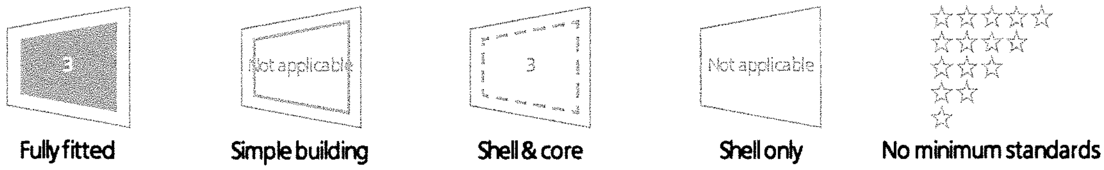
Pol 01 Impact of refrigerants



Aim

To reduce the level of greenhouse gas emissions arising from the leakage of refrigerants from building systems.

Value

- Increase system resilience and market value through the use of low impact refrigerants in buildings.
- Minimising future liabilities and adaptation costs associated with changes to statutory requirements relating to refrigerant use.
- Limit the potential release and impact of refrigerant gases into the atmosphere.
- Assist in meeting corporate social responsibility reporting targets relating to refrigerant use.

Context

The typical refrigerants used in building cooling systems are major greenhouse gases that are many times more potent than carbon dioxide in their contribution to global warming and climate change. Although released in much smaller quantities they are, never the less, a significant contributor to increasing global temperatures. As such, they are the focus of increasingly strict regulatory controls internationally and nationally. Worldwide agreements such as the 1992 United Nations Framework Convention on Climate Change (UNFCCC) and its extension the Kyoto Protocol commit signatories to reducing greenhouse gas emissions and banning the worst performing gases. The agreements seek to shift use to low impact refrigerants over time and so provide a timescale for the phasing out of more potent refrigerants because the use of the gases is widespread and key to industries across developed and developing countries.

BREEAM seeks to support this agenda and promote more rapid change by creating market value for developments with reduced impact refrigerants by limiting the volume or weight of gases used, their potential impact, and for specifying systems which detect and control leakage of gas to the atmosphere.

Assessment scope

	Fully fitted	Simple building	Shell and core	Shell only
Applicable Assessment criteria	All	Not applicable	All	Not applicable
Assessment type specific notes	Ref 1.1	None	See ref 1.0 and 1.1	None

Specific notes

Assessment type specific	
1.0	If the building is designed to avoid the need for refrigerant-containing building services, so no refrigerant use will be specified for the fit-out, the available credits can be awarded by default.
1.1	This assessment issue does not apply to buildings designed to be untreated, i.e. where internal spaces will not be serviced by heating, ventilation or air-conditioning systems and therefore have no noise-generating plant. Examples of such building types could include industrial warehouse storage.

Building type specific

None

Assessment criteria

Three credits - No refrigerant use

1 No refrigerant use within the installed plant or systems.

OR alternatively, where the building does use refrigerants, the three credits can be awarded as follows:

Prerequisite

2 All systems with electric compressors comply with the requirements of BS EN 378:2016[207] (parts 2 and 3). Refrigeration systems containing ammonia comply with the Institute of Refrigeration Ammonia Refrigeration Systems code of practice[208].

Impact of refrigerant

Two credits

3 The direct effect life cycle CO_2 equivalent emissions (DELC) of ≤ 100 CO_2-eq/kW. For systems which provide cooling and heating, the worst performing output based on the lower of kW cooling output and kW heating output is used to complete the calculation. To calculate the DELC, refer to the relevant definitions in Methodology below and Additional information on page 303.

OR

4 All refrigerants used have a global warming potential (GWP) ≤ 10.

OR

One credit

5 Systems using refrigerants have a DELC of ≤ 1000 kgCO_2-eq/kW cooling and heating capacity.

One credit - Leak detection

6 All systems are hermetically sealed or only use environmentally benign refrigerants (see Leak detection and Hermetically sealed systems on page 301).

OR

7 Where the systems are not hermetically sealed:

- 7.a Systems have:
  - 7.a.i A permanent automated refrigerant leak detection system, that is robust and tested, and capable of continuously monitoring for leaks.

  OR

  - 7.a.ii An inbuilt automated diagnostic procedure for detecting leakage is enabled.
- 7.b In the event of a leak, the system must be capable of automatically responding and managing the remaining refrigerant charge to limit loss of refrigerant (see Automatic isolation and containment of refrigerant on page 303).

Methodology

BREEAM Pol 01 calculator

The BREEAM Pol 01 calculator is used to determine the number of credits achieved.

The direct effect life cycle CO_2-eq emissions (DELC) per kW of cooling and heating capacity are calculated using the following equation:

$$\frac{[\textbf{Refrigerant loss operational+refrigerant loss system retirement}] \times GWP}{\textbf{Cooling Capacity (kW)}}$$

Where:

Refrigerant loss operational: $(Ref_{charge} \times Sys_{op\text{-}life} \times (L1 + L2 + S1 + S2))/100$

Refrigerant loss system retirement $= Ref_{charge} \times (1 - (Ref_{RecEff}/100))$

Where:

1. Ref_{charge}: Refrigerant charge (kg)
2. $Sys_{op\text{-}life}$: System operational lifetime (years)
3. Ref_{RecEff}: Refrigerant recovery efficiency factor (%)
4. L1: Annual leakage rate (units: % Refrigerant charge)
5. L2: Annual purge release factor (% Refrigerant charge)

6. S1: Annual service release (% Refrigerant charge)
7. S2: Probability factor for catastrophic failure (% refrigerant charge loss/year)
8. GWP: global warming potential of refrigerant
9. Cooling and heating capacity (kW).

The following default values must be used, where system-specific data are not available:
$Sys_{op\text{-}life}$: System operational design life (years): see Table 12.1 below.
Ref_{RecEff}: Refrigerant recovery efficiency factor (%): **95**
L1: Annual leakage rates (% refrigerant charge): see Table 12.2 below.
L2: Annual purge release factor (% refrigerant charge): **0.5** (if the system does not require an annual purge, zero should be used).
S1: Annual service release (% refrigerant charge): **0.25** (this applies where the system requires opening up to carry out the annual service. For systems which do not require opening up, there will be no associated annual release of refrigerant, therefore a default of zero should be used).
S2: Probability factor for catastrophic failure (% refrigerant charge loss/year): **1** (based on a failure rate of 1 in 100 systems).
The following information must be sourced from the design team's mechanical and electrical engineer or system manufacturer:
- System type
- Ref_{charge}: Refrigerant charge (kg)
- GWP: global warming potential of refrigerants
- Cooling and heating capacity (kW).

When manufacturers' provide figures used in the DELC calculation, the figures must be supported by published data, or such data must be readily available from the manufacturer. BREEAM Assessors must obtain this supporting evidence. The DELC calculation is a measure of the risk and severity of potential system leaks. The figures used must represent this for all installed systems;, i.e. across the expected range of maintenance and use.

Table 12.1 Default system operational design life values

System type	Default system operational design life values (years)
Small or medium capacity chillers	15
Large capacity chillers	20
Unitary split	15
Variable Refrigerant Flow (VRF) system	15
All other systems	10

Note: These figures are based on those reported in LOT 6 for air-conditioning units[209] and the British Refrigeration Association's (BRA) Guideline Methods of Calculating TEWI (Total Equivalent Warming Impact) (2006)[210].
The following should be considered when determining whether the system specified is defined as small, medium or large:
- Large capacity chiller: centrifugal compressor
- Medium capacity chiller: scroll or screw compressor
- Small capacity chiller: scroll compressor.

Table 12.2 Default values for DELC calculation when manufacturer's figures are not available

System type	Annual leakage rate (% of charge per annum)
Cold storage and display systems	
Integral cabinets	3%
Split or condensing units	18%
Centralised	19%
Air-conditioning systems	
Unitary split	15%
Small-scale chillers	10%
Medium or large chillers	5%
Heat pumps	6%

Note: These figures are based on those reported in LOT 6 for air-conditioning units and also Table 2 of the

System type	Annual leakage rate (% of charge per annum)
Market Transformation Programmes Briefing Note for Commercial Refrigeration no. 36, 'Direct Emission of Refrigerant Gases' (version 1.2)[211]. The figures are based on the average of the leakage rates from the four separate studies reported in Table 2 (where a range is reported, the higher value was used).	

Specification of multiple systems

Where more than one air-conditioning or refrigeration system is installed in the building, the assessor must source the relevant technical data for each system and enter it into the Pol 01 calculator. The calculator will then determine the weighted average DELC for the building.

Leak detection

The refrigerant leak detection criteria are applicable where any type of non-solid refrigerant is present, i.e. even if the refrigerant meets BREEAM's DELC CO_2-eq benchmarks. Exceptions to this are systems that use natural and environmentally benign refrigerants, such as air and water (e.g. lithium bromide or water absorption chillers) and installations of small multiple hermetically sealed systems. These types of system or refrigerants will achieve the leak detection credit by default. See criterion 6 on page 299.

District cooling systems

Where a project is connected to a district cooling system which is outside the scope of the project or the wider development (e.g. phased developments), the system does not need to be included in the assessment. This is because the design team will not have control over the specification of the system. If the design team do have control over the specification of the system, then it must be assessed.

Evidence

Criteria	Interim design stage	Final post-construction stage
All	One or more of the appropriate evidence types listed in The BREEAM evidential requirements on page 26 can be used to demonstrate compliance with these criteria.	
3, 5	Completed copy of the Pol 01 Calculator tool.	As per interim design stage.
3, 5	Documentary evidence supporting the data used to complete the calculator tool.	As per interim design stage.

Definitions

Direct effect life cycle (DELC) carbon dioxide equivalent

A measure of the effect on global warming arising from emissions of refrigerant from the equipment to the atmosphere over its lifetime (units: $kgCO_2$-eq). The calculation involves estimating the total refrigerant release over the period of operation and subsequent conversion to an equivalent mass of carbon dioxide. Should the system use several different refrigerants (e.g. a primary refrigerant and a secondary coolant) or a cascade system, individual calculations are made for all refrigerants which contribute to the direct effect (see Methodology on page 299 for a description of how DELC is calculated).

Hermetically sealed systems

Hermetically sealed plant (as defined in the F Gas regulations) can be awarded the Leak Detection credit by default. The Regulations' definition of hermetically sealed plant only allows systems to have a tested leakage rate of less than 3 grams per year. This results in the risk of a large refrigerant leak due to system failure being minimised.

Global warming potential (GWP)

GWP is defined as the potential for global warming that a chemical has relative to 1 unit of carbon dioxide, the primary greenhouse gas. In determining the GWP of the refrigerant, the Intergovernmental Panel on Climate Change methodology using a 100-year integrated time horizon should be applied.

Refrigerant

There are three main types of refrigerants:

1. Hydrogenated fluorocarbon refrigerants (HFCs) are made up of hydrogen, fluorine and carbon. These do not use a chlorine atom (which is used in most refrigerants), which means they are one of the least damaging to the earth's ozone layer.
2. Hydrogenated chlorofluorocarbon refrigerants (HCFCs) are made up of hydrogen, chlorine, fluorine and carbon. These refrigerants contain minimal amounts of chlorine; they are not as detrimental to the environment as some other refrigerants.
3. Chlorofluorocarbon refrigerants (CFCs) contain chlorine, fluorine and carbon. These refrigerants carry high amounts of chlorine so they are known to be the most hazardous to the ozone layer.

The use of CFCs and HCFCs as refrigerants has been addressed under the Montreal Protocol. Phase-out programmes have been agreed resulting in these substances no longer being used as refrigerants in all new installations and most existing situations. The industry's favoured replacements are currently HFCs which are often potent global warming contributors. The Kigali Amendment to the Montreal Protocol set a phase-out programme. Hydrocarbons and ammonia-based refrigerants have low or zero GWP and are therefore preferred long term options. These are now widely available and are valid alternatives to HFCs in all buildings, provided health and safety issues are fully addressed. The United Nations Environment Programme (UNEP) hosts a HCFC help centre which contains information about the management and phase-out of HCFCs and alternatives to HCFCs in the refrigeration and air-conditioning sector www.uneptie.org.

Refrigerant leak detection

An automated permanently installed multi-point sensing system, designed to continuously monitor the atmosphere in the vicinity of refrigeration equipment. In the event of detection it can raise an alarm. The system may be aspirated or have multiple-sensor heads linked to a central alarm unit or building management system (BMS). Various sensor types are available including infra-red, semi-conductor or electro-chemical.

Refrigerant recovery

The process of removing refrigerant from a system and storing it in an airtight container.

Refrigerant pump down

The specification of automatic refrigerant pump down can further limit potential losses and damage to the environment and have subsequent economic benefits to the building owner. Under the UK Environmental Protection Act 1990 refrigerant and refrigerating system oil are classified as either controlled or hazardous waste. It is an offence to discharge them to the environment, and there are procedures regarding transport, storage, transfer of ownership and ultimate disposal. Article 16 of EC Regulation 2037/2000 specifies that used CFCs and HCFCs must be recovered for destruction, recycling or reclamation.

Robust and tested refrigerant leak detection system

This is normally defined as systems included on the Enhanced Capital Allowance (ECA) Energy Technology Product List[212] (or an equivalent list). Where the system does not fall within the above scope the design team must demonstrate to the assessor that the system specified meets the principles of the scheme as far as is applicable.

Small-scale white goods

These are defined as domestic-scale white goods and include small individual display cabinets (e.g. drinks cabinets in small retail shops).

Systems using refrigerants

The criteria of this issue apply to all building services installed in the building, regardless of the systems refrigerant charge (kg). These services include, but are not limited to:

- Comfort cooling or space heating (including assessment of refrigerants in heat pumps)
- Cold storage, including commercial food and drink display cabinets but excluding small-scale white goods
- Process-based cooling loads (e.g. servers and IT equipment).

Additional information

Automatic isolation and containment of refrigerant

An example of a system which would meet criterion 7.b could be one which initiates an automated shut down and pump down of the refrigerant into a separate storage tank.

Limiting loss of refrigerant in the event of a leak

BREEAM has not set specific requirements or methods regarding the most appropriate way of limiting refrigerant loss. This will be different depending on the system type. Example methods are pump down, isolation or system shut-down, etc.

Common refrigerants

Table 12.3 List of some common refrigerant types with low GWP

R-Number	Chemical name	GWP 100-yr
R-30	Dichloromethane	9
R-170	Ethane	3
R-290	Propane	3
R-600	Butane	3
R-600a	Isobutane	3
R-702	Hydrogen	5.8
R-717	Ammonia	0
R-718	Water	0.2–0.2
R-729	Air (nitrogen, oxygen, argon)	1
R-744	Carbon dioxide	1
R1150	Ethylene	3
R-1234yf	2,3,3,3-Tetrafluoropropene	4
R-1270	Propylene	3

Sources: The United Nations Environment Programme '2010 Report of the Refrigeration, Air-conditioning and Heat Pumps Technical Options Committee'
EN 378-1:2016+A2:2012 Refrigerating systems and heat pumps - Safety and environmental requirements. Part 1: Basic requirements, definitions, classification and selection criteria - Annex E.
The Intergovernmental Panel on Climate Change' 5th Assessment Report, Chapter 8, 'Anthropogenic and Natural Radiative Forcing', 2013
'Global environmental impacts of the hydrogen economy', Derwent *et al*, Int. J. Nuclear Hydrogen Production and Application, Vol. 1, No. 1, 2006

The formula used to calculate the DELC emissions in BREEAM is based on the total equivalent warming impact (TEWI) calculation method for new stationary refrigeration and air-conditioning systems. TEWI is a measure of the global warming impact of equipment that takes into account both direct emissions and indirect emissions produced through the energy consumed in operating the equipment. This BREEAM issue is concerned with direct emissions and the BREEAM energy section is concerned with indirect emissions.