Plasti·Fab™ EPS PRODUCT SOLUTIONS **PlastiSpan™ Insulation**

How to Calculate Thermal Resistance and Overall Thermal Transmittance through Building Sections

Thermal resistances are usually specified for a building section to allow the maximum flexibility in building design. It is necessary to calculate the thermal resistance of the building section by an analysis of all the components including the air films on the inside and outside surfaces.

The air film thermal resistance has been determined to be the insulation value of the air film which is held to the wall by friction. Since air is a good insulator this factor is allowed for when calculating the thermal resistance of the building section.

Example 1. Wood Framed Wall

The following formula is used to calculate total thermal resistance in a wood-framed wall.

$$RSI_T\,(R_T) = \frac{100}{\frac{\%\text{ area with framing}}{RSI_F\,(R_F)} + \frac{\%\text{ area w/o framing}}{RSI_I\,(R_I)}}$$

Where,
$RSI_T\,(R_T)$ = Total thermal resistance,
$RSI_F\,(R_F)$ = Thermal resistance in framed wall,
$RSI_I\,(R_I)$ = Thermal resistance in insulated portion.

Note: Thermal resistance in SI System units is indicated by 'RSI' and in Imperial units as 'R'.

Values in this table are found in **Table B** on page 2	RSI_F through stud	RSI_I through insulation	R_F through steel stud	R_I through insulation
Outside Air Film	0.030	0.030	0.170	0.170
Vinyl Siding	0.110	0.110	0.635	0.635
Sheathing Paper	0.011	0.011	0.063	0.063
50 mm PlastiSpan Type 1 Insulating Sheathing	1.300	1.300	7.500	7.500
89 mm (2 x 4") Stud	0.721		4.159	
89 mm Batt Insulation		2.136		12.322
Vapour Barrier (Poly)				
13 mm Gypsum Board	0.079	0.079	0.457	0.457
Inside Air Film	0.120	0.120	0.681	0.681
TOTAL	**2.371**	**3.786**	**13.602**	**21.828**
% Area of Each (from Table A below)	**19%**	**81%**	**19%**	**81%**

$$RSI_T = \frac{100}{\frac{19}{2.371} + \frac{81}{3.768}} = 3.39\ m^2\cdot°C/W \qquad R_T = \frac{100}{\frac{19}{13.602} + \frac{81}{21.828}} = 20.89\ ft^2\cdot°F/BTU$$

The reciprocals of RSI_T and R_T yield the overall thermal transmittance, '**USI**' (SI System Units) and '**U**' (Imperial Units).

$$USI = \frac{1}{3.39} = 0.30\ W/m^2\cdot°C \qquad U = \frac{1}{19.58} = 0.051\ BTU/ft^2\cdot°F$$

Table A: Framing Percentages for Typical Assemblies

From 1995 National Energy Code		Wood Framing		Steel Framing	
Assembly	**Framed Spacing (mm)**	**Percentage Area With Framing**	**Percentage Area Without Framing**	**Percentage Area With Framing**	**Percentage Area Without Framing**
Ceiling/Attic	406	10	90	0.33	99.67
	610	7	93	0.23	99.77
A/G Wall/ Strapping	406	19	81	0.64	99.37
	610	11	89	0.37	99.63
B/G Wall/ Strapping	406	17	83	0.57	99.43
	610	10	90	0.33	99.67
Sheet Steel Wall	1830			0.08	99.92
	2400			0.06	99.94

Example 2. Steel Framed Wall

The following formula is used to calculate total thermal resistance of a wall with insulating sheathing board and steel stud framing spaced at greater than 500 mm (20").

$$RSI_T\,(R_T) = \frac{RSI_{T1}\,(R_{T1}) + RSI_{T3}\,(R_{T3})}{2}$$

Where,
$RSI_T\,(R_T)$ = Total thermal resistance,
$RSI_{T1}\,(R_{T1})$ = Thermal resistance in framed wall and insulation,
$RSI_{T2}\,(R_{T2})$ = Thermal resistance between the planes bounding the inner and outer faces of the metal framing members,
$RSI_{T3}\,(R_{T3})$ = Resistances of remaining components + $RSI_{T2}\,(R_{T2})$

STEP 1 – RSI_{T1}/R_{T1} Values in this table are found in **Table B** on page 2	RSI_F through stud	RSI_I through insulation	R_F through steel stud	R_I through insulation
Outside Air Film	0.030	0.030	0.170	0.170
19 mm Stucco	0.017	0.017	0.099	0.099
Sheathing Paper	0.011	0.011	0.063	0.063
50 mm PlastiSpan HD Insulating Sheathing	1.300	1.300	7.500	7.500
16 mm Gypsum Board	0.098	0.098	0.563	0.563
92 mm Steel Stud	0.001		0.008	
89 mm Batt Insulation		2.136		12.322
Vapour Barrier (Poly)				
16 mm Gypsum Board	0.098	0.098	0.563	0.563
Inside Air Film	0.120	0.120	0.681	0.681
TOTAL	**1.675**	**3.810**	**9.647**	**21.398**
% Area of Each (from Table A page 2)	**0.37%**	**99.63%**	**0.37%**	**99.63%**

$$RSI_{T1} = \frac{100}{\frac{0.37}{1.675} + \frac{99.63}{3.810}} = 3.792\ m^2\cdot°C/W \qquad R_{T1} = \frac{100}{\frac{0.37}{9.647} + \frac{99.63}{21.398}} = 21.302\ ft^2\cdot°F/BTU$$

STEP 2 – RSI_{T2}/R_{T2} Planes bounding the inner and outer faces of framing members	RSI_F through stud	RSI_I through insulation	R_F through steel stud	R_I through insulation
92 mm Steel Stud	0.001		0.008	
89 mm Batt Insulation		2.136		12.322
TOTAL	**0.001**	**2.136**	**0.008**	**12.322**
% Area of Each (from Table A page 2)	**0.37%**	**99.63%**	**0.37%**	**99.63%**

$$RSI_{T2} = \frac{100}{\frac{0.37}{0.001} + \frac{99.63}{2.136}} = 0.240\ m^2\cdot°C/W \qquad R_{T2} = \frac{100}{\frac{0.37}{0.008} + \frac{99.63}{12.322}} = 1.840\ ft^2\cdot°F/BTU$$

STEP 3 – Calculate RSI_{T3}/R_{T3} Include RSI_{T2}/R_{T2}, exclude Insulation and Steel Stud	RSI through steel stud and insulation	R through steel stud and insulation
Outside Air Film	0.030	0.170
Stucco	0.017	0.099
Sheathing Paper	0.011	0.063
50 mm PlastiSpan Type 1 Insulating Sheathing	1.300	7.500
16 mm Gypsum Board	0.098	0.563
RSI_{T2}/R_{T2}	0.240	1.840
Vapour Barrier (Poly)		
16 mm Gypsum Board	0.098	0.563
Inside Air Film	0.120	0.681
RSI_{T3}/R_{T3}	**1.816**	**11.479**

STEP 4 – Calculate Total Thermal Resistance

$$RSI_T = \frac{3.792 + 1.816}{2} = 2.804\ m^2\cdot°C/W \qquad R_T = \frac{21.302 + 11.479}{2} = 16.390\ ft^2\cdot°F/BTU$$

STEP 5 – Calculate Overall Heat Transmittance

$$USI = \frac{1}{2.804} = 0.36\ W/m^2\cdot°C \qquad U = \frac{1}{16.390} = 0.061\ BTU/ft^2\cdot°F$$

Thermal Resistances of Common Building Materials

Wall and roof systems require specific thermal resistance design values. As a convenience to designers, the table below provides RSI/R values for a number of common building materials for use in calculating the thermal resistance of walls and roofs. Values are taken from ASHRAE Handbook of Fundamentals and the Model National Energy Codes for Canada. Thermal resistance values for most building materials are proportional to material thickness, therefore, units of thickness are provided where applicable.

Material	SI System (RSI)		Imperial (R)	
CONCRETE				
Poured Concrete (2400 kg/m³)	100 mm	0.040	4.0″	0.231
	150 mm	0.060	6.0″	0.346
	200 mm	0.080	8.0″	0.462
Concrete Block - Sand Aggregate	90 mm	0.170	3.5″	0.981
	140 mm	0.190	5.5″	1.096
	190 mm	0.190	7.5″	1.096
	240 mm	0.240	9.5″	1.385
Concrete Block - Lightweight Aggregate	90 mm	0.240	3.5″	1.385
	140 mm	0.300	5.5″	1.731
	190 mm	0.430	7.5″	2.481
	240 mm	0.330	9.5″	1.904
AIR FILMS				
Outside - 24 km/h, 15 mph		0.030		0.170
Inside - Walls (heat flow horizontally)		0.120		0.681
- Floor (heat flow down)		0.160		0.908
- Ceiling (heat flow up)		0.110		0.635
AIR CAVITIES				
Walls - Faced with non-reflective material	13 mm	0.160	0.50″	0.923
	19 mm	0.180	0.75″	1.038
	38 mm	0.180	1.50″	1.038
	89 mm	0.180	3.50″	1.038
Floors - Faced with non-reflective material	13 mm	0.160	0.50″	0.923
	19 mm	0.180	0.75″	1.038
	38 mm	0.200	1.50″	1.154
	89 mm	0.220	3.50″	1.269
Ceiling - Faced with non-reflective material	13 mm	0.150	0.50″	0.865
	19 mm	0.150	0.75″	0.865
	38 mm	0.160	1.50″	0.923
	89 mm	0.160	3.50″	0.923
CLADDING MATERIALS				
Brick - Fired Clay	100 mm	0.070	4.00″	0.404
- Concrete	100 mm	0.040	4.00″	0.231
Stucco	19 mm	0.017	0.75″	0.099
Wood Shingles (all types) - Single		0.170		0.965
Wood Siding (all types) - Bevel - Lapped	13 mm	0.140	0.50″	0.808
- Bevel - Lapped	20 mm	0.180	0.75″	1.038
- Drop	20 mm	0.140	0.75″	0.808
Metal and Vinyl Siding - Hollow-backed		0.110		0.635
+ Insulating backer board	9.5 mm	0.210	0.375″	1.211
- As above with foil-faced backer board	9.5 mm	0.520	0.375″	3.000
Sheathing Paper		0.011		0.063
WINDOWS				
Single Glass (winter)		0.026		0.150
Insul. Glass - Double (winter)				
- 6mm (1/4″) airspace		0.153		0.883
- 13mm (1/2″) airspace		0.209		1.206
Insul. Glass - Triple (winter)				
- 6mm (1/4″) airspace		0.300		1.731
- 13mm (1/2″) airspace		0.418		2.411
WOOD PRODUCTS				
Particle Board (spruce, pine, fir)	9mm	0.070	0.375″	0.407
	13 mm	0.094	0.50″	0.542
	16 mm	0.117	0.625″	0.678
	19 mm	0.141	0.75″	0.813

Material	SI System (RSI)		Imperial (R)	
Lumber (spruce, pine, fir)	19 mm	0.154	0.75″	0.889
	38 mm	0.308	1.50″	1.776
	64 mm	0.518	2.50″	2.991
	89 mm	0.721	3.50″	4.159
	140 mm	1.134	5.50″	6.542
Plywood	6 mm	0.052	0.25″	0.301
	9 mm	0.078	0.375″	0.452
	13 mm	0.113	0.50″	0.652
	16 mm	0.139	0.625″	0.803
	19 mm	0.165	0.75″	0.954
INTERIOR FINISH				
Gypsum Board	9 mm	0.055	.375″	0.317
	13 mm	0.079	0.50″	0.457
	16 mm	0.098	0.625″	0.563
Hard Board (masonite)	3 mm	0.023	0.125″	0.164
	6 mm	0.057	0.25″	0.329
Vapour Barrier		neg'l		neg'l
Steel Studs	92 mm	0.001	3.625″	0.008
	152 mm	0.002	6.00″	0.014
FLOORING MATERIALS				
Carpet and Fibrous Pad		0.370		2.100
Carpet and Rubber Pad		0.220		1.259
Tile - Linoleum, Vinyl, Rubber		0.009		0.052
- Ceramic	9.5 mm	0.005	0.375″	0.029
Hardwood Flooring	19 mm	0.120	0.75″	0.692
ROOFING MATERIALS				
Asphalt - Roll Roofing		0.030		0.170
Built-up Roofing	9.5 mm	0.057	0.375″	0.329
Metal Deck		0.001		0.006
Shingles - Asphalt		0.080		0.454
- Wood		0.170		0.965
2-Ply Felt Vapour Barrier		0.021		0.119
RIGID INSULATION				
PlastiSpan - Type 1	25 mm	0.650	1.00″	3.750
PlastiSpan HD - Type 2	25 mm	0.700	1.00″	4.040
PlastiSpan - Type 3	25 mm	0.740	1.00″	4.270
Rigid Glass Fibre Roof Insulation	25 mm	0.525	1.00″	3.029
Semi-Rigid Glass Fibre Sheathing	25 mm	0.750	1.00″	4.327
Fibre Board - Roof Board	25 mm	0.450	1.00″	2.596
- Sheathing Board	25 mm	0.400	1.00″	2.308
Polyisocyanurate/Polyurethane	25 mm	1.050	1.00″	6.057
Extruded Polystyrene (all types)	25 mm	0.875	1.00″	5.048
BATT INSULATION				
Mineral Fibre (rock, slag, or glass)	25 mm	0.600	1.00″	3.461
Low Density (RSI = 0.024/mm)				
LOOSE FILL INSULATION				
Cellulose	25 mm	0.625	1.00″	3.606
Mineral Fibre (rock, slag, or glass)	25 mm	0.500	1.00″	2.885
Vermiculite	25 mm	0.375	1.00″	2.163
Perlite	25 mm	0.475	1.00″	2.740
Cellulosic Fibre Spray	25 mm	0.600	1.00″	3.461
Polyurethane Spray Foam	25 mm	1.050	1.00″	6.057
Glass Fibre Spray	25 mm	0.650	1.00″	3.750

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