	1 000	4.7
400	3.1	1 100	4.8
500	3.5	1 200	4.9
600	3.8	1 300	5.0
700	4.1	1 500	5.1
800	4.3	2 000	5.2

For guidance on maximum heat losses from DHW storage vessels with a storage volume less than 200 litres, see BS EN 15450:2007[27].

Table 29: Recommended minimum thermal efficiencies for domestic hot water systems

DHW system type	**Fuel type**	**Minimum thermal efficiency** (gross calorific value)	**Effective heat generating seasonal efficiency** (gross calorific value)
Direct-fired domestic hot water system	Natural gas	73%	
	LGP	74%	
	Oil	75%	
Indirect-fired systems	Natural gas		80%
	LPG		81%
	Oil		82%
Electric systems	Electricity	100%	

[27] BS EN 15450:2007 *Heating systems in buildings – Design of heat pump heating systems.*

Table 30: Recommended minimum controls package for domestic hot water systems

Type of DHW system	**Controls package**			
Gas and oil-fired direct-fired systems	a. Automatic thermostat control to shut off the burner/primary heat supply when the desired temperature of the hot water has been reached b. time control.			
Gas and oil-fired indirect systems	a. Automatic thermostat control to shut off the burner/primary heat supply when the desired temperature of the hot water has been reached b. high limit thermostat to shut off primary flow if system temperature too high c. time control.			
Electrically heated	**Point of use**	**Local**	**Centralised**	**Instantaneous**
Automatic thermostat control to interrupt the electrical supply when the desired storage temperature has been reached.	Yes	Yes	Yes	x
High limit thermostat (thermal cut-out) to interrupt the energy supply if the system temperature gets too high.	Yes	Yes	Yes	x
Manual re-set in the event of an over-temperature trip.	Yes	Yes	Yes	x
7-day time clock (or BMS interface) to ensure bulk heating of water using off-peak electricity. Facility to boost the temperature using on-peak electricity (ideally by means of an immersion heater fitted to heat the top 30% of the cylinder).	x	Yes	Yes	x
High limit thermostat (thermal cut-out) to interrupt the energy supply if the outlet temperature gets too high. (Note: Outlet temperature is controlled by rate of flow through the unit, which on basic units would be by the outlet tap or fitting.)	x	x	x	Yes
Flow sensor that only allows electrical input should sufficient flow through the unit be achieved.	x	x	x	Yes

8.5 Supplementary information on electric water heaters

Table 31 contains supplementary guidance on electric water heaters. The guidance does not need to be followed to meet the relevant energy efficiency requirements in building regulations.

Table 31: Supplementary information on electric water heaters

Point of use electrically-heated water heater systems	*These should be constructed to comply with BS EN 60335-2-21:1999[28] and the heat loss should not exceed 1.28 x (0.2+0.051$V^{2/3}$) kWh where V is the cylinder's nominal capacity in litres.*
Instantaneous electrically-heated water heater systems	*These should be constructed to comply with BS EN 60335-2-35:2002[29].*
Local electrically-heated water heater systems should be constructed to comply with	*Vented systems should be constructed to comply with either BS EN 60335-2-21 or BS 1566-1:2002[30] or BS 3198:1981[31].* *Unvented systems should be constructed to comply with BS 7206 or be certified by the BBA, WRC-NSF or other accredited body as complying with Building Regulation G3 for unvented systems.* *The heat loss should not exceed 1.28 x (0.051$V^{2/3}$) kWh where V is the nominal capacity of the cylinder in litres.*

28 BS EN 60335-2-35:2002 *Specification for safety of household and similar electrical appliances. Particular requirements for instantaneous water heaters.*

29 BS EN 60335-2-35:2002 *Specification for safety of household and similar electrical appliances. Particular requirements for instantaneous water heaters.*

30 BS 1566-1:2002 *Copper indirect cylinders for domestic purposes. Open vented copper cylinders. Requirements and test method.*

31 BS 3198:1981 *Specification for copper hot water storage combination units for domestic purposes.*

Table 31: Supplementary information on electric water heaters *(continued)*	
Centralised electrically-heated water heater systems	*The vessel should be constructed to comply with BS 853[32]. Bulk heating of the water should utilise off-peak electricity where possible.* *When using off-peak electricity a "Boost Heater" should be fitted to allow "on-peak" heating. The "Boost Heater" should heat the top 30% of the cylinder and be rated to approximately 30% of the main off-peak heater battery. The kW load will depend on the recovery time required.* *The heater battery should either be of removable core or rod element construction. Removable core construction allows elements to be changed without removing the heater from the vessel or draining the system. For removable core construction, the maximum element watts density should not exceed 3 W/cm^2 for copper tubes or 2.5 W/cm^2 for stainless steel tubes. For rod element construction, elements should be of Nickel Alloy 825 sheath, be U-bent and have a maximum watts density of 10 W/cm^2. Temperature control should be by means of "on/off" control of the heater battery utilising stage ramping for loadings above 30 kW. Thermostatic control is an ideal solution.*
Centralised electrically-heated water heater systems	*The control sensor should be mounted in the cylinder at an angle of approximately 45° to the heater and at a level just above the heating bundle. The over-temperature sensor (high limit) should be mounted in the top 30% of the cylinder directly above the heater bundle. A manual reset should be required in the event of an over-temperature trip.* *For loadings greater than 6 kW, temperature sensors should not be fitted to the heater bundle. This is to prevent thermostat and contactor cycling which will lead to premature failure of the equipment and poor temperature control.*

8.6 Heating efficiency credits for DHW systems in new and existing buildings

Heating efficiency credits are available for the optional measures listed in Table 32. If these measures are adopted, ***heating efficiency credits*** can be added to the ***heat generator seasonal efficiency*** to give the ***effective heat generator seasonal efficiency***, which is the value entered into the accredited NCM tool in order to calculate the carbon dioxide emission rate for a proposed new building.

32 BS 853- 1: *Calorifiers and storage vessels for central heating and hot water supplies.*

Effective heat generator seasonal efficiency = ***heat generator seasonal efficiency*** + ***heating efficiency credits***

where the ***heat generator seasonal efficiency*** is:

- the ***thermal efficiency*** for direct-fired systems, or
- the ***seasonal boiler efficiency*** for indirect gas or oil-fired systems.

Table 32: Heating efficiency credits for measures applicable to domestic hot water systems

System type	Measure	Heating efficiency credits %
All system types	De-centralisation	2, but not applicable to systems in new buildings
Direct-fired	Integral combustion circuit shut-off device	1
	Fully automatic ignition controls	0.5
All system types	Correct size of unit confirmed using manufacturer's technical help line and sizing software	2

Example: Using ***heating efficiency credits*** to exceed the minimum ***effective heat generator seasonal efficiency*** for a direct-fired system

Step 1: Calculating ***thermal efficiency*** of direct-fired DHW system

- recovery rate of heater = 0.4694 litres/s
- gross input rate of heater = 128 kW
- specific heat capacity of water = 4.187 kJ/(kg.K)
- temperature rise of water inside heater = 50°C.

Using Equation 9:

Heater output = recovery rate of heater in litres/second x specific heat capacity of water x temperature rise of the water

= 0.4694 x 4.187 x 50 = 96.26 kW

Using Equation 8:

Gross thermal efficiency = output of the heater divided by the gross input

= 96.26 ÷ 128 = 0.76

Step 2: Adding ***heating efficiency credits*** for ***additional measures***

The heater has been sized to closely match the system demand by using the manufacturer's sizing guide and it will be fitted with fully automatic controls.

Table 33 shows how credits would be assigned in this example.

Table 33: Example to illustrate allocation of heating efficiency credits for a DHW system

Measure	**Heating efficiency credits % points**
Sized according to manufacturer's guidance	2
Fully automatic ignition controls	0.5
Total credits	**2.5**

Effective heat generator seasonal efficiency = Gross thermal efficiency + heating efficiency credits

= 76 + 2.5 = 78.5%

In this example, the value 0.785 would be entered in the NCM tool.

Section 9

Comfort cooling

9.1 Introduction

This section gives guidance on specifying comfort cooling for new and existing buildings to meet relevant energy efficiency requirements in building regulations. It includes guidance on using SBEM to calculate the carbon dioxide emissions associated with comfort cooling from new buildings.

9.2 Scope of guidance

The guidance covers the specification of refrigeration plant efficiency in terms of the ***seasonal energy efficiency ratio*** (***SEER*** – see definition below), which is the value used by SBEM to calculate the carbon dioxide emission rate for a new building. SBEM allocates standard correction factors[33] to the performance of cooling plant to account for the use of the different systems of distributing cooling to the spaces. Evaporative cooling and desiccant cooling systems are not within the scope of this guidance.

9.3 Key terms

Cooling plant means that part of a cooling system that produces the supply of cooling medium. It does not include means of distributing the cooling medium or the delivery of the cooling into the relevant zone. It may consist, for example, of a single chiller or a series of chillers.

Cooling system means the complete system that is installed to provide the comfort cooling to the space. It includes the cooling plant and the system by which the cooling medium effects cooling in the relevant zone and the associated controls. This will in some cases be a complete packaged air conditioner.

Energy efficiency ratio (***EER***) means for chillers the ratio of the cooling energy delivered into the cooling system divided by the energy input to the cooling plant as determined by BS EN 14511[34].

33 The SBEM Technical Manual is available for download from www.2010ncm.bre.co.uk

34 BS EN 14511-2:2007 *Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling. Test conditions.*

In the case of packaged air conditioners, the ***EER*** is the ratio of the energy removed from air within the conditioned space divided by the effective energy input to the unit as determined by BS EN 14511 or other appropriate standard procedure. The test conditions for determining ***EER*** are those specified in BS EN 14511.

Part load energy efficiency ratio means the ratio of the cooling energy delivered into the cooling system divided by the energy input to the cooling plant. Part load performance for individual chillers is determined assuming chilled water provision at 7°C out and 12°C in, under the following conditions:

Percentage part load	**25%**	**50%**	**75%**	**100%**
Air-cooled chillers ambient entering air (°C)	20	25	30	35
Water-cooled chillers entering condenser water (°C)	18	22	26	30

Seasonal energy efficiency ratio **(*SEER*)** means the ratio of the total amount of cooling energy provided divided by the total energy input to the cooling plant (which may comprise more than one cooling unit), summed over the year.

Where an industry approved test procedure for obtaining performance measurements of cooling plant at partial load conditions exists, the ***SEER*** of the cooling plant may be estimated from the ***EER*** of the cooling plant measured at partial load conditions, adjusted for the cooling load profile of the proposed building.

Equation 10 illustrates how to determine the seasonal efficiency of the cooling plant at four steps of load control for a single chiller well matched to the applied load:

$$SEER = a(EER_{25}) + b(EER_{50}) + c(EER_{75}) + d(EER_{100})$$ **Equation 10**

where:

EER_x is the EER measured at the defined partial load conditions of 100%, 75%, 50% and 25%

and:

a, b, c, and d are the load profile weighting factors relevant to the proposed application.

9.4 Comfort cooling in new and existing buildings

For comfort cooling systems in new and existing buildings:

a. the full load ***energy efficiency ratio*** (***EER***) of each cooling unit of the cooling plant should be no worse than recommended in Table 34; and

b. controls should be no worse than recommended in Table 35.

Table 34: Recommended minimum energy efficiency ratio (EER) for comfort cooling

Type		**Cooling plant full load EER**
Packaged air conditioners	Single duct types	2.5
	Other types	2.5
Split and multi-split air conditioners		2.5
Variable refrigerant flow systems		2.5
Vapour compression cycle chillers, water cooled <750 KW		3.85
Vapour compression cycle chillers, water cooled >750 kW		4.65
Vapour compression cycle chillers, air cooled <750 kW		2.5
Vapour compression cycle chillers, air cooled >750 kW		2.6
Water loop heat pump		3.2
Absorption cycle chillers		0.7
Gas engine driven variable refrigerant flow		1.0

Table 35: Recommended minimum controls for comfort cooling in new and existing buildings

	Controls
Cooling plant	a. Multiple cooling modules should be provided with controls to provide the most efficient operating modes for the combined plant
Cooling system	a. Each terminal unit capable of providing cooling should be capable of time and temperature control either by its own or by remote controls. b. In any given zone simultaneous heating and cooling should be prevented by a suitable interlock.

9.5 Calculating the seasonal energy efficiency ratio for SBEM

The value of the ***SEER*** to be used in the SBEM tool can be calculated in a number of ways according to the availability of information and the application. The following section describes how the ***SEER*** may be calculated for situations where suitable data exist to a greater or lesser extent. The situations are:

- chillers with no part load performance data
- unknown load profiles
- office type buildings
- other building types with known load profile data.

For chillers with no part load data

For chillers that have no part load data, the ***SEER*** is the full load ***EER***.

When load profile is not known

For applications where the load profile under which the cooling plant operates is not known but there are some data on chiller part load ***EER***, then:

a. for chillers where the full and half load (50%) ***EER***s are known, the ***SEER*** is the average of the ***EER***s, i.e. the 100 per cent and 50 per cent are equally weighted

b. for chillers with four points of part load ***EER***, the ***SEER*** is calculated using Equation 10 with each ***EER*** weighted equally, i.e. a, b, c and d each equal to 0.25

c. if the chiller used does not have data for four steps of load, then the weights are apportioned appropriately.

For office type accommodation

For applications in general office-type accommodation, the weighting factors in the table below can be taken as representative of the load profile:

a	b	c	d
0.20	0.36	0.32	0.12

Other buildings with known load profile

If the load profile is known from detailed simulation or prediction, the ***SEER*** may be derived as above using appropriate weights and ***EER***s at given loads.

Examples:

1. For a single chiller with ***EER*** of 2.9 (known at full load only):

   SEER = 2.9

2. For a chiller with 100% and 50% EERs of 2.0 and 2.5 respectively in a building with unknown load profile:

   SEER = 2.25

3. For a chiller with unknown application load profile and part load EERs of EER_{100} = 4.89, EER_{75} = 4.42, EER_{50} = 3.93, and EER_{25} = 2.59:

   SEER = 0.25 x 2.59 + 0.25 x 3.93 + 0.25 x 4.42 + 0.25 x 4.89 = 3.96

4. If the above chiller is used in an office and the typical UK weighting factors used:

   SEER = 0.2 x 2.59 + 0.36 x 3.93 + 0.32 x 4.42 + 0.12 x 4.89 = 3.93

Multiple-chiller systems

For systems with multiple-chillers for use in office buildings, combined ***EER*** values may be calculated based on the sum of the energy consumptions of all the operating chillers. In this case care must be taken to include all the factors that can influence the combined performance of the multiple-chiller installation. These will include:

- degree of oversizing of the total installed capacity
- sizing of individual chillers
- ***EER***s of individual chillers
- control mode for the multiple-chiller – e.g. parallel or sequential
- load profile of the proposed cooling load.

When these are known it may be possible to calculate a ***SEER*** which matches more closely the proposed installation than by applying the simplifications described earlier.

Systems with free cooling or heat recovery

Systems that have the ability to use free cooling or heat recovery can achieve greater ***SEER***s than more conventional systems. In these cases the ***SEER*** must be derived for the specific application under consideration.

Absorption chillers and district cooling

Absorption chillers may be used in conjunction with on-site CHP or a community or district heating system. The carbon dioxide emissions are calculated in the same way as when using CHP for heating. The control system should ensure as far as possible that heat from boilers is not used to supply the absorption chiller.

The minimum ***EER*** of absorption chillers should be no worse than 0.7.

Where a district cooling scheme exists, lower carbon dioxide emissions may result if the cooling is produced centrally from CHP/absorption chillers, heat pumps or high efficiency vapour compression chillers. The district cooling company will provide information on the carbon dioxide content of the cooling energy supplied, and this figure can then be used to calculate the carbon dioxide emission rate for the building.

9.6 Supplementary information on comfort cooling systems

BS EN 15243:2007[35] provides additional guidance on calculating the seasonal efficiency of cold generators and chillers in air conditioning systems. The guidance does not need to be followed to meet relevant energy efficiency requirements in building regulations.

[35] BS EN 15243:2007 *Ventilation for buildings – Calculation of room temperatures and of load and energy for buildings with room conditioning systems*

Section 10

Air distribution systems

10.1 Introduction

This section gives guidance on specifying air distribution systems for new and existing buildings to meet relevant energy efficiency requirements in building regulations.

10.2 Scope of guidance

The guidance applies to the following types of air distribution system:

- central air conditioning systems
- central mechanical ventilation systems with heating, cooling or heat recovery
- all central systems not covered by the above two types
- zonal supply systems where the fan is remote from the zone, such as ceiling void or roof-mounted units
- zonal extract systems where the fan is remote from the zone
- local supply and extract ventilation units such as window, wall or roof units serving a single area (e.g. toilet extract)
- other local ventilation units, e.g. fan coil units and fan assisted terminal VAV units.

Gas and oil-fired air heaters installed within the area to be heated are not within the scope of this section.

10.3 Key terms

Air conditioning system means a combination of components required to provide a form of air treatment in which temperature is controlled or can be lowered, possibly in combination with the control of ventilation, humidity and air cleanliness.

Ventilation system means a combination of components required to provide air treatment in which temperature, ventilation and air cleanliness are controlled.

Central system means a supply and extract system which serves the whole or major zones of the building.

Local unit means an unducted ventilation unit serving a single area.

Zonal system means a system which serves a group of rooms forming part of a building, i.e. a zone, where ducting is required.

Demand control is a type of control where the ventilation rate is controlled by air quality, moisture, occupancy or some other indicator for the need of ventilation.

Specific fan power (SFP) of an air distribution system means the sum of the design circuit-watts of the system fans that supply air and exhaust it back outdoors, including losses through switchgear and controls such as inverters (i.e. the total circuit-watts for the supply and extract fans), divided by the design air flow rate through that system.

For the purposes of this guide, the ***specific fan power*** of an air distribution system should be calculated according to the procedure set out in EN BS 13779:2007[36] Annex D *Assessing the power efficiency of fans and air handling units – Calculating and checking the SFP, SFP_E and SFP_V.*

$$SFP = \frac{P_{sf} + P_{ef}}{q}$$

Equation 11

where:

SFP is the specific fan power demand of the air distribution system (W/(l/s))

P_{sf} is the total fan power of all supply air fans at the design air flow rate, including power losses through switchgear and controls associated with powering and controlling the fans (W)

P_{ef} is the total fan power of all exhaust air fans at the design air flow rate including power losses through switchgear and controls associated with powering and controlling the fans (W)

q is the design air flow rate through the system, which should be the greater of either the supply or exhaust air flow (l/s). Note that for an air handling unit, q is the largest supply or extract air flow through the unit.

[36] EN BS 13779:2007 *Ventilation for non-residential buildings – Performance requirements for ventilation and room-conditioning systems.*

External system pressure drop means the total system pressure drop excluding the pressure drop across the air handling unit (AHU).

10.4 Air distribution systems in new and existing buildings

Air distribution systems in new and existing buildings should meet the following recommended minimum standards:

a. Air handling systems should be capable of achieving ***a specific fan power*** at 25 per cent of design flow rate no greater than that achieved at 100 per cent design flow rate.

b. In order to aid commissioning and to provide flexibility for future changes of use, reasonable provision would be to equip with variable speed drives those fans that are rated at more than 1100 W and which form part of the environmental control system(s), including smoke control fans used for control of overheating. The provision is not applicable to smoke control fans and similar ventilation systems only used in abnormal circumstances.

c. In order to limit air leakage, ventilation ductwork should be made and assembled so as to be reasonably airtight. Ways of meeting this requirement would be to comply with the specifications given in:

   i. HVCA DW144[37]. Membership of the HVCA specialist ductwork group or the Association of Ductwork Contractors and Allied Services is one way of demonstrating suitable qualifications; or

   ii. British Standards such as BS EN 1507:2006[38], BS EN 12237:2003[39] and BS EN 13403:2003[40].

d. In order to limit air leakage, air handling units should be made and assembled so as to be reasonably airtight. Ways of meeting this requirement would be to comply with Class L2 air leakage given in BS EN 1886:1998[41].

e. The specific fan power of air distribution systems at the design air flow rate should be no worse than in Table 36 for new buildings and in Table 39 for existing buildings.

37 Ductwork Specification DW/144 *Specifications for sheet metal ductwork – Low, medium and high pressure/velocity air systems* (Appendix M revision 2002), HVCA, 1998.

38 BS EN 1507:2006 *Ventilation for buildings – Sheet metal air ducts with rectangular section – Requirements for strength and leakage*.

39 BS EN 12237:2003*Ventilation for buildings – Ductwork – Strength and leakage of circular sheet metal ducts*.

40 BS EN 13403:2003 *Ventilation for buildings – Non-metallic ducts – Ductwork made from insulation ductboards*.

41 BS EN 1886:1998 *Ventilation for buildings – Air handling units – Mechanical performance*.

f. Where the primary air and cooling is provided by central plant and an air distribution system which includes the additional components listed in Table 37, the allowed specific fan powers may be increased by the amounts shown in Table 37 to account for the additional resistance.

g. A minimum controls package should be provided in new and existing buildings as in Table 38.

Table 36: Maximum specific fan powers in air distribution systems in new buildings

System type	**SFP** (W/(l/s))
Central mechanical ventilation system including heating and cooling	1.8
Central mechanical ventilation system including heating only	1.6
All other central mechanical ventilation systems	1.4
Zonal supply system where the fan is remote from the zone, such as ceiling void or roof mounted units	1.2
Zonal extract system where the fan is remote from the zone	0.6
Zonal supply and extract ventilation units such as ceiling void or roof units serving a single room or zone with heating and heat recovery	2.0
Local supply and extract ventilation system such as wall/roof units serving a single area with heating and heat recovery	1.8
Local supply or extract ventilation units such as window/wall/roof units serving a single area (e.g. toilet extract)	0.4
Other local ventilation units	0.6
Fan assisted terminal VAV unit	1.2
Fan coil units (rating weighted average*)	0.6

Table 36: Maximum specific fan powers in air distribution systems in new buildings *(continued)*
Notes: * The rating weighted average is calculated by the following formula $$\frac{P_{mains,1}.SFP_1+P_{mains,2}.SFP_2+P_{mains,3}.SFP_3+\ldots}{P_{mains,1}+P_{mains,2}+P_{mains,3}+\ldots}$$ where P_{mains} is useful power supplied from the mains in W.

Table 37: Extending SFP for additional components

Component	**SFP** (W/(l/s))
Additional return filter for heat recovery	+0.1
HEPA filter	+1.0
Heat recovery – thermal wheel system	+0.3
Heat recovery – other systems	+0.3
Humidifier/dehumidifier (air conditioning system)	+0.1

Example:

For a central mechanical ventilation system including heating and cooling together with heat recovery via a plate heat exchanger:

SFP = 1.8 W/(l/s) for the central mechanical ventilation system including heating and cooling

+ 0.3 W/(l/s) for the plate heat exchanger

= 2.1 W/(l/s)

Table 38: Recommended minimum controls for air distribution systems in new and existing buildings from BS EN 15232:2007[42]

System type		Controls package
Central mechanical ventilation system including heating, cooling or heat recovery	Air flow control at the room level	Time control
	Air flow control at the air handler level	On/off time control
	Heat exchanger defrosting control	Defrost control so that during cold periods ice does not form on the heat exchanger
	Heat exchanger overheating control	Overheating control so that when the system is cooling and heat recovery is undesirable, the heat exchanger is stopped, modulated or bypassed
	Supply temperature control	Variable set point with outdoor temperature compensation
Central mechanical ventilation system including heating or heat recovery	Air flow control at the room level	Time control
	Air flow control at the air handler level	On/off time control
	Heat exchanger defrosting control	Defrost control so that during cold periods ice does not form on the heat exchanger
	Heat exchanger overheating control	Overheating control so that when the system is cooling and heat recovery is undesirable, the heat exchanger is stopped, modulated or bypassed
	Supply temperature control	Demand control

42 BS EN 15232:2007 *Energy performance of buildings – Impact of building automation, controls and building management.*

Table 38: Recommended minimum controls for air distribution systems in new and existing buildings from BS EN 15232:2007[42] *(continued)*

System type		Controls package
Zonal system	Air flow control at the room level	On/off time control
	Air flow control at the air handler level	No control
	Supply temperature control	No control
Local system	Air flow control at the room level	On/off
	Air flow control at the air handler level	No control
	Supply temperature control	No control

Table 39: Maximum specific fan powers in existing buildings	
System type	**SFP** (W/(l/s))
Central balanced mechanical ventilation system including heating and cooling	2.2
Central balanced mechanical ventilation system including heating only	1.8
All other central balanced mechanical ventilation systems	1.6
Zonal supply system where the fan is remote from the zone, such as ceiling void or roof mounted units	1.5
Zonal extract system where the fan is remote from the zone	0.6
Zonal supply and extract ventilation units such as ceiling void or roof units serving a single room or zone with heating and heat recovery	2.0
Local balanced supply and extract ventilation system such as wall/roof units serving a single area with heating and heat recovery	1.8
Local supply or extract ventilation units such as window/wall/roof units serving a single area (e.g. toilet extract)	0.5
Other local ventilation supply and/or extract units	0.6
Fan assisted terminal VAV unit	1.2
Fan coil units (rating weighted average*)	0.6

Notes:
* The rating weighted average is calculated by the following formula

$$\frac{P_{mains,1}.SFP_1+P_{mains,2}.SFP_2+P_{mains,3}.SFP_3+\ldots}{P_{mains,1}+P_{mains,2}+P_{mains,3}+\ldots}$$

where P_{mains} is useful power supplied from the mains, W.

10.5 Heat recovery in air distribution systems in new and existing buildings

Air supply and extract ventilation systems including heating or cooling should be fitted with a heat recovery system. The application of a heat recovery system is described in 6.5 of BS EN 13053:2006[43]. The methods for testing air-to-air heat recovery devices are given in BS EN 308:1997[44].

The minimum dry heat recovery efficiency with reference to the mass flow ratio 1:1 should be no less than that recommended in Table 40.

Table 40: Recommended minimum dry heat recovery efficiency for heat exchangers in new and existing buildings

Heat exchanger type	Dry heat recovery efficiency (%)
Plate heat exchanger	50
Heat pipes	60
Thermal wheel	65
Run around coil	45

10.6 Calculating the specific fan power for SBEM

SBEM assumes a value of ***SFP*** for the fan coil system, so this figure should not to be added to the ***SFP*** for the fan coil units when entering the data into SBEM.

HEPA filtration is recognised as an option in SBEM. The pressure drop can be specified or SBEM will assume a default value from the NCM activity database.

43 BS EN 13053:2006 *Ventilation for buildings – Air handling units – Rating and performance for units, components and sections*.

44 BS EN 308:1997 *Heat exchangers – Test procedures for establishing the performance of air to air and flue gases heat recovery devices.*

Section 11

Pipework and ductwork insulation

11.1 Introduction

This section gives guidance on insulating pipework and ducting serving space heating, hot water and cooling systems in new and existing buildings to meet relevant energy efficiency requirements in building regulations.

The insulation of pipework and ducting is essential to minimise heating system heat losses and cooling system heat gains.

For cooling systems, it is also important to ensure that the risk of condensation is adequately controlled. Condensation control is not within the scope of this section, but is covered by the TIMSA *HVAC Guide for achieving compliance with Part L of the building regulations*.

11.2 Scope of guidance

The guidance in this section covers insulation for the following types of pipework and ductwork serving space heating, domestic hot water and cooling systems:

- pipework: direct hot water, low, medium and high temperature heating, and cooled
- ductwork: heated, cooled and dual-purpose heated and cooled.

11.3 Insulation of pipes and ducts in new and existing buildings

Insulation of pipes and ducts serving heating and cooling systems should meet the following recommended minimum standards:

a. **Direct hot water and heating pipework**

   i. Pipework serving space heating and hot water systems should be insulated in all areas outside of the heated building envelope. In addition, pipes should be insulated in all voids within the building envelope and within spaces which will normally be heated if there is a possibility that those spaces might be maintained at temperatures different to those maintained in other zones. The guiding principles are that control should be maximised and that heat loss from uninsulated pipes should only be permitted where the heat can be demonstrated as "always useful".

ii. In order to demonstrate compliance, the heat losses shown in Table 41 for different pipe sizes and temperatures should not be exceeded.

b. Cooled pipework

i. Cooled pipework should be insulated along its whole length in order to provide the necessary means of limiting heat gain. Control should be maximised and heat gain to uninsulated pipes should only be permitted where the proportion of the cooling load relating to distribution pipework is proven to be less than 1 per cent of total load.

ii. In order to demonstrate compliance, the heat gains in Table 42 for different pipe sizes and temperatures should not be exceeded.

iii. Although unrelated to meeting relevant energy efficiency requirements in building regulations, provision should also be made for control of condensation by following TIMSA guidance[45].

c. Hot and cooled ductwork

i. Ducting should be insulated along its whole length in order to provide the necessary means of limiting heat gains or heat losses.

ii. The heat losses or gains per unit area should not exceed the values in Table 43. Where ducting may be used for both heating and cooling, the limits for chilled ducting should be adopted since these are more onerous. (Heat gains are shown as negative values.)

iii. As with pipework, additional insulation may be required to provide adequate condensation control, as detailed in TIMSA guidance.

45 TIMSA *HVAC Guide for achieving compliance with Part L of the Building Regulations*.

Table 41: Recommended maximum heat losses for direct hot water and heating pipes

	Heat loss (W/m)			
Outside pipe diameter (mm)	**Hot water**[1]	**Low temperature heating**[2]	**Medium temperature heating**[3]	**High temperature heating**[4]
		≤ 95°C	96°C to 120°C	121°C to 150°C
17.2	6.60	8.90	13.34	17.92
21.3	7.13	9.28	13.56	18.32
26.9	7.83	10.06	13.83	18.70
33.7	8.62	11.07	14.39	19.02
42.4	9.72	12.30	15.66	19.25
48.3	10.21	12.94	16.67	20.17
60.3	11.57	14.45	18.25	21.96
76.1	13.09	16.35	20.42	24.21
88.9	14.58	17.91	22.09	25.99
114.3	17.20	20.77	25.31	29.32
139.7	19.65	23.71	28.23	32.47
168.3	22.31	26.89	31.61	36.04
219.1	27.52	32.54	37.66	42.16
273.0 & above	32.40	38.83	43.72	48.48

To ensure compliance with the maximum heat loss criteria, insulation thicknesses should be calculated according to BS EN ISO 12241 using standardized assumptions:

[1] Horizontal pipe at 60°C in still air at 15°C

[2] Horizontal pipe at 75°C in still air at 15°C

[3] Horizontal pipe at 100°C in still air at 15°C

[4] Horizontal pipe at 125°C in still air at 15°C

Table 42: Recommended maximum heat gains for cooled water supplies

Outside diameter of steel pipe on which insulation has been based (mm)	Maximum heat gain (W/m)		
	Temperature of contents (°C)		
	>10[5]	4.9 to 10.0[6]	0 to 4.9[7]
17.2	2.48	2.97	3.47
21.3	2.72	3.27	3.81
26.9	3.05	3.58	4.18
33.7	3.41	4.01	4.60
42.4	3.86	4.53	5.11
48.3	4.11	4.82	5.45
60.3	4.78	5.48	6.17
76.1	5.51	6.30	6.70
88.9	6.17	6.90	7.77
114.3	7.28	8.31	9.15
139.7	8.52	9.49	10.45
168.3	9.89	10.97	11.86
219.1	12.27	13.57	14.61
273.0 and above	14.74	16.28	17.48

Note: Thicknesses given are calculated specifically to meet the criteria given in the table. Adopting these thicknesses may not necessarily satisfy other design requirements such as control of condensation. To ensure compliance with the maximum heat gain criteria, insulation thicknesses should be calculated according to BS EN ISO 12241 using standardized assumptions:
[5] Horizontal pipe at 10°C in still air at 25°C
[6] Horizontal pipe at 5°C in still air at 25°C
[7] Horizontal pipe at 0°C in still air at 25°C

Table 43: Recommended maximum heat losses and gains for insulated heating, cooling and dual purpose ducts

	Heated duct[8]	Dual purpose[9]	Cooled duct[10]
Heat transfer (W/m²)	16.34	-6.45	-6.45

To ensure compliance with maximum heat transfer criteria, insulation thicknesses should be calculated according to BS EN ISO 12241 using standardized assumptions:
[8] Horizontal duct at 35°C, with 600 mm vertical sidewall in still air at 15°C
[9] Horizontal duct at 13°C, with 600 mm vertical sidewall in still air at 25°C
[10] Horizontal duct at 13°C, with 600 mm vertical sidewall in still air at 25°C

Section 12

Lighting

12.1 Introduction

This section provides guidance on specifying lighting for new and existing buildings to meet relevant energy efficiency requirements in building regulations.

12.2 Scope of guidance

The guidance in this section applies to the following types of lighting:

- general interior lighting
- display lighting.

12.3 Key terms

Office area means a space that involves predominantly desk-based tasks, e.g. a classroom, seminar or conference room.

Daylit space means any space:

a. within 6 m of a window wall, provided that the glazing area is at least 20 per cent of the internal area of the window wall; or

b. below rooflights provided that the glazing area is at least 10 per cent of the floor area.

The normal light transmittance of the glazing should be at least 70 per cent; if the light transmittance is below 70 per cent, the glazing area should be increased proportionately for the space to be defined as daylit.

***Space classification* for control purposes**[46]:

> ***Owned space*** means a space such as a small room for one or two people who control the lighting, e.g. a cellular office or consulting room.

[46] These definitions are given in more detail in BRE Information Paper IP6/96 *People and lighting controls* and BRE Digest 498 *Selecting lighting controls.*

Shared space means a multi-occupied area, e.g. an open-plan office or factory production area.

Temporarily owned space means a space where people are expected to operate the lighting controls while they are there, e.g. a hotel room or meeting room.

Occasionally visited space means a space where people generally stay for a relatively short period of time when they visit the space, e.g. a storeroom or toilet.

Unowned space means a space where individual users require lighting but are not expected to operate the lighting controls, e.g. a corridor or atrium.

Managed space means a space where lighting is under the control of a responsible person, e.g. a hotel lounge, restaurant or shop.

Local manual switching means, in local or flexible manual switching, the distance on plan from any local switch to the luminaire it controls should generally be not more than six metres, or twice the height of the light fitting above the floor if this is greater. Where the space is a daylit space served by side windows, the perimeter row of lighting should in general be separately switched.

Photoelectric control is a type of control which switches or dims lighting in response to the amount of incoming daylight.

Presence detection is a type of control which switches the lighting on when someone enters a space, and switches it off, or dims it down, after the space becomes unoccupied.

Absence detection is a type of control which switches the lighting off, or dims it down, after the space becomes unoccupied, but where switching on is done manually.

Lamp lumens means the sum of the average initial (100 hour) lumen output of all the lamps in the luminaire.

Circuit-watt is the power consumed in lighting circuits by lamps and, where applicable, their associated control gear (including transformers and drivers) and power factor correction equipment.

Lamp lumens per circuit-watt is the total ***lamp lumens*** summed for all luminaires in the relevant areas of the building, divided by the total circuit-watts for all the luminaires.

LOR is the light output ratio of the luminaire, which means the ratio of the total light output of the luminaire under stated practical conditions to that of the lamp or lamps contained in the luminaire under reference conditions.

Luminaire lumens per circuit-watt is the (***lamp lumens*** x ***LOR***) summed for all luminaires in the relevant areas of the building, divided by the total circuit-watts for all the luminaires.

12.4 Lighting in new and existing buildings

a. Lighting in new and existing buildings should meet the recommended minimum standards for efficacy (averaged over the whole area of the applicable type of space in the building) in Table 44.

b. Metering of lighting for new and existing buildings (to record the lighting energy consumption) should meet the minimum standards in Table 46.

c. Lighting controls in new and existing buildings should meet the minimum standards in Table 47, or follow the guidance in BRE Digest 498 *Selecting lighting controls*. Display lighting, where provided, should be controlled on dedicated circuits that can be switched off at times when people will not be inspecting exhibits or merchandise or being entertained.

Table 44: Recommended minimum lighting efficacy in new and existing buildings

Lighting type	**Lighting efficacy** (%)
General lighting in office, industrial and storage areas	The average initial efficacy should be not less than 55 luminaire lumens per circuit-watt. In calculating the average luminaire lumens per circuit-watt, the circuit-watts for each luminaire may first be multiplied by the appropriate control factor in Table 45. Note: The value entered into NCM tools for calculating the CO_2 emission rate for new buildings (BER) should be the value **before** the control factor is applied, since NCM tools already take account of additional controls by reducing the BER.
General lighting in other types of space	The average initial efficacy should be not less than 55 lamp lumens per circuit-watt.
Display lighting	The average initial efficacy should be not less than 22 lamp lumens per circuit-watt.

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Table 45: Luminaire control factors for use in new and existing buildings

Light output control	Control factor
a. The luminaire is in a daylit space and its light output is controlled by photoelectric switching or dimming control, with or without override.	0.9
b. The luminaire is in a space that is likely to be unoccupied for a significant number of operating hours, and where a sensor switches off the lighting in the absence of occupants but switching on is done manually except where this would be unsafe.	0.9
c. Circumstances a. and b. combined.	0.85
d. None of the above.	1.0

Table 46: Recommended minimum standards for metering of general and display lighting in new and existing buildings

	Standard
Metering for general or display lighting	a. kWh meters on dedicated lighting circuits in the electrical distribution; or b. local power meter coupled to or integrated in the lighting controllers of a lighting or building management system; or c. a lighting management system that can calculate the consumed energy and make this information available to a building management system or in an exportable file format. (This could involve logging the hours run and the dimming level, and relating this to the installed load.)

Table 47: Recommended minimum controls for general and display lighting in new and existing buildings

Space classification[47]	Control type
Owned	Manual by door
Shared	Flexible manual switching, e.g. local pull cords or wireless transmitter
Temporarily owned	Local manual switching*
Occasionally visited	Local manual switching*
Unowned	Time switching
Managed	a. Time switching; or b. centralised manual

* Note definition of *local manual switching* given above

[47] The definitions are given in BRE Information Paper IP6/96 and BRE Digest 498.

Section 13

Heating and cooling system glandless circulators and water pumps

13.1 Introduction

Heating and cooling water in HVAC systems of non-domestic buildings can circulate for extensive periods and be responsible for considerable energy use.

This section provides guidance on specifying circulators and water pumps for new and existing buildings to limit their energy consumption and meet relevant energy efficiency requirements in building regulations.

13.2 Scope of guidance

The guidance covers heating and cooling system glandless circulators and water pumps when used in closed systems. The guidance does not apply to circulators integrated within a boiler housing.

13.3 Key terms

Heating system glandless circulator means a pump used to circulate hot water in closed circuit heating systems. The glandless (or wet rotor) circulator is a centrifugal pump with an integral motor and no mechanical seal. It can have an integrated motor drive unit for variable speed operation.

Water pump (also known as "dry rotor" or "direct coupled" pump) means a centrifugal pump driven by an electric motor and generally having mechanical seals. Common pump types include in-line, end suction and vertical multi-stage. The first two are usually single-stage pumps having single-entry volute. By design they can all be used as circulators for all HVAC applications depending on configuration and duty.

13.4 Glandless circulators and water pumps in new and existing buildings

For heating and cooling system glandless circulators and water pumps in new and existing buildings, the recommended minimum standards in Table 48 should be adopted.

Table 48: Recommended minimum standards for heating system glandless circulators and water pumps in new and existing buildings

Standard
a. All glandless circulators up to 2.5 kW should be labelled under the Europump Labelling Scheme, and have a rating within the range A to G. b. Variable speed glandless circulators should be used on variable volume systems. c. If a water pump is used on a closed loop circuit and the motor is rated at more than 750 W, then it should be fitted with or controlled by an appropriate variable speed controller on any variable volume system. On water pump booster sets with an open loop circuit, the static head should be checked before an appropriate variable speed controller is used.

13.5 Supplementary information

Further information and guidance is available from www.bpma.org.uk where a list of approved glandless circulators and water pumps can be found.

The EuP Directive will introduce a requirement for all circulators placed on the market from January 2013 to have a minimum Energy Efficiency Index (EEI), initially equivalent to an A-rating under the Europump Labelling Scheme, and later equivalent to an A rating. To meet these standards, over the next three to five years the circulator industry will have to switch from using induction motors to permanent magnet motors.*

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