MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HIKINA WHAKATUTUKI

Determination 2016/031

Regarding the issuing of a code compliance certificate in respect of thermal insulation to a hot water cylinder and hot water pipework to a house at 177 Keyes Road, Christchurch

Summary

This determination considers the requirements under Clause H1.3.4 in regards to insulation of a TPR valve and a length of hot water pipework, and Clause G9 in regards to the location of an electrical cable in a duct with the water supply pipework. The determination discusses the application of the relevant Acceptable Solutions and associated Standards as a means of establishing compliance.

1. The matter to be determined

1.1 This is a determination under Part 3 Subpart 1 of the Building Act 2004[1] ("the Act") made under due authorisation by me, John Gardiner, Manager Determinations and Assurance, Ministry of Business, Innovation and Employment ("the Ministry"), for and on behalf of the Chief Executive of the Ministry.

1.2 The parties to the determination are:

- M Pring, the owner of the house ("the applicant")
- Christchurch City Council ("the authority"), carrying out its duties as a territorial authority or building consent authority

1.3 I consider the building company and the electrician are persons with an interest in the determination.

1.4 This determination arises from the applicant's opinion that the code compliance certificate was incorrectly issued by the authority. The applicant holds the view that the un-insulated hot water pipework running from the hot water cylinder ("HWC") to the kitchen sink and dishwasher, plus the installation of the HWC itself, does not comply with the consented plans, the Building Code, Acceptable Solution H1/AS1, and NZS 4305[2].

1.5 During the assessment of the above the compliance of an electrical cable also located in the same duct as the hot water pipe was brought into question (refer paragraph 5.2.4).

[1] The Building Act, Building Code, compliance documents, past determinations and guidance documents issued by the Ministry are all available at www.building.govt.nz or by contacting the Ministry on 0800 242 243.
[2] New Zealand Standard NZS 4305: 1996 Energy efficiency - domestic type hot water systems, cited in H1/AS1

1.6 The matters to be determined[3] are therefore:

- whether the HWC TPR[4] valve and the hot water pipework run from the HWC and through a duct to serve the kitchen sink and dishwasher complies with Clause H1 of the Building Code (First Schedule, Building Regulations 1992)[5]
- whether the location of the electrical cable in the duct complies with Clause G9 Electricity
- whether the authority correctly exercised its powers in issuing a code compliance certificate for the building work in respect of the hot water pipework serving the kitchen sink and dishwasher.

1.7 In making my decision, I have considered the submissions of the parties, the reports of the independent experts engaged by the Ministry to advise on this dispute, and the other evidence in this matter.

2. The building work

2.1 The house is timber-framed with a reinforced concrete foundation slab incorporating a grid of polystyrene formers that also serves as insulation. The house is clad with fibre-cement weatherboards and a steel roof. The house has three bedrooms with a bathroom, laundry, ensuite bathroom, plus kitchen/ living/ dining area. The plan of the house is shown in Figure 1 below.

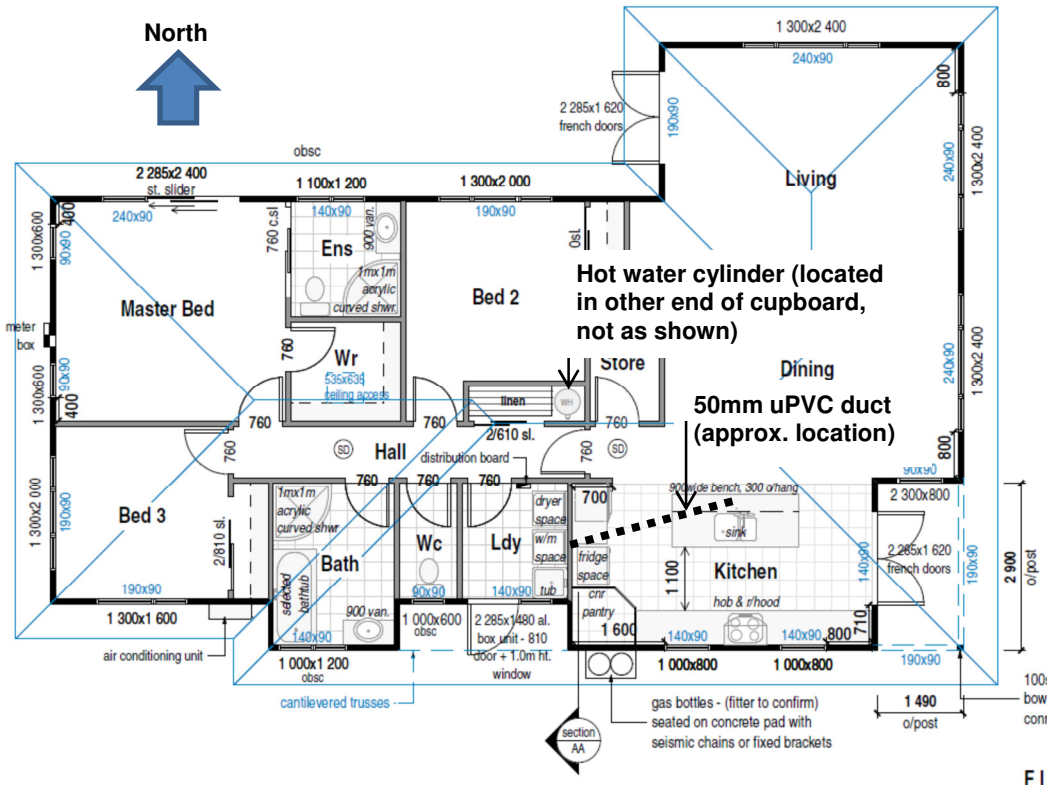

Figure 1: Floor plan of the house showing location of the duct

[3] Under sections 177(1)(a), 177(1)(b) and 177(2)(d) of the Act
[4] Hot water cylinder temperature pressure relief valve
[5] In this determination, unless otherwise stated, references are to sections of the Building Act and references to clauses are references to the Building Code.

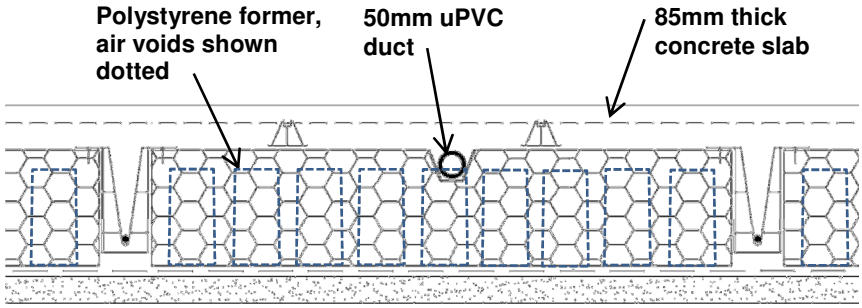

Figure 2: Schematic section showing 50mm duct located in floor slab

2.2 The hot water is produced by an electric mains pressure hot water cylinder centrally located between the, bathroom, ensuite bathroom, laundry, and kitchen.

2.3 Copper pipework is installed immediately adjacent the hot water cylinder with the first 500mm section of copper from the cylinder to the tempering valve fitted with closed cell foam insulation. The remaining water supply pipework is made of polybutylene in 15mm and 20mm diameter pipe.

2.4 From the photographic evidence provided, none of the polybutylene pipe is insulated. Hot and cold polybutylene pipework is installed in the ceiling space and is covered by the ceiling insulation (200mm thick fibreglass batts).

2.5 The kitchen sink and dishwasher are located in an island bench in the middle of the kitchen, with water and power run to the bench in a 50mm diameter uPVC duct, located in a slot cut into the polystyrene formers under the slab that runs west from the sink to the adjacent wall: the duct is approximately 3.0m long. The hot and cold water pipes and power cable run loose in the duct.

2.6 The house foundation is a proprietary reinforced concrete system that uses 1100x1100x200mm expanded polystyrene formers located on a 1200mm two-way grid. The foundation system has a nominal thickness of about 300mm with a slab thickness of 85mm.

2.7 The formers are not solid polystyrene and have a 'honeycombed' underside with air voids formed in the underside of the former (refer Figure 2 above). The underside of the duct will be located over and/or be in contact with a mix of polystyrene and the air voids in the former. The minimum R-value of individual formers through their vertical dimension is approximately 1.2 $m^2.^oC/W$ (based on a minimum 50mm thickness of low density polystyrene taking account of the air voids).

2.8 The pipe run from the hot water cylinder to the kitchen sink is approximately 11m in total; the pipe run varies in diameter with the first approximately 3.5m from the hot water cylinder being 20mm in diameter pipe, and the remainder 15mm in diameter pipe.

2.9 An electrical cable is installed in the 50mm duct along with the hot and cold water pipes; the cable provides power to the dishwasher. The cable is TPS sheathed $2.5m^2$, twin plus earth.

3. Background

3.1 On 26 August 2013, the authority issued Building Consent BCN/2013/7284 for the construction of the dwelling and detached garage.

3.2 On 21 February 2014 the authority emailed the applicant seeking information regarding the hot water pipework to confirm it would meet the performance requirements of Clause H1.

3.3 On 25 February 2014 the applicant emailed the authority noting that the solution would be either to comply with the current standard, or for the building company to supply further information. The applicant commented that any possible thermal resistance improvement gained by the insulated slab construction 'would be negated by the added thermal conductivity from the cold water supply and power cable directly contacting the hot water pipework within the under floor duct'.

3.4 On 5 March 2014 the authority emailed the applicant with the following advice, in summary:

- Clause H1.2(b) states buildings must be constructed to achieve an adequate degree of energy efficiency when that energy is used for providing hot water to sanitary fixtures or sanitary appliances, or both. This section does not apply as the fixture in question (the kitchen sink) is not considered a sanitary facility.
- The authority provided definitions for sanitary appliance, sanitation and sanitary fixture from Clause A2 of the Building Code, and referred to commentary in the Acceptable Solution G12/AS1.
- The authority stated 'the hot water run to a kitchen sink … can be delivered … at a temperature hotter than the specified 55 degrees for sanitary facilities in a dwelling'.

3.5 On 7 March 2014 the applicant emailed a response to the authority stating (in summary):

- the actual kitchen plan of the building has a dishwasher installation which receives its hot and cold water supply from the same pipes in the 'island' bench next to the kitchen sink
- the kitchen sink is a sanitary fixture as it is also used to wash utensils. Paragraph 1.1.2 of NZS4305 refers to sanitary appliances and sanitary fixtures as including 'utensil washing'

3.6 The authority responded on the same day noting that the installation was 'typical through-out' the region, and that the R value 'needed to be achieved for lagging pipes in this location is R 0.54.' The authority then suggested the applicant apply for a determination on the issue.

3.7 On 27 March 2014 the authority issued a code compliance certificate for the dwelling and detached garage.

3.8 The Ministry received an application for determination on 15 September 2014.

4. The submissions

4.1 The initial submissions

4.1.1 On 24 September 2014 the Ministry sought clarification from the applicant on how the matter for determination had arisen and requested clarification of certain matters relating to the construction of the hot water pipework. The applicant responded on 25 September 2014 (in summary):

- The house has been built without insulated hot water pipes 'in accordance with the consented plans'; the hot water pipework does not meet Clause H1.3.4(b).
- The consented plans require the hot water pipes to be thermally insulated to meet H1/AS1. Only a 500mm long section of pipe has been insulated. The TPR valve is not insulated.
- The utensil washing in a dish washer falls within the definition of a sanitary appliance.
- Full insulation surrounding the full circumference of the hot water pipework to the kitchen sink is required under NZS 4305.

4.1.2 The applicant provided the following documentation with the application:

- Photographs of the kitchen floor showing hot water pipework (the applicant provided further photographic evidence in colour of the kitchen pipework on 6 October 2014).
- Excerpts from NZS 4305.
- The code compliance certificate.
- Correspondence between the applicant and the authority between 21 February 2014 and 7 March 2014.
- The definition of 'utensil' from the Oxford Dictionary.
- An article from the BRANZ Build magazine on pipe insulation[6].

4.1.3 The authority responded to a request for information from the Ministry on 3 October 2014, providing site inspection records. It is stated on the inspection records that issues with water supply pipework needed to be addressed before the final inspection took place: for example, on inspection record dated 18 February 2014 it is noted:

> No inspection completed. Miner (sic) issue with water feed from exterior [wall] to Island bench. Pipe work, lagging.
>
> Until this issue is addressed. [Residential – Final] inspection for compliance cannot be completed.

4.1.4 In a follow-up final inspection on 5 March 2014 the authority recorded:

> Prior issue regarding water pipe connecting to Island sink in kitchen.
>
> Thought to have compromised H1 code clause due to ducting of pipework in PVC sleeve not insulated inside raft foundation
>
> However, this applies to connections to sanitary fixtures. Kitchen sink is not a sanitary fixture.
>
> Code compliance [certificate] can now be issued.

[6] *Pipe insulation,* Build Issue No. 125 (1 August 2011)

4.2 The first draft determination and responses received

4.2.1 After considering the findings in the two experts' reports (refer paragraph 5) I issued a first draft of this determination to the parties on 30 April 2015. The first draft confirmed that the water supply to the kitchen sink was required to comply with Clauses H1 and G12. The draft stated that although the means of compliance set out in the building consent documentation was unclear and the installation is not in accordance with NZS 4305, the loss of heat from the pipework located in the duct was not significant. The draft concluded that the hot water pipework complies with Clause H1.3.4(b) and confirmed the authority's decision to issue the code compliance certificate.

4.2.2 The authority accepted the draft without further comment in a response received on 11 May 2015.

4.2.3 The applicant did not accept the draft and made a further submission in response to the draft, which was received on 13 May 2015. The applicant noted some minor errors that have subsequently been amended, and raised some issues regarding the second expert's report which I have summarised at paragraph 5.3.

4.2.4 The applicant also submitted the following:

- There are mandatory requirements in NZS 4305 that have not been complied with.
- The Build article notes 'that hot water pipes must be insulated and enclosed in a duct when embedded in concrete[7], and that all hot water piping should be lagged'.
- The heat loss calculated in the second expert's report shows there has been disregard for the requirement under Clause H1.1 to 'Facilitate efficient use of energy'.
- Paragraph 3.7.4 of NZS 4305 has been misread; it requires that the hot water pipe be thermally insulated and installed within a duct.
- There is no data to prove that there is any insulation advantage with a waffle slab foundation.
- Paragraph 3.3.2 of NZS 4305 states that the TPR valve must be insulated, and this has not been carried out. Paragraph 3.7.2 of NZS 4305 states that all the hot water supply pipes to the kitchen should be insulated.
- For the authority to 'make a decision based on common practice and possible commercial pressure … is improper'. Insufficient objective information was used to support the authority's conclusion.

4.3 The second draft determination and responses received

4.3.1 I engaged a third expert to provide advice on the thermal properties of the materials (refer paragraph 5.4). I considered the submissions of the parties and the findings of the third expert and amended the draft determination as I considered appropriate. A second draft determination was issued to the parties on 7 August 2015. The second draft maintained that the hot water pipework complies with Clause H1.3.4(b) and confirmed the authority's decision to issue the code compliance certificate; the draft discussed compliance by way of an Acceptable Solution and as

[7] The Build article lists some of the requirements and recommendations of NZS 4305 in relation to the insulation of residential pipework.

an alternative solution, and also commented briefly on the electrical cable installed in the duct with the hot water pipe.

4.3.2 The authority accepted the draft on 17 August 2015 noting typographical errors.

4.3.3 The applicant responded on 21 August 2015 saying that the draft was not accepted. The applicant made a substantial submission noting the following (in summary):

- The Objective Clause H1.1 is to "Facilitate efficient use of energy"'. Clause H1.3.4(c) was at issue here and required hot water systems to facilitate the efficient use of hot water.
- The determination arises from the non-compliance with the consented building plans in regard to the insulation of the hot water system in accordance with H1/AS1 5.0. There is no insulation on any other hot water pipe (apart from .5m next to water cylinder).
- The BRANZ Build article (refer paragraph 4.1.2, 6th bullet) states 'insulation is required on the hot water pipes as per NZS 4305'
- 'The remainder of the hot water supply is in contention', not just the insulation to the pipe under the slab. The applicant referred to the email to the Ministry dated 25 September 2014 (refer paragraph 4.1.1).
- Verification Method G12/VM1 'states that AS/NZS 3500 Part 4 is an acceptable means of compliance. … the plumber should have followed the [AS/NZS] 3500 Part 4…'
- 'The pipe manufacturer's instructions for installation are clear, they state "The system must be installed to the requirements of AS/NZ 3500 [1.2 and 4.2] …", and that the pipes require insulation in freezing conditions.'
- Photos of the foundations show slots cut into the polystyrene formwork to take pipework
- The temperature of the outside of the pipe observed by the first expert (refer paragraph 5.1.3, 3rd bullet) shows there is heat loss from the pipe. The determination's contention that still air acted as an insulator was not apparent from the evidence. The time it had taken for the cold water to the sink to run cold showed there was heat transfer between the hot and cold pipes.

4.3.4 The applicant restated the breaches as he saw them, and said the conclusions reached in the second draft determination were inaccurate and based on subjective information.

4.3.5 In an email received on 11 September 2015, in response to a request for clarification from the Ministry, the applicant stated that the following requirements of NZS 4305 had not been met:

- Paragraph 3.3.1 – TPR valves shall be thermally insulated
- Paragraph 3.7.2 – Pipe from HWC to kitchen sink should be insulated
- Paragraph 3.7.4 – Hot water pipes embedded in concrete to be insulated and installed in a duct
- Paragraph 3.8.1 – Pipe insulation shall have an R-value not less than 0.30 m2.C/W.

4.4 The third draft determination and responses received

4.4.1 I considered the submissions received and amended the draft determination as I considered appropriate and a third draft determination was issued to the parties on 12 October 2015. The discussion included a more detailed analysis, but the conclusions reached remained the same.

4.4.2 The authority accepted the draft without comment on 21 October 2015

4.4.3 The applicant responded on 26 October 2015. The applicant did not accept the findings and submitted (in summary):

- It was the authority's responsibility to ensure the consent documents correctly specified the work. The authority had failed to properly address the requirements of NZS 4305. The matter was disputed with the builder and the authority 'well before the final inspection'
- A craftsman plumber should be able to fabricate an insulated cover to a TPR valve.
- The water flow when the system was tested by the first expert (refer paragraph 5.1.4) was low and it would take longer for any latent heat build-up to dissipate.
- The assumption that hot and cold water pipes were located alongside one another was incorrect – before the pipes entered the wall leading to the duct they came from different directions.
- The insulation effect of still air being trapped around an uninsulated pipe was far below the minimum required by the relevant standards.
- The requirements of the standards were mandatory. The installation requirements of the standards sited in G12/VM1 were not followed. The requirements stated in the consent drawings were also not followed.

4.5 The fourth draft determination and responses received

4.5.1 A fourth draft of this determination was prepared that included consideration of the installation of the electrical cable in the duct, noting that the installation was not in accordance with AS/NZS 3000 and concluding it did not satisfy Clause G9 Electricity. The draft was issued to the parties and persons with interest for comment on 15 March 2016.

4.5.2 The applicant's response was received on 31 March 2016. The applicant did not accept the draft and made a detailed submission: this reiterated some of the points raised previously, and noted some errors and omissions. In summary the submission stated:

- 'There has not been any scientific data provided by the builder, the authority or [the Ministry] to justify the fact that there is an actual increase in thermal resistance within the duct due to the rib raft type foundation'
- The instructions by the pipe manufacturer in relation to insulation were not followed. The consent documents were clear in what was required, the builder and the plumber did not refer to 'the specifications'.
- Site photos show the duct embedded in the concrete floor. 'If the duct was laid according to the floor designer's specifications, the pipes would be wrapped or sleeved with tape. … There is no tape or sleeve around the duct'

- 'The word embed means "to place or set (something) firmly in something else" (Online Webster Dictionary). The duct is firmly embedded in the floor …'. This meant the hot water pipe is embedded in a concrete floor and must be insulated.
- The submission listed the Building Code non-compliances in relation to the G12/VM1, Clause H1.3.4, NZS 4305, and the Act. The determination's decision was not accepted as an alternative solution.

4.5.3 On 18 May 2016 the applicant provided annotated photos of the foundation before the concrete was laid showing drainage pipework and the 50mm duct located in open channels formed in the polystyrene formers. I note that the drainage pipework is wrapped in plastic so it is isolated from the concrete and is able to move independently of it. There is no requirement for the 50mm duct to be similarly isolated.

4.5.4 The electrician responded by email on 27 June 2016 saying that the installation of a duct for the cable was the responsibility of the builder who prepared all ducting in the house. The electrician did not know which was installed first, the electrical cable or the water pipes.

4.5.5 The authority responded to the draft on 14 July 2016. The authority accepted the draft and offered no comment other than that it would rely on the expertise of others.

4.5.6 The building company made no substantive submission in response to the fourth draft.

4.5.7 I have amended the determination as I consider appropriate.

5. The experts' reports

5.1 The first expert's report

5.1.1 As stated in paragraph 1.7, I commissioned an independent expert who is a member of the New Zealand Institute of Building Surveyors ("the first expert") to confirm the as-built construction and to carry out some temperature testing. The first expert visited the site on 5 November 2014, and provided a report on 19 November 2014. That report was forwarded to the parties on 18 December 2014. (It is noted that the expert inadvertently identified the pipework manufacturer incorrectly, but identification of the manufacturer is clear from the pipe markings in the photographs included in the expert's report.)

5.1.2 The first expert recorded the diameter and the estimated the length of pipe from the hot water cylinder to the sink as described in paragraphs 2.5 and 2.8.

5.1.3 The first expert recorded the following temperatures during testing:

- 55°C within less than 1 minute at the kitchen faucet.
- The surface of the polybutylene pipe under the sink at 24°C[8] after running the hot tap for about five minutes, with the surface of the pipe at the top of the wall between the kitchen and laundry at the same temperature immediately after.

[8] The expert noted that the infrared thermometer used to record the surface temperature was not calibrated and the accuracy could not be guaranteed.

- 35°C at both locations after 10 minutes of running the hot tap.

5.1.4 The expert also noted that the temperature of the cold water was 'hot for approximately 15 seconds' after running the hot tap continuously for 10 minutes before shutting it off.

5.2 The second expert's report

5.2.1 Following the assessment by the first expert, I commissioned an independent expert who is a services engineer ("the second expert") to assess the likely heat loss from the hot water pipe under the slab and provide technical comment. The second expert reviewed the relevant documentation and provided a report on 12 February 2015. The expert's report was forwarded to the parties on 6 March 2015.

General

5.2.2 The second expert observed that the installation was not in accordance with the consent documentation, with construction notes stating that the hot water pipework was to be insulated to comply with H1/AS1 paragraph 5.0, which in turn cites NZS 4305. However, paragraph 3.1.1 of that standard states that 'all installations shall be installed according to the manufacturer's instructions, and appropriate Standards'. In this case the manufacturer's technical manual states:

> Insulation
>
> The thermal conductivity of [polybutylene] is a lot lower than that of metal therefore hot water pipes do not require insulation.

5.2.3 The second expert also stated his view that the use of NZS 4305 is 'contentious' as it does not reflect the thermal characteristics of various plastic piping systems now available, it is not fully complied with by the plumbing community, and not fully enforced by the regulatory authorities. The expert noted that plastic piping, particularly polybutylene, is in practice generally not insulated.

5.2.4 The second expert also pointed out that AS/NZS 3500.4, paragraph 4.3.2.2, states that above ground pipework associated with heated water services shall not be installed within 100mm of electrical cables.

Heat loss calculations

5.2.5 The thermal conductivity of the polybutylene pipe stated by the manufacturer is 0.22 W/(m.K).

5.2.6 The second expert noted there would be little difference in heat loss of an uninsulated hot water pipe should it be located within a wall, ceiling, or duct in a concrete floor, and the same could be said for an insulated pipe.

5.2.7 The second expert calculated the heat loss per metre of pipe as 27.1 W/m for the uninsulated pipework within the 50 uPVC duct. In comparison the heat loss was calculated at 8.5 W/m with 13mm of insulation.

5.2.8 On 16 March 2015 I sought further clarification from the second expert regarding the calculation of the R-value. The information received was superseded by the information received from the third expert.

5.3 The applicant's submission on the experts' reports

5.3.1 In the applicant's submission in response to the draft determination, the applicant commented on aspects of the second expert's report as follows:

- The second expert identifies heat loss from an uninsulated polybutylene pipe as being three times that of an insulated polybutylene pipe.
- Polybutylene pipe has been in use since 1970 and was therefore known when NZS 4305 was written. NZS 4305 is generic for all pipe materials and does not make reference to any particular pipe material.
- If the determination finds the hot water pipework is compliant, by inference it condones the breach of NZS 4305 in respect of the underground piping next to the electrical cables.
- The difference between the pipes in the walls/ceilings and those within the duct is that the hot water pipe in the duct is in contact with the cold water pipe and the electrical cable. There is thermal conductivity between the various pipes.

5.4 The third expert's report

5.4.1 I engaged a third expert who has specialist expertise in insulation and the thermal properties of materials to verify the R-value of the polybutylene pipe, with and without insulation, and the effect of the contact between the uninsulated hot water pipe and cold water pipe.

5.4.2 The expert provided comment in an email on 21 July 2015, and this was forwarded to the parties on 28 July 2015. The expert's comment provided the following calculations on thermal resistance (in summary):

	Given or typical thermal conductivity W/(m.K)	Calculated thermal resistance m^2.K/W(R-value)
polybutylene pipe** (uninsulated)	0.22*	0.007
Copper pipe ** (uninsulated)	400	0.0000025
polybutylene pipe insulated with 12mm closed-cell foam		0.307
Insulated copper pipe insulated with 12mm closed-cell foam		0.300

* As stated in the pipe manufacturer's literature.

** Pipes are 15mm nominal diameter

5.4.3 The expert referred to an article[9] that provides an explanation of pipe insulation and the difference between metal and plastic pipes in terms of the impact on heat loss due to thermal conductivity. The expert noted that:

> Whilst the thermal conductivity of plastic is orders of magnitude lower than the thermal conductivity of metal (thermal resistance is orders of magnitude greater) the difference becomes much less significant when a still air space is included around a pipe. This is because the thermal resistance of still air spaces is an order of magnitude greater than thermal resistance for a typical wall thickness of plastic pipe.

[9] *Insulation for plastic piping: How much is needed?* Crall, C. Insulation Outlook (2012, September 1).

> The difference in thermal conductivity between plastic and metal becomes insignificant once pipes are insulated and therefore the difference in heat loss becomes essentially identical and substantially less than occurs with un-insulated pipe, even it if is plastic.

5.4.4 In regards to the contact between the un-insulated hot and cold water pipes, the third expert considered that thermal transfer would be minimal compared with the heat transfer associated with the hot water pipe not being insulated.

6. Discussion

6.1 The application of the legislation

6.1.1 Under section 17 of the Act, all building work must comply with the Building Code. In the current case the relevant Clauses are H1 relating to energy efficiency, G12 relating to water supplies, and G9 in relation to the electrical cable located in the duct (refer Appendix A.1).

6.1.2 Section 18 of the Act states that building work is not required to be carried out to achieve performance criteria that are additional to, or more restrictive than, the performance criteria prescribed in the Building Code. Neither H1/AS1 nor NZS4305 are prescribed under section 20 of the Act as being the one means of complying with the Building Code. This means that if any building work does not comply with H1/AS1 or NZS 4305, then an assessment is made against the performance requirements of Clause H1.

6.1.3 Clause H1.1 has an objective to facilitate efficient use of energy. Whether a house satisfies Clause H1 is assessed against its Building Performance Index (BPI) which measures the performance of the building as a whole rather than against individual building elements.

6.2 Compliance with Clause H1 Energy efficiency

6.2.1 Clause H1.3.4 (b) requires systems for distribution of hot water to and from sanitary fixtures or sanitary appliances be constructed 'to limit heat losses' from distribution systems. The Clause A2 definition of 'sanitary appliance' includes 'machines for washing dishes and clothes'; therefore the hot water pipe from the HWC to the kitchen sink and dishwasher is required to comply with H1.3.4(b).

6.2.2 The question for this determination is therefore whether the hot water system, in relation to the HWC and the supply to the kitchen sink and dishwasher, is meeting the performance requirements of Clause H1.3.4. Clauses H1.3.4(b) and (c) require:

> H1.3.4 Systems for heating, storage, or distribution of hot water to and from sanitary fixtures or sanitary appliances must, having regard to the energy source used
>
> (b) be constructed to limit heat losses from storage vessels and from distribution systems; and
>
> (c) be constructed to facilitate the efficient use of hot water

6.2.3 The applicant is of the view that there is 'no data to prove that there is any insulation advantage with a waffle slab foundation'. This is not correct. Technical information is provided by the manufacturer of the floor system used in the house, and BRANZ technical articles provide information on the thermal performance of such systems. The insulation value to be gained from waffle slabs as a whole is determined by the ratio of the floor area to the length of the slab perimeter, the thickness of the exterior walls and by what, if any, insulation is applied to the perimeter of the foundation.

6.3 The relevant Acceptable Solutions and associated Standards

6.3.1 NZS 4305 is cited as a means of compliance with Acceptable Solution H1/AS1, but its requirements are not mandatory.

6.3.2 In relation to pipework insulation Acceptable Solution G12/AS1 says insulation is required where water pipes, vents, etc., outside the thermal envelope are likely to freeze.

6.3.3 The applicant contends that AS/NZS 3500.4 is a means of compliance with Clause H1 as this standard is referenced to by the pipework manufacturer, and the plumber should have followed this standard.

6.3.4 The Verification Method for Clause G12 says 'A design method for water supply systems may be verified as satisfying the Performances of NZBC G12 if it complies with: [AS/NZS 3500.1 and AS/NZS 3500.4].' The use of AS/NZS 3500 is therefore in relation to establishing compliance with Clause G12, not Clause H1.

6.3.5 AS/NZS 3500 is not included as a reference standard for Clause H1; however, it could be used as an alternative solution proposal in order to satisfy Clause H1.

6.4 The requirements of the approved consent

6.4.1 The 'Construction Notes' on the floor plan (Plan No. 04) that formed part of the approved consent state:

> Hot water supply pipes shall be thermally insulated to comply with H1/AS1 5.0

Paragraph 5.0 of H1/AS1 is headed 'Hot water systems'; paragraph 5.0.1 says:

> Hot water systems complying with NZS 4305 satisfy the requirements of NZBC H1.3.4 for the provision of hot water to sanitary fixtures and sanitary appliances.

6.4.2 The specification that formed part of the approved consent states:

> 3.17 Hot water pipework
>
> Lag all pipes with rigid insulation to the manufacturer's requirements and G12/VM1 or G12/AS1.

and:

> 3.21 Installing hot water pipe insulation
>
> Insulate all hot water pipes to NZBC H1/AS1, AS/NZS 3500.5, 3.11.7[10] Insulation of piping and to the insulation manufacturer's instructions. …

(As noted in paragraph 6.3.4 above, AS/NZS 3500.5 is not cited as a reference document in the Acceptable Solutions or Verification Methods for Clause H1 Energy efficiency.)

6.4.3 The pipework manufacturer's technical manual states:

> The system must be installed to the requirements of AS/NZS 3500 1.2 1998 and AS/NZS 3500 4.2 1997. The thermal conductivity of [polybutylene] is a lot lower than that of metal therefore hot water pipes do not require insulation.

In my view this statement is not correct. While it is correct to say that the thermal conductivity of polybutylene is less than that for copper (refer table at paragraph 5.4.2), additional insulation to polybutylene pipe is necessary to achieve the minimum thermal resistance stated in NZS 4305.

[10] I take this reference to AS/NZS 3500.5 paragraph 3.11.7 to be an error as there is no such paragraph in AS/NZS3500.5; the correct reference is most likely to be AS/NZS 3500.5 paragraph 3.33.

6.4.4 The consented plans provide no specific detail in relation to any duct(s) providing a route for services to the kitchen unit. The foundation plan (sheet 03) shows the location of plumbing fittings only. The specification gives several means by which the hot water pipework is to be insulated; some of which are conflicting.

6.4.5 In my view the consent documents are not clear in this respect. Given the applicant's requirement that the hot water pipework to the kitchen sink be insulated, this should have been specifically detailed in the consent documentation and/or in the contract agreement with the builder: this is particularly relevant in relation to building features that, for whatever reason, are not provided as normal practice.

6.4.6 The applicant's view is that the authority was responsible for ensuring the consent documents were correct. I note that under section 14D the designer is responsible for ensuring the plans and specification are sufficient to result in the building work complying with the Building Code.

6.5 The compliance of the hot water pipework

6.5.1 Performance requirement Clause H1.3.4 says systems for distributing hot water shall be constructed to minimise heat loss and to facilitate the efficient use of hot water. NZS 4305 is cited in Acceptable Solution H1/AS1 as a means of compliance with Clause H1. As above, it is noted that the requirements of NZS 4305 are not mandatory.

6.5.2 The construction notes and specifications both refer to H1/AS1, and therefore NZS 4305, as the means of compliance with Clause H1. The relevant paragraphs of NZS 4305, and those raised by the applicant (refer paragraph 4.3.5), are as follows:

> 3.3.1 Pressure relief valves and temperature and pressure relief (TPR) valves shall be thermally insulated.
>
> 3.7.1 Hot water distribution pipes shall be thermally insulated between the storage water heater and … (c) To the first pipe drop of at least 250mm, i.e. heat trap. The insulation shall extend at least 150mm past the top of the heat trap (refer figure 3(c)).
>
> 3.7.2 The kitchen sink distribution pipe from the water heater to the outlet should be insulated.
>
> 3.7.4 Hot water pipes embedded in concrete or buried underground shall be thermally insulated and installed within a duct.
>
> 3.8.1 Pipe insulation shall have an R-value (thermal resistance) not less than $0.3 m^2 \cdot ^\circ C/W$ or a thermal conductivity value (k) of not more than $0.04 W/m \cdot ^\circ C$

The application of each of these paragraphs is considered below:

Insulation of the TPR valve

6.5.3 A TPR valve is one of three safety devices commonly found on unvented HWC's[11]; the valve should be opened manually from time-to-time to ensure it is operating properly. While paragraph 3.3.1 of NZS 4305 requires TPR valves to be insulated, any insulation installed shall also meet paragraph 3.3.2 of that standard (refer Appendix A.3). The insulation must be removable and not impede the safe operation of the valve.

[11] The three devices for an unvented HWC are, typically, a TPR valve, an energy cut-off switch, and a cold water expansion valve.

6.5.4 It is noted that the insulation of TPR valves is not commonly done and this is accepted as normal industry practice. There is no proprietary off-the-shelf product that serves this purpose. NZS 4305 gives no minimum value for the thermal insulation to the TPR valve.

6.5.5 The HWC is installed within a house that, as a whole, is deemed to satisfy Clause H1 and the cylinder itself is insulated. The effect of the heat loss from the TPR valve is negligible in terms of the house satisfying the objectives of Clause H1 to facilitate the efficient use of energy.

Pipework from the HWC to the sink

6.5.6 Paragraph 3.7.1 of NZS 4305 contains the requirements for the insulation of distribution pipes from the HWC. Photographs provided by the applicant show the hot water supply pipe as it exits the HWC. While no dimensions are provided, it appears the pipe goes about 250mm horizontally before turning through 90 degrees downward for about 300mm to the tempering valve. The supply pipe is insulated from the HWC and down bend well in excess of the 150mm vertical dimension required by paragraph 3.7.1(c). This pipework insulation therefore satisfies paragraph 3.7.1(c) of NZS 4305.

6.5.7 Paragraph 3.7.2 of NZS 4305 says the pipework from a HWC to a kitchen sink should be insulated (my emphasis): this is a recommendation only and cannot be viewed at a requirement of the standard.

The pipework installed within the PVC duct

6.5.8 Paragraph 3.7.4 of NZS 4305 says that hot water pipes 'embedded in concrete' shall be thermally insulated and installed within a duct. The on-line Oxford English Dictionary[12] definition of "embedded" is to "Fix (an object) firmly and deeply in a surrounding mass".

6.5.9 The inspection records for the foundation show that the polystyrene formers were installed following the layout in the consent documents: this layout has the PVC duct running through two polystyrene formers in order to get from the sink to the adjoining wall as shown in Figure 1. The applicant says other pipework was installed in slots cut in the polystyrene formers and this is supported by site photographs taken during construction. It is therefore likely that the duct will have been installed in the bottom of such a slot as shown in Figure 2.

6.5.10 The requirement in NZS 4305 that hot water pipes not be embedded and in direct contact with concrete is to ensure that heat from the hot water is not lost to the surrounding mass. In this case the duct itself is partially embedded in concrete as it sits on the boundary between the concrete and the polystyrene formers, and I do not consider the hot water pipe itself is embedded in the manner contemplated in NZS 4305.

6.5.11 However, the central issue is not whether the hot water pipework meets NZS 4305, but whether it satisfies Clause H1.3.4. I accept the first expert's observations that hot water is being delivered to the kitchen sink at the correct temperature without apparent heat loss; tempered water supplied by the HCW was reaching the sink at 55^{o}C. The still air in the duct will have an insulating effect and is why insulation such as closed-cell foam or fibreglass is used: both materials trap still air.

[12] Refer www.oxforddictionaries.com/definition/english

6.5.12 While insulation to the hot water pipe serving the kitchen sink would stop the cold water being heated, the need to insulate a hot water pipe running from a HWC to a kitchen sink is only a recommendation of NZS 4305 and not a requirement, as noted above. Notwithstanding this, hot water pipework would still need to meet the requirements of paragraph 3.7.4 of NZS 4305 with respect to pipework 'embedded in concrete or buried underground'.

The minimum insulation value to pipework

6.5.13 Paragraph 3.8.1 of NZS 4305 says that pipe insulation shall have an R-value not less than $0.3 m^2 \cdot {}^oC/W$. The third expert has calculated the R-value of the un-insulated hot water pipe at $0.007 m^2 \cdot {}^oC/W$, which is significantly less than the value set in NZS 4305. However, the minimum R-value stated in NZS 4305 is only to be applied where pipework is to be insulated.

Conclusion

6.5.14 In conclusion, I do not consider the HWC TPR valve and the hot water pipework to the sink and dishwasher is failing to satisfy the performance requirements of Clause H1.3.4, given the following:

- A TPR valve is a safety device requiring ready access. There is presently no off-the-shelf product that will insulate such valves, and it is essential that any insulation that is applied does not interfere with the safe operation of the valve. I consider heat loss from the valve is negligible in terms of the hot water distribution system's overall thermal performance.
- The hot water pipe from the HWC is insulated in accordance with paragraph 3.7.1 of NZS 4305.
- Paragraph 3.7.2 of NZS 4305 recommends, but does not require, the insulation of the hot water supply pipe from the HWC to the kitchen sink.
- Paragraph 3.7.4 of NZS 4305 does not apply in this particular instance: the duct is partially embedded in the concrete slab, but the hot water pipe itself is not embedded.

6.6 Compliance with Clause G12 Water supplies

6.6.1 The functional requirement for Clause G12 is that sanitary fixtures or sanitary appliances must have safe and adequate water supplies. Clause G12.3.5 requires fixtures and appliances to 'be provided with hot water' when intended to be used for utensil washing, and used for personal washing, showering, and bathing.

6.6.2 From the first expert's assessment (refer paragraph 5.1.1) hot water is being delivered to the kitchen sink and dishwasher. I conclude that the hot water system complies with G12.3.5 in this respect.

6.6.3 Clause G12.3.6 requires hot water to sanitary fixtures and appliances used for personal hygiene be delivered at a temperature that avoids the likelihood of scalding. The Building Code does not require tempered water to be delivered to the kitchen sink or dishwasher because neither are used for personal hygiene.

6.6.4 I consider the requirements of Clauses G12.3.5 and G12.3.6 have been met and I do not consider them further in this determination.

6.7 The electrical cable and compliance

6.7.1 The second expert commented on the electrical cable being installed in the duct with the pipework. From the photographs provided by the applicant the electrical cable in the duct is a standard multi-core cable with a practiced PVC outer sheathing (TPS cable). The cable is contact with the water pipes along the length of the duct.

6.7.2 The fourth draft of this determination said that electrical cable in the PVC duct did not satisfy Clause G9 Electricity, and I have subsequently reviewed that decision. The view was based on the specific provisions of AS/NZS 3000[13], in that paragraph 3.9.8.4 of that standard requires a 25mm separation between wiring systems and water piping.

6.7.3 The overriding principal of AS/NZS 3000 is that the separation is required 'so as to avoid detrimental effects arising'. However, the standard TPS cable is typically rated for a normal and maximum permissible operating temperature of 75^{o}C.

6.7.4 AS/NZS 3008.1.2[14] limits the cable temperature to 75^{o}C to allow for clipping and mechanical restraint. The cable is also not subject to risk of thermal deformation as it is not clipped nor is it under mechanical pressure in the duct. The cable would be softer and more pliable the warmer it is, but located in the duct it is in a protected and unstrained environment.

6.7.5 Installing the electrical cable in the PVC duct is not a good installation practice and is not recommended, but it is considered that the cable is safe and will operate within its manufacturing specifications given the load being drawn, the intermittent nature of the load, and the likely temperature in the duct. I suggest the circuit breaker protecting this circuit should be a maximum of 16 Amps.

6.8 The code compliance certificate

6.8.1 Under section 94(1)(a) of the Act an authority must issue a code compliance certificate for building work carried out under a building consent if it is satisfied, on reasonable grounds, that the building work complies with the consent. As noted in paragraph 6.4, the means of compliance as set out in the documentation for building consent was unclear and presented possibly conflicting requirements.

6.8.2 The matter for consideration by the authority under section 94 in deciding to issue the code compliance certificate was whether it was satisfied that the building work complies with the building consent. In previous determinations (see 2008/30[15]) I have come to the view that where either the as-built construction differs from that consented or where there is conflicting detail in the consent or information that was not known when the consent was granted, confirmation of a building's compliance with the Building Code is required before an authority can issue a code compliance certificate.

6.8.3 I am still of that opinion and consider it applies in this case. I note the applicant had raised their concern regarding compliance of the hot water system with the authority prior to the code compliance certificate being issued.

[13] AS/NZS 3000:2007 Electrical installations (known as the Australian / New Zealand Wiring Rules)
[14] AS/NZS 3008:2010 Electrical installations - Selection of cables - Part 1.2: Cables for alternating voltages up to and including 0.6/1 kV - Typical New Zealand conditions
[15] Determination 2008/30: The issuing of a code compliance certificate for a multi-storey apartment building *(Department of Building and Housing)* 5 May 2008.

6.8.4 In correspondence with the applicant (refer paragraph 3.4), the authority held the mistaken view that the water supply to the kitchen sink did not require compliance with Clauses H1 and G12 as the authority considered there was no sanitary fixture. The authority erred in this respect (refer paragraph 6.2.1). The dishwasher is also served by the hot water pipework and the kitchen sink is also likely to be used for washing of dishes or other kitchen utensils. A kitchen sink is a sanitary fixture and a dishwasher is a sanitary appliance under Clause A2; accordingly, the pipework to the kitchen island is required to comply with the performance requirements of Clauses H1 and G12.

6.8.5 As I have determined the hot water pipework complies with the relevant clauses of the Building Code, I consider the authority's decision to issue the code compliance certificate should not be reversed.

6.9 Other matters

6.9.1 The authority has stated that an R-value of 0.54 is required (see paragraph 3.6); the authority has provided no justification for this value and I can see no reason why an R-value significantly higher than that set out in the relevant standards would be required.

7. The decision

7.1 In accordance with section 188 of the Building Act 2004, I hereby determine that the hot water cylinder and the hot water pipework serving the kitchen sink comply with Clause H1 of the Building Code and the electrical cable located in the duct complies with Clause G9; in respect of these building elements the authority's decision to issue the code compliance certificate is confirmed.

Signed for and on behalf of the Chief Executive of the Ministry of Business, Innovation and Employment on 19 July 2016.

John Gardiner
Manager Determinations and Assurance

Appendix A

A.1 The relevant interpretation and performance clauses of the Building Code discussed in this determination include:

Clause A2 – Interpretation

fixture an article intended to remain permanently attached to and form part of a building

sanitary appliance an appliance which is intended to be used for sanitation, but which is not a sanitary fixture. Included are machines for washing dishes and clothes

sanitary fixture any fixture which is intended to be used for sanitation

sanitation the term used to describe the activities of washing and/or excretion carried out in a manner or condition such that the effect on health is minimised, with regard to dirt and infection

Clause G9 – Electricity

Objective

The objective of this provision is to ensure that:

(a) in buildings supplied with electricity, the electrical installation has safeguards against outbreak of fire and personal injury, and

…

Functional requirement

G9.2 Where provided in a *building*, *electrical installations* shall be safe for their *intended use*.

Performance requirement

G9.3.1

The *electrical installation* shall incorporate systems to:

(a) protect people from contact with parts of the installation which are live during normal operation, and to prevent parts of the installation or other building elements becoming live during fault conditions,

Clause G12 – Water supplies

Performance

G12.3.5 Sanitary fixtures and sanitary appliances must be provided with hot water when intended to be used for—

(a) utensil washing; and

(b) personal washing, showering, or bathing.

G12.3.6 If hot water is provided to sanitary fixtures and sanitary appliances used for personal hygiene, it must be delivered at a temperature that avoids the likelihood of scalding.

Clause H1 – Energy efficiency provisions

H1.3.2E *Buildings* must be constructed to ensure that their *building performance index* does not exceed 1.55.

Limits on application: Performance H1.3.2E applies only to *housing*.

H1.3.4 Systems for heating, storage, or distribution of hot water to and from sanitary fixtures or sanitary appliances must, having regard to the energy source used

(a) limit the energy lost in the heating process; and
(b) be constructed to limit heat losses from storage vessels and from distribution systems; and
(c) be constructed to facilitate the efficient use of hot water

A.2 The relevant paragraph of the Acceptable Solution H1/AS1:

Paragraph 5.0.1

Hot water systems complying with NZS 4305 satisfy the requirements of NZBC H1.3.4 for the provision of hot water to sanitary fixtures and sanitary appliances.

A.3 The relevant paragraphs of NZS 4305 discussed in this determination include:

1.1.2 This Standard is applicable to all domestic type hot water systems irrespective of energy source. Domestic type hot water systems are those which:
(a) Supply hot water to sanitary appliances and sanitary fixtures. This includes water used for domestic type uses such as personal washing, showering, bathing, utensil washing and clothes washing regardless of the classified use of the building (e.g. commercial or industrial).

3.3.1 …Pressure relief valves and temperature and pressure relief (TPR) valves shall be thermally insulated. …

3.3.2 Thermal insulation shall be fitted around valves without preventing the free operation or obstruction of the valve mechanism or inflow of air. The thermal insulation must be easily removed for maintenance of the valve.

3.7.1 Hot water distribution pipes shall be thermally insulated between the storage water heater and …
(c) To the first pipe drop of at least 250mm, i.e. heat trap. The insulation shall extend at least 150mm past the top of the heat trap (refer figure 3(c)).

3.7.2 The kitchen sink distribution pipe from the water heater to the outlet should be insulated.

3.7.4 Hot water pipes embedded in concrete shall be thermally insulated and installed within a duct

3.8.1 Pipe insulation shall have an R-value (thermal resistance) not less than $0.3 m^2 \cdot ^\circ C/W$ or a thermal conductivity value (k) of not more than $0.04 W/m \cdot ^\circ C$.

A.4 Excerpt from the pipe manufacturer's undated technical manual

INSULATION

The thermal conductivity of Polybutene-1 is a lot lower than that of metal therefore hot water pipes do not require insulation.

Always check with your local council for any specific requirements for lagging in freezing conditions.