Report for

Energy Efficiency and Conservation Authority

INVESTIGATING QUALITY OF INSULATION IN NEW BUILD RESIDENTIAL HOMES

Realsure the house inspectors

23/09/2010

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1 DEFINITIONS:

"BCA" means the Territorial authority who must act as building consent authority (BCA) within its district, this being commonly referred to as the local BCA

"Building Code" means the Building Code contained in Schedule 1 of the Building regulations 1992, which sets performance standards all new building work must meet, and covers aspects such as stability, fire safety, access, moisture, safety of users, services and facilities, and energy efficiency.

"Cavity" means the space to which insulation is to be installed, as opposed to the vented cavity of a cladding system. A vented cavity of a cladding system should NOT be breached.

"Client" means EECA.

"CCC" means the Code of Compliance Certificate, which is issued by the BCA as a Final sign off of the Building Consent Process.

"DBH" The Department of Building and Housing

"Downlights" means recessed light fitting or recessed luminaire, being a light fitting that is recessed into a cavity, most commonly found in the roof cavity

"EECA" means the Energy Efficiency and Conservation Authority

"Final" means the building consent process where the property has been completed and awaiting inspection by BCA for approval to issue the CCC

"H1" means Clause H1 of the Building Code, which sets the energy efficiency performance level for new housing.

"LBP" Licensed Building Practitioner

"Preline" means the building consent process where the property has been enclosed and is awaiting inspection by BCA for approval to proceed with the internal lining and fit out

"Professional Installer" for the purposes of this research means a person or company who is purporting to be a suitably qualified installer of insulation, in compliance with the Standard.

"Safety" relates to the manner in which the insulation has been installed in relation to potential fire risks or hazards

"Standard" means the New Zealand Standard, Energy Efficiency – Installing Insulation in Residential Buildings NZS 4246:2006[1]. See Appendix 7.1.

"System design" means the installation design for the plumbing, electrical or other services, systems, and physical design within the home

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[1] The original version of the Standard was used before Amendment 1 was published in April 2010.

The Audit Rating System*:

"Minor" means the defect or fault has occurred in only one or two places and is limited to only a few areas within the home.

"Medium" means the defect or fault has occurred in several places and is repeated in several areas within the home.

"Major" means the defect or fault has occurred repeatedly throughout the home.

* These ratings denote the extent of the occurrence, not the nature of the defect, or the severity in terms of safety risk, or impact on performance.

"Workmanship" means the work or quality of work undertaken by the installer of the insulation

2 EXECUTIVE SUMMARY

100% of the properties audited did not meet all of the requirements of the Standard NZS 4246:2006 for insulation installation.

2.1 Scope and Objective of Report

EECA requested that the installation of insulation in new build homes be assessed. Realsure Ltd was contracted to undertake the research.

The objective of the research is to:

1. establish the typical installed quality of insulation in new houses;
2. identify the nature of installation faults with insulation, if any; and
3. establish the reasons why the installation faults occur; and
4. identify and recommend practices to improve the installed quality of insulation in new houses.

The four key points to be addressed in this research are as follows:

1. how well is insulation installed in New Zealand houses?
2. what installation faults occur, if any?
3. why the installation faults occur?
4. how quality of insulation installation can be improved?

2.2 The Audit Development and Undertaking

EECA instructed that the quality of installation will be assessed against the Standard **NZS 4246:2006**, which provides guidance for installation in both new and existing houses in order to help achieve the design thermal performance and thermal durability of building elements.

The Standard is not actually mandatory for Building Code compliance, but it offers a best practice guideline and as the benchmark used to audit the government's insulation scheme in existing houses, is a logical document to measure against.

To comply with the Building Code requirements for energy efficiency and internal moisture, a new house needs to have minimum levels of insulation installed – how much depends on a number of factors, including the geographical area it is in, the design, and construction type. Incorrect installation can reduce the insulation's effectiveness and have safety implications.

Single occurrences of minor defects, such as gaps and tucks, do not necessarily mean a house doesn't comply with the building code, but if they occur throughout the house, the cumulative effect may mean the overall thermal performance is compromised and therefore the house doesn't meet the energy efficiency requirements of the building code.

In some instances, failure to comply with aspects of the Standard and manufacturers installation instructions will also risk the property being non-compliant with other clauses of the Building Code covering fire safety, electrical safety , energy efficiency, and burst water pipes.

The following categories were identified and set, as being the most likely areas of fault:

a. Workmanship
b. Territorial authority (BCA)
c. System design
d. Safety.

Once the Standard had been set as the control, likely areas of fault established, and possible defects identified from the Standard, an inspection audit check sheet and process was established by Realsure in accordance with and as approved by EECA.

It was determined that approaching BCA's and working with them to obtain access to the building sites at the appropriate times was the most logical and practical option. An approach was made to selected BCA's and for the majority of BCA's approached, access arrangements were organised.

A total of 58 properties were audited in the Auckland, Waikato, Wellington and Christchurch regions.

2.3 The Audit Findings

2.3.1 How well is insulation installed in New Zealand Homes?

Of the 58 audits undertaken, when applying the Standard for installation of insulation, none of the installations met all requirements of the Standard. Based on these findings, it is evident that the insulation in new build homes in New Zealand is not well installed and requires improvement.

2.3.2 What installation faults appear?

The findings have shown that there has been an example found of almost <u>every</u> installation defect audited.

The installation faults found include: damaged insulation, folds, tucks, gaps or insulation overlap, and areas not insulated where they should have been. Insulation has been compressed, incorrectly fixed or supported, incorrectly fitted around top plates, downlights, auxiliary equipment, or extractor fans. Insulation has also been incorrectly fitted around electrical wiring and plumbing systems.

It has also been found that where the Standard requires the cladding materials to have been installed and the moisture content of timber to be less than 16% prior to installation, these requirements have not always been met.

The most significantly occurring faults found are: folds, tucks, gaps, compressions, missing insulation, a lack of a 25mm gap to the underside of the roof underlay, and a lack of insulation to the middle of the top plate. These all have the capacity to affect the R-value of the home, apart from the lack of gap to the roof underlay, which has the potential to transfer moisture to the insulation.

Significant safety faults were also found being: recessed downlights and auxiliary equipment covered with insulation and/or insulated within the required clearances, and extractor fans, metal chimneys or flues within 150 mm of the insulation.

2.3.3 Why the installation faults occur

The Audit Overview by Defect (S6.2.5) clearly shows that the majority of installation faults will occur due to workmanship, as opposed to another cause. Many of these defects had more than half of them rated medium to major, indicating they were occurring repeatedly, in several areas throughout the home. It is also found that it is workmanship that mostly causes the safety related defects.

The research findings identified who is responsible for the insulation installation:

1. Professional Installer - 61%
2. Builder - 23%
3. Homeowner - 8%
4. Unknown Installer - 8%

There are however other factors causing or contributing to the fault occurring.

The first is as a result of another party's work inhibiting or preventing compliant installation, or interfering with the original installation. These parties have been identified as the Sub Trades, most prominent among them being the Electrician and Plumber.

The second contributory factor to some of these faults comes down to design. This can refer to construction design, or design of plumbing, electrical, lighting, heating, or ventilation systems. It is the failure in the design to ensure the appropriate cavity is maintained for insulation, whilst accommodating any system requirements that has caused the fault. These faults have affected the R-value of the home.

2.4 Recommendations

2.4.1 How quality of insulation installation can be improved

When reviewing the findings the predominant reason for the faults occurring is a mix of sub standard workmanship and /or problematic design.

This research has shown there are four key "identities" in relation to design and workmanship:

1. The designer, this may be an architect or draughtsperson.
2. The builder and/or project manager.
3. The professional installer.
4. The other sub trades, and in particular the electricians and plumbers.

2.4.2 Education and Training

In the first instance education and training for the four key "identities" is required to address many of the identified faults, defects, and consequential non-compliance with the Standard and Building Code.

Education needs to take on a two-pronged approach. Firstly, there needs to be education in the requirements of the Standard so that each person involved is ensuring compliance is met.

Secondly, to be effective, the ramification of poor installation also needs to be covered to ensure that each party contributing to the insulation installation understands why compliance with the Standard is desirable, and how it helps to achieve compliance with the Building Code.

A "whole of house" philosophy should be core to the training procedures to ensure each identity understands the contribution and impact their work has on the entire construction project.

2.4.3 The BCA

The research has also clearly demonstrated the need for rigorous inspection processes to ensure quality and Building Code compliance for each installation.

The key "identity" in relation to quality assurance and Building Code compliance has been identified at this point in time as the BCA.

It was observed that some of the BCA's undertake a physical inspection, identifying the faults and requiring they be addressed, before the BCA inspection would be passed.

The results of this research would support that those BCA's not taking the same approach should be reviewing their inspection processes relating to insulation at Preline, Insulation and Final inspections to determine whether they are enforcing Building Code requirements for installations of insulation.

While the BCA is not specifically causing the fault or defect, they are required to identify and enforce compliance; otherwise they are contributing to the issue through acquiescence.

There is a naturally occurring deterrent when a BCA refuses to sign off on the Preline, Insulation, or Final inspection until the insulation issues have been addressed and reinspected. This deterrent is only occurring where the BCA is actively enforcing compliance. Therefore, it is not happening in all situations.

The desired effect of such a deterrent would be to create an impact on all parties involved in such a way that compliance will be the desired outcome for every property

2.4.3.1 R-value Consideration.

The latest BRANZ research could also indicate that the R-value of these homes audited may in fact fall short of the minimum required R-value in the Acceptable Solution, H1/AS1 for Clause H1 of the Building Code.

If the minimum R-value has been applied, then new homes being built with incorrect insulation installation may not meet the requirements of H1 of the Building Code.

In these cases, a BCA may be unable to issue CCC.

2.5 Additional Recommendations

2.5.1 Self Certification

This research highlights some steps that would need to be put in place if the Building Act Review proposal from DBH for self certification of building work, including the construction of new houses is to be successful. None of the installations met all requirements of the Standard, and all of the properties had builders or project managers involved, one of which may likely become a self certifier.

If the self certification program is to be implemented, then it will require the LBP or suitably qualified person to have a sound knowledge of the requirements of the Building Code, and ideally the reasoning for, or ramifications of non-compliance with the Standard and its consequences on building code compliance

2.5.2 Downlight Manufacturers.

There is clearly confusion for installers of recessed lighting fittings regarding their installation and appropriate clearances to insulation. It is evident from the findings of this audit that the Standard is not being followed and suggests that clearer instructions need to be provided, ideally to the light fitting itself.

2.5.3 Recognising the Standard

The findings of this audit have clearly demonstrated that the Standard is not being adhered to, given the high rate of non-compliance found.

The Standard is an important reference document to help ensure insulation is installed safely and correctly. Complying with the Standard would aid compliance with the relevant clauses of the Building Code; therefore consideration should be given to recognising the Standard as an accepted reference in the Building Code Compliance Documents.

Note: The original version of NZS 4246 was used for this research. An amended version of this Standard was launched towards the completion of the audit for this research in April 2010. It is identified by the words "Incorporating Amendment No.1" under the Standard identification NZS4246:2006 at the top right of the cover page.

3 RESEARCH BACKGROUND

EECA requested research be undertaken to assist their Research Project - **Investigating quality of insulation in new builds - BP081.**

EECA instructed that installations will be assessed against NZS4246 Energy efficiency - Installing insulation in residential buildings, a Standard developed in 2006 that sets quality requirements for installation in both new and existing houses. NZS4246 is not referenced in Building Code Compliance Documents, so is not required for Building Code compliance. However, in looking to determine why faults are occurring and what might be done to improve insulation installation, consideration will be given to whether utilising the Standard can assist in achieving Building Code compliance.

Realsure Ltd was contracted to undertake the research. Realsure is ISO9001 Registered to undertake Building Surveying of properties in compliance with NZS 4306:2005 – Residential Property Inspection. Realsure sat on the expert committee that developed the inspection Standard, and was also involved in the development of the Accreditation Process for Building Surveyors in compliance with the Inspection Standard. The Realsure Group is the only building surveying group in NZ specialising in non-invasive surveying of buildings that is ISO registered and provides Accredited Building Surveyors.

Realsure was required to develop a research methodology to provide representative findings that would need to consider installation quality both pre and post building inspection.

4 SCOPE AND OBJECTIVE OF REPORT.

The scope of this project is to investigate the quality of insulation installation in new build homes.

The four key points to be addressed in this research are as follows:

1. how well is insulation installed in New Zealand houses?
2. what installation faults occur, if any?
3. why the installation faults occur?
4. how quality of insulation installation can be improved?

The objective of this report is to:

1. establish the typical installed quality of insulation in new houses;
2. identify the nature of installation faults with insulation, if any; and
3. establish the reasons why the installation faults occur; and
4. identify and recommend practices to improve the installed quality of insulation in new houses.

It is expected that the results of this research will assist in determining what improvements would need to be made and as a corollary, what areas or groups might need to be approached.

4.1 Audit Background and development

Whilst voluntary, there is a New Zealand Standard for installing insulation in residential buildings. The Standard was implemented, at the request of EECA, as the measure to be used as the control for this audit. The audits were carried out in conjunction with BCA inspections.

New houses must comply with the Building Act 2004 and the Building Code, which set the legal framework for building in New Zealand. The Building Code sets minimum levels of performance that new houses must be designed to meet in order to get building consent approval. Standards are often used to set out how these minimum levels can be achieved, but are not always used for this purpose. Standards not used for Building Code compliance can provide useful guidance for building to Building Code compliance or a better standard than the Building Code requires, when owners or builders want to adopt good or best practice.

NZS 4246 is not a requirement for Building Code compliance, however it provides useful guidance on how to install insulation well. Poor insulation installation can affect compliance with the energy efficiency, fire safety and electrical safety requirements of the Building Code. So, following the Standard will help to ensure that houses are built to the designs and insulation performs well.

As the insulation installation is assessed against the Standard, the terminology used throughout this report reflects the terminology used in the Standard.

In order to consider the questions and drivers of why any installation faults appear and how quality of installation might be improved, the following categories have been set, being the most likely areas of fault:

a. Workmanship
b. Territorial authority (BCA)
c. System design
d. Safety.

It is expected that the results of this data will assist in determining what improvements would need to be made and as a corollary, what areas or groups might need to be approached.

Once the control had been set, likely areas of fault established, and possible defects identified from the Standard, an inspection audit check sheet and process was established by Realsure in accordance with and as approved by EECA.

A training module was developed within Realsure's ISO 9001 processes for training purposes for the Realsure Auditors.

A training day was conducted, with the assistance of EECA, to ensure that all auditors would undertake the audits correctly; identifying any issues, defects, or faults, whilst gathering the necessary data to determine the likely areas of fault.

The appropriate number of inspections required to collect sufficient data needed to be established. In order to obtain a true indicator of the performance of any subject matter, we were informed by EECA that a sample of 5% is ideally recommended.

Based on Statistics New Zealand* data of January 2010, 14,425 consents were issued for the year as at December 2009, which included apartments.

(*Hot off the Press, 29 January 2010 ISSN 1178-0231 Building Consents Issued: December 2009)

For this research, only the four main centres were considered:

Centre	Total Annual Units	5% rounded to the nearest 1
Auckland	3475	174
Wellington	1314	66
Waikato	1764	88
Canterbury	2620	131
Total *NB1	9173	459

Applying the 5% rule this would equate to approximately 721 properties to be inspected nationally, or 459 properties covering off the four key centres of Auckland, Wellington, Waikato, and Canterbury.

EECA decided to initially commission 52 audits to obtain an indication of the standard of installation. The audits were to be undertaken in the Auckland, Wellington and Christchurch regions.

In order to undertake this audit, the insulation needed to be inspected once installed in the newly constructed home, prior to any internal linings being fitted. To know when construction was at this stage, and to have access to the property at that time, a relationship needed to be formed with the building owner, builder/project manager, or BCA. If access were to be made through the builder or project manager it would require they not be swayed to change any normal patterns of behaviour in relation to the installation process, to ensure true results could be obtained.

Whilst the building owner could be an access point, the logistics of liaising with them and the builder to obtain access on the appropriate day would be difficult, and could also risk interference. It was therefore concluded that being able to access the properties in conjunction with BCA at the times that they undertake their inspection would prove to be the best approach to take.

The inspection stages were established through discussion with the various BCA's as to when installation was installed in new buildings and inspected by them. The majority of BCA's advised that installation was to be in the building at the time the BCA Inspector undertook their "Preline" inspection. We recommended to EECA that a Final inspection stage also be included, due to various trade work undertaken after the ceiling linings had been installed.

It was agreed the following audits would be undertaken:

- 25 in Auckland, 20 at Preline and 5 at Final;
- 12 in Wellington, 10 at Preline and 2 at Final; and,
- 15 in Christchurch, 12 at Preline and 3 at Final.

Finally, access to new buildings had to be arranged. In order to obtain genuine results, it was important that the research project was undertaken as quietly and quickly as possible. The audits had to be conducted without prior knowledge of the installer, to ensure true results were obtained. This left the only option of working with BCA's or, the building owner. It was determined that approaching BCA's and working with them to obtain access to the building sites at the appropriate times was the most logical and practical option. Two to three BCA's in each area were approached, apart from Christchurch where one BCA predominantly managed the area.

An approach was made to selected BCA's and for the majority of BCA's approached, access arrangements were organised.

4.2 Audit Categories

4.2.1 Workmanship

The Standard clearly sets out the requirements for installing insulation into walls, floors and ceilings.

Prior to installing insulation, Section 3 of the Standard, requires the following conditions shall be satisfied:

1.	There is sufficient space for the insulation to achieve its designed thermal performance
2.	The Final cladding material has been installed
3.	There is provision for insulation support, or it is in place
4.	Moisture content of timber is less than 16%

In reviewing the Standard, it clearly describes the fundamental defects in the various Sections and Tables that shall be met, or shall or should be avoided in relation to the installation of insulation.

These are identified as follows.

1.	There shall be no gaps around the outer edges of the segments and framing, or between butted joins
2.	There shall be no folds in the segments themselves
3.	There shall be no tucking
4.	It shall not be compressed
5.	It shall be dry
6.	It shall be undamaged.

In addition to the above there are clear installation requirements to be met for specific areas:

Ceilings:	
1.	All areas shall be insulated.
2.	Insulation above interior walls, and to at least the middle of the top plate of the exterior walls.
3.	A clear space of at least 25mm shall be maintained between the insulation and roof or roof underlay. This shall take precedence over the top plate coverage.
4.	Temporary strapping to be installed if necessary.
5.	Trim around recessed downlights and auxiliary control equipment. For the purposes of this audit a clearance of 100 mm may be required. Refer to clause 3.4 of the Standard.
6.	A clearance of 150mm shall be left around metal chimneys and flues and where they penetrate the ceiling.
Walls:	
1.	All areas shall be insulated.
2.	Shall be fitted flush to the internal side of the framing
3.	Shall be laid behind pipes and electrics – not compressed.
4.	A clearance of 150mm shall be left around metal chimneys and flues and where they penetrate the wall.

4.2.2 BCA

The purpose of the Building Act 2004, as it relates to this research is as follows:

3 Purpose

The purpose of the Building Act is to provide for the regulation of building work, and the setting of performance Standard for buildings, to ensure that –

(a) people who use buildings can do so safely and without endangering their health; and

(b) buildings have attributes that contribute appropriately to the health, physical independence, and well-being of the people who use them; and

(d) buildings are designed, constructed, and able to be used in ways that promote sustainable development.

Building Act 2004, Part 1, 3 (a), (b), & (d).

In consideration of the Act and the responsibility of the BCA, it could be considered reasonable that the BCA look to the Standard as a measure for assessing whether the installation of insulation would contribute to Building Code compliance or otherwise.

Upon discussion with the various BCA's involved it was established that the insulation installation was assessed at the Preline or insulation inspection, then again at the Final inspection in the Consent inspection process.

However, there is an alternative used by some BCA's where a professional installer undertakes the installation. These BCA's will accept a producer statement stating the installation has been undertaken to NZ Standard and/or manufacturer's specifications, in lieu of an inspection.

4.2.3 System Design

The construction and design of the house can affect the performance of the insulation. Plumbing, ducting, and wiring can lead to compression of the insulation, therefore reducing its in-situ performance. The Standard states that one of the main components in achieving the design R-value of a bulk insulation material is design thickness. It is critical to material performance that when installing any given material, the design thickness is known and achieved in order for the design R-value to be met.

Insulation materials shall be installed in a cavity at least sufficiently large to accommodate the design thickness plus any required cavity. Compressing the insulation into a cavity smaller than the designed thickness will reduce the actual delivered R-value approximately in direct relation to the amount compressed. This means it is important to ensure that the insulation has room to remain at its designed thickness.

During the construction of a building there are areas that require special consideration when designing, both in terms of the systems and design, to ensure the insulation material will not be compromised.

The first system to be considered is the electrical system.

Recessed lighting, and any associated auxiliary equipment, requires specific design in terms of clearances for safety and allowances for a possible increase in the R-value.

It is recommended that installers should avoid putting insulation around or over electrical cables. When installing polystyrene insulation there shall be no contact between any PVC coated cables and the polystyrene, and methods of avoiding such contact are provided in the Standard.

Thermal insulation should not be placed around built-in appliances, or enclosures containing electrical equipment. A clearance of 150 mm shall be left around metal chimneys and flues also.

The second system to be considered is the plumbing system.

The Standard states that where possible, insulation should be installed between the plumbing and the outside of the building.

The third consideration is the design of the cavities themselves to ensure they are sufficiently large to accommodate the design thickness of the insulation, plus any required cavity. The most common situations are:

- Wall systems which include a cavity between the exterior cladding and the insulated frames phase to allow for drainage and / or insulation;
- Skillion and low slope roof systems where there is a need to have a cavity of at least 25 mm between the top surface of the insulation and the underside of the roof (and underlay) to prevent the wicking of moisture into the insulation; and
- Around the perimeter of an attic space under a pitched roof where there is limited space between the underside of the roof (and/or underlay) and the ceiling. This is also to prevent the wicking of moisture.

4.2.4 Safety

There are safety aspects that need to be considered in terms of creating potential hazards. Recessed light fittings, more commonly known as downlights, will impact on the effectiveness of ceiling insulation. This is because they often require a clearance from insulation to prevent overheating of the downlight. Clearances allow for higher heat losses through the uninsulated part of the ceiling. Recessed downlights are also susceptible to convective heat losses through ventilation openings in the fittings themselves. If recessed downlights were installed prior to the insulation, unless specified by the manufacturer on the light fittings, they will have to have a 100 mm clearance from the insulation to comply with the Standard.

Any auxiliary equipment associated with the recessed light fitting shall not be covered by insulation.

Metal chimneys and flues shall have a clearance of 150 mm from any installation where they penetrate a wall or ceiling.

Installing insulation over or around electrical cables should be avoided, and there shall be no direct contact between polystyrene insulation and any PVC coated electrical cables.

The reason these have been identified as safety aspects, and/or risks, is due to evidence that the incorrect installation of insulation around these items can cause overheating and potentially fire to break out.

4.3 The Inspection Audit Check Sheet.

There were 40 points to be assessed and commented on in the audit.

These points were numbered 1 – 40 and remained unchanged whether the audit was of a ceiling, underfloor or wall. Therefore, some numbering does not appear in specific audits. For example, in a Wall Audit, Defects 16, 19 and 20 do not appear, as they relate to ceilings only.

The first information to be captured is the insulation type.

Loose fill	Wool, Rock Wool, Glass Wool, Macerated Paper
Segments and Blanket	Wool, Rock Wool, Glass Wool, Polyester
Rigid Sheet	Polystyrene
Foil	Perforated, Non-perforated

The points to be assessed and commented on were broken down into the four identified categories to assist in determining the possible causes or sources of any fault:

a. Workmanship
b. Territorial authority (BCA)
c. System design
d. Safety.

Audit #	**Category**	**In All Audits**	**Additional Ceiling Query**	**Additional Wall Query**
1	**Condition**	Wet		
2	**Condition**	Damaged		
3	**Workmanship**	Folds		
4	**Workmanship**	Tucks		
5	**Workmanship**	Gaps		
6	**Workmanship**	Overlaps		
7	**Workmanship**	Missing insulation		
8	**Workmanship**	Compressed – installer		
9	**System design**	Compressed – plumbing		

Audit #	Category	In All Audits	Additional Ceiling Query	Additional Wall Query
10	**System design**	Compressed – electrical		
11	**System design**	Compressed – insufficient space		
12	**Workmanship**	Fixings correct		
13	**Workmanship**	Temporary supports in place		
14	**Workmanship**	Recessed spaces insulated		
15	**Workmanship**	Unlined wall (EG stub walls) strapped horizontally at max 300mm centres*		
16	**Workmanship**		Soffit / Porch not covered	
17	**Workmanship**			Insulated between plumbing and outside wall (should)
18	**Workmanship**			Clear of cladding cavity
19	**Workmanship**		Access hatch insulated and attached	
20	**Workmanship** **System Design**		25mm gap between insulation and underside of roof/underlay	
21	**Workmanship** **System Design**		Insulation to middle of top plate	
22	**Workmanship**			Loose fill – finished flush
23	**Workmanship**		Loose fill – even depth	
24	**Workmanship**	Installation completed		
25	**Safety**		Downlights Covered	
26	**Safety**		100mm from downlights	
27	**Safety**	Auxiliary Equip Covered		

Audit #	Category	In All Audits	Additional Ceiling Query	Additional Wall Query
28	**Safety**		150mm from extractor fans, metal chimneys and flues	
29	**Safety**		50mm from outer faces of brick or concrete chimneys	
30	**Safety**		Electrical cables covered by insulation	
31	**Safety**	Electrical cables in contact with Poly insulation		
32	**Safety**	Clear of appliance or enclosure for appliance		
33	**BCA**	Building Envelope appear complete		
34	**BCA**	Comment on Incomplete work		
35	**BCA**	Moisture content of the timber is less than 16%		
36	**Informational**	Installed by Builder		
37	**Informational**	Installed by Professional Installer		
38	**Informational**	Installed by Other (Who)		
39	**Informational**	Installer unknown		
40	**Informational**	Comment on source of installation instructions (if possible)		

These points were worded in such a way to require a yes/no or non-applicable answer. It should be noted that these were taken from the Standard; therefore there is a mix of Yes or No answers determining the Defect. The Defect has been highlighted in the Green in the Audit Results Table for clarity.

EECA asked for a rating[2] of minor, medium, or major to be applied, in line with other research projects. See Section2 – Definitions – The Audit Rating System.

Photographs were required to show an example of any identified defect or fault, or of correct installation. It was requested that a large number of photos be provided to create a substantial portfolio of evidence to support the findings of the report.

The properties, their location, and BCA's within each region will remain anonymous.

[2] These ratings denote the extent of the occurrence, not the nature of the defect, nor the severity in terms of safety risk, or impact on performance

5 THE AUDIT

The Audits were conducted by Realsure between 18th March 2010 and 1st June 2010.

Obtaining the required number of audits in the three specified areas proved to be more difficult than anticipated. This was, in part, due to BCA's generally working on a day's notice for bookings. While specific days were set aside for auditing there was no guarantee that on the specified days there would be a request for the BCA Inspector to undertake a Preline or Final inspection for a new build home. Furthermore, in the larger BCA's it was possible that the inspections would be undertaken by different BCA Inspectors at the same time, therefore we would be unable to inspect both properties. This sometimes resulted in scheduled days with maybe only one or two suitable properties to audit, and on the odd occasion no properties to audit. It was also not uncommon for the inspections to be postponed to another day.

For a variety of reasons we were unable to access the required 12 properties in Wellington region, and it was therefore agreed that the Waikato region should be approached. By involving Waikato we were able to undertake 10 audits, thus ensuring we met our minimum required target of 52.

Upon completion of all audits, the following total and breakdown were achieved.

Auckland region:

Required 25 audits; 20 at Preline and 5 at Final.

Achieved 25 audits; 21 at Preline and 4 at Final.

Waikato region:

Achieved 10 audits; 4 at Preline and 6 at Final.

Wellington region:

Required 12 audits; 10 at Preline and 2 at Final.

Achieved 4 audits; 4 at Preline and 4 at Final.

Christchurch region:

Required 15 audits; 12 at Preline and 3 at Final.

Achieved 15 audits; 12 at Preline and 3 at Final.

Total Audits achieved:

Required 52 audits; 42 at Preline and 10 at Final.

Achieved 58 audits; 41 at Preline and 17 at Final.

For each of the audits there will be up to three sub-audits, being a ceiling audit, wall audit, and underfloor audit. For example, an audit of a property at Preline may require an audit of all three, while a Final may only require a ceiling and underfloor.

Of the 58 audits undertaken, there were a total of 55 ceiling audits, 39 wall audits, and 3 underfloor audits. Of the 55 ceiling audits, 17 were undertaken at the Final inspection stage, and 37 during the Preline stage.

The Defect or Fault has been highlighted in Green in the Audit Results Table for clarity, and the Defect Rating relates to the Defective number found.

5.1 Audit Results.

5.1.1 Workmanship

Audit #	Fault / Defect	Result	Ceiling (55)		Wall (39)		Underfloor (3)	
			Count	%	Count	%	Count	%
1	Wet S3.1[3]	**Yes**			**1**	**3**		
		No	55	100	38	97	3	100
		N/A						
	Defect Rating	**Minor**			**1**	**100**[4]		
		Medium						
		Major						
2	Damaged S3.1	**Yes**	**13**	**24**	**5**	**13**		
		No	42	76	34	87	3	100
		N/A						
	Defect Rating	**Minor**	**11**	**85**	**4**	**80**		
		Medium	**2**	**15**	**1**	**20**		
		Major						
3	Folds S3	**Yes**	**30**	**55**	**26**	**67**		
		No	25	45	13	33	3	100
		N/A						
	Defect Rating	**Minor**	**18**	**60**	**14**	**54**		
		Medium	**9**	**30**	**11**	**42**		
		Major	**3**	**10**	**1**	**4**		
4	Tucks S3	**Yes**	**30**	**55**	**33**	**85**		
		No	25	45	6	15	3	100
		N/A						
	Defect Rating	**Minor**	**19**	**64**	**10**	**30**		
		Medium	**7**	**23**	**15**	**46**		
		Major	**4**	**13**	**8**	**24**		

[3] Refers to the relevant section in NZS4246
[4] This % relates to the proportion of houses with that defect, in that building element, which were given this defect rating.

Audit #	Fault / Defect	Result	Ceiling (55)		Wall (39)		Underfloor (3)	
			Count	%	Count	%	Count	%
5	Gaps S3	**Yes**	**50**	**91**	**37**	**95**	**2**	**67**
		No	5	9	2	5	1	33
		N/A						
	Defect Rating	**Minor**	**26**	**52**	**18**	**49**	**2**	**100**
		Medium	**12**	**24**	**16**	**43**		
		Major	**12**	**24**	**3**	**8**		
6	Overlaps S3	**Yes**	**31**	**56**				
		No	24	44	39	100	3	100
		N/A						
	Defect Rating	**Minor**	**17**	**55**				
		Medium	**11**	**35**				
		Major	**3**	**10**				
7	Missing insulation Eg: S5.1.1 Step 7	**Yes**	**20**	**36**	**30**	**77**		
		No	35	64	9	23	3	100
		N/A						
	Defect Rating	**Minor**	**10**	**55**	**20**	**67**		
		Medium	**2**	**10**	**6**	**20**		
		Major	**7**	**35**	**4**	**13**		
8	Compressed – installer S3.2	**Yes**	**25**	**45**	**34**	**87**	**1**	**33**
		No	30	55	5	13	2	67
		N/A						
	Defect Rating	**Minor**	**16**	**64**	**19**	**56**		
		Medium	**7**	**28**	**12**	**35**		
		Major	**2**	**8**	**3**	**9**		
12	Fixings correct Eg: S6.1	Yes					1	33
		No	**2**	**4**			**2**	**67**
		N/A	53	96	39	100		
	Defect Rating	**Minor**						
		Medium						
		Major	**2**	**100**			**2**	**100**

Audit #	Fault / Defect	Result	Ceiling (55)		Wall (39)		Underfloor (3)	
			Count	%	Count	%	Count	%
13	Temporary supports in place Eg:5.1.1 - Step 5	Yes	1	2	8	20	1	33
		No	**24**	**44**	**5**	**13**		
		N/A	28	54	26	67	2	67
	Defect Rating	**Minor**	**6**	**25**	**2**	**40**		
		Medium	**6**	**25**	**3**	**60**		
		Major	**12**	**50**				
14	Recessed spaces insulated S3.5	Yes	1	2	3	8		
		No	**3**	**5**	**7**	**18**		
		N/A	51	93	29	74	3	100
	Defect Rating	**Minor**	**2**	**50**	**6**	**86**		
		Medium	**1**	**25**	**1**	**14**		
		Major	**1**	**25**				
15	Unlined wall (e.g. stub walls) strapped horizontally at max 300mm centres* S3.13	Yes	1	2	3	8		
		No	**3**	**5**	**5**	**13**		
		N/A	51	93	31	79	3	100
	Defect Rating	**Minor**	**1**	**33**	**1**	**20**		
		Medium	**2**	**67**	**4**	**80**		
		Major						
16	Soffit / Porch not covered Eg:S5.2.1 –Step 4	Yes	21	38				
		No						
		N/A	34	62				
	Defect Rating	**Minor**						
		Medium						
		Major						

Audit #	Fault / Defect	Result	Ceiling (55)		Wall (39)		Underfloor (3)	
			Count	%	Count	%	Count	%
17	Insulated between plumbing and outside wall (should) S3.9	Yes			25	64		
		No			**12**	**31**		
		N/A			2	5		
	Defect Rating	**Minor**			**7**	**58**		
		Medium			**3**	**25**		
		Major			**2**	**17**		
18	Clear of cladding cavity S3.11	Yes			33	85		
		No			**1**	**3**		
		N/A			5	12		
	Defect Rating	**Minor**			**1**	**100**		
		Medium						
		Major						
19	Access hatch insulated and attached S3.12	Yes	1	2				
		No	**22**	**40**				
		N/A	32	58				
	Defect Rating	**Minor**						
		Medium						
		Major	**22**	**100**				
20	25mm gap between insulation and underside of roof/underlay	Yes	20	36				
		No	**35**	**64**				
		N/A						
	Eg:S5.2.1 -Step 5 **Defect Rating**	**Minor**	**2**	**6**				
		Medium	**18**	**51**				
		Major	**15**	**43**				

Audit #	Fault / Defect	Result	Ceiling (55)		Wall (39)		Underfloor (3)	
			Count	%	Count	%	Count	%
21	Insulation to middle of top plate Eg:S5.2.1 –Step 4	Yes	22	40				
		No	**33**	**60**				
		N/A						
	Defect Rating	**Minor**	**2**	**6**				
		Medium	**20**	**61**				
		Major	**11**	**33**				
22	Loose fill – finished flush S4.1 – Step 3	Yes						
		No						
		N/A			39	100		
	Defect Rating	**Minor**						
		Medium						
		Major						
23	Loose fill – even depth S4.2 – Step 6	Yes						
		No	**1**	**2**				
		N/A	54	98				
	Defect Rating	**Minor**						
		Medium						
		Major						
24	Installation completed Eg:S5.1.1 –Step 7	Yes	52	95	35	90	3	100
		No	**3**	**5**	**4**	**10**		
		N/A						
	Defect Rating	**Minor**	**3**	**100**				
		Medium			**2**	**50**		
		Major			**2**	**50**		

Audit #	Fault / Defect	Result	Ceiling (55)		Wall (39)		Underfloor (3)	
			Count	%	Count	%	Count	%
36	Installed by Builder	Yes	13	24	7	18	2	67
37	Installed by Professional Installer	Yes	31	56	27	69	1	33
38	Installed by Other (Who)	Yes	4	7	4	10		
39	Installer unknown	Yes	7	13	1	3		
40	Comment on installation instruction source				29	74		

	Ceiling	Wall	Underfloor	Total (97)	%
Installed by Builder	13	7	2	22	23
Installed by Professional Installer	31	27	1	59	61
Installed by Other*	4	4	0	8	8
Installer unknown	7	1	0	8	8

Installed by Other*. It was found that the Homeowner undertook all 8 installations.

5.1.2 BCA

Audit #	Fault / Defect	Result	Ceiling (55)		Wall (39)		Underfloor (3)	
			Count	%	Count	%	Count	%
33	Building Envelope appear complete S3	Yes	51	93	19	49	3	100
		No	**4**	**7**	**20**	**51**		
		N/A						
	Defect Rating	**Minor**	**2**	**50**	**11**	**58**		
		Medium	**2**	**50**	**4**	**21**		
		Major			**4**	**21**		
34	Comment on Incomplete work	**Yes**	**4**	**7**	**20**	**51**		
		No						
		N/A	51	93	19	49	3	100
	Defect Rating	**Minor**	**2**	**50**	**11**	**58**		
		Medium	**2**	**50**	**4**	**21**		
		Major			**4**	**21**		
35	Moisture content of the timber is less than 16% N/A Steel Frame	Yes	50	91	26	67	3	100
		No	**2**	**4**	**11**	**28**		
		N/A	3	5	2	5		
	S3 (e)	**Minor**	**1**	**50**	**4**	**36**		
	Defect Rating	**Medium**	**1**	**50**	**3**	**27**		
		Major			**4**	**36**		

5.1.3 System Design

Audit #	Fault / Defect	Result	Ceiling (55)		Wall (39)		Underfloor (3)	
			Count	%	Count	%	Count	%
9	Compressed – plumbing	**Yes**	**26**	**47**	**32**	**82**		
		No	29	53	7	18	3	100
	S3.2	N/A						
	Defect Rating	**Minor**	**20**	**77**	**22**	**69**		
		Medium	**6**	**23**	**10**	**31**		
		Major						
10	Compressed – electrical	**Yes**	**29**	**53**	**33**	**85**		
		No	26	47	6	15	3	100
	S3.2	N/A						
	Defect Rating	**Minor**	**24**	**83**	**18**	**55**		
		Medium	**5**	**17**	**15**	**45**		
		Major						
11	Compressed – insufficient space	**Yes**	**26**	**47**	**33**	**85**		
		No	29	53	6	15	3	100
	S3.2	N/A						
	Defect Rating	**Minor**	**10**	**39**	**24**	**73**		
		Medium	**12**	**46**	**7**	**21**		
		Major	**4**	**15**	**2**	**6**		
20	25mm gap between insulation and underside of roof/underlay	Yes	20	36				
		No	**35**	**64**				
		N/A						
	Eg:S5.2.1 -Step 5	**Minor**	**2**	**6**				
	Defect Rating	**Medium**	**18**	**51**				
		Major	**15**	**43**				
21	Insulation to middle of top plate	Yes	22	40				
		No	**33**	**60**				
	Eg:S5.2.1 -Step 4	N/A						
	Defect Rating	**Minor**	**2**	**6**				
		Medium	**20**	**61**				
		Major	**11**	**33**				

5.1.4 Safety

Audit #	Fault / Defect	Result	Ceiling (55)		Wall (39)		Underfloor (3)	
			Count	%	Count	%	Count	%
25	Downlights Covered S3.4.1	**Yes**	**9**	**16**				
		No	8	15				
		N/A	38	69				
	Defect Rating	**Minor**	**2**	**20**				
		Medium	**4**	**40**				
		Major	**4**	**40**				
26	100mm from Downlights S3.4.1	Yes						
		No	**15**	**27**				
		N/A	40	73				
	Defect Rating	**Minor**	**2**	**13**				
		Medium	**3**	**20**				
		Major	**10**	**67**				
27	Auxiliary Equip Covered S3.4.2	**Yes**	**4**	**7**				
		No	4	7				
		N/A	47	86	39	100	3	100
	Defect Rating	**Minor**						
		Medium						
		Major	**4**	**100**				
28	150mm from extractor fans, metal chimneys and flues	Yes	6	11				
		No	**9**	**16**				
		N/A	40	73				
	S3.6 **Defect Rating**	**Minor**	**1**	**11**				
		Medium	**3**	**33**				
		Major	**5**	**56**				
29	50mm from outer faces of brick or concrete chimneys	Yes	1	2				
		No						
		N/A	54	98				
	S3.6 **Defect Rating**	**Minor**						
		Medium						
		Major						

Audit #	Fault / Defect	Result	Ceiling (55)		Wall (39)		Underfloor (3)	
			Count	%	Count	%	Count	%
30	Electrical cables covered by insulation S3.7	**Yes**	**51**	**93**				
		No	3	5				
		N/A	1	2				
	Defect Rating	**Minor**	**13**	**26**				
		Medium	**21**	**41**				
		Major	**17**	**33**				
31	Electrical cables in contact with Poly insulation S6.4	**Yes**						
		No			1	3	3	100
		N/A	55	100	38	97		
	Defect Rating	**Minor**						
		Medium						
		Major						
32	Clear of appliance or enclosure for appliance S3.8	Yes	2	4	2	5	1	33
		No						
		N/A	53	96	37	95	2	67
	Defect Rating	**Minor**						
		Medium						
		Major						

6 FINDINGS AND RECOMMENDATIONS.

The scope of this project is to investigate the quality of insulation installation in new build homes and there are four key points to be addressed, as follows:

6.1 How well is insulation installed in New Zealand Homes?

Of the 58 audits undertaken, when applying the Standard for installation of insulation, none of the installations met all requirements of the Standard. 100% of the properties audited, for one reason or another, failed. Based on these findings, the insulation in new build homes in New Zealand is not well installed and requires significant improvement.

The Building Code has requirements that *shall* be met in relation to energy efficiency of the building envelope. The Standard also has requirements that *shall* be met, though these are not necessarily the same as the Building Code requirements.

Failure to comply with the Standard and manufacturers installation instructions will risk the property being non-compliant with the Building Code and may affect the safety of the occupants and the energy efficiency performance of the house..

For the purposes of ascertaining the extent of the faults or defects found to be occurring we have rated the defects, minor, medium, or major. This information will help to evaluate the areas of greatest concern and failure, requiring targeted training and improvement; through to areas that are occurring less frequently, however will still require improvement.

6.2 What installation faults appear? If any, identify the nature of installation faults with insulation.

The findings have shown that there has been an example found of almost every installation defect audited. The installation faults found include: damaged insulation, folds, tucks, gaps or insulation overlap, and areas not insulated where they should have been. Insulation has been compressed, incorrectly fixed or supported, incorrectly fitted around top plates, downlights, auxiliary equipment, or extractor fans. Insulation has also been incorrectly fitted around electrical wiring and plumbing systems.

It has also been found that where the Standard requires the cladding materials to have been installed and the moisture content of timber to be less than 16% prior to installation, these requirements have not always been met.

The nature of these faults is self-explanatory for the most part. For example, a gap in insulation means that the insulation has been fitted in such a way that the insulation segment does not touch all sides of the cavity, face, butted segments. An example of each fault is shown in section 6.2.5 Audit overview by Defect.

To assist in identifying the nature of the fault, the faults were categorised into four areas, being Workmanship, BCA, System Design, and Safety.

6.2.1 Workmanship

Fault / Defect	Impact
Wet	R-value reduction, will retain water – moisture related issues
Damaged	R-value reduction
Folds	R-value reduction
Tucks	R-value reduction
Gaps	R-value reduction
Overlaps	R-value reduction
Missing insulation	R-value reduction
Compressed – installer	R-value reduction
Fixings not correct	Could allow for movement – R-value reduction
Temporary supports not in place	Could allow for movement – R-value reduction
Recessed spaces not insulated	R-value reduction
Unlined wall (EG stub walls) not strapped horizontally at max 300mm centres*	Could allow for movement – R-value reduction
Soffit / Porch covered	Not a requirement
Insulation between plumbing and outside wall not achieved	R-value reduction
Protruding into cladding cavity	Impact on cavity performance
Access hatch not insulated and attached	R-value reduction
25mm gap between insulation and underside of roof/underlay not achieved	Potential for moisture wicking into insulation
Insulation to middle of top plate not achieved	R-value reduction
Loose fill – finished flush	R-value reduction
Loose fill – even depth	R-value reduction
Installation not completed in all required areas	R-value reduction

6.2.2 BCA

<table>
<tr><th>Fault / Defect</th><th>Impact</th></tr>
<tr><td>Building Envelope incomplete</td><td rowspan="2">Could allow insulation to become wet creating other moisture related issues, and consequentially affect the R-value</td></tr>
<tr><td>Moisture content of the timber is greater than 16%</td></tr>
</table>

6.2.3 System Design

<table>
<tr><th>Fault / Defect</th><th>Impact</th></tr>
<tr><td>Compressed – plumbing</td><td rowspan="3">R-value reduction</td></tr>
<tr><td>Compressed – electrical</td></tr>
<tr><td>Compressed – insufficient space</td></tr>
<tr><td>25mm gap between insulation and underside of roof/underlay not achieved</td><td>Potential for moisture wicking into insulation</td></tr>
<tr><td>Insulation to middle of top plate not achieved</td><td>R-value reduction</td></tr>
</table>

6.2.4 Safety

Fault / Defect	Impact
Downlights covered	Overheating and potential for damage. Risk to safety of the home's occupants.
Appropriate clearance from downlights not achieved	
Auxiliary Equip covered	
150mm from extractor fans, metal chimneys and flues not achieved	
50mm from outer faces of brick or concrete chimneys not achieved	
Electrical cables covered by insulation	
Electrical cables in contact with Poly insulation	
Clearance from appliance or enclosure for appliance not achieved	

6.2.5 Audit Overview by Defect

In the following overview:

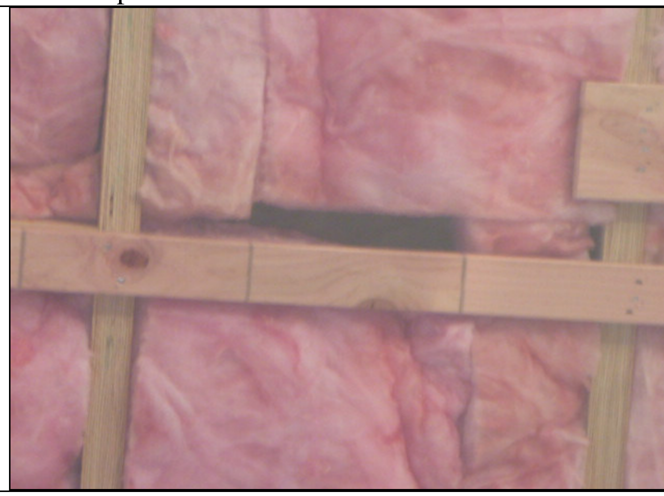
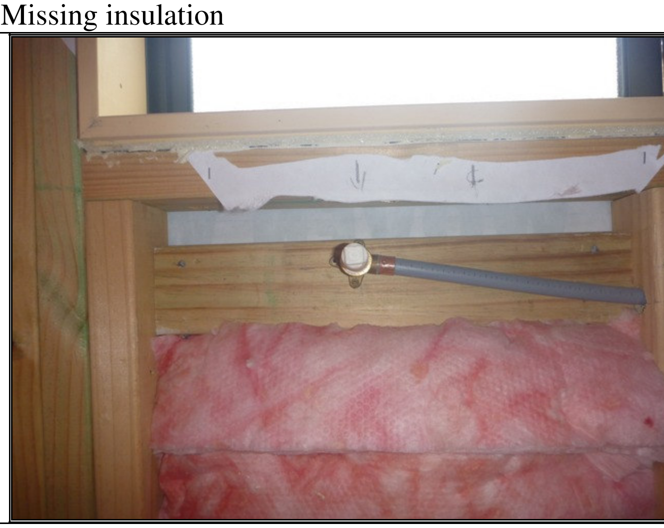
1. A defect that has been found to be greater than 50% has been highlighted; and of those defects
2. A medium or major rating[5] has also been highlighted to draw attention to those occurring more frequently throughout the property.

---

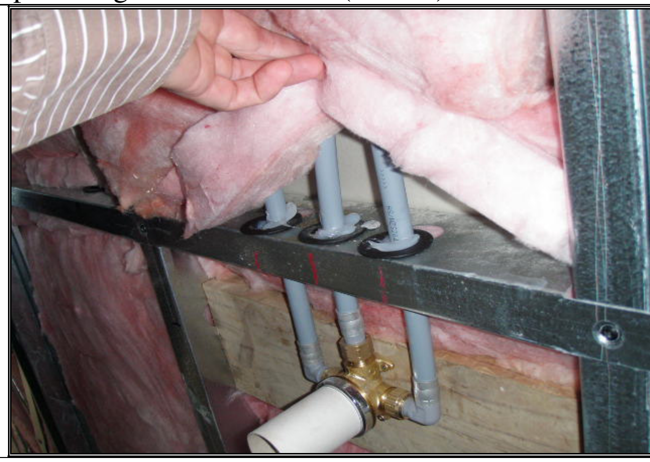
[5]See Section2 – Definitions – The Audit Rating System. These ratings denote the extent of the occurrence, not the nature of the defect, nor the severity in terms of safety risk, or impact on performance

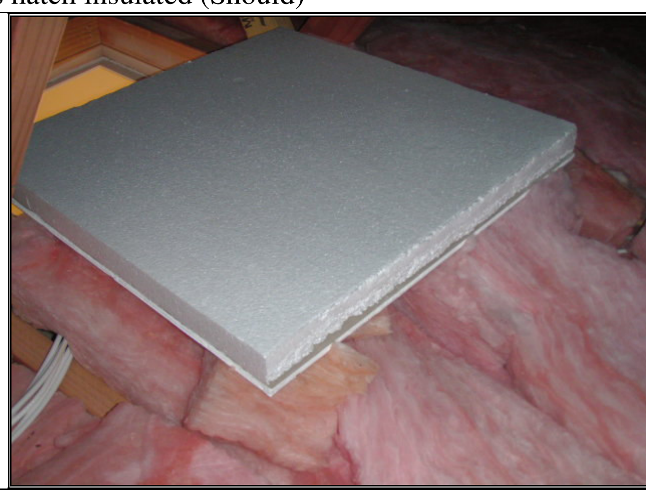
6.2.5.1 Workmanship

Damaged	
The Auditors looked for whether any of the insulation material installed was damaged. It was found that 24% of ceiling installations and 13% of wall installations had damaged insulation. Of those defects, 85% of the ceiling defects and 80% of the wall defects were rated as minor.	
Folds	
The Auditors looked for whether any of the insulation material installed was subject to folds. It was found that **55% of ceiling installations and 67% of wall installations had folds in the insulation.** Of those defects, 60% of the ceiling defects and 54% of the wall defects were rated as minor.	
Tucks	
The Auditors looked for whether any of the insulation material installed was subject to tucks. It was found that **55% of ceiling installations and 85% of wall installations had tucks in the insulation**. Of those defects, 64% of the ceiling defects were rated as minor. However, **70% of the wall defects were rated as medium to major**	

Gaps	
The Auditors looked for whether any of the insulation material installed was subject to gaps. It was found that **91% of ceiling installations, 67% of underfloor installations, and 95% of wall installations had gaps in the insulation**. Of those defects, 52% of the ceiling defects and 100% of the underfloor defects were rated as minor. However, **51% of the wall defects were rated as medium to major**	
Overlaps	
The Auditors looked for whether any of the insulation material installed was subject to overlaps. It was found that **56% of ceiling installations had overlaps in the insulation**. Of those defects, 55% were rated as minor.	
Missing insulation	
The Auditors looked for whether there was any missing insulation. It was found that 36% of ceiling installations and **77% of wall installations had missing insulation.** Of those defects, 55% of the ceiling defects and 67% of the wall defects were rated as minor.	

<table>
<tr><td colspan="2">Compressed by installer</td></tr>
<tr><td>The Auditors looked for whether any of the insulation material installed was compressed, as a result of the installer. It was found that 45% of ceiling installations, 33% of underfloor installations, and 87% of wall installations had compressed insulation, due to the installer. Of those defects, 64% of the ceiling defects and 56% of the wall defects were rated as minor.</td><td></td></tr>
<tr><td colspan="2">Fixings not correct</td></tr>
<tr><td>The Auditors looked for whether any of the insulation material was incorrectly fixed. It was found that 4% (2 audits) of ceiling installations and 67% (2 audits) of underfloor installations had been incorrectly fixed. Of those defects, 100% of the ceiling and underfloor defects were rated as major.</td><td></td></tr>
<tr><td colspan="2">Temporary supports not in place</td></tr>
<tr><td>The Auditors looked for whether any of the insulation material installed had temporary supports to keep the insulation in place, where required. It was found that 44% of ceiling installations and 13% of wall installations did not have temporary supports in place. Of those defects, 75% of ceiling defects were rated as medium to major. 60% of the wall defects were rated as minor.</td><td></td></tr>
</table>

<table>
<tr><td colspan="2">Insulation between plumbing and outside wall (Should)</td></tr>
<tr><td>The Auditors looked for whether the insulation material had been installed between any plumbing and the outside wall. It was found that 31% of wall installations did not have insulation fitted between the plumbing and wall. Of that 31%, 58% were rated as minor.</td><td></td></tr>
<tr><td colspan="2">Protruding into cavity (Should not)</td></tr>
<tr><td>The Auditors looked for whether the insulation material could be seen to be protruding into the cladding cavity. It was found that 1 property audited (3%) was subject to this defect and was rated as minor. This was identified because the brick veneer had not been installed.</td><td></td></tr>
<tr><td colspan="2">Access hatch insulated (Should)</td></tr>
<tr><td>The Auditors looked for whether the insulation material was fitted to the access hatch. It was found that 22 of 23 access hatches installed were not insulated.

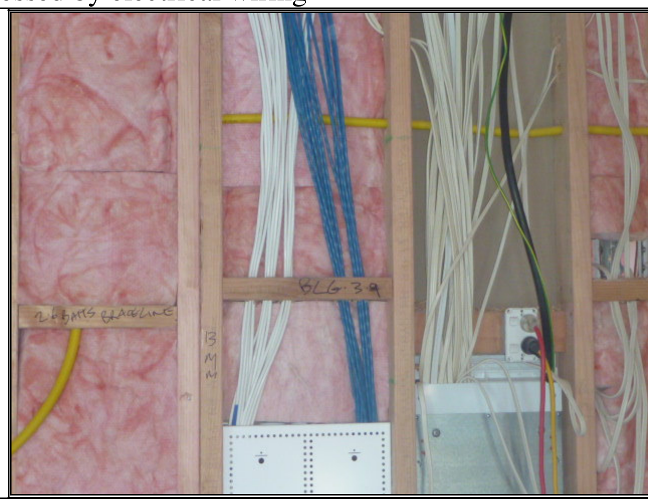
The Photo shows the insulated hatch.</td><td></td></tr>
</table>

<table>
<tr><td colspan="2">Lack of 25 mm gap to under side of roof underlay</td></tr>
<tr><td>The Auditors looked for whether the insulation material had been installed with a 25 mm gap to the underside of the roof underlay. It was found that 64% of ceiling installations failed to achieve the clearance. Of those defects, 94% were rated as medium to major.</td><td></td></tr>
<tr><td colspan="2">Insulation to middle of top plate</td></tr>
<tr><td>The Auditors looked for whether the insulation material had been installed to the middle of the top plate. It was found that 60% of ceiling installations failed to achieve the clearance. Of those defects, 94% were rated as medium to major. The photo shows insulation within the ceiling framing, rather than over the top plate. It also shows an example of missing insulation behind a window lintel, due to design.</td><td></td></tr>
<tr><td colspan="2">Insulation not complete</td></tr>
<tr><td>The Auditors looked for whether the insulation installations were indeed complete. It was found that 5% of ceiling installations and 10% of wall installations were found to be incomplete, although they had been deemed completed. Of those defects, 100% of the ceiling defects were rated as minor. 94% of the wall defects were rated as medium to major.</td><td></td></tr>
</table>

6.2.5.2 BCA

<table>
<tr><td colspan="2">Building envelope complete (Should)</td></tr>
<tr><td>The Auditors looked for whether the building envelope appeared to have been completed, prior to the insulation material being installed. It was found that 7% of ceiling installations and 51% of wall installations were undertaken, while the building envelope had not been completed. Of those defects, 50% of the ceiling defects were rated as medium. 58% of the wall defects were rated as minor.</td><td></td></tr>
<tr><td colspan="2">Moisture levels under 16% (Should)</td></tr>
<tr><td>The Auditors looked for whether the moisture levels of the timber framing were less than 16%, prior to the insulation material being installed. It was found that 4% of ceiling installations and 28% of wall installations were undertaken, while the moisture levels were greater than 16%. Of those defects, 50% of the ceiling defects and 63% of the wall defects were rated as medium to major.</td><td></td></tr>
</table>

6.2.5.3 System Design

<table>
<tr><td colspan="2">Compressed by plumbing</td></tr>
<tr><td>The Auditors looked for whether any of the insulation material installed was compressed, as a result of the plumbing. It was found that 47% of ceiling installations and 82% of wall installations had compressed insulation, due to plumbing. Of those defects, 77% of the ceiling defects and 69% of the wall defects were rated as minor.</td><td></td></tr>
<tr><td colspan="2">Compressed by electrical wiring</td></tr>
<tr><td>The Auditors looked for whether any of the insulation material installed was compressed, as a result of electrical wiring. It was found that 53% of ceiling installations and 85% of wall installations had compressed insulation, due to electrical wiring. Of those defects, 83% of the ceiling defects and 55% of the wall defects were rated as minor.</td><td></td></tr>
<tr><td colspan="2">Compressed by insufficient space</td></tr>
<tr><td>The Auditors looked for whether any of the insulation material installed was compressed, as a result of the design not allowing for sufficient space for the insulation. It was found that 47% of ceiling installations and 85% of wall installations had compressed insulation, due to insufficient space. Of those defects, 61% of the ceiling defects were rated as medium to major. 73% of the wall installations were rated as minor.</td><td></td></tr>
</table>

<table>
<tr><td colspan="2">25mm Gap to underlay not achieved due to design</td></tr>
<tr><td>The Auditors looked for whether the insulation material was able to be installed with a 25 mm gap to the underside of the roof underlay. It was found that 64% of ceiling installations failed to achieve the clearance. Of those defects, 94% were rated as medium to major.</td><td></td></tr>
<tr><td colspan="2">Insulation to middle of top plate</td></tr>
<tr><td>The Auditors looked for whether the insulation material was able to be installed to the middle of the top plate. It was found that 60% of ceiling installations failed to achieve the clearance. Of those defects, 94% were rated as medium to major.</td><td></td></tr>
</table>

6.2.5.4 Safety

Downlights covered

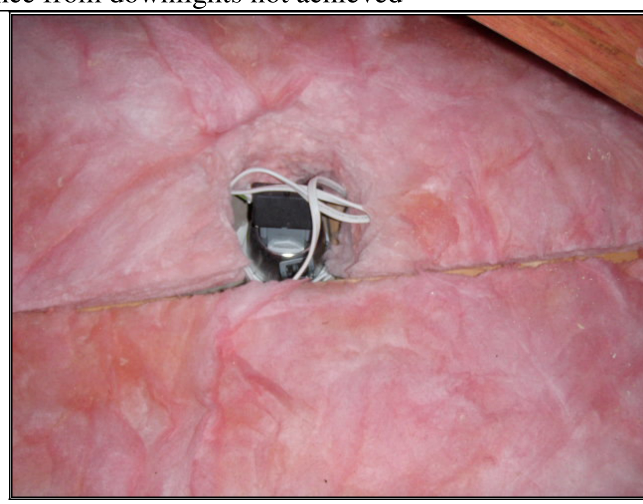
The Auditors looked for whether the insulation material had been installed over recessed downlights. It was found that **8 of 17 audits with downlights installed were found to be covered** Of those defects, **80% were rated as medium to major.**

The bright light on the right side of the photo shows a recessed downlight covered by insulation. It also shows an example of insufficient clearance of the insulation from the metal flue.

100mm clearance from downlights not achieved

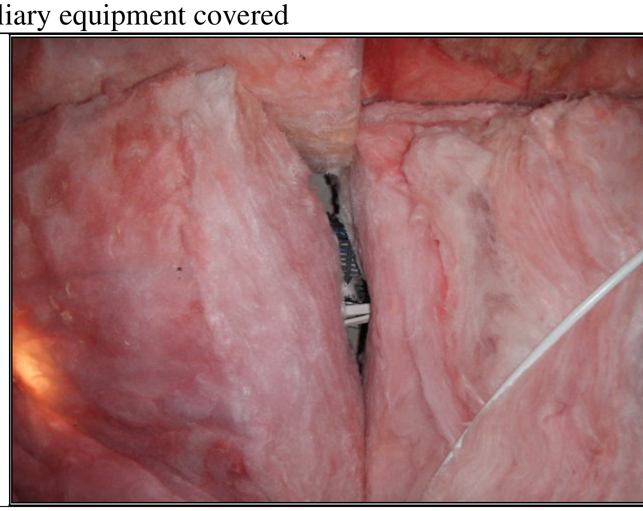
The Auditors looked for whether the insulation material had been installed with a 100 mm clearance from recessed downlights, unless there was information to advise otherwise. It was found that of 17 audits with downlights installed, **15 audits (88%) found insulation within 100mm of the downlights**. Of those, **87% were rated as medium to major**.

In 2 audits, documentation was provided to show insulation could be butted to the downlight.



Auxiliary equipment covered

The Auditors looked for whether the insulation material had been installed over auxiliary equipment. It was found that **of 8 audits with auxiliary equipment installed, 4 audits (50%) found auxiliary equipment to be covered with insulation.** Of those, **100% were rated as major.**



150 mm from extractor fans, metal chimneys and flues	
The Auditors looked for whether the insulation material had been installed with a 150 mm clearance from extractor fans, metal chimneys and flues. It was found that of 15 audits with one or more of these installed, **9 audits (60%) failed to achieve the required clearance**. Of those, **89% were rated as medium to major**.	
Electrical cables covered by insulation	
The Auditors looked for whether the insulation material had been installed over electrical cables. It was found that **93% of ceiling installations had electrical cables covered by insulation.** Of those defects, **74% were rated as medium to major.**	

6.3 Why the installation faults occur

It is clear from the findings of this audit that the installation of insulation is falling well short of the Standard.

The Audit Overview by Defect (S6.2.5) clearly shows that the majority of installation faults will occur due to workmanship, as opposed to another cause.

Following, is a list of those workmanship related defects, where the occurrence number was found to be greater than 50%:

1. folds,
2. **tucks**,
3. **gaps**,
4. overlaps,
5. missing insulation,
6. compression by Installer,
7. **incorrect fixings**,
8. **temporary supports not in place**,
9. **access hatches not insulated**,
10. **lack of 25mm to underside of roof underlay,**
11. **failure to insulate to middle of top plate**,
12. insulating while the building envelope is incomplete,
13. **covering downlights and auxiliary equipment,**
14. **failing to achieve an appropriate clearance to downlights and auxiliary equipment, and**
15. **failing to achieve a 150 mm clearance from extractor fans, metal chimneys, and flues.**

The highlighted defects were rated as medium to major, indicating they were occurring repeatedly, in several areas throughout the home.

Those in red, also show the safety related defects.

In considering why these faults are occurring in the first instance, we must look at who the installer was. The findings show that 23% of the installations were undertaken by the builder, 61% were undertaken by a professional installer, and 16% were undertaken by either the owner or an unknown party.

6.3.1 Impact of the Professional Installer

61% of installations were installed by a Professional Installer. It would be expected that a professional installer would be conversant and compliant with the industry Standard.

Furthermore, in reviewing various manufacturers' instructions and a BRANZ appraisal, all consistently provide clear statements and instructions regarding how the respective insulation shall be installed. See Appendix 7.2 Manufacturers and Industry Insulation Installation Instructions and Appraisals - Extracts.

The reason for a professional installer to fail to install insulation predominantly free of faults can not be due to a lack of industry information. The logical conclusions that could be drawn from these audit results would be that;

a. the installer has not been properly trained, or has not understood the training; or
b. the installer has knowingly failed or had no incentive to meet the required Standard, which would therefore indicate a lack of quality assurance by the installation company.

As an aside, it was commented upon by the auditors that some of the builders were clearly not aware of the recommended installation requirements of the Standard; however some were very keen to learn. In these instances, they were relying on the premise that using a professional installer would ensure a compliant installation.

6.3.2 Impact of the Builder

The builder has been identified as the installer of 23 % of the total installations. As for a professional installer, failure to install insulation predominantly free of faults cannot be due to a lack of industry information. However, whether the builder has undertaken any formal training for installation is unknown. Findings of this audit could conclude that it would be unlikely.

6.3.3 Impact of other Trades

There are however, other factors causing or contributing to the fault occurring. The first, which has been identified clearly in the ceiling audits during the Final inspection of a home, is as a result of another party interfering with the original installation.

<u>The Electrician</u> has been found to contribute to defects due to the initial installation of the electrical system making proper installation of insulation in some areas difficult or impossible; and as a result of interfering with insulation (disturbing insulation that has already been installed) during the final installation of the electrical system.

The Standard and industry documentation all recommend the insulation should not be placed around or over electrical cables if it can be avoided. Although, the Standard does state that to avoid compression some insulation can be cut to fit around the wiring. Due to the initial installation of the electrical system, 53% of ceiling audits and 85% of wall audits were found to be substandard because the placement of the wiring caused significant compression of the insulation. 93% of ceiling audits were found to have the cables covered by insulation, which is a practice that is recommended to be avoided in the Standard and by the Manufacturers.

Another defective area affecting safety that is a result of the Electrician is the installation of the downlights, auxiliary equipment and extractor fans. These are installed after the insulation has been installed.

In this research 17 audits of roof cavities were undertaken at the time of the Final inspection by the BCA for CCC. Of the 17 audits, 9 were found to have had the insulation placed over downlights, 15 were found to have failed to create a required clearance from the downlights, 4 were found to have also had insulation cover the auxiliary equipment to downlights that were separate to the downlights system, and 9 were found to have lacked the 150 mm clearance to extractor fans, vents and flues.

It should be noted that two of the downlights systems were found to be the type that could be abutted to the insulation (CA rated). Although this was only found out through the appropriate tradesperson being on site at the time of the BCA inspection, and being able to provide the appropriate documentation. It should be noted that the rating is not stated on the downlight fitting.

We were informed by various BCA inspectors and builders that the majority of downlight systems would require the 100 mm clearance.

<u>The Plumber</u> can also impact negatively on the installation of insulation, due to the placement of the plumbing systems making proper installation of insulation difficult or impossible within the wall and ceiling cavity. 31% of wall installations were found to be defective due to a lack of insulation between the plumbing and the outside wall, which results in an R-value reduction.

47% of ceiling audits and 82% of wall audits were found to be substandard due to plumbing installation significantly compressing the insulation. While a designer will draw in where the plumbing fittings are required, it is generally up to the Plumber to install the plumbing system to suit the designed placements.

As with the builder, the findings of this audit could conclude that it is also unlikely the Electrical or Plumbing Industry have been provided with, or taken up, any formal training in relation to insulation installation and design.

6.3.4 Impact of the Design

The second contributory factor to some of these faults comes down to design making proper installation of insulation difficult or impossible in some places. This can refer to construction design, or design of plumbing, electrical, lighting, heating, or ventilation systems.

This can be most simply demonstrated by the example where insulation was cut to fit behind plumbing, and removed completely behind power boxes. The installer had cut the insulation to fit around the plumbing, which the Standard does recommend in lieu of compression. However, it is also required behind the power boxes. It is the failure in the design to ensure the appropriate cavity is maintained for insulation, whilst accommodating any plumbing or electrical requirements that has caused the fault. These faults have affected the R-value of the home.

In Section 6.2.5.3 Audit Overview by Defect, the extent of compression faults due to the placement of plumbing or electrical wiring is shown. Wiring and plumbing are often placed in the exterior wall cavity where it either makes placement of insulation hard or even impossible.

The use of downlights has been found to cause a large percentage of both thermal efficiency and safety related defects. Appendix C of the Standard identifies that the use of recess lighting will reduce the effective thermal resistance for insulation. The Appendix quantifies the approximate reduction in effective thermal resistance for insulation due to missing insulation around recessed light fittings. In the case with many downlights there will be convective heat losses as well due to air movement through the downlight fittings.

We are unable to comment on whether a greater R-value was used in the ceiling audits where downlights were installed to compensate for this effect, as that was outside the scope of this research. However, with the evidence from this audit clearly identifying insulation is not well installed; it does raise potentially justifiable concerns regarding this element of design.

Another common area of the design causing a fault is in the roof cavity. Here, the two most common faults that can be attributed to design are compression, or failure to achieve the minimum required clearance to the roof underlay.

A design area that seems to cause the most faults is towards the outer edge of the roof above the top plate of the outer wall. See Appendix 7.3 Typical Wall to Truss Detail.

In the first instance the insulation in the ceiling is required to be insulated to the middle of the top plate. It was found that this had not been achieved in 60% of the ceiling audits, in part due to a lack of clearance to the roof, or the placement of structural timbers. The installer is then left with the options of:

- Compressing the installation into the space, affecting the R-value, or
- Failing to insulate the space at all, affecting the overall R value of the ceiling, or
- Installing the insulation, whilst placing it in contact with or within the 25 mm required clearance of the roof underlay. This option may not only affect the R-value, it has the potential to transfer moisture to the insulation.

A further roof design that has been seen to cause a defect or fault in the installation is a Skillion roof. A Skillion roof by its nature has a limited cavity between the roof, underlay or substrate, and ceiling. Therefore careful consideration must be given when designing this space to ensure a sufficient cavity free of any systems or obstructions is created for the insulation to fit into in accordance with the Standard and manufacturers requirements. As with a wall cavity, when designing the Skillion roof cavity, the depths of the structural timbers must be sufficient for the required thickness of the insulation. The thickness required for roofs will be greater than the one for walls due to higher insulation requirements.

The same applies for low-pitched roofs.

64% of ceiling audits failed to achieve the minimum 25mm gap required between the insulation and underside of the roof/underlay. However, it must be noted that the roof to outer wall (top plate) design was the predominant cause of this defect occurring.

Finally, current practices in timber and steel framing design are resulting in cavities requiring insulation, being unable to be insulated during the normal insulation process. See Appendix 7.4 Typical Wall Framing Detail.

Hollow corners are created where two runs of framing meet. Every corner of the home, both internal and external will have this problem. This also occurs where internal wall frames meet the external walls. Similarly, blocking of double studs, window lintels, and timber battens added to the framing for various reasons can all create inaccessible cavities preventing insulation being installed. An additional problem noted with Steel framing is that it is a box or C-section, and when grouped together it creates inaccessible cavities that are required to be insulated. For example, depending upon the span of a lintel, up to 4 C-section Studs can be placed together leaving three of those C-sections uninsulated, and unable to be accessed to be insulated.

This defect contributed to the 77% of wall audits with missing insulation. Examples of design preventing access to insulate a cavity that should be insulated can be seen in Appendix 7.5 of this report in Photo's 18, 20 and 37.

6.4 How quality of insulation installation can be improved – identify and recommend practices to improve the installed quality of insulation in new houses

When reviewing the findings the predominant reason for the problems is a mix of sub standard workmanship and /or problematic design.

This research has shown there are four key "identities" in relation to design and workmanship:

1. The designer, this may be an architect or draughtsperson.
2. The builder and/or project manager.
3. The professional installer.
4. The other sub trades, and in particular the Electricians and Plumbers.

The research has also clearly demonstrated the need for robust inspection processes to ensure quality and compliance for each installation.

The key "identity" in relation to quality assurance and compliance has been identified at this point in time as the BCA.

It is the BCA who is charged, under the Building Act, with ensuring the standard of building design and construction is achieving compliance with the Building Code. [6]

When issuing a building consent, the BCA must be satisfied on reasonable grounds that the provisions of the building code would be met if the building work were properly completed in accordance with the plans and specifications that accompanied the application.[7]

A building consent is subject to the condition of inspection by the BCA authorised agents. The definition of inspection means taking all reasonable steps to ensure that building work is being carried out in accordance with the building consent.[8]

However, this should not limit nor relinquish the responsibilities of the four key identities to comply with the Standard and have internal quality assurance procedures in place.

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[6] Building Act 2004 Part 1 s 4 (f)
[7] Building Act 2004, Part 2 s 49 (1)
[8] Building Act 2004, Part 2 s 90 (1) & (3)

6.4.1 Education and Training

In the first instance education for the four key "identities" is required to address many of the identified faults and defects.

Education needs to take on a two-pronged approach. Firstly, there needs to be education in the requirements of the Standard and manufacturer's instructions so that each person involved is ensuring compliance is met.

Secondly, to be effective, the ramification of poor installation also needs to be covered to ensure that each party contributing to the insulation installation understands why they must ensure compliance is achieved.

It could be argued, or at least expected, that the designer and professional installer should know the requirements for compliance. However, this research has shown clear evidence of consistent faults occurring as a result of non-compliance from these groups.

This also indicates a lack of understanding of the potential magnitude of the problems that could result due to poor installation of insulation.

6.4.1.1 Education and Training for the Designer

It is the designer who in the first instance will have an impact on whether the insulation can be correctly installed. When considering the design, they must ensure that construction R-values of the roof, walls, and floor meet the energy efficiency requirements of the Building Code.

Once the required R-value of these areas is determined, then the choice of insulation material needs to be made. Either the appropriate insulation needs to be specified for the desired cavity space, or the type of insulation chosen will determine the required cavity that must be created to ensure that the insulation will fit without undue compression.

Each manufacturer clearly identifies in their literature the R-value and corresponding nominal thickness of the products. It should therefore be a relatively straightforward consideration to ensure that cavities are designed with adequate room to accommodate the insulation.

The second consideration the designer must take into account when designing, is the placement and impact of the services within the home. These services; predominantly being plumbing, electrical, lighting, ventilation, and heating systems, must be able to be incorporated into the design without adversely impacting on the insulation installation and its effectiveness.

Particular consideration should be given to minimising the placement of these services in external walls, or where it becomes necessary, creating a cavity with sufficient depth to accommodate both the services and insulation. The use of service cavities to accommodate all of the above services should also be considered in the design.

A third area requiring consideration is in ensuring the design does not prevent specified areas requiring insulation to be unable to be appropriately insulated or accessed at the time of insulation installation. Where such situations cannot be avoided, then instructions may be required to ensure the cavity is suitably insulated at the time the building envelope is enclosed.

6.4.1.2 Education and Training for the Builder and / or Project Manager

Regardless of whether the builder or project manager installs the insulation or not, they will hold ultimate responsibility for the construction process. Therefore, it is critical they understand how and why the insulation must be correctly installed. They should be able to identify faults or defects and know when it is correct.

Training is required to ensure that builders and project managers have sound knowledge of the requirements of the Standard and manufacturers specifications for installation. Whether they be the installer or overseer, it is critical they recognise their role as the site auditor of the installation.

With the introduction of LBP's, and proposed move towards self certification, many astute builders and building companies are looking to internal and external quality assurance processes and systems. The correct installation of insulation in all cavities should be part of this process. However, it will only be as useful as the level of documentation and training provided to the builders and project managers.

6.4.1.3 Education and Training for the Professional Installer

The "professional installer" is referenced in many manufacturers and industry documents relating to insulation and its installation. To be a professional installer it should be reasonably expected that they would have training and a clear understanding of the requirements of the Standard.

The findings of this research show this is not the case in all instances. Whilst undertaking the audits it was found that there is significant variation in the quality of installation among professional installers, even within the same brand company.

The findings of this research indicate that there is a requirement for this industry to reassess its processes and systems, as the rate of non-conformance and non-compliance is too high. There will be those that may only require minor adjustments, while others will require more.

The process for someone to become a competent professional installer would be expected to look something like:

1. a comprehensive training document
2. training
3. a rigorous installation process, and
4. an auditing process to ensure quality and compliance.

In order to determine where and how the system or processes are not working will require each area to be reassessed.

1. In the first instance the training documentation of the professional installers may need to be reviewed against the requirements of the Standard and manufacturers

specifications. The documentation should cover all requirements, as well as the ramifications of non-compliance.

2. The training programme itself can then be reviewed to ensure that it is providing the necessary information required by installers to ensure compliance. This should also include some form of measure of performance to ensure it is delivered appropriately and correctly understood.
3. The installation process can then be assessed for clues or evidence of why this non-conformance is being found.
4. Finally, the internal auditing or quality assurance process requires review and amendment, as the findings of this research indicate that ultimately this part of the professional installer system is not working.

6.4.1.4 Education and Training for the Sub Trades

When a home is constructed, the wiring, plumbing, and fit out for ventilation and heating systems are generally installed prior to the insulation. These systems are installed within the wall cavity, the ceiling cavity, and underfloor cavity, for lack of any other suitable service ducting being available.

However, the ceiling cavity may be revisited to install lighting, heating and venting systems towards the completion of the home. The research findings show that the systems installed at this stage are negatively impacting on the original insulation installation.

Plumbers and Electricians were the two identified trades in this research, impacting on the insulation installer's ability to complete Standard compliant, well-installed insulation.

Insulation training is required for these sub trades. It is clear from the research they need to be aware of the insulation Standard to ensure plumbing, electrical, and related systems are installed in collaboration with the Standard. A little more thought and placement of these systems could result in a minimal or zero defect rating, due to the Plumbers and Electricians work.

For example, it is generally up to the Plumber to install the plumbing system to suit the designed placements. Consideration should therefore be given to minimising the placement of these systems in external walls as much as possible.

The Electricians knowledge of the Standard is quite critical, as failure to meet the requirements may not only reduce the effective R-value of the home, it could also pose a safety risk for the occupants. This has been found to be a predominant concern of this research with the number of downlights, and auxiliary equipment being covered by insulation.

6.4.1.5 Education for the Homeowner

The homeowner is one other party that can be accountable for the installation of insulation. This may occur when the homeowner is project managing the construction, or as an approach to the builder to cut some construction costs. However, only 8% of the installations audited were undertaken by the homeowner.

Throughout all the audits, if any instructions were found on site relating to installation, they were found on the manufacturer's bags. Whilst they were basic, this method of imparting the information is not successful given the research results.

It may be necessary to provide more information or training by way of hardcopy documentation, DVD's, or online information. It is unknown whether the information would be used; therefore as with all installers, a quality assurance process needs to be in place. Currently this would likely be the builder, project manager, or if the homeowner is the project manager, the BCA.

6.4.1.6 Training Overview

Education and training is clearly needed within each of the related trades and professions to address the significant amount of defects and faults identified, and consequential non-compliance with the Standard and Building Code.

However, for the related trades and professions for training to be effective, a "whole of house" philosophy should be core to the training procedures. The research indicates an inability by the individual trades and professions to identify the contribution and impact their work has on the entire construction project. Providing a clear picture of each person's role and how it all fits together in the "bigger picture" may help prevent many of the issues identified.

This "whole of house" overview would be overseen by a project manager or a building company's quality assurance process, if these are in place. However, they should not be relied upon to relinquish or minimise any of the responsibilities of the individual.

The training and education for all parties involved with the design, construction, insulation, and inspection of new homes should also include the ramifications of non-compliance. Whilst undertaking the necessary research for this project and communicating with various parties involved with the audit process, it became clear that there is in general lack of understanding of the ramifications and consequences of defective installation processes. For those involved in the installation process, be it an installer, builder or BCA, the dos and don'ts for installation are important aspects, However, what has become evident is that the reason for the dos and don'ts must also be explained.

Were this information also provided to the end user, being the home owner and/or occupier, pressure brought by this party could also result in helping to enforce compliance.

6.4.2 The BCA

Based on the results of this research, it would be timely for BCA's to review their inspection processes relating to insulation at Preline and Final inspections. While the BCA is not specifically causing the fault or defect, they are required to identify and enforce compliance; otherwise they are contributing to the issue through acquiescence.

Two types of BCA insulation inspection practices were observed by the Auditors.

1. The BCA undertakes a physical inspection, identifying the faults and requiring they be addressed,

a) before the BCA inspection would be passed, or
b) pass the inspection, on the proviso that the faults would be corrected before lining.

2. The BCA accepts a Producer Statement from the installer, in lieu of an inspection, which they are relying upon as being accurate.

Inspection option 1 a) was the most common type observed. This action addressed the faults, where practicably achievable, and enforced as much compliance as they could. To achieve full compliance in some instances would have required deconstruction of some areas of the building.

Option1 b) allows for continuance of the construction; however it is reliant on the builder or project manager undertaking what was asked.

To ensure the BCA requirements have been met, Option 1 b) requires robust processes by the BCA during latter inspections, to determine whether all defects identified have been corrected. While a roof and floor cavity can be re-inspected, the wall cavity can not without the aid of additional tools such as a thermal imaging camera.

The findings of this research do indicate that Option 2 may not be prudent or acceptable. It is recommended that any BCA's using this method should be reassessing this process to ensure they are meeting their requirements under the Building Act.

6.4.2.1 R-value Consideration.

A recent research article in BRANZ Build Magazine, Build 117 April/May 2010 by Ian Cox-Smith, BRANZ Building Physicist, states that research had shown that gaps as small as a few millimetres around the edges of wall insulation can sometimes halve the overall thermal resistance. The statement follows the acknowledgement of the Standard requirement that insulation is fitted without gaps, tucks and folds.

Research has shown this is also the case where there are also gaps between the faces of the insulation and the inside faces of the cladding and lining materials. Whilst we would be unable to specifically identify face gaps, the article acknowledges that even if there were only gaps around the edges of the insulation, the thermal resistance of a building component will be less than the calculated thermal resistance based on the nominal R-value of the insulation product.

Two thermal models were used with two common framing layouts of studs at 450 mm centres and no dwangs, and studs and dwangs both at 600 mm centres, to assess the impact of edge gaps on the R-value. The latter framing layout being more likely in new housing. The model shows that what starts out with an R-value of R 2.6 and R 2.4 respectively becomes R 1.7 and R 1.5 when edge gaps of 20 mm are included.

It acknowledges that in reality gaps as bad as 20 mm would be less likely found in high-performance wall insulation products. The reason given being the higher density allows that they can usually be cut and fitted with a better tolerance than lower R-value products.

However, an expanded view of the modelling results for small gaps suggests that gaps are still significant, given that 4 mm gaps result in a 12% to 15% lower system R-value.

The article concludes that well fitted high-performance insulation products will insulate effectively.

This latest BRANZ research could also indicate that the R-value of these homes audited may in fact fall short of the required R-value of the Building Code. The homes that would be at greater risk would be those where the minimum required R-value has been applied. If this were to be found, then new homes being built with incorrect insulation installation that did not meet the requirements of H1 of the Building Code should not be issued a CCC.

This current audit research would conclude that "well fitted" is the critical denominator that is failing to be achieved at this point in time.

6.4.2.2 Deterrents

Education and training is a proactive approach to this issue of non-compliance and non-conformance. However, another aspect that could be considered would be possible deterrents.

There is a naturally occurring deterrent when a BCA refuses to sign off on the Preline, insulation, or Final inspection until the insulation issues have been addressed and reinspected.

The ramifications of this deterrent may be many.

- Firstly, the builder cannot proceed with building work; therefore there is an immediate cost and time delay to him.
- There could be financial penalties due to non-conformance of completion deadlines.
- There may be a cost to the party that caused the non-compliance to revisit the property and make good any issues.
- They may also incur financial penalties for breach of contractual agreements.
- Consistent poor performance or non-conformance could result in service contracts being cancelled.

This deterrent is only occurring where the BCA is actively enforcing compliance. Therefore, it is not happening in all situations.

The desired effect of such a deterrent would be to create an impact on all parties involved in such a way that compliance will be the desired outcome for every property.

Currently the BCA would be the natural deterrent enforcer, although with proposals to allow self certification,, other quality assurance systems or deterrents may need to be considered.

6.4.3 Additional Recommendations

6.4.3.1 Documented Processes and Systems for the Builder / Project Manager

For those not already doing so, it is recommended this industry implement documented building processes and systems, which should include internal compliance auditing for quality assurance. The processes and systems for the installation of insulation should be as recommended for the professional installer.

6.4.3.2 Self Certification

This research highlights some steps that would need to be put in place if the Building Act Review proposal from DBH for self certification of building work, including the construction of new houses is to be successful. None of the installations met all requirements of the Standard, and all of the properties had builders or project managers involved one of which may likely become a self certifier.

If the self certification program is to be implemented, then it will require the LBP or suitably qualified person to have a sound knowledge of the requirements of the Building Code, and ideally the reasoning for, or ramifications of non-compliance with the Standard. Sub-standard installations could result in a failure to meet Building Code compliance.

It is also recommended the person undertaking the self certification must implement documented building processes and systems, which should include internal compliance auditing to ensure a quality assurance process is in place.

If this does not occur, the results of this research would indicate the self certification system will not work.

6.4.3.3 Downlight Manufacturers.

There is clearly confusion for installers of recessed lighting systems regarding their installation and appropriate clearances to insulation. The Standard requires that insulation shall be installed to ensure that the clearance (if any) is in accordance with Table 1 of the Standard. This table has been taken from NZECP 54 and classifies recessed luminaires into five classes and three thermal insulation clearance classes.

It is evident from the findings of this audit that this is not being followed and suggests that clearer instructions need to be provided, ideally to the light fitting itself. On viewing the downlights in situ, it is not possible to determine whether it is in a class that permits the insulation to be butted to the lighting, requires a 100 mm gap, or is as specified by the manufacturer.

It was noted that in two instances upon questioning by the BCA, the tradesperson on site was able to provide documentation that confirmed the down light system could be butted to the insulation. However, this was only provided upon questioning, and was obtained from the tradesperson's vehicle. Given the thermal insulation clearance distance is in relation to safety aspects as well, it may be time the manufacturers help resolve this significantly occurring issue.

6.4.3.4 Professional Installers Comments

During the audit, we were contacted by a professional installation company seeking information. During this conversation the installer advised that he was finding many of his installations in new properties were failing the Preline inspection by the BCA. This was purportedly happening due to this audit. However, we were not auditing in some of the areas he identified. In the first instance, the statement would suggest that there are BCA's identifying defective installations and enforcing it be rectified, as is their duty.

The installer then went on to make the statement that while he conceded gaps and tucks are not acceptable and could justify a failed Preline, there were other areas that were difficult to insulate and he took exception to them being failed. This supports some of the points raised with this report whereby consideration has to be given in the design process to ensure the appropriate cavity spaces are provided where required for insulation under the Standard. It also supports the points raised regarding the design requiring some areas may need to be insulated by the builder as the building envelope is being enclosed.

The installer also raised the point that the failure to obtain an approved Preline inspection came at a cost, however he did not venture as to who should incur the additional cost. In this instance he was referring to the additional secondary Preline inspection cost.

6.4.3.5 Audit Continuance

It was decided by EECA that 52 audits should be undertaken to obtain a snapshot of what might be happening in the industry, and determine if any trends could be established. However, it was an overwhelming result of 100% of properties audited that were subject to defects whether they were minor, medium, or major in the rate of their occurrence.

Logic would suggest there are two possible positions to take in considering whether to proceed with further audits.

1. It is suggested by EECA that 5% of the total units should be assessed to obtain an accepted indicator of the performance of a given subject. With 12% of that target showing a 100% trend, there may be merit in accepting this trend will continue and moving straight to resolution mode. This position could be a further supported by the relative randomness and geographic spread of the audits undertaken to date.

   Rather than spending more energy and costs in continuing to audit, it could be better directed towards the necessary implementation of training and auditing of those identified as being involved in the insulation installation process.

2. The results to date show 100% non conformance and non-compliance with the Standard for insulation installation in new build homes. Such a definitive outcome would certainly support the need to investigate this further to establish the extent of this issue to support the necessity for change at Code, Standard, and legislative levels.

   However, in order for this to be achieved it would require that all BCA's would have to provide access to properties at the required times for further audits to be undertaken. Without this assistance from BCA's, it could be timely and difficult to undertake the number of audits that would be required.

It will take time for the necessary implementations to take place. Therefore the findings of this research show that it is important some form of audit or quality assurance be continued until such a time that it is known that the quality of insulation installation has been improved.

6.4.3.6 Recognising the Standard

The Standard was developed in 2006 and sets the quality requirements for installation of insulation in both new and existing houses. The findings of this audit have clearly demonstrated that the Standard is not being adhered to, given the high rate of non-compliance found.

While compliance with the Standard may arguably exceed the requirements of the Building Code, this research shows strong evidence that significant failure to comply with the Standard will result in non-compliance with the Building Code.

The Standard is an important reference document to help ensure insulation is installed safely and correctly. Complying with the Standard would aid compliance with the relevant clauses of the Building Code; therefore consideration should be given to recognising the standard as an accepted reference in the Building Code Compliance Documents. Currently the Standard is not referenced.

7 Appendix

7.1 NZS4246:2006 Energy Efficiency – Installing insulation in residential buildings

This is a copyright document. An authorised copy of the Standard can be reviewed at:

https://ewhg.eeca.govt.nz/UserFiles/Best%20Practice%20Guide.pdf

An amended version of this Standard was launched at the completion of this Audit. It was not used for this research.

The amended version is identified by the words "Incorporating Amendment No.1" under the Standard identification NZS4246:2006 at the top right of the cover page.

7.2 Manufacturers and Industry Insulation Installation Instructions and Appraisals - Extracts.

Pink Batts: Installation instructions for Pink Batts insulation April 2004.

"It is presently mandatorily to install insulation to required Standard in all new houses and building inspectors/certifiers are checking to ensure that these Standards are maintained."

Other references are made;

To where it is necessary, cut Pink Batts insulation to allow for obstructions, and fit them into smaller spaces.

In a framed roof the ceiling joists are usually spaced at 450 mm centres and the Pink Batts installation will fit snugly between the joists. The truss centres on a truss roof are generally 900 mm and two pieces of Pink Batts insulation should be installed snugly side-by-side between the trusses.

All areas of ceiling should be insulated to the top plates of exterior walls.

If Pink Batts insulation does get wet, ensure it is removed and dried, or replaced, before proceeding.

All of the wall space and exterior walls should be insulated from top to bottom plates. Insulation offcuts can be used to insulate the small gaps around window frames and doors.

Special attention must be given to electrical and plumbing fittings when insulation is installed.

Wherever possible, Pink Batts insulation should be laid beneath electrical wiring or pipes. However, if the insulation is likely to be considerably compressed, it should be placed over the pipes or wiring.

Generally 150 mm gap should be provided between insulation and recessed light fittings.

Extractor fan units should be insulated around, and not over.

Timber framing should be sufficiently dry before the insulation is installed.

BRANZ appraisal 238[2008] for Pink Batts glasswool insulation:

Pink Batts must be installed in accordance with the manufacturer's technical literature to meet the stated thermal performance rating of the insulation.

Pink Batts are designed to be friction fitted between wall ceiling or roof framing.

To prevent moisture transfer to Pink Batts glasswool insulation, a separation (minimum 25 mm) is required between Pink Batts glasswool insulation and any flexible roof underlay.

The specified clearances of heating appliances and recessed light fittings must be met. The use of recessed light fittings may, therefore, reduce the thermal performance of insulated ceilings.

Installation is to be carried out by trained installers only.

NZS4246 should be used as a guide for installing insulation in residential buildings. The product must be installed only when the building is enclosed and when the construction materials have achieved the required maximum moisture content or less, to ensure the insulation does not become wet.

Pink Batts must be cut to fit into cavities where required.

The insulation must either be neatly friction fitted between framing members and linings, or fitted over framing members and butted tightly so that the potential for gaps and convective heat loss is eliminated.

The material must not be folded, tucked or compressed.

A close, even fit provides the most efficient thermal performance.

The insulation must be continuous across the entire roof or ceiling plane between top plates of external walls, and fitted either between or over rafters, ceiling joists or truss chords.

Wherever possible, the insulation should be fitted beneath wiring or plumbing.

The technical literature must be referred to during the inspection of Pink Batts installation by the building consent authorities and territorial authorities

4711B Bradford thermal insulation (2009)

Install in housing to NZS 4218, and NZS 4246:

Do not cover extractor fan units, and cut around all recessed light fittings and metal flues to the safety requirements of NZECP 54.

Lift up all electrical wires and lay segments underneath.

Friction fit Bradford Gold insulating segments in place. Carefully scribe cut insulation slightly oversize to maintain friction fit to each other, to smaller spaces and around penetrations.

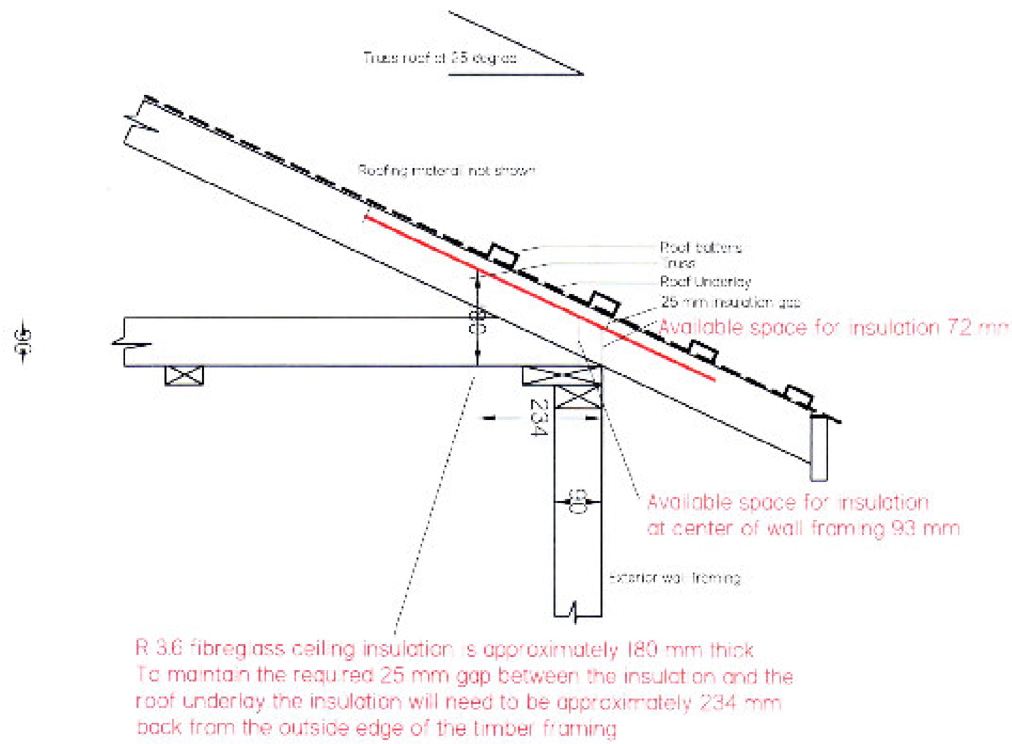
Leave no gaps between, and maintain full thickness of the insulation over the whole of the installation.

Leave a 150 mm gap around metal flues and recessed light fittings, when not using CA approved downlights.

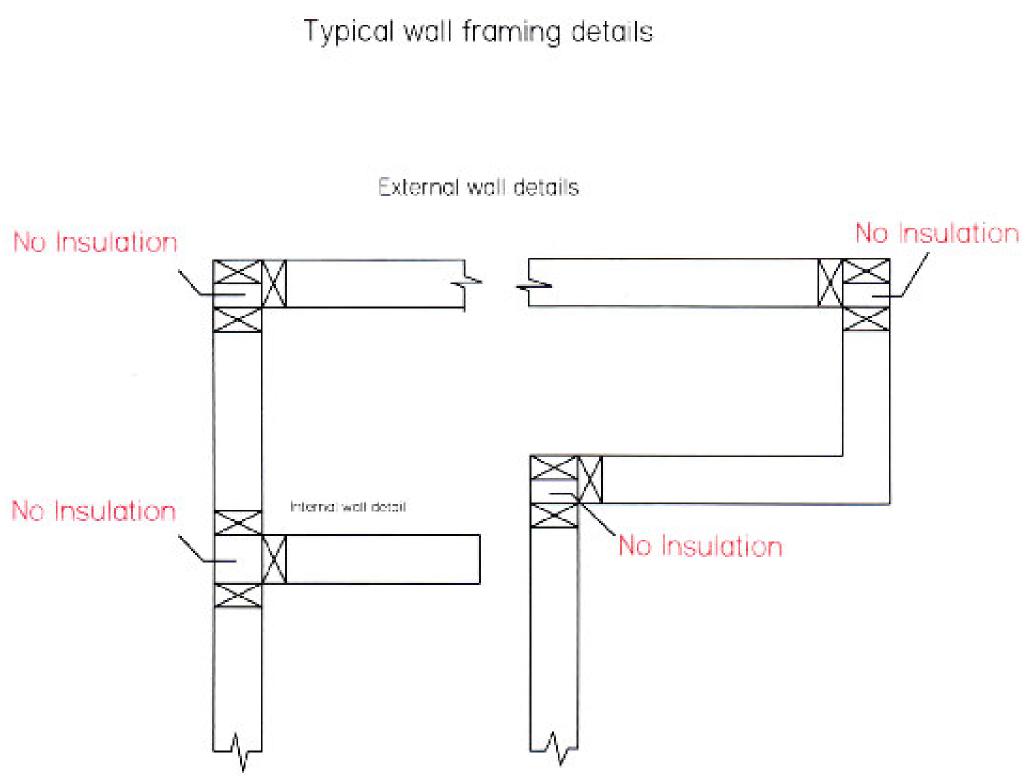
There are similar comments made for roof installation.

7.3 Typical Wall to Truss Detail

Typical wall to truss detail



7.4 Typical Wall Framing Detail



7.5 Gallery of pictures taking during auditing

Photo 1

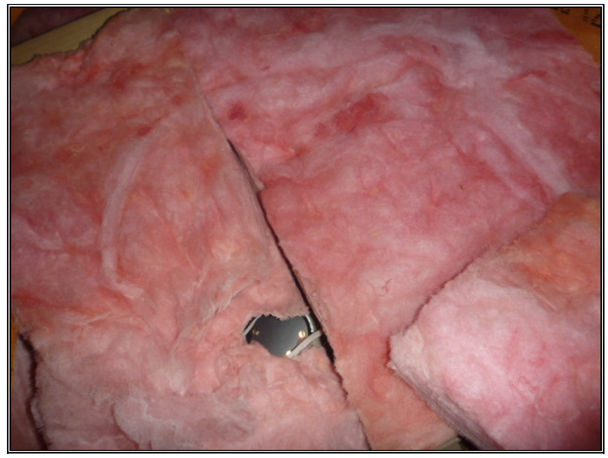
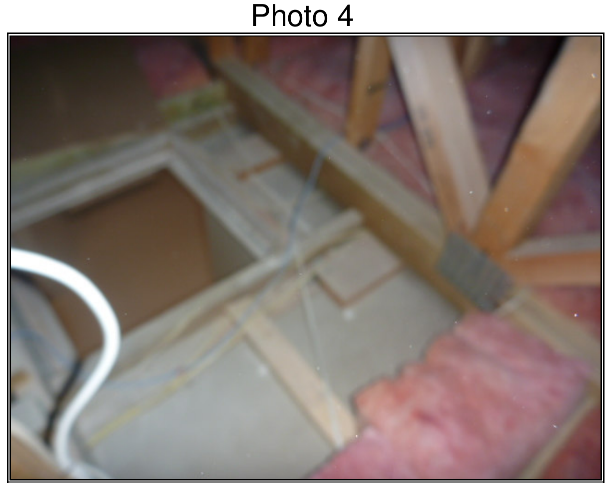


Photo 2

Photo 3

Photo 4

Photo 5



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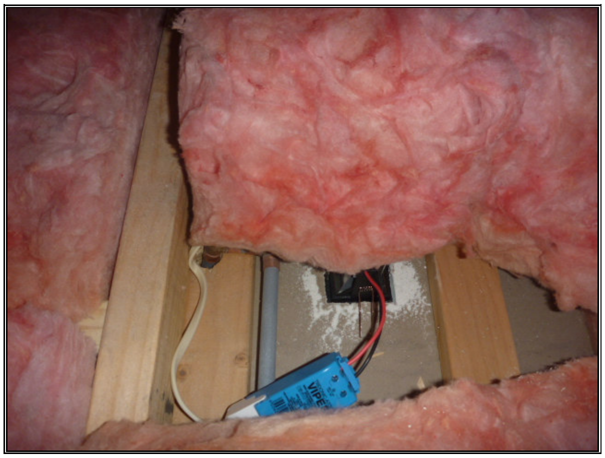

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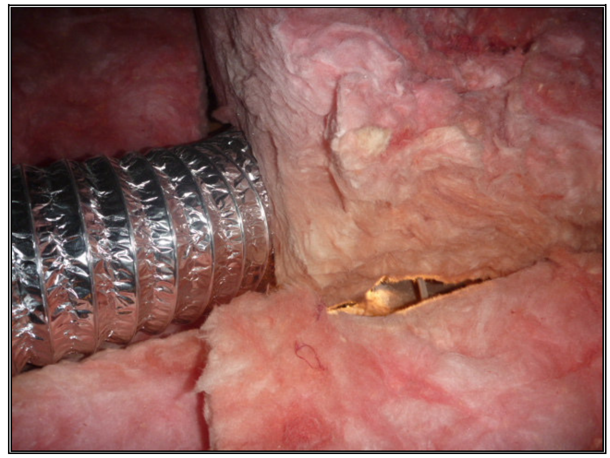


Photo 8

Photo 9

Photo 10

Photo 11

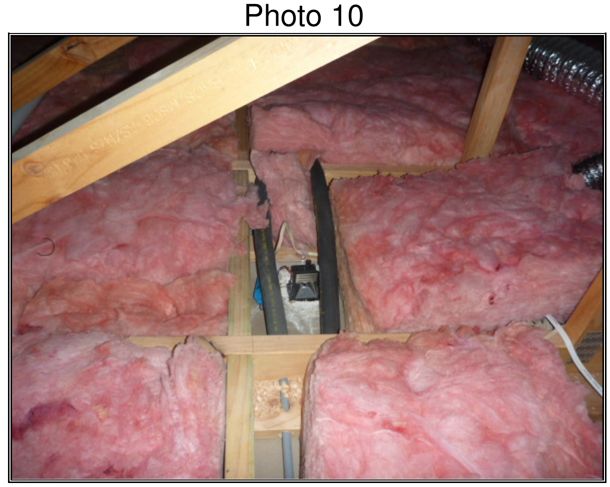


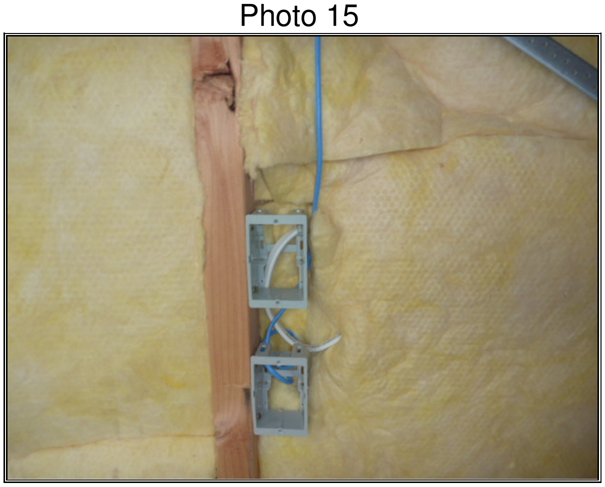
Photo 12

Photo 13

Photo 14

Photo 15

Photo 16



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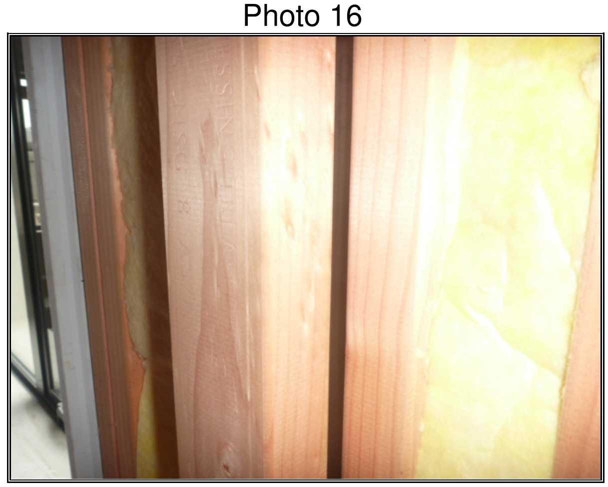

Photo 18

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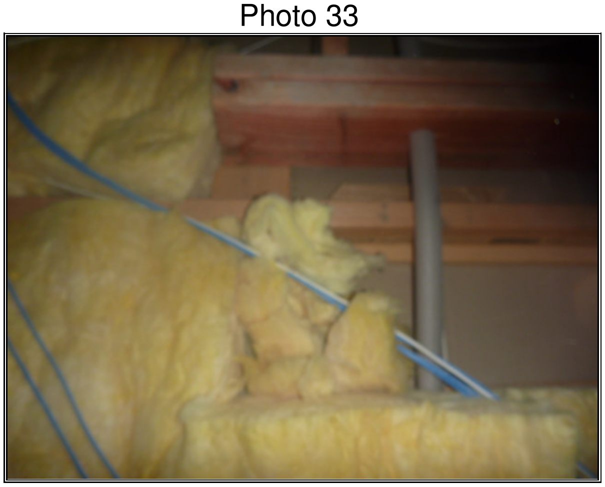
Photo 34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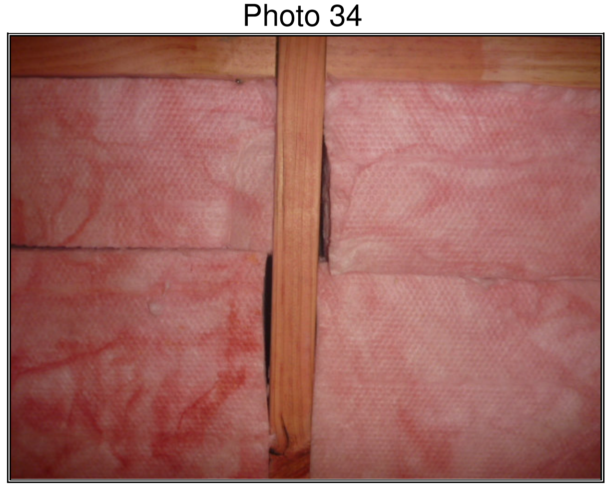
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Photo 37

Photo 38

Photo 39

Photo 40

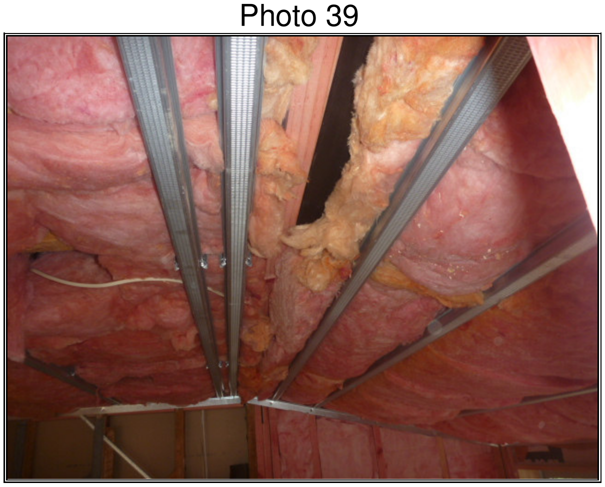

Photo 41

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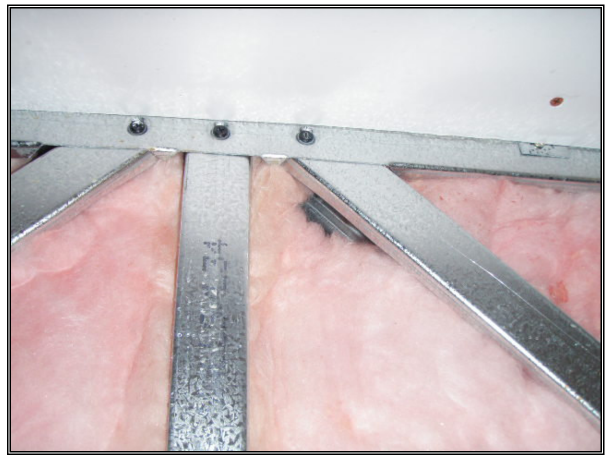
Photo 57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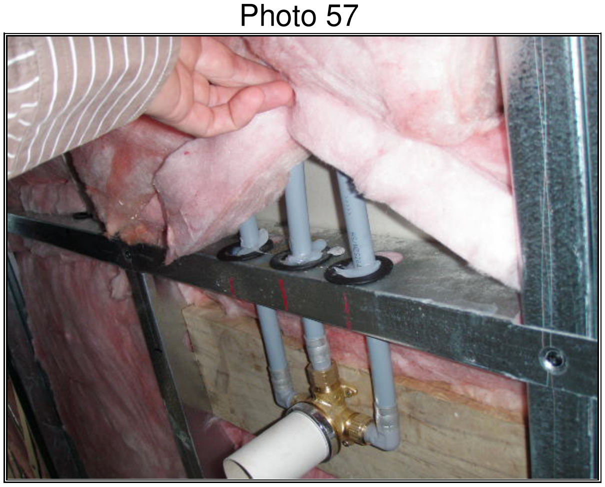
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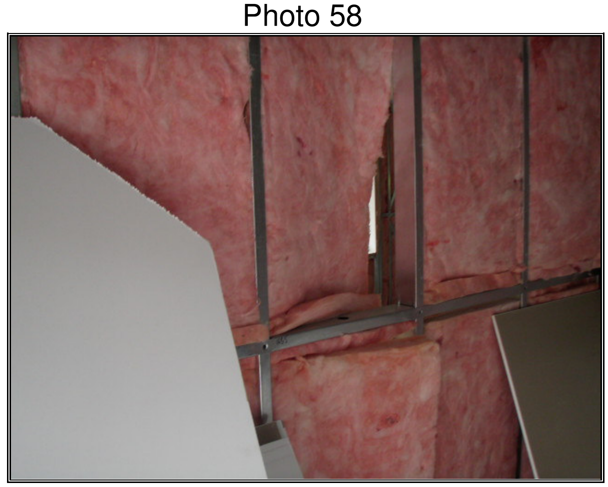
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