U-values

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Introduction

U-values (sometimes referred to as heat transfer coefficients or thermal transmittances) are used to measure how effective elements of a building's fabric are as insulators. That is, how effective they are at preventing heat from transmitting between the inside and the outside of a building.

R-values, which measure thermal resistance rather than thermal transmission, are often described as being the reciprocal of **U-values**, however, R-values do not include surface heat transfers.

The lower the **U-value** of an element of a building's fabric, the more slowly heat is able to transmit through it, and so the better it performs as an insulator.

Very broadly, the better (i.e. lower) the **U-value** of a building's fabric, the less energy is required to maintain comfortable conditions inside the building.

As energy prices increase, and there is greater awareness of sustainability, performance measures such as **U-values** have become more important, and building standards (such as the Building Regulations) have required that lower and lower **U-values** are achieved. This has required changes in the design of buildings, both in the use of materials (such as insulation), the make-up of the building elements (such as cavity walls and double glazing), and the overall make up of a building's fabric (for example, reducing the proportion of glazing).

Typical values

U-values are measured in watts per square metre per kelvin ($W/(m^2K)$). For example, a double glazed window with a **U-value** of 2.8, for every degree difference in temperature between the inside and outside of the window, 2.8 watts will be transmitted every square metre.

A range of **U-values** are indicated below for the purposes of comparison only:

- Solid brick wall: 2 $W/(m^2K)$

- Cavity wall with no insulation: 1.5 W/(m²K).
- Insulated wall: 0.18 W/(m²K).
- Single glazing: 4.8 to 5.8 W/(m²K).
- Double glazing: 1.2 to 3.7 W/(m²K) depending on type.
- Triple glazing below: 1 W/(m²K).
- Solid timber door: 3 W/(m²K).

Part L of the Building Regulations (Conservation of fuel and power) now prevents certain forms of construction by setting limiting standards (i.e. maximum **U-values**) for building elements. See Limiting fabric parameters for more information.

It should be noted however that these are maximum permitted values, the specification for the notional domestic building referred to in Part L1A has considerably lower values, for example:

- External wall: 0.18 W/(m²K).
- Floor: 0.13 W/(m²K).
- Roofs: 0.13 W/(m²K).
- Windows, roof windows, glazed rooflights and glazed doors: 1.4 W/(m²K).

See Standard Assessment Procedure SAP for more information.

NB: It is important to distinguish between **U-values** for materials (such as glass), or assemblies (such as windows, which have frames, air gaps, and so on), or elements (such as walls, which may have complex constructions comprising a number of different components).

Calculation

The U value of an element (in W/(m²K)) can be calculated from sum of the thermal resistances (R-values in m^2K/W) of the layers that make up the element plus its inside and outside surface thermal resistances (Ri and Ro).

U-value = 1 / (ΣR + Ri + Ro)

Where the thermal resistance of the layers of the element R = the thickness of each layer / the thermal conductivity of that layer (its k-value or lambda value (λ) in W/(mK)).

This can become a complicated calculation when there are a large number of layers, ventilated or unventilated cavities are introduced, or the element is inclined. Manufacturers will generally provide **U-values** for products that they supply. There are also a number of **U-value** calculators available online (such as the BRE U-value calculator, although this is not free).

Calculation methods for **U-values** appropriate for demonstrating compliance with the building regulations are based on standards developed by the European Committee for Standardisation (CEN) and the International Organisation for Standardisation (ISO) and published as British Standards. See Conventions for U-value calculations (2006 edition) BR 443.

Whilst **U-values** are still used in the Building Regulations to set limiting standards for the elements of a building's fabric, the overall thermal performance of buildings is now assessed using more complex modelling procedures.

For non-domestic buildings, the Simplified Building Energy Model (SBEM) developed by the BRE for the Department for Communities and Local Government, determines the energy performance of a proposed building by comparing its annual energy use with that of a comparable notional building. SBEM can be downloaded from the National Calculation Methodology website.

For dwellings, energy performance is assessed using the Government's Standard Assessment Procedure (SAP).

NB: Whilst **U-values** and methods of modelling the thermal performance of buildings are invaluable in setting standards and providing a means of comparing alternative solutions, they are simplifications of reality, and performance in use rarely matches that which was predicted. Poor workmanship can result in reduced thermal resistance, as can poor detailing and the presence of water in insulating materials. See Insulation specification and performance gap for more information.

NB: The building regulations now require that 'consequential improvements' are carried out on certain non-domestic buildings when they are extended or altered in order to bring the entire building more into line with the requirements of Part L of the Building Regulations. See Consequential improvements for more information.

Related articles on Designing Buildings Wiki

- Air tightness in buildings.
- Building performance.
- Cavity wall insulation.
- Co-heating test.
- Conduction.
- Conductor.
- Conventions for calculating linear thermal transmittance and temperature factors.
- Computational fluid dynamics.
- Double glazing.
- Double glazing v triple glazing.
- Emissivity.

- Floor insulation.
- g-value.
- k-value.
- Heat loss.
- Heat transfer.
- Insulation specification.
- Limiting fabric parameters.
- PA ratio.
- R-value.
- Roof insulation.
- Shading coefficient.
- Solar heat gain coefficient.
- Solid wall insulation.
- Standard Assessment Procedure SAP.
- Thermal admittance.
- Thermal bridge.
- Thermal mass.
- Thermal resistance.
- Thermographic survey.
- Triple glazing.
- U-value conventions in practice: Worked examples using BR 443.
- Zero carbon homes.
- Zero carbon non-domestic buildings.

External references

- Planning Portal: Approved Document L (Conservation of fuel and power).
- BRE: Conventions for U-value calculations (2006 edition).
- BRE U-value calculator.

- National Calculation Methodology website.
- Standard Assessment Procedure.