

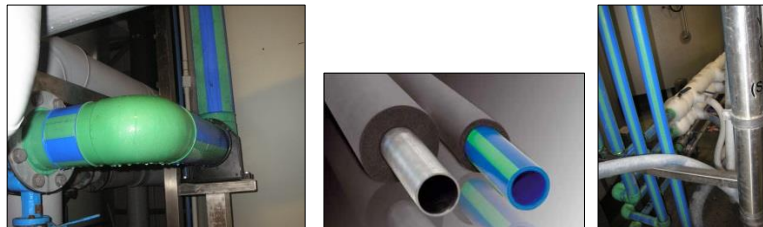


## R-value (thermal insulation) for heated and chilled water in combination with aquatherm PP-R pipes.

Every type of heated or cooling pipe system, whether it is made of metal or plastic, will have a heat flow through their pipe wall. Excessive heat flow, i.e. energy loss (heated water) or energy absorption (chilled water), will result in high energy bills. To prevent excessive heat flow we have to insulate the pipes and fittings.



For chilled water systems, with water temperatures below ambient temperature, we also have to insulate the pipes and fittings to prevent the formation of condensation.



We use a “R-value” or thermal resistance to measure the ability of a material to retard heat flow. The higher the R-value, the higher the insulation value. The R-value is normally calculated on a m<sup>2</sup> basis.

### R = thermal resistance [m<sup>2</sup>K/W]

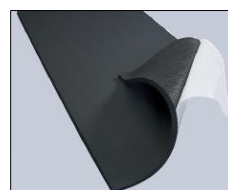
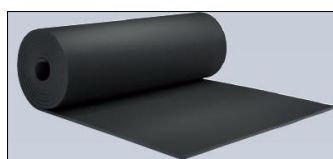
R-values for flat surfaces such as (homogeneous) sheet materials are easily (approximately) calculated by dividing the thickness of the insulation by the thermal conductivity of the insulation.

This is the way the R-value is calculated in accordance with AS/NZS 3500.4:2003 (section 8.6) (heated potable water piping)

$$R = \frac{x_i}{k_i} + \frac{x_p}{k_p}$$

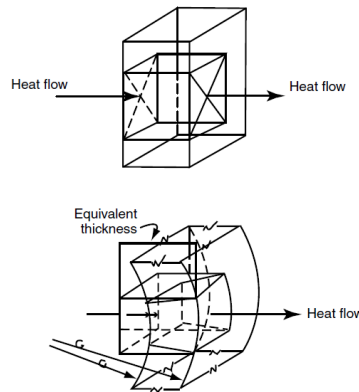
where:

- R = total thermal resistance [m<sup>2</sup>K/W]
- x<sub>i</sub> = thickness of insulation [m]
- k<sub>i</sub> = thermal conductivity of insulation material [W/mK]
- x<sub>p</sub> = thickness of pipe wall [m]
- k<sub>p</sub> = thermal conductivity of pipe material [W/mK]





This simple way of R-value calculation doesn't hold true when looking at cylindrical pipe insulations. For cylindrical pipe insulation the heat flow is not the simple straight through heat flow found with a flat surface material but rather a radial heat flow. This is true because the inner radius surface area is much smaller than the outer radius surface area.



Because of these differences in surface area, heat flow must be calculated using an equivalent thickness.

For cylindrical pipe insulation, the following equation should be used to calculate the R-value.

This is the way the R-value is calculated in accordance with AS/NZS 4859.1-2002 (section 2.3.3.8) / BCA J5.4 (chilled/cooling and heating water):

$$R = \frac{r_2}{k} \ln \frac{r_2}{r_1}$$

where:

R = total thermal resistance [m<sup>2</sup>K/W]

r<sub>2</sub> = outer insulation radius [m]

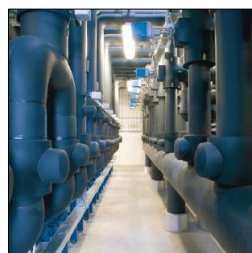
k = thermal conductivity of insulation material [W/mK]

r<sub>1</sub> = inner insulation radius / uninsulated outer pipe radius [m]

**Not including:**

R values for air films (BCA Specification J1.2 Table 2b)	R-Value
Air films (still air)	0.120
Air Films (not more than 3m/s wind speed)	0.040
Air films (more than 3m/s wind speed & not more than 7m/s wind speed)	0.030

R values for water films
Water films (still water) (dependent on fluid)

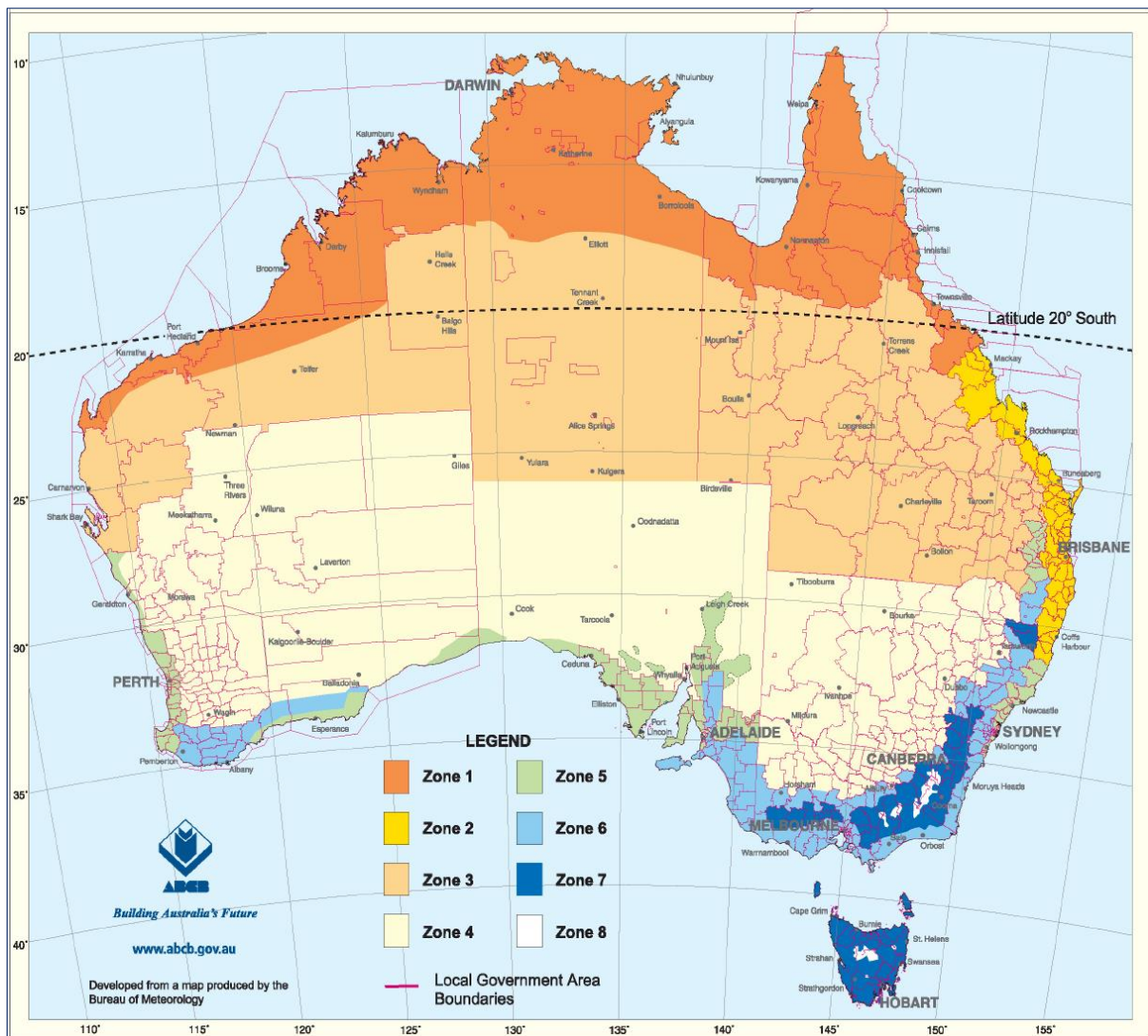




As well under **AS/NZS 3500.4:2003** as under the **Building Code of Australia (BCA)** the map of Australia is divided in specified Climate Zones/Regions.

The AS/NZS 3500.4:2003 divides the map of Australia in Climate Regions A, B and C, the BCA uses Climate Zones 1 – 8.

### Climate Zones in Accordance with BCA (2012)



The minimum required thermal insulation for hot potable water piping should comply with the specific R-value in accordance with table 8.1 and 8.2 mentioned in the **AS/NZS 3500.4:2003**.

The minimum required thermal insulation for chilled/cooling or heating water piping should comply with the specific R-value in accordance with table 2A of the **Building Code of Australia (BCA)**, **specification J5.4**.

The required minimum R-value depends on the climate zone/region, application and cooling/heating capacity (BCA J5.4).

For the required minimum R-values, please refer to the latest edition of the **AS/NZS 3500.4** or the **BCA section J5.4**.



**The R-values [m<sup>2</sup>K/W] are material (insulation) values.** Depending on the thermal conductivity [W/mK] of the insulation material and the thickness of the insulation, the material R-value of the insulation can be calculated. Especially the BCA J5.4 doesn't include the R-value of the pipe material into the equation.

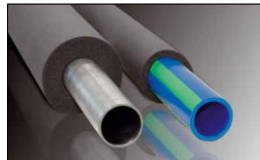
The R-value of metal pipes can normally be ignored since metals are conductors of heat. Plastic pipe materials (i.e. Polypropylene, **aquatherm PP-R**) on the other hand are insulators and do contribute to the **total R-value**.

The thermal conductivity of **aquatherm PP-R** is **0,15 W/mK** compared to **385 W/mK** for copper and **50 W/mK** for carbon steel.

Especially large bore aquatherm PP-R pipes, with large wall thicknesses, do contribute to the total R-value.



By using **aquatherm PP-R** pipes, especially in large pipe sizes and wall thickness, you can save insulation costs by using a lesser insulation thickness.



Other advantages of using (pre-) insulated aquatherm PP-R pipes in lieu of insulated metal pipes are:

- No corrosion of the pipe (longevity and constant smooth bore)



- Very good sound insulating characteristics

Aquatherm Australia Pty Ltd can provide you the Excel sheets to calculate the R-values of any insulation material in accordance with AS/NZS 3500.4:2003 (section 8.6) or AS/NZS 4859.1-2002 (section 2.3.3.8) / BCA J5.4

*Below you will find examples of these Excel sheets in combination with Armaflex® FR insulation (at 23°C).*






Calculation of the (total) R-value of insulated **aquatherm PP-R** pipes in accordance with **AS/NZS 3500.4:2003**  
(based on Armaflex® FR insulation at 23°C)

$$R = \frac{x_i}{k_i} + \frac{x_p}{k_p}$$

**R-value [m²K/W] of Climatherm SDR 17.6 Faser composite pipe**

Climatherm PP-R λ [W/mK] **0.15 W/mK**

Insulation λ [W/mK] **0.036 W/mK** (Armaflex FR at 23°C)








Diameter	160	200	250	315	355	400	450	500	560	630
Wall thickness	9.1	11.4	14.2	17.9	20.1	22.7	25.5	28.4	31.7	35.7
No Insulation	0.06	0.08	0.09	0.12	0.13	0.15	0.17	0.19	0.21	0.24
Insulation thickness [mm]	R-value insulation + pipe									
10	0.34	0.35	0.37	0.40	0.41	0.43	0.45	0.47	0.49	0.52
13	0.42	0.44	0.46	0.48	0.50	0.51	0.53	0.55	0.57	0.60
20	0.62	0.63	0.65	0.67	0.69	0.71	0.73	0.74	0.77	0.79
25	0.76	0.77	0.79	0.81	0.83	0.85	0.86	0.88	0.91	0.93
38	1.12	1.13	1.15	1.17	1.19	1.21	1.23	1.24	1.27	1.29
50	1.45	1.46	1.48	1.51	1.52	1.54	1.56	1.58	1.60	1.63

**R-value [m²K/W] of Climatherm SDR 7.4/SDR11 Faser composite pipe**

Climatherm PP-R λ [W/mK] **0.15 W/mK**

Insulation λ [W/mK] **0.036 W/mK** (Armaflex FR at 23°C)



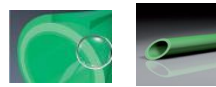
Diameter	20*	25*	32	40	50	63	75	90	110	125	160	200	250	315	355	400	450
Wall thickness	2.8	3.5	2.9	3.7	4.6	5.8	6.8	8.2	10	11.4	14.6	18.2	22.7	28.6	32.2	36.3	40.9
No Insulation	0.02	0.02	0.02	0.02	0.03	0.04	0.05	0.05	0.07	0.08	0.10	0.12	0.15	0.19	0.21	0.24	0.27
Insulation thickness [mm]	R-value insulation + pipe																
10	0.30	0.30	0.30	0.30	0.31	0.32	0.32	0.33	0.34	0.35	0.38	0.40	0.43	0.47	0.49	0.52	0.55
13	0.38	0.38	0.38	0.39	0.39	0.40	0.41	0.42	0.43	0.44	0.46	0.48	0.51	0.55	0.58	0.60	0.63
20	0.57	0.58	0.57	0.58	0.59	0.59	0.60	0.61	0.62	0.63	0.65	0.68	0.71	0.75	0.77	0.80	0.83
25	0.71	0.72	0.71	0.72	0.73	0.73	0.74	0.75	0.76	0.77	0.79	0.82	0.85	0.89	0.91	0.94	0.97
38	1.07	1.08	1.07	1.08	1.09	1.09	1.10	1.11	1.12	1.13	1.15	1.18	1.21	1.25	1.27	1.30	1.33
50	1.41	1.41	1.41	1.41	1.42	1.43	1.43	1.44	1.46	1.46	1.49	1.51	1.54	1.58	1.60	1.63	1.66

\* = SDR7.4

**R-value [m²K/W] of Aquatherm PP-R SDR 7.4 Faser composite pipe**

Fusiotherm PP-R λ [W/mK] **0.15 W/mK**

Insulation λ [W/mK] **0.036 W/mK** (Armaflex FR at 23°C)

Diameter	20	25	32	40	50	63	75	90	110	125	160	200	250
Wall thickness	2.8	3.5	4.4	5.5	6.9	8.6	10.3	12.3	15.1	17.1	21.9	27.4	34.2
No Insulation	0.02	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.10	0.11	0.15	0.18	0.23
Insulation thickness [mm]	R-value insulation + pipe												
10	0.30	0.30	0.31	0.31	0.32	0.34	0.35	0.36	0.38	0.39	0.42	0.46	0.51
13	0.38	0.38	0.39	0.40	0.41	0.42	0.43	0.44	0.46	0.48	0.51	0.54	0.59
20	0.57	0.58	0.58	0.59	0.60	0.61	0.62	0.64	0.66	0.67	0.70	0.74	0.78
25	0.71	0.72	0.72	0.73	0.74	0.75	0.76	0.78	0.80	0.81	0.84	0.88	0.92
38	1.07	1.08	1.08	1.09	1.10	1.11	1.12	1.14	1.16	1.17	1.20	1.24	1.28
50	1.41	1.41	1.42	1.43	1.43	1.45	1.46	1.47	1.49	1.50	1.53	1.57	1.62





Calculation of the (total) R-value of insulated **aquatherm PP-R** pipes in accordance with  
**AS/NZS 4859.1-2002 (section 2.3.3.8) / BCA J5.4**  
(based on Armaflex® FR insulation at 23°C)

$$R = \frac{r_2}{k} \ln \frac{r_2}{r_1}$$

Not included: R-value of Air films (BCA Specification J1.2 Table 2b) and Water films

**R-value [m²K/W] of Climatherm SDR17,6 Faser composite pipe**



Climatherm PP-R λ [W/mK] **0.15 W/mK**  
Insulation λ [W/mK] **0.036 W/mK** (Armaflex FR at 23°C)

Diameter	160	200	250	315	355	400	450	500	560	630
Wall thickness	9.1	11.4	14.2	17.9	20.1	22.7	25.5	28.4	31.7	35.7
No Insulation	0.06	0.08	0.10	0.13	0.14	0.16	0.18	0.20	0.22	0.25
Insulation thickness [mm]	<b>R-value insulation + pipe</b>									
10	0.36	0.37	0.39	0.41	0.43	0.45	0.46	0.48	0.51	0.53
13	0.45	0.46	0.48	0.50	0.52	0.53	0.55	0.57	0.59	0.62
20	0.68	0.69	0.70	0.72	0.73	0.74	0.76	0.78	0.80	0.83
25	0.86	0.86	0.86	0.87	0.88	0.90	0.91	0.93	0.95	0.97
38	1.34	1.32	1.30	1.30	1.30	1.31	1.32	1.33	1.35	1.37
50	1.82	1.77	1.74	1.72	1.71	1.71	1.71	1.72	1.73	1.75

**R-value [m²K/W] of Climatherm SDR 7.4/SDR11 Faser composite pipe**

Climatherm PP-R λ [W/mK] **0.15 W/mK**  
Insulation λ [W/mK] **0.036 W/mK** (Armaflex FR at 23°C)






Diameter	20*	25*	32	40	50	63	75	90	110	125	160	200	250	315	355	400	450
Wall thickness	2.8	3.5	2.9	3.7	4.6	5.8	6.8	8.2	10	11.4	14.6	18.2	22.7	28.6	32.2	36.3	40.9
No Insulation	0.02	0.03	0.02	0.03	0.03	0.04	0.05	0.06	0.07	0.08	0.11	0.13	0.17	0.21	0.24	0.27	0.30
Insulation thickness [mm]	<b>R-value insulation + pipe</b>																
10	0.41	0.39	0.37	0.37	0.36	0.36	0.36	0.37	0.38	0.38	0.40	0.43	0.46	0.50	0.52	0.55	0.58
13	0.55	0.53	0.50	0.49	0.48	0.47	0.47	0.47	0.47	0.48	0.50	0.52	0.55	0.59	0.61	0.64	0.67
20	0.94	0.89	0.83	0.80	0.77	0.75	0.73	0.72	0.72	0.72	0.73	0.74	0.76	0.80	0.82	0.85	0.88
25	1.24	1.17	1.09	1.04	1.00	0.96	0.94	0.92	0.91	0.90	0.90	0.91	0.93	0.96	0.98	1.00	1.03
38	2.11	1.99	1.85	1.74	1.65	1.57	1.52	1.47	1.43	1.41	1.38	1.37	1.37	1.38	1.40	1.42	1.44
40	2.26	2.12	1.97	1.86	1.76	1.67	1.61	1.56	1.52	1.49	1.46	1.44	1.44	1.45	1.46	1.48	1.51
45	2.63	2.46	2.29	2.16	2.04	1.93	1.86	1.79	1.73	1.70	1.66	1.63	1.62	1.62	1.63	1.65	1.67
50	3.01	2.82	2.62	2.46	2.32	2.19	2.11	2.03	1.96	1.92	1.86	1.82	1.80	1.80	1.81	1.82	1.83

\* = SDR7.4

**R-value [m²K/W] of Aquatherm PP-R SDR 7.4 Faser composite pipe**

Fusiotherm PP-R λ [W/mK] **0.15 W/mK**  
Insulation λ [W/mK] **0.036 W/mK** (Armaflex FR at 23°C)

Diameter	20	25	32	40	50	63	75	90	110	125	160	200	250
Wall thickness	2.8	3.5	4.4	5.5	6.9	8.6	10.3	12.3	15.1	17.1	21.9	27.4	34.2
No Insulation	0.02	0.03	0.03	0.04	0.05	0.07	0.08	0.10	0.12	0.13	0.17	0.21	0.27
Insulation thickness [mm]	<b>R-value insulation + pipe</b>												
10	0.41	0.39	0.38	0.38	0.38	0.38	0.39	0.40	0.42	0.43	0.47	0.50	0.55
13	0.55	0.53	0.51	0.50	0.50	0.49	0.50	0.50	0.52	0.53	0.56	0.60	0.65
20	0.94	0.89	0.85	0.81	0.79	0.77	0.76	0.76	0.76	0.77	0.79	0.82	0.86
25	1.24	1.17	1.11	1.06	1.02	0.98	0.97	0.95	0.95	0.95	0.96	0.99	1.03
38	2.11	1.99	1.86	1.76	1.67	1.59	1.55	1.51	1.47	1.46	1.44	1.45	1.47
50	3.01	2.82	2.63	2.48	2.34	2.22	2.14	2.07	2.00	1.97	1.92	1.90	1.90