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.

NCC 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 NCC provides two means of achieving adequate thermal performance of walls and roofs:

- Deemed-to-Satisfy Solutions.
- Performance Solutions.

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 NCC 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, thermal bridging 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, thermal bridging 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 Total System U-Value of 0.5.

In general, the NCC mandates minimum Total R-Values and Total System U-Values in relation to the thermal performance of the building fabric, including roof and ceiling construction, roof lights, walls and glazing, and floors.

For the building fabric, the designer may consult the NCC to find the mandated minimum Total R-Value, determine the Total R-Value of the proposed construction without insulation by calculation or from other sources, and find the additional insulation required for compliance (being the difference between the two).

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

CALCULATION OF TOTAL R-VALUE

The heat transfer between solid materials and air is a complex function of convective heat transfer and thermal radiation. 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 NCC approximates these by converting them into notional air space and surface resistances analogous to R-Values. BCA Specification 36 nominates thermal properties for common construction materials of typical wall, roof and floor materials. It also sets out R-Values for airspaces and air films, including airspaces with reflective surfaces.

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

References

Calculation of Total R-Value:
Australian Institute of Refrigeration, Air Conditioning and Heating (AIRAH).

AIRAH *Technical handbook*.

AIRAH *DA09 Air conditioning load estimation and psychrometrics.*

AIRAH *DA16 Air conditioning water piping.*

NCC Volume One:

- BCA Specification 36 *Material properties* with typical R-Values for materials, airspaces and air films.
- BCA Specification 37 *Calculation of U-Value and solar admittance* to calculate U-Value of wall-glazing construction.
- BCA Specification 38 *Spandrel panel thermal performance.*
- BCA Specification 39 *Sub-floor and soil thermal performance.*

Relevant standards

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

AS/NZS 4859 *Thermal insulation materials for buildings.*

Part 1 General criteria and technical provisions.

Part 2 Design.

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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 R-Value, but 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 its insulation effect occurs at the surface. This effect can degrade over time because of corrosion (e.g. on reflective foil) and the accumulation of dust. The NCC references AS/NZS 4859.2 which 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 NCC directly, for example in *0744 Ductwork insulation*.
- By providing a place to specify insulation R-Values, either to achieve the Total R-Value mandated by the NCC or to exceed minimum mandatory requirements.
- By requiring, when appropriate, evidence of conformance with AS/NZS 4859.2.

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.
- The effect of compression on bulk insulation in the intended situation. See AS 4426 Figure 2.3 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 4859.2 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. Insulation 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 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

0171 General requirements
0420 Roofing – combined
0423 Roofing – profiled sheet metal
0424 Roofing – seamed sheet metal
0426 Roofing – slate
0427 Roofing – tiles
0432 Curtain walls
0433 Stone cladding
0463 Glass blockwork
0471 Thermal insulation and pliable membranes
0701 Mechanical systems
0702 Mechanical design and install
0712 Water heating boilers
0715 Chillers – combined
0716 Chillers – centrifugal
0717 Chillers – water cooled screw
0718 Chillers – air cooled screw and scroll
0719 Chillers – absorption
0721 Packaged air conditioning
0724 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