Heat Transfer Units Conversion Chart

Thermal conductivity, U-value, R-value and RSI, heat transfer coefficient, heat flux and specific heat

For: Building services, HVAC and mechanical engineers, energy assessors and students

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EXACT DEFINITION	FORMULA	REVERSE	WORKED EXAMPLE
1 BTU = 1055.055 852 62 J (IT), 1 ft = 0.3048 m, 1 °F interval = 5/9 K	RSI = R × 0.1761102; U (W/m²·K) = U (IP) × 5.678263	R = RSI × 5.678263; U-value = 1 ÷ total R-value	R-19 insulation = 19 × 0.17611 = 3.35 m²·K/W (RSI 3.35), U = 0.299 W/m²·K

Factors to 7 significant figures; tables to 5. All factors follow from the exact definitions above.

Multiply-by factors

Quantity	From	To	Multiply by
Thermal conductivity k	BTU/(h·ft·°F)	W/(m·K)	1.730735
Thermal conductivity k	W/(m·K)	BTU/(h·ft·°F)	0.5777893
Thermal conductivity k	BTU·in/(h·ft²·°F)	W/(m·K)	0.1442279
Thermal conductivity k	W/(m·K)	BTU·in/(h·ft²·°F)	6.933472
Thermal conductivity k	kcal/(h·m·°C)	W/(m·K)	1.163
U-value, heat transfer coefficient	BTU/(h·ft²·°F)	W/(m²·K)	5.678263
U-value, heat transfer coefficient	W/(m²·K)	BTU/(h·ft²·°F)	0.1761102
U-value, heat transfer coefficient	kcal/(h·m²·°C)	W/(m²·K)	1.163
Thermal resistance R	h·ft²·°F/BTU (R-value)	m²·K/W (RSI)	0.1761102
Thermal resistance R	m²·K/W (RSI)	h·ft²·°F/BTU (R-value)	5.678263
Heat flux	BTU/(h·ft²)	W/m²	3.154591
Heat flux	W/m²	BTU/(h·ft²)	0.3169983
Specific heat capacity	BTU/(lb·°F)	kJ/(kg·K)	4.1868
Specific heat capacity	kcal/(kg·°C)	kJ/(kg·K)	4.1868
Specific heat capacity	kJ/(kg·K)	BTU/(lb·°F)	0.2388459

Insulation R-value to RSI and U-value

R-value (h·ft²·°F/BTU)	RSI (m²·K/W)	U (W/m²·K)	U (BTU/h·ft²·°F)
1	0.18	5.678	1.0000
2	0.35	2.839	0.5000
3	0.53	1.893	0.3333
4	0.70	1.420	0.2500
5	0.88	1.136	0.2000
6	1.06	0.946	0.1667
8	1.41	0.710	0.1250
10	1.76	0.568	0.1000
11	1.94	0.516	0.0909
13	2.29	0.437	0.0769

R-value (h·ft²·°F/BTU)	RSI (m²·K/W)	U (W/m²·K)	U (BTU/h·ft²·°F)
15	2.64	0.379	0.0667
19	3.35	0.299	0.0526
21	3.70	0.270	0.0476
25	4.40	0.227	0.0400
30	5.28	0.189	0.0333
38	6.69	0.149	0.0263
40	7.04	0.142	0.0250
49	8.63	0.116	0.0204
50	8.81	0.114	0.0200
60	10.57	0.095	0.0167

U-value (W/m²·K) to imperial U and R-value

U (W/m²·K)	U (BTU/h·ft²·°F)	R-value (IP)	RSI (m²·K/W)
0.1	0.0176	56.8	10.00

U (W/m²·K)	U (BTU/h·ft²·°F)	R-value (IP)	RSI (m²·K/W)
0.45	0.0792	12.6	2.22

U (W/m²·K)	U (BTU/h·ft²·°F)	R-value (IP)	RSI (m²·K/W)
0.11	0.0194	51.6	9.09
0.13	0.0229	43.7	7.69
0.15	0.0264	37.9	6.67
0.16	0.0282	35.5	6.25
0.18	0.0317	31.5	5.56
0.2	0.0352	28.4	5.00
0.25	0.0440	22.7	4.00
0.28	0.0493	20.3	3.57
0.3	0.0528	18.9	3.33
0.35	0.0616	16.2	2.86

U (W/m²·K)	U (BTU/h·ft²·°F)	R-value (IP)	RSI (m²·K/W)
0.5	0.0881	11.4	2.00
0.7	0.1233	8.1	1.43
1	0.1761	5.7	1.00
1.4	0.2466	4.1	0.71
1.6	0.2818	3.5	0.63
2	0.3522	2.8	0.50
2.8	0.4931	2.0	0.36
4.8	0.8453	1.2	0.21
5.7	1.0038	1.0	0.18

Thermal conductivity

k (W/m·K)	BTU/(h·ft·°F)	BTU·in/(h·ft²·°F)	kcal/(h·m·°C)
0.02	0.011556	0.13867	0.017197
0.025	0.014445	0.17334	0.021496
0.03	0.017334	0.208	0.025795
0.035	0.020223	0.24267	0.030095
0.04	0.023112	0.27734	0.034394
0.05	0.028889	0.34667	0.042992
0.1	0.057779	0.69335	0.085985
0.15	0.086668	1.04	0.12898
0.2	0.11556	1.3867	0.17197
0.5	0.28889	3.4667	0.42992

k (W/m·K)	BTU/(h·ft·°F)	BTU·in/(h·ft²·°F)	kcal/(h·m·°C)
1	0.57779	6.9335	0.85985
2	1.1556	13.867	1.7197
5	2.8889	34.667	4.2992
10	5.7779	69.335	8.5985
16	9.2446	110.94	13.758
50	28.889	346.67	42.992
100	57.779	693.35	85.985
200	115.56	1,386.7	171.97
237	136.94	1,643.2	203.78
401	231.69	2,780.3	344.8

Heat transfer coefficient h

h (W/m²·K)	BTU/(h·ft²·°F)	kcal/(h·m²·°C)
2	0.35222	1.7197
5	0.88055	4.2992
10	1.7611	8.5985
25	4.4028	21.496
50	8.8055	42.992
100	17.611	85.985
250	44.028	214.96

h (W/m²·K)	BTU/(h·ft²·°F)	kcal/(h·m²·°C)
500	88.055	429.92
1,000	176.11	859.85
2,500	440.28	2,149.6
5,000	880.55	4,299.2
10,000	1,761.1	8,598.5
20,000	3,522.2	17,197
100,000	17,611	85,985

Typical convection heat transfer coefficients

Process	h (W/m²·K)	h (BTU/h·ft²·°F)
Free convection, gases	2–25	0.35–4.4
Free convection, liquids	50–1,000	8.8–176
Forced convection, gases	25–250	4.4–44
Forced convection, liquids	100–20,000	17.6–3,522
Boiling or condensation	2,500–100,000	440–17,611

Heat flux

W/m²	BTU/(h·ft²)	kW/m²
1	0.317	0.001

W/m²	BTU/(h·ft²)	kW/m²
1,000	317	1

W/m²	BTU/(h·ft²)	kW/m²
10	3.17	0.01
50	15.85	0.05
100	31.7	0.1
500	158.5	0.5

W/m²	BTU/(h·ft²)	kW/m²
1,361	431.43	1.361
5,000	1,585	5
10,000	3,170	10
100,000	31,700	100

Specific heat of liquid water at 1 atm (IAPWS-IF97)

T (°C)	T (°F)	cp (kJ/kg·K)	cp (BTU/lb·°F)
0.01	32.02	4.2194	1.0078
10	50	4.1954	1.0021
20	68	4.1848	0.9995
25	77	4.1819	0.9988
30	86	4.1800	0.9984
40	104	4.1786	0.9980

T (°C)	T (°F)	cp (kJ/kg·K)	cp (BTU/lb·°F)
50	122	4.1796	0.9983
60	140	4.1828	0.9990
70	158	4.1881	1.0003
80	176	4.1955	1.0021
90	194	4.2050	1.0043
99	210.2	4.2154	1.0068

Heat transfer formulas

Formula	Meaning	Worked example
Q = m × c × ΔT	Heat to change the temperature of a mass	Heating 10 kg of water by 50 K: 10 × 4.18 × 50 = 2,090 kJ (0.58 kWh)
q = k × A × ΔT ÷ L	Conduction through a slab	k 0.04, 10 m², 20 K, 0.1 m: q = 80 W
q = U × A × ΔT	Heat loss through a wall or window	U 0.3, 50 m², 20 K: q = 300 W
U = 1 ÷ ΣR	U-value from the layer resistances (including surfaces)	R total 3.33 m²·K/W: U = 0.30 W/m²·K
R = L ÷ k	Resistance of one layer	100 mm at k 0.035: R = 2.86 m²·K/W

Sources and method

- **NIST Special Publication 811** — Conversion factors; BTU is the International Table BTU (1055.055 852 62 J) (www.nist.gov/pml/special-publication-811)
- **IAPWS-IF97 (IAPWS R7-97, 2012 revision)** — Industrial formulation for the thermodynamic properties of water and steam; reference state u = s = 0 for saturated liquid at the triple point (iapws.org/relguide/IF97-Rev.html)
- **Incropera et al., Fundamentals of Heat and Mass Transfer** — Table 1.1, typical convection heat transfer coefficients

Every factor is calculated from the exact definitions of the BTU, foot, pound and degree Fahrenheit; specific heat of water is calculated with IAPWS-IF97. Interactive version, corrections and more charts: **allunitconversions.com/heat-transfer-conversion-chart**