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Introduction

This White Paper is about the In-Use Factors (IUFs) relating to loft insulation, namely the reasons why insulation doesn't perform as well as it should do. It was originally written for Sustain Ltd, who were commissioned by the Department of Energy and Climate Change to review the current IUFs; however this version is published for the public good as a general resource and overview of the research literature available on the subject, as understood by LoftZone at the time of writing.

This paper focuses primarily on the issue of loft insulation compression but touches upon other issues, as and when we have evidence for these.

Previous research

This first section of this paper seeks to examine previous research into loft insulation IUFs, to examine the evidence base extant at the time the IUFs were last set by the Government.

It has to be said that this evidence base is sparse. The primary (perhaps the only?) research used as the basis for the current IUFs for loft insulation is the report "Review of Differences between Measured and Theoretical Energy Savings for Insulation Measures", by Glasgow Caledonian University in 2006. This report was a desk study of seven previous empirical studies and examined both loft and cavity wall insulation together. It recommended that an IUF of 35% be used, and a comfort factor of 15%. Effectively, this suggests that loft insulation only works half as well as it should do theoretically.

We in LoftZone have come to the presumption that this report was the only evidence used in calculating the IUF of loft insulation because:

1. It exactly matches the IUF currently used by DECC and Ofgem for loft insulation,
2. It is well known in the industry that the evidence base for the IUF for loft insulation was particularly weak,
3. No one else in Ofgem nor DECC has been able to identify any other sources for the IUF in our discussions with them.

If anyone else has knowledge of any other research which was used as the basis for the IUF for loft insulation, we would be pleased to be made aware of this.

However this Glasgow Caledonian report has its limitations; it is a purely desk-based study of other peoples' empirical reports, all of which used different methodologies. Its research also combines both loft and cavity wall insulation, with no means of distinguishing the results between them. Moreover, there are no large scale data samples, nor any controlled scientific testing.

LoftZone therefore set out to look to see if there had been any other reports on loft insulation IUF at all, and we did come across one, “Research into the effectiveness of loft insulation” (Phases 2 and 3), by the Buildings Research Establishment (BRE) in 2006. Whilst we are not aware that this was used at all in the calculation of IUFs, it does provide some useful background information and is presented here to contribute to the general gathering of evidence.

Phases 2 and 3, described in this report, were a study of 193 lofts in Great Britain. (We have not seen the Phase 1 report; we are not sure if this is in the public domain). The report was not aimed at calculating IUFs, but rather at the predicted lifetime of the insulation and the benefits of insulation top-up. Whilst not focusing on IUFs, the BRE report does mention some sources for the reduction of insulation performance (they call them “disturbances”), which is a useful list. We in LoftZone have taken their list and added a few more causes, to make it more complete:

- Poor workmanship in the original fitting of the insulation, whether that be missing areas, gaps around joists or around obstructions, not fitting the top-up layer transversely to the bottom layer, etc.
- Down lighters requiring an area without insulation, in order to dissipate heat
- Cold bridging through the joists
- Wind scour (‘washing’) along the top of the insulation
- Biological processes such as vermin attack
- Accumulation of dust and debris (which can be very substantial if a roof has been replaced)
- Damage to the insulation from water ingress through the roof
- Condensation in the loft (eg from extractor fans) causing the insulation to become wet
- Interstitial condensation occurring on the underside of loft boards and dripping down on to the insulation
- Ageing of the material
- Air-gaps in the first layer of insulation, alongside the joists, causing a cold air path from eave to eave
- Compression of the loft insulation (eg by storage or boarding)
- Safe access paths installed in the loft, usually below the required 270mm of insulation
- Householder (or maintenance contractor) action, eg moving the insulation away to create safe access pathways and then not replacing it properly, or folding it in places, creating double thickness in some areas and half in others
- Raised insulation, with an item or air underneath
- Un(der)-insulated loft hatches
- Building works in the property causing the loft insulation to be removed and not replaced.

It is interesting to note that, of the 193 properties assessed in the BRE report, only 7 did not suffer from any insulation disturbance (!)

In Section 3.5, the report makes one curious assumption, namely that when items stored in a loft are removed in order to allow top-up insulation, that they are not replaced afterwards. This assumption has been shown to be incorrect by subsequent research, described later in this paper. Moreover, it also contradicts the BRE report’s own findings in Table 6, which shows that for lofts with insulation greater than joist height (i.e. 125mm or above), the sample size of 30 lofts showed that:

- 16 suffered from boarding (but without items stored on the boards)
- 13 suffered from boarding (with items stored on the boards)
- 12 had items placed on the joists, and

- 19 had light, medium or heavy compression.

In fact, in their sample size of 30 lofts, all bar one had some sort of insulation compression occurring, and several had multiple occurrences of compression.

Another table in the BRE report, table B3, gives estimates for the proportion of the area of the loft affected by these boarding/storage and compression occurrences. The total area affected was 23.6% of the loft. This was however a small sample size (30 lofts) and seemed not to have included any lofts that were extensively boarded. However it is commonly known that many such lofts are extensively boarded and subsequent research, described later in this paper, indicates that this 23.6% figure is an underestimate.

As mentioned earlier, the focus of the BRE report was the longevity of the insulation. Interestingly, the report's authors conclude that insulation degradation is not strongly correlated with the age of the insulation. It's worth quoting their conclusion here in full; this is important to any review of IUFs, as the conclusion means that any IUF is likely to become apparent soon or immediately after installation, not built up over time:

> The figures show no relationship between total Delta-U and age of installation, and in particular there is no indication of an increase with age. There are a number of lofts showing significantly larger than average Delta-U's; these are in general lofts with areas of missing insulation.
>
> > ***We therefore propose that for modelling the thermal performance of insulation in the existing stock, the insulation should be considered to have been disturbed within the first few years after installation (this will include workmanship issues at the time of installation).***
>
> Some of the disturbances may reasonably be thought to increase with age, such as 'Boarding with items', 'Items on joists', 'Compression', which are associated with storage in the loft, and 'Reduced near eaves', which may be associated with loss of insulation from vermin or wind. However, it may be more realistic in general to consider that use of the loft for storage increases over the first few years after installation, and after a time reaches a stable level of 'dynamic equilibrium', with items being removed as well as added to the loft. As regards 'Reduced near eaves', the survey shows this to be infrequent, and not significant in terms of Delta-U and therefore the thermal performance of the loft.

<u>New research</u>

LoftZone sought to improve upon the deficiencies in the previous evidence base (lack of a large scale sample, no controlled scientific testing, focus on mixed insulation measures rather than just loft insulation) in research that we commissioned during 2011/2012. There are two reports that form new evidence.

The first report was commissioned by LoftZone in 2012 and was carried out by the National Physical Laboratory (NPL). The objective of the task was to conduct a scientific experiment in controlled conditions on loft insulation compression, to see how this affected its thermal resistance. It is actually surprising that this data were not available previously; if they were known to the manufacturers, they had not been made public.

The market-leading mineral wool product was tested and results of the research were clear and unequivocal:

- 270mm compressed to 100mm (the most common joist height) lost 49.5% of its thermal resistance
- 270mm compressed to 75mm (the second most common joist height, and particularly common in new builds) lost 60.5% of its thermal resistance

- The average of these figures is 55%.

Or, to put it another way, a loft with a nominal U value of 0.16 would in fact have a U value of 0.32 or 0.40 over the compressed area. Thus, any boarded area, or any area used extensively for storage of boxes and possessions placed on top of the insulation would suffer this level IUF.

The next obvious questions are: how many lofts with 270mm of insulation suffer from this, and what is the proportion of the loft area so affected? The results from the BRE report mentioned above are 97% of lofts (29 out of 30) and 23.6% respectively (again from their sample of 30 lofts).

However this sample size is extremely small. LoftZone requested Carbon Trust to commission new research of a much larger group, using a professional consumer research agency. This was delivered by Conduit Partners Ltd, in 2011, and paid for Carbon Trust, who oversaw the independence of the study. The result is the largest ever survey of how people use their lofts in the UK, with 6,000 responders.

This survey had more than 20 questions, and not all of them are described in detail here, though the report is available upon request. However the key points with relation to the IUFs are:

1. 82% of those with access to their loft said that they used the loft to store items
2. Of those who stored items in their loft, 78% said that the loft was “half full or more” and 5% said it was “completely full”
3. Of those who stored items in their loft, 76% said that storage in the loft is either very important or essential
4. Of those who stored items in their loft, 65% have either partially or fully boarded their loft
5. Those who confirmed they had boarding in place were then asked how much of the loft was boarded, and the replies were: 11% “almost none”, 49% “about half”, 25% “almost all” and 15% “fully boarded”
6. 54% said that their loft had been accessed in order to maintain equipment situated in the loft (which means that a walkway may have been needed, or the insulation may have been squashed under crawl boards, or may have been set aside (and possibly not properly replaced))
7. The survey sample was asked whether squashing loft insulation reduced its effectiveness. 26% said they thought this was true, 26% thought it was false and the rest didn’t know.
8. The following statement was given and the consumers were asked to what degree they agreed or disagreed; “The best way of using my loft for storage is to place boards on top of the insulation where access is needed and screw them down onto the joists”. Only 15% disagreed with this statement, despite the severe IUF implication.

This much larger survey size would therefore seem to validate the earlier research showing that loft storage is extremely common. Whilst not quite at BRE’s 97% figure, the 82% (in point 1 above) would seem to be the figure to use that has the most valid statistical sample in the evidence base that we have seen.

The percentage of the loft area where the insulation is compressed is a harder one to gauge. Just because a respondent has said their loft is “half full or more” (point 2) does not mean that literally 50% of the total area is covered; people may just be thinking of the accessible area away from the eaves, for example. However we suggest that the statistics for boarding in point 5 are more likely to be accurate, as people who have boarded lofts are more likely to be aware of how much area they have boarded, or that they have access too. The percentage of those who have boarded half or more (89%) is depressing reading for people wishing alleviate IUFs.

Therefore, based upon this largest ever survey of householders, we can gauge the area of UK lofts where the insulation is compressed. The headline figure is 82% (of lofts) x 78% (more than half full) = 64%. We tend to err on the side of caution however and recommend instead a more conservative estimate of 50%.

Conclusions from the research

If we take the conservative estimate above that 50% of the surface area of all of the UK's loft insulation is compressed for storage or access purposes, and that the U-value reduction is on average 55%, then the overall IUF from loft insulation compression in the UK is 27.5%.

Of course, loft insulation compression is only one of many possible causes of IUF, and many others are listed earlier in this paper. Therefore the 35% overall IUF for loft insulation would seem to be too low, and a higher percentage would be warranted.

Good practice going forwards

The final section in this paper refers to ways to avoid the IUFs in general. It's good to know how to solve the problem as well as how to quantify it!

This is put more eloquently by Paul Ruyssevelt, Professor of Energy and Building Performance at the University College London Energy Institute, in emails sent to the author of this paper and to Hunter Danskin, an official within DECC:

> "I was very impressed with the LoftZone product and the research they have conducted. It would seem to me that it would be much better to be installing systems that are more likely to perform as we expect them to rather than universally applying In Use Factors and effectively stifling innovation.
>
> I very much agree that we should be moving away from In Use Factors towards methods and systems that explicitly account for the individual components that lead to the differences between design predictions and actual performance in practice. Without this explicit approach to dealing with the issues that cause these differences the benefits delivered by innovations cannot be recognised."

So, what are the methods and systems that are relevant to stopping loft insulation compression?

The traditional way to incorporate a greater depth of insulation is to raise the joists up with extra timber. The materials for this are relatively cheap, but the labour is not, the job is time-consuming and the timber places significant extra weight on the joists. Moreover, it has been recognised that the timber itself causes a thermal bridge. Indeed, the 2013 Part L1A building regulations require a new SAP calculation if the joists are raised with timber. Whilst this new regulation may currently be rarely enforced, it is not good practice to recommend raising the height of joists with extra timber. So, this isn't the solution.

Another historical approach is to lay rigid foam insulation, with boards placed, or bonded, above these. However, research by BRE (a different report from the one mentioned earlier, and which we can supply upon request) shows that there is a very high interstitial condensation risk from this approach, and this should be ameliorated by raising the board above the insulation, leaving an air gap of around 50mm between them. Therefore using rigid insulation does not remove the need for a raised structure, eg higher joists. And whilst products that include boards bonded on to the insulation do exist on the market, we are wary of recommending them, given the condensation risk. So, again, this is unlikely to be a mass-market adopted solution, although it does have a place in those properties where the pitch height inside the loft is very low.

More recently, a suite of raised loft decking products have come to market, which all consist of supports or a supporting structure that lifts the boards up above the insulation. LoftZone has invented and sells one of these products. Some of the products are strong enough to walk upon, whilst others are more for storage; some allow for an air-gap between the insulation and the boards to combat interstitial condensation whilst others do not; some also allow for cables and other services to be raised above the insulation too, whilst others do not.

It would seem sensible that if an IUF was put forward that related specifically to loft insulation compression, that companies installing loft insulation should be able to wholly discount this proportion of the total IUF should they install a raised deck, by any approved method.

Finally, it is worth making a submission on the subject of IUF owing to down lighters. Typically, areas around down lighters are not insulated, and/or not topped-up. Sometimes a diffusion box is placed around each down lighter. However, again this IUF can be alleviated through appropriate technology. Two options spring to mind:

1. Some LEDs are now so low power that they permit insulation to be laid directly on to them, so long as the insulation is not compressed down on to the lights
2. New products have come on to the market, including http://www.downlightatticseal.com which seal around the light fitting and permit insulation around the light fitting, and top up insulation over them.

LoftZone has not investigated these products ourselves, this reference here is for information only. However we recommend further investigation by others as potential for further reduction of IUFs for loft insulation.

Conclusion

When designing energy efficiency programmes, it is necessary to quite simply assume significant in-use reduction factors for loft insulation unless mitigating measures have been put in place. Most of the UK's loft insulation simply isn't working as well as promised, and many people refuse it in the first place as they value access and storage more highly. This paper evaluates existing and new research and recommends that an IUF of 27.5% be applied to loft insulation, for compression reasons alone.

This paper also provides an overview of a suite of technology options to design out the IUF for loft insulation compression and recommends that installers should be allowed to wholly discount this proportion of the total IUF should they install a raised deck, by any approved method.

You wouldn't specify external wall insulation on a building and then not insist upon render on the outside to protect it from damage. So why would you not protect loft insulation from damage, too?

References / People to contact for further information

The reports referenced in this paper are listed below for convenience. Copies of each are available from LoftZone:

- Review of Differences between Measured and Theoretical Energy Savings for Insulation Measures, Glasgow Caledonian University, 2006
- Research into the effectiveness of loft insulation (Phases 2 and 3), Buildings Research Establishment, 2006
- Test Report, Thermal Resistance of Mineral Wool, National Physical Laboratory, 2012
- EcoAnswers / LoftZone Loft Storage & Insulation Consumer Survey, Conduit Partners (for Carbon Trust), 2011

In addition, LoftZone is able to provide introductions and references from numerous industry experts whom we thank for their contribution to our research.

Author: Dave Raval, Chief Executive, LoftZone, 4 November 2014.