SPECIFYING R-VALUES

This TECHnote describes the various meanings of R-Value, its use in the National Construction Code (NCC) *Volume One - Building Code of Australia (BCA) Class 2 to Class 9 Buildings*, and the ways in which designers and specifiers can document compliance with statutory requirements.

BCA AND R-VALUES

The thermal resistance of the walls and roof of a building directly influence its thermal performance. Similarly, heat gain and loss from heating and cooling ductwork, piping and components are dependent on their thermal insulation. The BCA provides two means of achieving adequate thermal performance of walls and roofs:

- Deemed-to-satisfy provisions.
- Performance requirements.

In all cases, appropriate R-Values for insulation materials must be designed and documented. To do this correctly, it is essential to distinguish between similar terms.

The BCA defines these, as follows:

- **R-Value** (m².K/W): The thermal resistance of a component calculated by dividing its thickness by its thermal conductivity (W/(m.K)).
- **Total R-Value**: The sum of the R-Values of the individual component layers in a composite element including any building material, insulating material, airspace and associated surface resistances.
- **Total System U-Value** (W/(m².K)): The thermal transmittance of the composite element allowing for the effect of any airspaces and associated surface resistances.

R-Values are a measure of thermal resistance (hence the R) while U-Values express thermal transmittance. Each is the reciprocal of the other so a Total R-Value of 2.0 is equivalent to a U-Value of 0.5. Note that BCA uses Total System U-Value only in relation to glazing but U-Value is in common use in engineering calculations for all building elements.

The BCA also uses the term Material R-Value in Specifications J5.2 and J5.4 but does not define it. NATSPEC uses the following definition:

- **Material R-Value**: The thermal resistance (m².K/W) of a component calculated by dividing its thickness by its thermal conductivity. Material R-Value does not include for air space or surface resistances.

In general, the BCA mandates Total R-Value in relation to the thermal performance of walls, floors and roofs and Material R-Value in relation to insulation on ducts and pipes, simplifying design and documentation. For walls, floors and roofs, the designer consults the BCA to find the mandated Total R-Value and then determines the Total R-Value of the proposed construction without insulation by calculation or from other sources, the additional insulation required for compliance being the difference between the two.

In the case of pipes and ducts, the BCA uses the simpler approach of mandating Material R-Value, since for a given duct, the Total R-Value is different on the top, bottom and sides and, in the case of pipes, Total R-Value is dependent on whether the pipe is horizontal, vertical or at an angle to horizontal.

Consider the effect of compression and lack of continuity when specifying R-Values for bulk insulation.

References

Calculation of Total R-Value:

AIRAH. *DA09: Air conditioning load estimation and psychrometrics.* Melbourne: Australian Institute of Refrigeration, Air Conditioning and Heating.

AIRAH. *Technical handbook.* 5th ed. Melbourne: Australian Institute of Refrigeration, Air Conditioning and Heating

AIRAH. *DA16 Air conditioning water piping*. Melbourne: Australian Institute of Refrigeration, Air Conditioning and Heating.

BCA Specifications :

- J1.2 Material properties.
- J1.3 Roof and ceiling construction.
- J1.5 Wall construction.
- J1.6 Floor construction.

Material R-Value

- J5.2 Ductwork insulation and sealing.
- J5.4 Insulation of piping, vessels, heat exchangers and tanks

Relevant standards

AS 4426 *Thermal insulation of pipework, ductwork and equipment – Selection, installation and finish*.

AS/NZS 4859.1 *Materials for the thermal insulation of buildings - General criteria and technical provisions.*

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CALCULATION OF TOTAL R-VALUE

BCA Specifications J1.2, J1.3, J1.5, and J1.6 illustrate the calculation of Total R-Value. The heat transfer between solid materials and air is a complex function of convective heat transfer and thermal radiation. In particular, these convection and radiation effects mean that these air space and surface resistances are influenced by the reflectivity of the surfaces, the direction of heat flow (e.g. up or down through a roof) and the air velocity past the surface. In response, the BCA approximates these by converting them into notional air space and surface resistances analogous to material R-Values.

BULK AND REFLECTIVE INSULATION

Bulk insulation (fibreglass, rock wool, polyester, polystyrene, etc.) achieves its insulation effect by trapping still air within it, so that twice the thickness means twice the R-Value. If its thickness remains constant so does its material R-Value, but material R-Value can be affected by compression (e.g. between purlins and sheeting) and by moisture penetration.

Reflective insulation achieves its insulation effect by reducing radiant heat transfer. To have an effect, the reflective surface must face an air space, typically at least 25 mm wide. As reflective insulation is thin compared to bulk insulation, all of its insulation effect occurs at the surface. This effect can degrade over time due to the effects of corrosion (e.g. on reflective foil) and the accumulation of dust. The BCA references AS/NZS 4859.1, of which Appendix K (Normative) deals with calculation of System and Total R-Values and includes derating factors for these effects.

NATSPEC PROVISIONS

NATSPEC deals with the specification of R-Values in a number of ways:

- By referencing the BCA directly, for example in 0744 *Ductwork insulation*.
- By providing a place to specify material R-Values, either to achieve the Total R-Value mandated by the BCA or to exceed minimum mandatory requirements.
- By requiring, when appropriate, evidence of conformance with AS/NZS 4859.1.

SPECIFYING R-VALUES

When specifying R-Values, specifiers need to take into consideration a number of factors including:

- The effect of non-continuous insulation, e.g. if installed between studs in walls, or removed around light fittings in ceilings. The actual Total R-Value will be the area weighted average with and without insulation. For ceilings, BCA provides a ready reckoner in Table J1.3b for compensating for the effect of removal of insulation.
- The effect of compression on bulk insulation in the intended situation. See AS 4426 Figure 2.2 for the effect of compressing insulation. In general, for every 2% compression, a loss of 1% in R-Value will occur.
- The effects of derating of reflective insulation to AS/NZS 4859.1 Appendix K since the manufacturer's published R-Values for reflective insulation are normally for new materials under ideal conditions.
- The temperature at which bulk insulation performance is stated. Insulation R-Values should be selected for the average temperature within the insulation, typically 23°C. Material R-Values are temperature dependent, so values at 20°C will be 1% to 2% better than for the same material at 23°C.

When considering published Material R-Values, check that performance does not include surface resistance.

Consider the effects of derating of reflective insulation. Manufacturer's R-Values are normally for new materials under ideal conditions.

Relevant worksections

0168 *Green star – as built submissions*
0169 *Green star – office as built submissions*
0171 *General requirements*
0421 *Roofing – combined*
0423 *Roofing – profiled sheet metal*
0424 *Roofing – seamed sheet metal*
0426 *Roofing – slab*
0427 *Roofing – tiles*
0432 *Curtain walls*
0433 *Stone cladding*
0463 *Glass blockwork*
0471 *Thermal insulation and pliable membrane*
0701 *Mechanical systems*
0702 *Mechanical design and install*
0711 *Chillers – combined*
0712 *Water heating boilers*
0716 *Chillers – centrifugal*
0717 *Chillers – water cooled screw*
0718 *Chillers – air cooled screw and scroll*
0719 *Chillers – absorption*
0721 *Packaged air conditions*
0722 *Air handling plant – combined*
0725 *Air handling plant – built up*
0726 *Air handling plant – minor*
0727 *Air handling plant – packaged*
0741 *Ductwork*
0744 *Ductwork insulation*
0752 *Mechanical piping insulation*
0761 *Refrigeration*
0762 *Cool rooms*

