Technical Note 2

GUIDANCE FOR CALCULATING CEILING PENETRATIONS (Version 1.0 – 2012)

Introduction

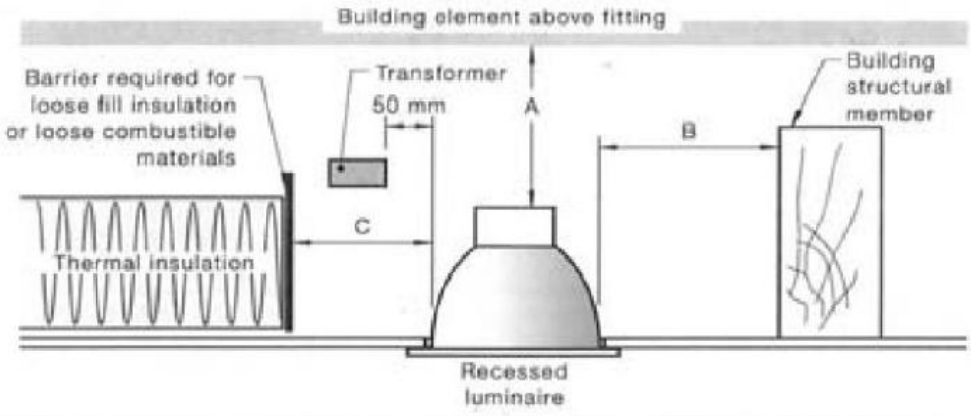
The clearance required around downlights by "Australian Standard AS/NZS 3000 – 2007 Electrical Installations" (AS/NZS 3000), introduces a significant area of uninsulated ceiling and therefore increases heat loss and gain through the ceiling. This can be allowed for by reducing the R value of ceiling insulation.

This note provides NatHERS assessors with techniques to reduce the ceiling R value to allow for the gaps that the clearance around downlights and other ceiling penetrations including flues, exhaust fans, electrical resistance heaters. This note also offers alternative solutions for assessor's to calculate the loss of ceiling insulation on a zone by zone basis. Note that downlights can also provide a significant source of air leakage.

Types of downlights: Required clearances

AS/NZS 3000 requires the following clearances:

Figure 1 Downlight clearances required by AS/NZS 3000



Dimension	Incandescent lamp	Halogen lamp
A – clearance above luminaire	50 mm	200 mm
B - side clearance to structural member	100 mm	200 mm
C – clearance to thermal insulation	50 mm	200 mm
D – clearance to supply transformer	50 mm	

Different clearances are required depending on the type of globe. The hotter halogen globes are required to have the greatest clearance to the insulation or framing. For the purposes of this practice note LED's and CFL's are to have the same clearances as incandescent lamps.

A variety of downlight covers are available on the market. These downlight covers may allow insulation to be installed up to the side of the downlight cover, and in some cases may allow insulation to be installed over the top of the cover. The downlight covers may also have a significant thermal resistance, so calculation of the effective R value should take this into account as well.

While it is the architect/building designer's responsibility to supply a product specification and fully detail these covers and their location on the electrical plans, NatHERS assessors should explicitly request this information.

BCA: maximum light power density, and derating of ceiling insulation R

The BCA provides an upper limit to the number of downlights which may be installed throughout the house by setting a minimum lighting density of 5W/$m^{2,}$ however, this is an average over the house, and so individual rooms may have significantly higher lighting densities and therefore significant areas of uninsulated ceiling.

The BCA "Table 3.12.1.1b Adjustment of Minimum R-Value for Loss of Ceiling Insulation" provides a technique for adjusting the overall minimum required ceiling R value depending on the proportion of the total ceiling area in the house which is left uninsulated due to *downlights, exhaust fans, flues and other penetrations (except skylights)*.

Table 3.12.1.1b shows higher minimum required R values given various uninsulated proportions of the ceiling **r**ather than the extent of reduction in the R value of the insulation so cannot be used to determine R values to be input to NatHERS tools**. *NatHERS tools also require ceiling R-values to be entered on a room-by-room basis, not as an average for the whole house.***

In addition these calculations are based on of the overall R-value of the Roof/Ceiling element when NatHERS simulation tools need to describe the change in R value to the ceiling only as the boundary between the room below and the attic space above.

While the BCA lighting provisions will limit the extent of loss of performance, if all downlights are concentrated in the room with the largest heating/cooling loads then significant reductions in rating results are possible where several uncovered luminaries are used.

Impact of penetrations on ceiling R values

In practice the requirements of AS/NZS 3000 means that insulation installers will leave out half a batt (450mm x 450mm) around each halogen downlight/luminaries. As halogen downlights are typically installed at one per 2.5 m^2, in a 10 m^2 room this means that 0.81 m^2 of the ceiling is uninsulated. The heat lost through the uninsulated part of the ceiling will double the heat lost through the ceiling. This would reduce the effective R value of R3.5 insulation to R1.2.

The other case which may occur under the BCA is where the covered halogen recessed downlights **can** have insulation laid over the suitably approved fireproof downlight cover. In this case, the R value to be entered is the same as the installed ceiling R value.

As previously explained, BCA Table 3.12.1.1b methodology does not take into account whether the zone below is conditioned or impacts on a room by room basis.

In NatHERS software assessments the impact of ceiling insulation on the rating depends on the conditioning of the zone below and as well as the ventilation of the attic /roof space and roof material colour and not simply the overall building ceiling area. Consequently the methodology described in Table 3.12.1.1b may not reflect the actual impacts of the additional uninsulated area required for ceiling penetrations.

Table 1 shows the impact on average ceiling R-values of halogen downlights with a 450 x 450 mm clearance left around them. The number of downlights is expressed as the number of downlights per 10 square metres of ceiling. 4 downlights per square metre would be a typical downlight density in those rooms in which they are installed.

Table 1 - Halogen recessed downlights – impact on ceiling R value

	Area weighted average R value							
Downlights per 10 m^2	Initial Ceiling R value							
	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00
1	1.25	1.58	1.88	2.16	2.42	2.65	2.86	3.06
2	1.06	1.30	1.50	1.67	1.83	1.96	2.08	2.18
3	0.92	1.09	1.24	1.36	1.46	1.54	1.61	1.68
4	0.80	0.94	1.05	1.13	1.20	1.26	1.31	1.35
5	0.71	0.82	0.90	0.96	1.02	1.06	1.09	1.12

While downlights can no longer be installed in all rooms at densities of 4 per 10 m^2 due to the new lighting density requirements they can still be installed in a few rooms while maintaining compliance for the house as a whole. In those rooms where they are installed at these densities the effective R value of ceiling insulation is cut by between 50% (at low R values) and 75% (at high R values). This can result in substantial reductions in star ratings, so it is critical that assessors take the impact of ceiling penetrations into account when undertaking ratings for regulatory purposes - See the 'Methodology' section on page 5 for how this should be implemented by assessors.

Default loss of ceiling insulation calculations

Allowing for penetrations does require additional data input time for assessors; however the assessments can be a star lower if these haven't been allowed for. And it may be possible that assessors could be found liable to upgrade a building if it is not compliant due to errors in data entry.

It is common for insulation installers to allow greater clearances around downlights and other ceiling penetrations than that required in AS/NZS 3000; this can be as great as 0.25m2 per halogen or incandescent light fitting.

As previously explained, the clearance (area of uninsulated ceiling) around downlights depends on:

- the type of globe,
- clearances also required to framing members and transformers
- if an approved fireproof downlight cover/shield is noted on the electrical plans

- whether this cover allows insulation to be installed above the downlight or just closely to the sides.

For the purposes of this practice note, the following default allowances (Table 2) can be made for ceiling penetrations. To easily align with standard insulation practice all calculations are based on a square or rectangle, not the diameter of the product.

Table 2 – default allowances for downlight ceiling penetrations

Globe type					
Type	Globe	Insulation clearance	Ceiling penetration allowance	Uninsulated area (actual & rounded)	
Halogen*	50mm	200mm	450mm x 450mm	0.203m^2	0.21m^2
Incandescent **	60mm	100mm	260mm x 260mm	0.068m^2	0.07m^2
CFL	60mm	50mm	160mm x 160mm	0.026m^2	0.03m^2
LED (GU10)	50mm	50mm	150mm x 150mm	0.023m^2	0.03m^2
LED standard	50mm	50mm	150mm x 150mm	0.023m^2	0.03m^2
Separate Transformers***		50mm	75mm x 75mm	0.060m^2	0.06m^2
* includes transformer ** Since 2009 Incandescent globes have been in a process of being phased out *** Clearance between transformer and insulation					

Note: If approved fireproof downlight covers, which can be fully covered by insulation, are specified and noted on the electrical plan by the building designer or architect, then there is no need to allow for the ceiling penetration.

Other ceiling penetrations

For the purposes of this practice note, the following default allowances (Table 3) can be made for ceiling penetrations other than downlights. The following common clearance guidance should apply:

Table 3 – other ceiling penetrations

Other ceiling penetrations						
Exhaust fans, vents, flues and ceiling speakers	160mm	180mm	200mm	225mm	250mm	300mm
	0.26 m^2	0.032 m^2	0.040m^2	0.51m^2	0.063m^2	0.09m2
Exhaust fans with electrical resistance heater and lights or electrical resistance heaters with lights						
Actual size plus 100mm clearance	ie: Actual size 262 x 262		Clearance 100mm	Total area 0.131m^2		

Downlight Covers

Downlight covers reduce the extent of uninsulated ceiling area.

Approved ventilated downlight cover or shield: *which allows for the insulation to be closely installed to the sides.* The area of the cover is used to calculate the ceiling penetration.

Approved non ventilated cover or shield: which allows for the insulation to be closely installed to the sides and top. Then no ceiling penetration allowance need be made.

The use of downlight covers must be noted on the electrical plan otherwise insulation installers will assume the default values will apply. Where downlight covers have been allowed for in the rating, Assessors cannot certify plans that do not explicitly show the use of approved downlight covers.

Further information on approved fire proof down light covers can be obtained from your electrical wholesaler, supplier or direct from the manufacturer. These can also be found by simply entering "downlight covers" in your search engine.

Air infiltration through downlights

Unless otherwise noted on the electrical plan, all downlights will be considered to be ventilated. This does not apply to downlights fitted with approved non ventilated covers which allow for the ceiling insulation to closely enclose the sides and top. This must be noted on the electrical plan otherwise the default values will apply.

Ceiling insulation in sloping roofs

Ceiling insulation is required by Australian Standards to extend 50 mm beyond the top plate of external walls to prevent thermal bridging at the wall/ceiling junction. In an attic space with a sloping roof the use of higher R-values can mean that the roof may come into contact with the insulation. This can result in a loss of R-value and moisture penetration issues. In a typical 22.5^{o} pitch roof there is approximately 180mm clearance between the external wall top plate and the roofing material and this is further reduced when roof framing members are taken into account. Loss of R value through compression of insulation or use of less insulation at the roof/ceiling junctions should also be taken into account.

Ceiling Penetration Methodology

Ascertain the actual area of ALL ceiling penetrations. If this is less than 0.5% of the "insulated ceiling area" then no further action need be taken. It would however be good practice to note this in the comments section of the NatHERS software report.

If the actual area of all ceiling penetrations is greater than 0.5 % of the "total insulated ceiling area", then for **each** zone that has ceiling penetrations: Enter both the insulated ceiling area and the uninsulated penetration ceiling area.

In NatHERS software ceiling penetrations are considered to be an uninsulated ceiling area.

Worked Example:

- For a living zone with a 50m2 ceiling area,
    - the ceiling construction being 10mm plasterboard with R4.1 insulation
        1. Ceiling area less penetration area is entered in the assessment
    - 6x35w Halogen recessed downlights,

1. Halogen globe ceiling penetrations = 6 x 0.203m^2 = 1.218m^2 rounded to 1.22m^2

- This would be entered in your NatHERS software for this particular zone as:

1. A 10mm (uninsulated) plasterboard ceiling with an area of 1.22m^2
2. A 10mm plasterboard ceiling with R4.1 insulation with an area of 48.78m^2

When regulatory compliance has been achieved, note in the comments section of the rating software that all ceiling penetrations have been allowed for within the assessment. Do not certify plans which do not explicitly state the extent and type of downlights and other ceiling penetrations.

This Practice Note is to be read in conjunction with the NatHERS national principles document, Technical Note 1.

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NatHERS supports improvements to the thermal performance (energy efficiency) of Australia's residential buildings by providing a standardised approach and guidelines for energy rating software tools used to assess dwellings across Australia.

NatHERS is administered by the Department of Climate Change and Energy Efficiency on behalf of the Commonwealth, state and territory governments.

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