Consultation Paper: CONSP:09

U-values and Ψ-values of elements adjacent to unheated spaces

Issue 1.0

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DOCUMENT REVISION LOG

DATE	VERSION NO.	AMENDMENT DETAILS	APPROVED BY
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1. INTRODUCTION

The National Calculation Methodology for energy rating of dwellings (SAP) provides recommendations for treatment of U-values of elements adjacent to unheated spaces. These were sufficient for a period of time but the constructions, insulation levels and requirements to the building fabric have changed over time and therefore there is a need to update the treatment of U-values for elements adjacent to unheated spaces.

In addition this paper gives recommendations for treatment of Ψ-values of elements adjacent to unheated spaces. This has not been considered explicitly in SAP before.

In SAP the U-value of a wall adjacent to an unheated space is adjusted to take into account the buffering by the unheated space of the 'external' environment. In other words the temperature difference across the partially exposed element will be less than the temperature difference between the heated space and the external environment. The magnitude of the buffering effect depends upon the amount of exposure of the unheated space itself and includes the effect of ventilation of the unheated space.

The adjustment to the U-value is to add an additional thermal resistance R_u in the calculation of the U-value of the plane element. R_u is obtained from the various tables 3.1 to 3.4 in section 3.3 of SAP 2012.

2. U-VALUES OF ELEMENTS ADJACENT TO UNHEATED SPACES

2.1 The procedure for calculating U-values of elements adjacent to unheated spaces

The following procedure is proposed for calculating adjusted U-values for building elements adjacent to typical unheated spaces (garages, corridors, stairwells).

$$U = \frac{1}{\frac{1}{U_0} + R_u} \quad (1)$$

where: U=resultant U-value of element adjacent to unheated space, W/m^{2}K;

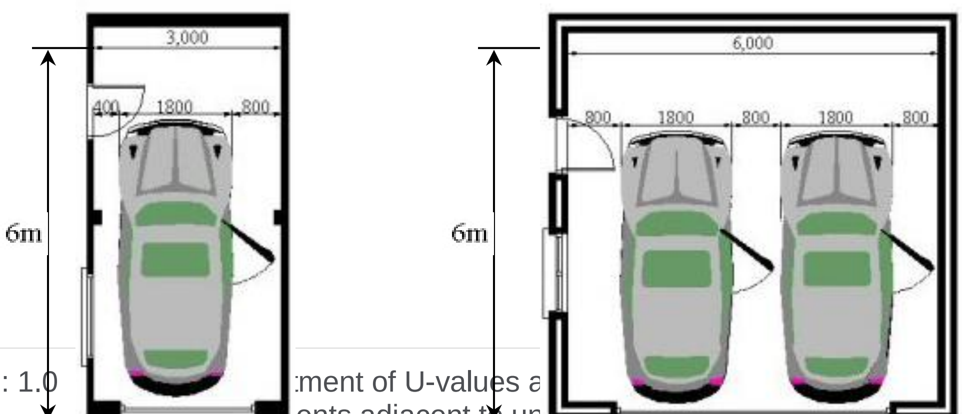
U_o=U-value of the element between heated and unheated spaces calculated as if there were no unheated space adjacent to the element, W/m^{2}K;

R_u=effective thermal resistance of unheated space from the appropriate table.

R_u values for typical unheated structures (including garages, access corridors to flats and rooms in roof), with assumed U-values of their elements, are given in Tables 3.1, 3.2, 3.3 and 3.4. These can be used when the precise details on the structure providing an unheated space are not available, or not crucial.

2.2 Garages

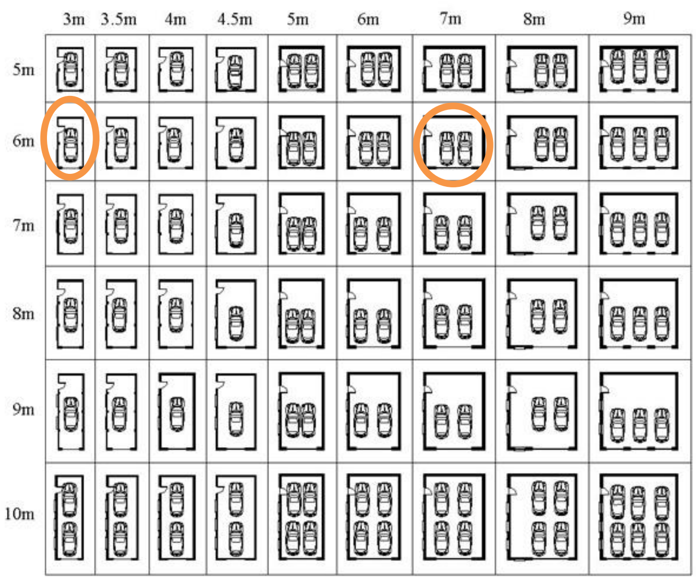
The R_u values in Tables 3.1 and 3.2 were calculated for typical single and double garages shown below.



Single garage Double garage

If the construction of the proposed garage is different from these garages then it is advisable to calculate R_u for the actual dimensions and air change rate.

Garages come in all sizes, depending upon the size of the site available and finances. Typical dimensions of garages are shown below. The proposed Ru values are for the typical 3 x 6 m garage.



The table below contains calculated R_u for typical single and double garages for dwellings with different constructions types and levels of integration with the dwelling.

In the case of internal garages, i.e. built inside of the insulated envelope, the proposed Ru values are those calculated with the U-value of external envelope of 0.30 W/m^{2}K.

For external garages, i.e. built outside the insulated envelope, the proposed Ru values are those calculated for the wall between a dwelling and a garage with U=0.30 W/m^{2}K and a typical uninsulated external garage wall with U-value of 1.6 W/m^{2}K.

Internal garages:		Elements between dwelling and garage	Proposed for 2016	2013 Regs	2002 Regs
				U_{wall}=0.30	U_{wall}=0.35
Single fully integral	3mx6m; n[1]=3;	Side wall, end wall and floor	0.71	**0.71**	0.69
Single fully integral	3mx6m; n=3;	Side wall and floor	0.56	**0.56**	0.54
Single, partially integral, displaced	3mx6m; n=3;	End wall and some side wall and floor	0.60	**0.60**	0.58
Double fully integral	6mx6m; n=3	Side wall, end wall and floor	0.61	**0.61**	0.59
Double fully integral	6mx6m; n=3	Side wall and floor	0.35	**0.35**	0.33
Double, partially integral, displaced	6mx6m; n=3	End wall and some side wall and floor	0.30	**0.30**	0.28

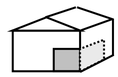
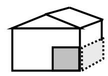
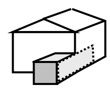
External garages:

Single fully integral	3mx6m; n=3;	Side wall, end wall and floor	0.37
Single fully integral	3mx6m; n=3;	Side wall and floor	0.27
Single, partially integral, displaced	3mx6m; n=3;	End wall and some side wall and floor	0.30
Double fully integral	6mx6m; n=3	Side wall, end wall and floor	0.34
Double fully integral	6mx6m; n=3	Side wall and floor	0.23
Double, partially integral, displaced	6mx6m; n=3	End wall and some side wall and floor	0.23

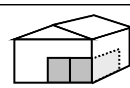
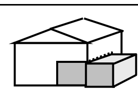
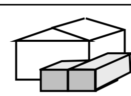
SAP 2005 and SAP2009 contained the following tables:

Existing Table 3.1 R_u for integral single garages (single garage is a garage for one car)

[1] "n" is the assumed air change rate in air changes per hour

Garage type		Elements between garage and dwelling	R_u for a single garage	
			Inside[1]	Outside[2]
Single fully integral (3m × 6m; n=3ach;		Side wall, end wall and floor	0.68	0.33
Single fully integral		One wall and floor	0.54	0.25
Single, partially integral displaced forward		Side wall, end wall and floor	0.56	0.26

Existing **Table 3.2 - R_u for integral double garages** (double garage is a garage for two cars)

Garage type		Element between garage and dwelling	R_u for a double garage	
			Inside[1]	Outside[2]
Double garage fully integral		Side wall, end wall and floor	0.59	0.28
Double, half integral		Side wall, halves of the garage end wall and floor	0.34	n/a
Double, partially integral displaced forward		Part of the garage side wall, end wall and some floor	0.28	n/a

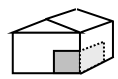
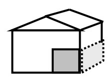
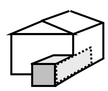
[1]inside garage – when the insulated envelope of the dwelling goes round the outside of the garage
[2]outside garage – when the walls separating the garage from the dwelling are the external walls

These values were calculated assuming U-values of elements and air change rate that were applicable at the time.

Both U-values and air tightness have been improved so the values in Table 3.1 have become out of date, especially for new dwellings.

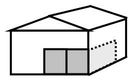
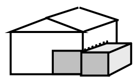
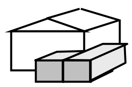
The following tables are equivalent to Tables 3.1 and 3.2 but are based on U-values required by the current Building Regulations. These are the same values shown earlier, but put into the existing SAP table format.

Proposed Table 3.1 - R_u for integral single garages (single garage is a garage for one car) assuming n=3; U-value=0.3 W/m^{2}K

Garage type		Elements between garage and dwelling	R_u for a single garage	
			Inside[1]	Outside[2]
Single fully integral (3m × 6m; n=3ach;		Side wall, end wall and floor	0.71 (70)	0.37 (0.35)
Single fully integral		One wall and floor	0.56 (0.55)	0.27 (0.25)
Single, partially integral displaced forward		Side wall, end wall and floor	0.60 (0.60)	0.30 (0.30)

Note: The calculated values are shown with 2 decimals, but since the calculated Ru values are based on assumed U=0.30, assumed n=3, assumed dimensions 3/6/2.5m, the calculated values are rounded; the rounded values are shown in brackets.

Proposed Table 3.2 - R_u for integral double garages (double garage is a garage for two cars) assuming n=3; U-value=0.3 W/m^{2}K

Garage type		Element between garage and dwelling	R_u for a double garage Inside[1]	R_u for a double garage Outside[2]
Double garage fully integral		Side wall, end wall and floor	0.61(0.60)	0.34 (0.35)
Double, half integral		Side wall, halves of the garage end wall and floor	0.35 (0.35)	0.23 (0.25)
Double, partially integral displaced forward		Part of the garage side wall, end wall and some floor	0.30 (0.30)	0.23 (0.25)

Note: The calculated values are shown with 2 decimals, but since the calculated Ru values are based on assumed U=0.30, assumed n=3, assumed dimensions 6/6/2.5m, the calculated values are rounded; the rounded values are shown in brackets.

For new dwellings we propose to use these R_u values for various configurations of typical 3 x 6 m garages or similar.

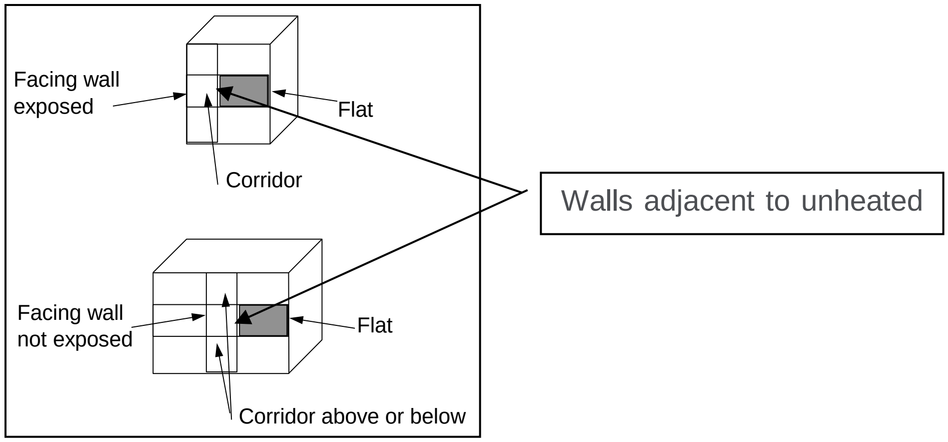
If the garage is substantially different from the typical garage then R_u value should be calculated using formula (5) given in section "Other cases"

2.3 Stairwells and access corridors in flats

2.3.1 Revision of Ru factor for stairwells

Stairwells and access corridors are not regarded as parts of the dwelling. If they are heated the wall between stairwell or corridor and the dwelling is treated as a party wall.
If unheated, the U-value of walls between the dwelling and the unheated space should be modified using the following data for R_u.

The following diagram shows the configuration of two types of corridors



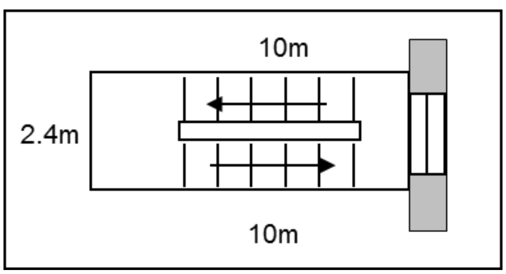
The existing table from SAP 2012 is shown below. The proposed Table 3.3 follows after a description of the parameters used for the calculation.

The existing R_u values were calculated with an air change rate of n=3; the proposed values are calculated with n=1. This is because the quality of construction and therefore air tightness has improved.

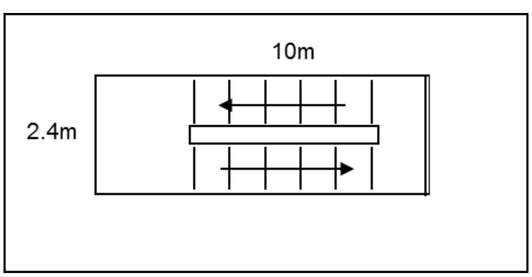
Existing Table 3.3 - R_u for common configurations of stairwells and access corridors.

Elements between stairwell/corridor and dwelling	Heat loss from corridor through:	R_u
Stairwells:		
Facing wall exposed		0.82
Facing wall not exposed		0.90
Access corridors:		
Facing wall exposed, corridors above and below	facing wall, floor and ceiling	0.28
Facing wall exposed, corridor above or below	facing wall, floor or ceiling	0.31
Facing wall not exposed, corridor above and below	floor and ceiling	0.40
Facing wall not exposed, corridor above or below	floor or ceiling	0.43

The values have been re-calculated for two common configurations of staircases:



Staircase adjacent to exposed external wall



Internal staircase, not adjacent to any external wall.

Case a) Staircase adjacent to exposed external wall

R_u calculated for n=1 ach which is the basis of the proposed R_u

n=	**1**	**ach**

Proposed R_u	2013 Regs	2002 Regs	not insulated	
2.09	2.09	2.07	1.00	2 storeys
2.23	2.23	2.21	1.19	3 storeys
2.31	2.31	2.29	1.31	4 storeys

Average = 2.21

And R_u calculated for n=3 ach (the basis of the previously used Ru, which was used in SAP2009 and 2012)

n=	**3**	**ach**

Proposed Ru	2013 Regs	2002 Regs	not insulated	
0.84	0.84	0.84	0.59	2 storeys
0.87	0.87	0.86	0.65	3 storeys
0.88	0.88	0.87	0.68	4 storeys

Average = 0.86

Parameters used for the calculation:

storeys:	2			
Total height (one storey = 2,6 m high)	5.2			
width	2.4			
length	10			
Pi=	22.4		U-value of exposed wall	
Pe=	2.4	U-value 1.6	2002 regs	2013 Regs
Aint	**116.48**	1.6	0.35	0.3
Aceiling	24	1.6	0.2	0.2
Afloor	24	0.70	0.25	0.25
Aext wall	12.48	1.60	0.35	0.30
Aext (wall+ceiling+floor)	**60.48**			
Volume=	**124.8**			
	Sum AxU=	75.17	15.17	14.54
	Ru=	1.00	2.07	2.09

storeys:	3			
Total height (one storey = 2,6 m high)	7.8			
width	2.4			
length	10			
Pi=	22.4	Not insulated		
Pe=	2.4	U-value	2002 regs	2013 Regs
Aint	**174.72**	1.60	0.35	0.30
Aceiling	24	1.60	0.20	0.20
Afloor	24	0.70	0.25	0.25
Aext wall	18.72	1.60	0.35	0.30
Aext (wall+ceiling+floor)	**66.72**			
Volume=	**187.2**			
	Sum AxU=	85.15	17.35	16.42
	Ru=	1.19	2.21	2.23

storeys:	4			
Total height (one storey = 2,6 m high)	10.4			
width	2.4			
length	10			
Pi=	22.4	Not insulated		
Pe=	2.4	U-value	2002 regs	2013 Regs
Aint	232.96	1.60	0.35	0.30
Aceiling	24	1.60	0.20	0.20
Afloor	24	0.70	0.25	0.25
Aext wall	24.96	1.60	0.35	0.30
Aext (wall+ceiling+floor)	72.96			
Volume=	249.6			
	Sum AxU=	95.14	19.54	18.29
	Ru=	1.31	2.29	2.31

Case b) Internal staircase, not adjacent to any external wall.

These parameters are used for the calculation of Ru for internal staircase:

storeys:	2			
Total height (one storey = 2,6 m high)	5.2			
width	2.4			
length	10			
Pi=	24.8			
Pe=	0	U-value		
Aint	**128.96**	1.60	0.45	0.30
Aceiling	24	1.60	0.20	0.20
Afloor	24	0.70	0.25	0.25
Aext wall	0	1.60	0.35	0.30
Aext (wall+ceiling+floor)	**48**			
Volume=	**124.8**			
	Sum AxU=	55.20	10.80	10.80
	Ru=	1.34	2.48	2.48

storeys:	3			
Total height (one storey = 2,6 m high)	7.8			
width	2.4			
length	**10**			
Pi=	24.8			
Pe=	0	U-value		
Aint	193.44	1.60	0.45	0.30
Aceiling	**24**	1.60	0.20	0.20
Afloor	**24**	0.70	0.25	0.25
Aext wall	**0**	1.60	0.35	0.30
Aext (wall+ceiling+floor)	**48**			
Volume=	187.2			
	Sum AxU=	55.20	10.80	10.80
	Ru=	1.65	2.67	2.67

storeys:	**4**			
Total height (one storey = 2,6 m high)	10.4			
width	2.4			
length	10			
Pi=	**24.8**			
Pe=	**0**	U-value		
Aint	257.92	1.60	0.45	0.30
Aceiling	**24**	1.60	0.20	0.20
Afloor	24	0.70	0.25	0.25
Aext wall	0	1.60	0.35	0.30
Aext (wall+ceiling+floor)	48			
Volume=	249.6			
	Sum AxU=	55.20	10.80	10.80
	Ru=	1.87	2.77	2.77

The summary of results for internal staircase is shown below.

	n=	1.00	ach		
	Ru=				
	Proposed	2013 Regs	2002 Regs	U=1.6	
	2.48	2.48	2.48	1.34	2 storeys
	2.67	2.67	2.67	1.65	3 storeys
	2.32	1.87	2.77	1.87	4 storeys
Average =	**2.49**				

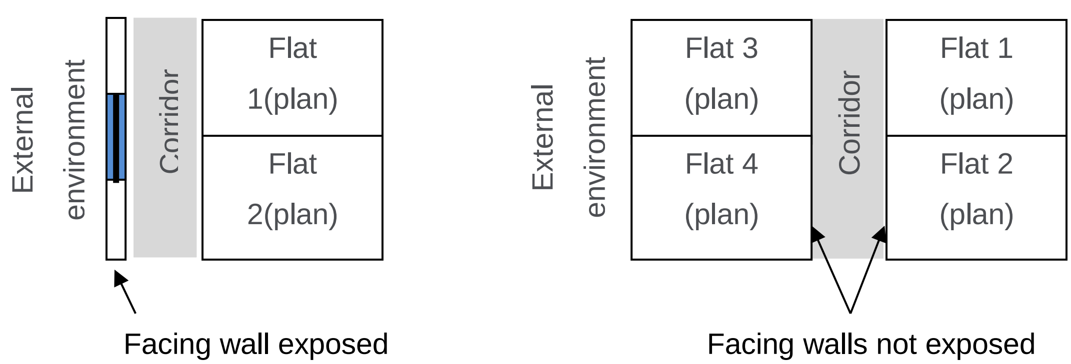
	n=	3.00	ach		
	Ru=				
	Proposed	2013 Regs	2002 Regs	U=1.6	
	0.96	0.96	0.96	0.72	2 storeys
	0.99	0.99	0.99	0.80	3 storeys
	0.93	0.85	1.00	0.85	4 storeys
Average =	**0.96**				

2.3.2 Revision of Ru factor for corridors

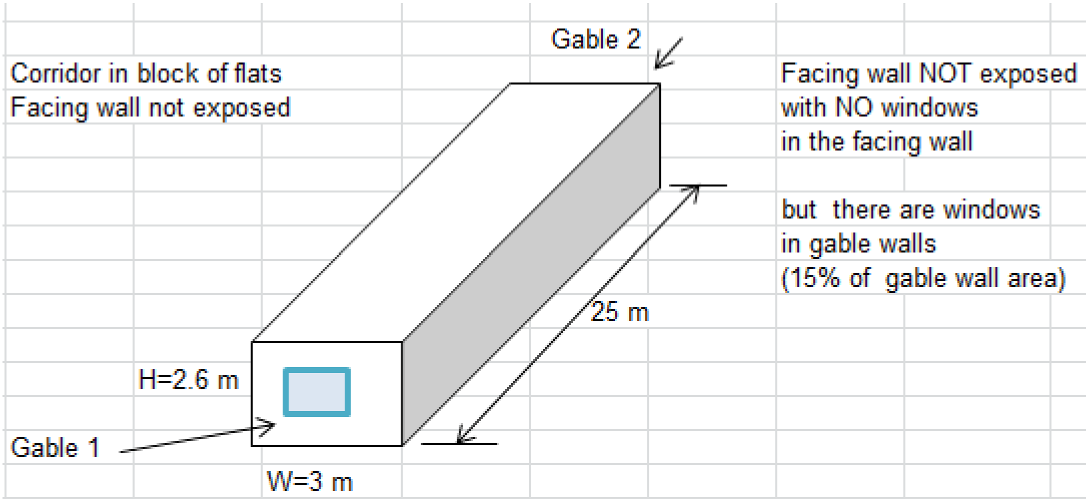
R_u factors were calculated for the two types of corridors:

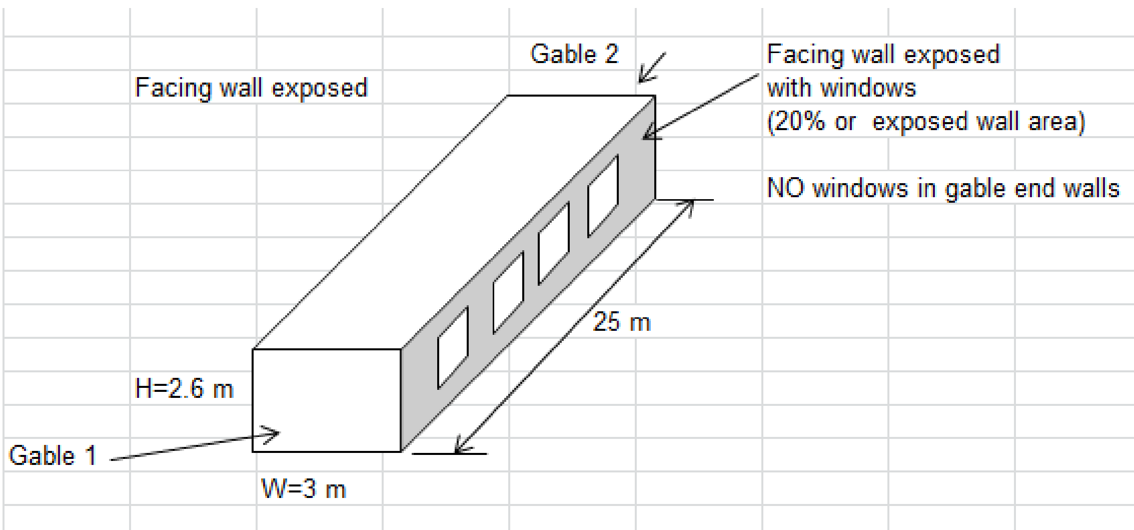
- corridors with facing wall exposed
- corridors with facing wall not exposed

An unexposed facing wall means a wall which is facing the wall between a dwelling and corridor.



The following dimensions were used for deriving R_u values





The calculated Ru values are:

		U-value, 2016 Regs			
2016 Regs	m²	scenario 1	scenario 2	scenario 3	scenario 4
Floor/roof	75		0.25		0.25
Roof	75				
Wall between flat and corridor	65				
Facing wall	65	0.3	0.3		
Gable 1	7.8	0.3	0.3	0.3	0.3
Gable 2	7.8	0.3	0.3	0.3	0.3
Window 15% in gable walls, m²	1.17			2	2
Windows 20% in exposed facing wall, m²	13	2	2		
AxU=		45.578	64.328	6.318	25.068
Volume, m³	195				
n, ach	1				
	Ru =	**0.59**	**0.51**	**0.92**	**0.73**
		element not losing heat marked			

Scenarios:	Description
1	Facing wall exposed, corridors above and below
2	Facing wall exposed, corridor above or below
3	Facing wall not exposed, corridor above and below
4	Facing wall not exposed, corridor above or below

The proposed table with R_u values calculated with n=1.0 is therefore as follows:

Proposed Table 3.3 - R_u for common configurations of stairwells and access corridors.

Elements between stairwell/corridor and dwelling	Heat loss from corridor through:	R_u
Stairwells:		
Facing wall exposed		2.09 (2.1)
Facing wall not exposed		2.49 (2.5)
Access corridors:		
Facing wall exposed, corridors above and below	facing wall, floor and ceiling	0.59 (0.6)
Facing wall exposed, corridor above or below	facing wall, floor or ceiling	0.51 (0.5)
Facing wall not exposed, corridor above and below	floor and ceiling	0.92 (0.9)
Facing wall not exposed, corridor above or below	floor or ceiling	0.73 (0.7)

2.4 Room in roof

An approximate procedure applies in the case of a room-in-roof in an existing dwelling. The following applies to new dwellings and conversions to create a room-in-roof.

In the case of room-in-roof construction where the insulation follows the shape of the room, the roof U-value of the room-in-roof construction is calculated using the procedure described in paragraph 3.3 using a thermal resistance of R_u from Table 3.4. The same applies to the ceiling of the room below.

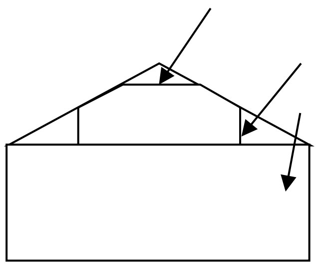


Diagram of Room in roof

The Ru values for typical rooms in roof were recalculated but the Ru value has not changed, so we propose that **the existing table 3.4 remains as is in SAP 2012.**

Table 3.4 R_u for room in roof adjacent to unheated loft space (no changes)

Area (figure 3.2)	**Element between dwelling and unheated loft space**	**R_u**
Room in roof built into a pitched roof insulated at ceiling level	insulated wall of room in roof	0.50
	or insulated ceiling of room below	0.50

As before, if the insulation follows the slope of the roof, the U-value should be calculated in the plane of the slope.

3. Ψ-VALUES OF ELEMENTS ADJACENT TO UNHEATED SPACES

3.1 The principle

As explained in Section 2.1 above, the calculated U-value of the plane element to the unheated space is determined using equation (4) in SAP 2012, namely:-

$$U = \frac{1}{\frac{1}{U_0} + R_u} \qquad (1)$$

Where: U_0 is the U-value of the plane element to the unheated space, as though it were exposed to the external environment.

R_u is the additional thermal resistance to be added to the thermal resistance of the 'exposed' plane element such that the calculated heat flow through the plane element is the same as would be the case when the calculation considers the 'external' temperature (to be used in the calculation of the heat flow) as the actual heat-balance temperature of the unheated space.

This additional resistance is a weighted average value of either precise values determined using the 'full' heat balance equation in SAP, or approximated using the tabulated values in SAP. Strictly, any heat balance involving the unheated space should also involve the residual heat flows through the junctions, i.e. involve the linear thermal bridging to and from the unheated space, i.e. involve all the Ψ-values. However, although such a differently calculated R_u would be an appropriate average value to apply to U_o (and hence to Ψ_o), this is a complication too far.

Thus, to simplify, since R_u (determined still as an average value to be used for each exposed plane element to the unheated space) will be the major influence on the heat balance temperature of the unheated space (compared to that of the linear thermal bridge), the most convenient adjustment to make for each 'exposed' Ψ-value is to multiply this by $\Sigma AU/\Sigma AU_0$ where U is determined using equation (1).

The Ψ-value for a junction exposed via an unheated space is first calculated as being the fully exposed Ψ_0 value and subsequently adjusted assuming the same general exposure via the unheated space, i.e. the same heat balance temperature of the unheated space as determined from SAP for the plane area U-values to the unheated space. For example, in a particular project or calculation, the fully exposed Ψ-value(s) provided by the SAP user would be adjusted by them using the procedure described above.

On a basis of the above, a new formula is introduced to calculate a Ψ-value adjustment for an unheated space

$$F_{\Psi}=\Sigma AU/\Sigma AU_0 \qquad (2)$$

Where:

ΣAU sum of areas of elements multiplied by the U-value corrected to take account of the effect of unheated space;

ΣAU_0 is the sum of areas of elements multiplied by the U-value before the corrections.

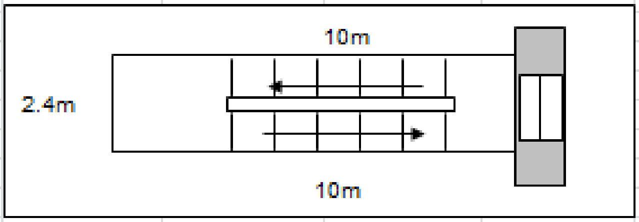
3.2 Adjustments to Ψ-values for garages

The following table shows calculated F_{Ψ} values proposed for the SAP.

Description of a garage	Dimensions	Elements between dwelling and a garage	Proposed Ru	Uo= 0.3	U=	Proposed RΨ
Internal garages:		Elements between dwelling and garage				
Single fully integral	3mx6m; n=3;	Side wall, end wall and floor	**0.71**	0.3	0.25	**0.82**
Single fully integral	3mx6m; n=3;	Side wall and floor	**0.56**	0.3	0.26	**0.86**
Single, partially integral, displaced	3mx6m; n=3;	End wall and some side wall and floor	**0.60**	0.3	0.25	**0.85**
Double fully integral	3mx6m;n=3	Side wall, end wall and floor	**0.61**	0.3	0.25	**0.85**
Double fully integral	3mx6m;n=3	Side wall and floor	**0.35**	0.3	0.27	**0.91**
Double, partially integral, displaced	3mx6m;n=3	End wall and some side wall and floor	**0.30**	0.3	0.28	**0.92**
External garages:		Elements between dwelling and garage				
Single fully integral	3mx6m; n=3;	Side wall, end wall and floor	**0.37**	0.3	0.27	**0.90**
Single fully integral	3mx6m; n=3;	Side wall and floor	**0.27**	0.3	0.28	**0.92**
Single, partially integral, displaced	3mx6m; n=3;	End wall and some side wall and floor	**0.30**	0.3	0.28	**0.92**
Double fully integral	3mx6m;n=3	Side wall, end wall and floor	**0.34**	0.3	0.27	**0.91**
Double fully integral	3mx6m;n=3	Side wall and floor	**0.23**	0.3	0.28	**0.93**
Double, partially integral, displaced	3mx6m;n=3	End wall and some side wall and floor	**0.23**	0.3	0.28	**0.94**

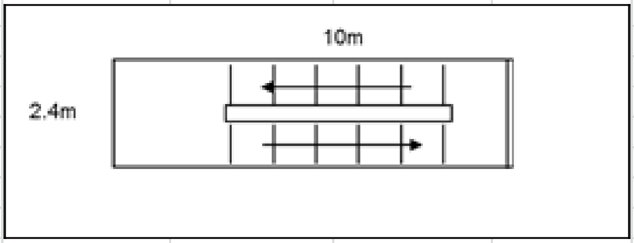
3.3 Adjustments to Ψ-values for stairwells

The calculated F_Ψ values for typical staircases are shown below.



Proposed Ru	Uo	U	FΨ	
2.09	0.30	0.1844	0.61	2 storeys
2.23	0.30	0.1796	0.60	3 storeys
2.31	0.30	0.1771	0.59	4 storeys
2.21	**0.30**	**0.1803**	**0.60**	average

Internal stairwell



Proposed Ru	Uo	U	FΨ	
2.48	0.30	**0.1720**	0.57	2 storeys
2.67	0.30	**0.1667**	0.56	3 storeys
2.32	0.30	**0.1768**	0.59	4 storeys
2.49	**0.30**	**0.1717**	**0.57**	average

3.4 Adjustments to Ψ-values for corridors

	scenario 1	scenario 2	scenario 3	scenario 4
U	0.30	0.30	0.30	0.30
Uo	0.36	0.35	0.41	0.38
FΨ	0.82	0.85	0.72	0.78

3.5 Adjustments to Ψ-values for elements of room in roof

Ru	0.5
Uo	0.20
U	0.18
FΨ	0.91

4. PROPOSED TEXT OF SECTIONS 3.3 AND 3.4 in SAP

3.3 U-values of elements adjacent to an unheated space

The procedure for treatment of U-values of elements adjacent to unheated space is described in BS EN ISO 6946 and BS EN ISO 13789.

The following procedure may be used for typical structures (no measurements are needed of the construction providing an unheated space, just select the appropriate R_u from Tables 3.1 to 3.3 below).

$$U = \frac{1}{\frac{1}{U_0} + R_u} \qquad (4)$$

where: U = resultant U-value of element adjacent to unheated space, W/m^2K;
U_o = U-value of the element between heated and unheated spaces calculated as if there were no unheated space adjacent to the element, W/m^2K;
R_u = effective thermal resistance of unheated space from the appropriate table below.

R_u for typical unheated structures (including garages, access corridors to flats and rooms in roof) with typical U-values of their elements are given below. These can be used when the precise details on the structure providing an unheated space are not available, or not crucial.

The effect of unheated spaces, however, need not be included if the area of the element covered by the unheated space is small (i.e. less than 10% of the total exposed area of all external walls if the unheated space abuts a wall, or 10% of the total area of all heat-loss floors if the unheated space is below a floor). Consequently a door in an element abutting an unheated space would not need to have its U-value changed (unless it is part of a very small flat where the U-value of the door might make a significant contribution to the result).

Garages
The U-value of elements between the dwelling and an integral garage should be adjusted using R_u from Table 3.1 or Table 3.2. Attached garages (not integral) should be disregarded.

Table 3.1 R_u for integral single garages (single garage is a garage for one car)

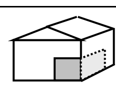
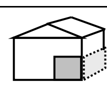
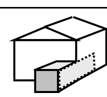
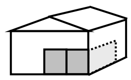
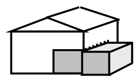
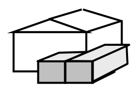
Garage type		Elements between garage and dwelling	R_u for a single garage	
			Inside[1]	Outside[2]
Single fully integral		Side wall, end wall and floor	0.71	0.37
Single fully integral		One wall and floor	0.56	0.27
Single, partially integral displaced forward		Side wall, end wall and floor	0.60	0.30

Table 3.2 R_u for integral double garages (double garage is a garage for two cars)

Garage type		Element between garage and dwelling	R_u for a double garage	
			Inside[1]	Outside[2]
Double garage fully integral		Side wall, end wall and floor	0.61	0.34
Double, half integral		Side wall, halves of the garage end wall and floor	0.35	0.23
Double, partially integral displaced forward		Part of the garage side wall, end wall and some floor	0.30	0.23

[1]*inside garage* – when the insulated envelope of the dwelling goes round the outside of the garage
[2]*outside garage* – when the walls separating the garage from the dwelling are the external walls

Stairwells and access corridors in flats

Stairwells and access corridors are not regarded as parts of the dwelling. If they are heated the wall between stairwell or corridor and the dwelling is treated as party wall, see section 3.7. If unheated, the U-value of walls between the dwelling and the unheated space should be modified using the following data for R_u.

Figure 3.1 shows examples of access corridors in flats.

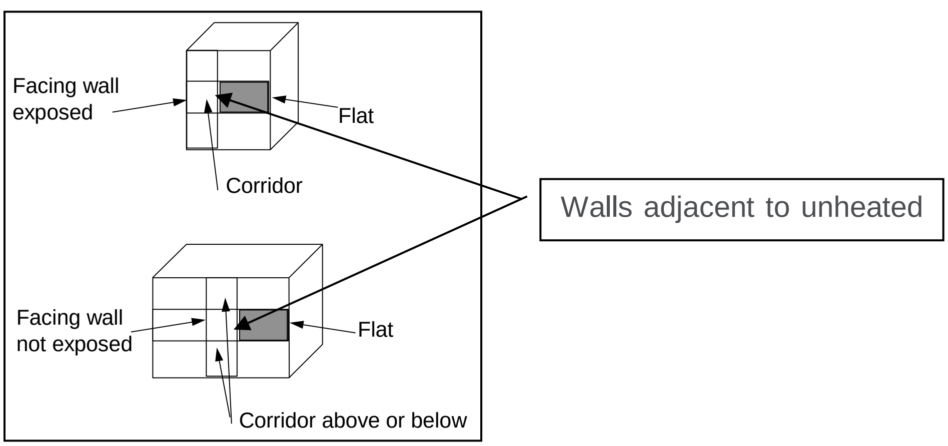


Figure 3.1 Access corridors

The following table gives recommended values of R_u for common configurations of access corridors and stairwells.

Table 3.3 R_u for common configurations of stairwells and access corridors.

Elements between stairwell/corridor and dwelling	Heat loss from corridor through:	R_u
Stairwells:		
Facing wall exposed		2.1
Facing wall not exposed		2.5
Access corridors:		
Facing wall exposed, corridors above and below	facing wall, floor and ceiling	0.6
Facing wall exposed, corridor above or below	facing wall, floor or ceiling	0.5
Facing wall not exposed, corridor above and below	floor and ceiling	0.9
Facing wall not exposed, corridor above or below	floor or ceiling	0.7

Conservatories

Since the definition of a conservatory can vary, use the definition and any additional requirements that are appropriate to the building regulations of the administration where the dwelling is situated.

Thermal separation between a dwelling and a conservatory means that they are divided by walls, floors, windows and doors for which the U-values are similar to, or in the case of a newly-constructed conservatory not greater than, the U-values of the corresponding exposed elements elsewhere in the dwelling; in the case of a newly constructed conservatory, windows and doors have similar draught-proofing provisions as the exposed windows and doors elsewhere in the dwelling.

For a conservatory which is thermally separated, the calculation should be undertaken as if it were not present.

Other large glazed areas

Any structure attached to a dwelling that is not a thermally separated conservatory according to the definitions in 3.3.3 should be treated as an integral part of the dwelling. This means that the glazed parts of the structure should be input as if they were any other glazed component (both in the heat loss section, and in the solar gain section according to orientation). See also section 3.2.

Room in roof

An approximate procedure applies in the case of a room-in-roof in an existing dwelling (see Appendix S). The following applies to new dwellings and conversions to create a room-in-roof.

In the case of room-in-roof construction where the insulation follows the shape of the room, the U-value of roof of the room-in-roof construction is calculated using the procedure described in paragraph 3.3 using thermal resistance R_u from Table 3.4. The same applies to the ceiling of the room below.

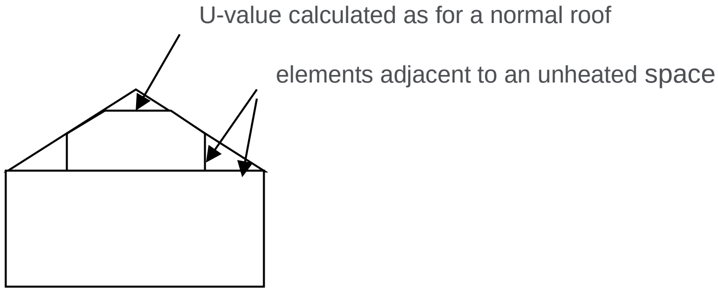


Figure 3.2 Room in roof

Table 3.4 R_u for room in roof adjacent to unheated loft space

Area (figure 3.2)	Element between dwelling and unheated loft space	R_u
Room in roof built into a pitched roof insulated at ceiling level	insulated wall of room in roof	0.50
	or insulated ceiling of room below	0.50

If the insulation follows the slope of the roof, the U-value should be calculated in the plane of the slope. For existing dwellings see Appendix S.

Other cases

In most other cases the effect of an unheated space should be disregarded. Where it needs to be accounted for a general formula for R_u is:

$$R_u = \frac{A_i}{\sum (A_e \times U_e) + 0.33nV} \qquad (2)$$

A_i; A_e = areas of internal and external elements (m²), excluding any ground floor
U_e = U-values of external elements (W/m²K)
V = volume of unheated space (m³)
n = air change rate of unheated space (ach)

Typical values of the air change rate in unheated spaces are given in Table 3.5. A default value of n = 3 ach should be used if the airtightness of the unheated space is not known.

Table 3.5 Typical air change rates for unheated spaces

Air tightness type	n (air changes per hour)
No doors or windows, all joints between components well-sealed, no ventilation openings provided	0.1
All joints between components well-sealed, no ventilation openings provided	0.5
All joints well-sealed, small openings provided for ventilation	1.0
Not airtight due to some localised open joints or permanent ventilation openings	3.0
Not airtight due to numerous open joints, or large or numerous permanent ventilation openings	10.0

3.4 Thermal bridging

The SAP calculation takes account of thermal bridging, at junctions between elements and around openings. If linear thermal transmittance values are available for these junctions, they can be multiplied by the length of the junction concerned, and the total added to the transmission heat transfer coefficient.

If specific values for thermal bridges are not known, and the calculation can be done by including an allowance based on the total exposed surface area. Further details are in Appendix K.

The correction factor for linear thermal bridges F_Ψ adjacent to typical unheated structures (including garages, access corridors to flats and rooms in roof) with typical U-values of their elements are given below. These can be used when the precise details on the structure providing an unheated space are not available, or not crucial.

The following procedure may be used for typical structures:

$$\Psi = \Psi_o \times F_\Psi \qquad (4)$$

Where:

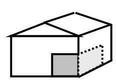
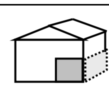
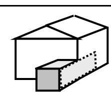
Ψ – resultant Ψ-value of element adjacent to unheated space

Ψ_o – is a Ψ-value of the linear thermal bridge calculated as if there were no unheated space adjacent to the junction

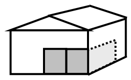
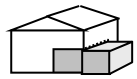
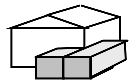
F_Ψ – correction factor

Proposed Table 4.1 F_Ψ for integral single garages (single garage is a garage for one car)

U-value=0.3 W/m^{2}K

Garage type		Elements between garage and dwelling	F_Ψ for a single garage	
			Inside[1]	Outside[2]
Single fully integral (3m × 6m; n=3ach;		Side wall, end wall and floor	0.82	0.90
Single fully integral		One wall and floor	0.86	0.92
Single, partially integral displaced forward		Side wall, end wall and floor	0.85	0.92

Proposed **Table 4.2 F_Ψ for integral double garages (double garage is a garage for two cars)** ; U-value=0.3 W/m^{2}K

Garage type		Element between garage and dwelling	F_Ψ for a double garage Inside[1]	Outside[2]
Double garage fully integral		Side wall, end wall and floor	0.85	0.91
Double, half integral		Side wall, halves of the garage end wall and floor	0.91	0.93
Double, partially integral displaced forward		Part of the garage side wall, end wall and some floor	0.92	0.94

[1]*inside garage* – when the insulated envelope of the dwelling goes round the outside of the garage
[2]*outside garage* – when the walls separating the garage from the dwelling are the external walls

The following table gives recommended values of F_Ψ for common configurations of access corridors and stairwells.

Proposed Table 4.3 F_Ψ for common configurations of stairwells and access corridors.

Elements between stairwell/corridor and dwelling	Heat loss from corridor through:	F_Ψ
Stairwells:		
Facing wall exposed		0.60
Facing wall not exposed		0.57
Access corridors:		
Facing wall exposed, corridors above and below	facing wall, floor and ceiling	0.82
Facing wall exposed, corridor above or below	facing wall, floor or ceiling	0.85
Facing wall not exposed, corridor above and below	floor and ceiling	0.72
Facing wall not exposed, corridor above or below	floor or ceiling	0.78

The F_Ψ value of roof of the room-in-roof construction is given in Table 4.4.

Proposed Table 4.4 F_Ψ for room in roof adjacent to unheated loft space

	Element between dwelling and unheated loft space	F_Ψ
Room in roof built into a pitched roof insulated at ceiling level	insulated wall of room in roof	0.80
	or insulated ceiling of room below	0.80

Other cases

In other cases where it is needed to calculate, a formula is introduced to calculate a Ψ-value adjustment for an unheated space

$$F_\Psi = (A \times U) / \Sigma(A \times U_o) \qquad (5)$$

Where:

$\Sigma(A \times U)$ sum of areas of elements multiplied by the U-value corrected to take account of the effect of unheated space; see formula (2);

$\Sigma(A \times U_o)$ is the sum of areas of elements multiplied by the U-value before the corrections.