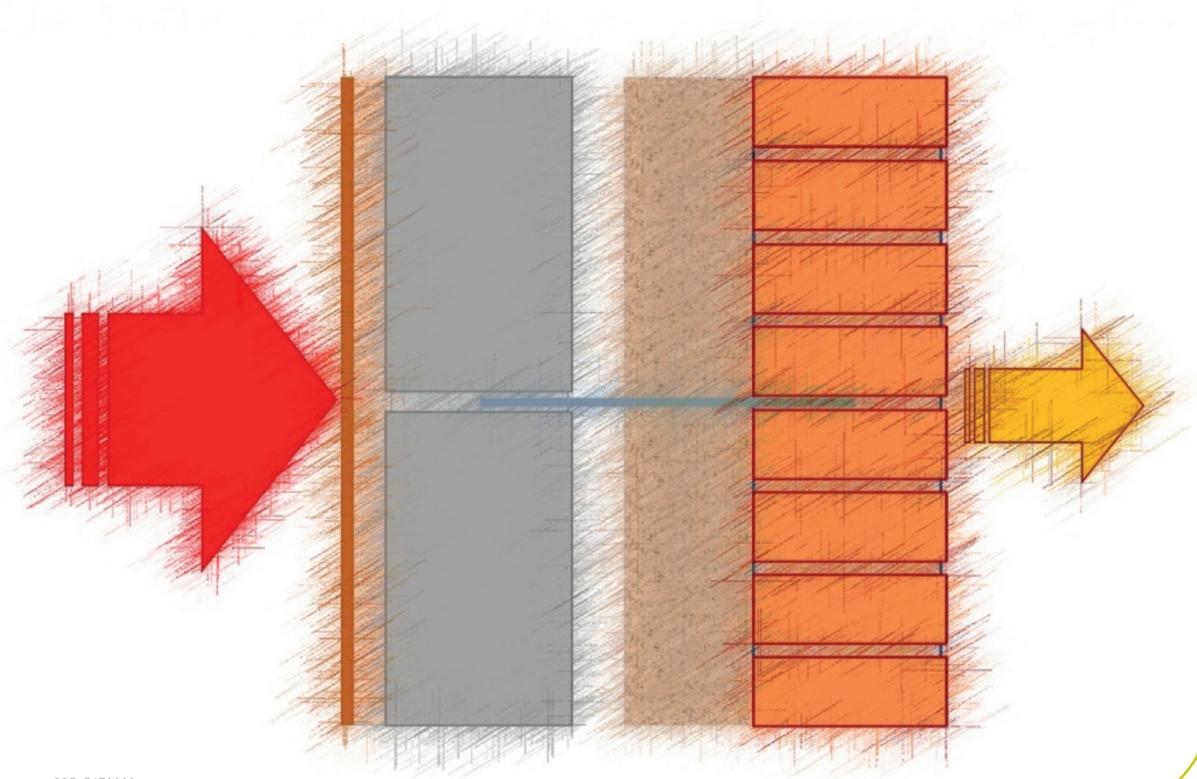


Conventions for U-value calculations

[Brian Anderson], Ludmilla Kosmina



Authors, contributors, and acknowledgements

Authors:

[Brian Anderson] (BRE)
Ludmilla Kosmina (BRE)

Contributors:

Gerry Pettit (CBA, BSI)
Bill Hawker (Brett Martin)
Jeremy Dunn (Glazing Vision)
Nigel Blacklock (Bauder)
Andrew Carpenter (Structural Timber)
Chris Roddick (Bauder)
Ian Loughnane (Kingspan)
Gary Morgan (BFRC/GGF)
Jon Denyer (BBA)
James Walker (Structural Timber)
Jonathan Ducker (Kingspan)
Matthew Evans (Kingspan)
Martin Ford (CAB)
Martin Milner (Structural Timber)
Nicolas Dupin (Velux)
Nick Selves (MCRMA)
Paul Felgate (Bauder)
Peter Wilcox (Recticel)
Thomas Wiedmer (Actis Insulation)
Carol Houghton (BSI)

Acknowledgements:

Paul Davidson (BRE)
Sean Doran (BRE)
John Henderson (BRE)
Steve Abnett (BRE)
Bob Richardson (NFRC)
Carlton Jones (MCRMA)
Duncan King (CPA)
David Roy (MCRMA)
Guy Lewis (Structural Timber)
Jim Hooker (SPRA)
Lauren Fairley (TIMSA)
Lee Davies (MCRMA)
Lewis Taylor (TRADA)
Liz Wynder (NHBC)
Mark Magennis (Xtratherm)
Mark Stevenson (Kingspan)
Mel Price (IMA)
Malcolm Macleod (NHBC)
Nick Burton (Steel-Window-Association)
Nick Boulton (TTF)
Paul Newman (Kingspan)
Paul Cribbens (NHBC)
Philip Lever (Aggregate, CBA)
Richard Milward (Jablite)
Rob Warren (Celotex)
Sam Dawe (Innovare Systems)
Steve Chaytor (NHBC)
Stephen Wise (Knauf Insulation)
John Hefford (Thermal Economics)

BR 443
ISBN 978-1-84806-481-2
© Copyright IHS Markit 2020

First published 2002
Second edition 2006
Third edition 2019

In memory of Dr Brian Anderson

This document is published in memory of **Brian Anderson [1948–2016]**, the author of the 2002 and 2006 editions of this document.

Dr Brian Anderson was the lead author for the original BR 443 – Conventions for U-values, and the newly published revised version has been shaped by his initial input at the technical scoping stage prior to his unexpected passing in 2016.

Brian's contribution to the industry was huge, and with his expertise he guided, informed, and enabled both government and generations of engineers, architects, builders, teachers, and students to understand and construct better performing homes. He led the development and maintenance of BREDEM, and later SAP (the methodology by which we assess the compliance of domestic dwellings against the Energy Performance of Buildings Directive) and authored a range of more than 30 technical publications and papers to support this.



He also played a leading role in the preparation of European standards for thermal insulation and thermal performance, including chairing the committees for British Standards Institution (BSI) that coordinates the UK input to the European Committee for Standardisation's (CEN) 'Thermal performance of buildings and building components', and playing a strategic role within CEN to ensure consistency and compatibility of various standards. The sum of Brian's work has had a profound, lasting, and positive impact on us all – enabling the United Kingdom to measure and reduce household fuel use and provide a mechanism for reducing the nation's carbon emissions and addressing fuel poverty.

Brian was recognised and held in the highest esteem by those who knew him or of his work. He was admired and respected by colleagues and clients alike, based on his deep knowledge and experience, positive attitude, and polite manner. He was a quiet and unassuming gentleman who had a passion for his work. His passing has been an enormous loss to both BRE and the industry, and BRE is proud to publish the revised BR 443 in honour of his great contribution to the built environment.

Contents

1	Introduction	8
1.1	General	8
1.2	The use of U-values in calculating heat transfer	9
1.3	Calculation methods for the determination of thermal transmittance (U-values).	10
1.4	Calculation methods for the determination of linear thermal transmittance (Ψ) and point thermal transmittance (χ).	11
1.5	U-values obtained by in-situ measurement	12
1.5.1	Heat flow meter method	12
1.5.2	Infrared method for frame structure dwelling	12
2	U-value calculation: Simplified methods and numerical methods	13
2.1	Simplified methods of establishing U-values	13
2.2	Numerical methods of establishing U-values	14
2.3	Simplified and numerical methods used together	14
3	Thermal properties of materials and products	15
3.1	Declaration of thermal properties of thermal insulation products	15
3.2	Thermal values for use in calculations	15
3.3	Masonry	15
3.4	Concrete beams and concrete screeds	16
3.5	Stone	16
3.6	Insulation materials	16
3.7	Gypsum plasterboard	17
3.8	Timber, structural timber, and timber-based sheathing	17
3.9	Metals and alloys	17
3.10	Reflective foil products	17
3.10.1	Thermal resistance of foam or mineral wool insulation with aluminium foil facing	18
3.10.2	Thermal resistance of bubble-foil and multi-foil insulation	18
3.10.3	Thickness of multi-foil insulation and adjacent air cavity	20
3.10.4	Reflective breather membranes, vapour control layers, air barriers.	20
4	Details of U-value calculations	21
4.1	Surface resistance	21
4.2	Mortar joints in masonry construction	21
4.3	Voided masonry units	22
4.4	Timber fraction for timber-framed walls	22
4.4.1	Conventional timber studs	22
4.4.2	I-beam studs	23

4.5	Timber fractions for other elements	24
4.5.1	Ceiling joists	24
4.5.2	Metal web joists	25
4.5.3	Doubled-up timbers	26
4.5.4	Suspended timber floor	26
4.6	Plasterboard wall lining (unventilated)	26
4.6.1	Plasterboard on dabs	26
4.6.2	Plasterboard on battens (47 mm at 600 mm centres)	26
4.6.3	Plasterboard on battens (47 mm at 400 mm centres)	27
4.7	Thermal resistance of air layers	27
4.7.1	Thermal resistance of unventilated air layer with normal emissivity surface	29
4.7.2	Thermal resistance of unventilated air layer with low emissivity surface	29
4.7.3	Resistance of slightly ventilated air layer with low emissivity surface	30
4.7.4	Resistance of small airspaces (up to 0.3 m in components other than glazing).	30
4.7.5	Resistance of roof spaces	30
4.7.6	Resistance of profiled metal decks	31
4.8	Corrections to thermal transmittance (ΔU)	31
4.8.1	Corrections for air gaps	31
4.8.2	Wall ties	32
4.8.3	Corrections for mechanical fasteners (fixing screws and other fixings)	33
4.8.4	Windposts and masonry support brackets	33
4.8.5	Rainscreen cladding	34
4.8.6	Inverted roofs	36
4.8.7	Loft hatches	37
4.8.8	Recessed light fittings	37
4.9	Metal-faced roofing and wall cladding	38
4.9.1	Rail-and-bracket systems	38
4.9.2	Compression of insulation by profile ribs	38
4.10	Light steel-framed walls	39
4.11	Timber building kits	39
5	Elements adjacent to an unheated space	40
6	Expression of results and areas to which U-values apply	41
6.1	Expression of the U-value results	41
6.2	Areas for which calculated U-values apply	41
7	U-values for walls	42
8	U-values for roofs	45

9	U-values for floors	48
9.1	Slab-on-ground floor (ground-bearing floor slabs)	49
9.2	Suspended floors	51
9.2.1	Suspended timber floor	52
9.2.2	Suspended beam-and-block floor	52
9.2.3	Concrete beam floor with polystyrene layers	52
9.2.4	Solid suspended floor – precast concrete planks	53
9.2.5	Solid suspended floor – composite steel and concrete	53
9.3	Floor fully exposed to external air on underside	53
9.4	Semi-exposed floor	53
9.5	Effect of ground water	53
10	U-values for basements and swimming pools	54
10.1	Heated basements	54
10.2	Unheated basements	54
10.3	Swimming pools	54
11	U-values for windows, roof windows and rooflights	55
11.1	Methods for establishing U-values for windows and roof windows	55
11.2	Calculation of U-values for windows with secondary glazing	58
11.3	Calculation of U-values for windows with closed shutters or blinds	58
11.4	Adjustments to U-values for inclined roof windows (for energy calculations)	58
11.5	Out-of-plane rooflights (rooflights on upstands or kerbs)	59
11.5.1	Components of out-of-plane rooflights	59
11.5.2	Rooflights with the upstands as an integral part of the product	60
11.5.3	Rooflights mounted on upstands or kerbs that are supplied or built separately	61
11.6	Lantern or box-style rooflights kerb or upstand	63
11.7	In-plane continuous rooflights	64
12	Curtain walls	66
13	Dynamic transparent building elements	67
14	U-values for doors	68
15	U-values of existing (old) walls, roofs, and floors in dwellings	69
15.1	Existing (old) walls in dwellings.	69
15.2	Existing (old) roofs in dwellings.	69
15.3	Existing (old) floors in dwellings.	69

16 Appendix A: Glossary/definitions	70
17 Appendix B: U-values of uninsulated floors	73
18 Appendix C: Example of calculating U-value for elements with multi-foil insulation	74
19 References and further reading	76

1 Introduction

1.1 General

This BRE report, BR 443 (2019), is an update to the 2006 edition, primarily reflecting changes in British, European, and international standards.

Calculation methods for the determination of heat transfer through building elements between internal and external environments are based on standards that were developed in the CEN and the International Organization for Standardization (ISO) and published as British Standards.

Since publication of the previous edition of this document, European standards specifying calculation methods for thermal properties have been amended, replacing the previous British standards BS EN ISO 6946, BS EN ISO 10211, BS EN ISO 10456, BS EN ISO 13370, and BS EN ISO 13789, in addition to many other standards.

Earlier versions of this publication included references to the standards that were applicable at the time of publication. This document uses references to BS EN ISO standards published from 2017 onwards.

For constructions that cannot be handled by the basic calculation methods, the U-value can be calculated by numerical analysis or measured by a hot box method. This document gives guidance on the appropriate standards used for establishing measured values of thermal transmittance (U-value) and the appropriate standards used for establishing the thermal resistance (R-value) of a construction layer by numerical calculation. See section 2.

The guidance in this document is concerned with the calculated U-values of new building elements, including walls, roofs, floors, windows, and doors.

Guidance is given on

- Thermal conductivity of materials (section 3)
- Various issues that commonly arise when undertaking U-value calculations (section 4)
- Various types of construction element, identifying which of the issues mentioned in section 4 apply to which construction type (sections 7 to 14)

The document does not reproduce the details of the calculation methods, for which the reader is referred to the relevant British Standards and other sources (see *References and further reading*).

In existing buildings, the calculation of the thermal resistance (R-value) or thermal transmittance (U-value) can be difficult for the following reasons:

- Materials traditionally used in buildings may not be homogeneous and their thermal conductivity values may not be available
- Establishing the exact composition and dimensions of layers of materials requires destructive methods, which will not always be possible

Generic U-values for various elements of existing domestic buildings can be obtained from SAP (the Standard Assessment Procedure for energy rating of dwellings); see also section 15 of this document.