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Fire assessment report

Performance of PE-Xa, PE-Xa/Al/PE pipes encapsulated in Rehau gas protect or uPVC MD conduits embedded in concrete

Client: Rehau Pty Ltd and Hilti Australia Pty Ltd

Report number: FAS180496A Revision: R1.2

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Amendment schedule

Version	Date	Information relating to report			
R1.0	Issue: 19/12/2019	Reason for issue	Report issued to Rehau Pty Ltd and Hilti Australia Pty Ltd for review and comment.		
			Prepared by	Reviewed by	Approved by
	Expiry: 31/12/2024	Name	Hon Wong	Mahmoud Akl	Omar Saad
R1.1	Issue: 31/01/2020	Reason for issue	Revised summary table 1 and corrections to test data.		
			Prepared by	Reviewed by	Approved by
	Expiry: 31/12/2024	Name	Hon Wong	Mahmoud Akl	Omar Saad
R1.2	Issue: 27/02/2020	Reason for issue	Minor changes to assessment summary table		
			Prepared by	Reviewed by	Approved by
	Expiry: 31/12/2024	Name	Hon Wong	Mahmoud Akl	Mahmoud Akl
R1.3	Issue: 24/06/2020	Reason for issue	Signature panels not filled		
			Prepared by	Reviewed by	Approved by
	Expiry: 31/12/2024	Name	Hon Wong	Mahmoud Akl	Mahmoud Akl
					

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General conditions of use

Executive summary

This report presents an assessment on the fire-resistant properties of PE-Xa and PE-Xa/Al/PE pipes embedded in a 180mm thick concrete ceiling slab and traversing over a separating element wall if tested in general accordance with AS 1530.4:2014 when exposed from either above or below. This assessment is carried out at the request of Rehau Pty Ltd and Hilti Australia Pty Ltd.

The analysis conducted in section 5 of this report found that the proposed variations are likely to achieve an FRL rating as shown as shown in Table 1, if tested in accordance with AS 1530.4:2014.

Table 1 Variations and assessment outcome

Pipe type	Pipe size (mm)	Encapsulation	Cast in electrical box	Sealant in annular gaps	Separating Wall	Assessed FRL
Rehau PE-Xa or PE-Xa/Al/PE	16	24mm corrugated PE conduit or 32mm uPVC MD rigid conduit	Maximum 4 pipes in electrical box of 235mm × 155mm × 75mm deep.	Hilti CP611A on both sides, 20mm minimum depth finished with 10mm × 10mm triangular fillet.	Any wall system with 75mm minimum thickness and FRL of -/120/120 or 120/120/120	Up to -/120/120
	20	28mm corrugated PE conduit or 32mm uPVC MD rigid conduit				
	25	42mm corrugated PE conduit or 40mm uPVC MD rigid conduit				

Notes:
1. Recessed boxes cast in the concrete slab for service pipes entry and exit may be installed at 30 mm minimum from the separating wall, provided the entry and exit boxes are spaced at least 771 mm apart. Maximum of two boxes of 225 mm × 225 mm × 75 mm deep may be installed side by side with any additional box spaced at least laterally 100 mm apart. A maximum of 4 pipes may only be installed within each box. The plastic boxes may be optionally removed after casting in the concrete slab.
2. Fire exposure may be either from below concrete slab or above (with embedded pipes traversing over or under the wall system).
3. Concrete slab thickness shall be 180 mm or thicker.

The outcome of this assessment is subject to the limitations and requirements described in section 2, 4 and 6 of this report. The results of this report are valid until 31 December 2024.

Contents

1. Introduction

This report presents an assessment on the fire-resistant properties of PE-Xa and PE-Xa/Al/PE pipes embedded in a 180mm thick concrete ceiling slab and traversing over a separating element wall if tested in general accordance with AS 1530.4:2014 when exposed from either above or below. This assessment was carried out at the request of Rehau Pty Ltd and Hilti Australia Pty Ltd. The sponsors details are included in Table 2.

Table 2 Sponsor details

Client	Address
Rehau Pty Ltd	Suite 1.02, Level 1, Quad 1, 8 Parkview Drive Sydney, NSW 2127 Australia
Hilti Australia Pty Ltd	203-205 Normanby Road South Melbourne, VIC 32054 Australia

2. Framework for the assessment

An assessment is an opinion about the likely performance of a component or element of structure if it were subject to a standard fire test.

No specific framework, methodology, standard or guidance documents exists in Australia for doing these assessments. Therefore, we have followed the Guide to Undertaking Assessments In Lieu of Fire Tests prepared by the Passive Fire Protection Federation (PFPF) in the UK[1].

This guide provides a framework to undertake assessments in the absence of specific fire test results. *'Some areas where assessments may be offered are:*

- *Where a modification is made to a construction which has already been tested*
- *Interpolation or extrapolation of results of a series of fire resistance tests, or utilisation of a series of fire test results to evaluate a range of variables in a construction design or a product*
- *Where, for various reasons – eg size or configuration – it is not possible to subject a construction or a product to a fire test.'*

Assessments will vary from relatively simple judgements on small changes to a product or construction through to detailed and often complex engineering assessments of large or sophisticated constructions.

2.1 Limitations of assessment

The results of the referenced assessment are applicable to wall and floor junctions where pipes pass over the wall embedded in the concrete ceiling or floor slab with fire exposure from either above or below slab.

2.2 Declaration

The guide to undertaking assessments in lieu of fire tests prepared by the PFPF in the UK requires a declaration from the client. By accepting our fee proposal dated 29 October 2019, Rehau Pty Ltd and Hilti Australia Pty Ltd confirmed that

- To their knowledge the component or element of structure, which is the subject of this assessment, has not been subjected to a fire test to the standard against which this assessment is being made.

[1] Guide to Undertaking Assessments In Lieu of Fire Test - The Passive Fire Protection Federation (PFPF), June 2000, UK.

- They agree to withdraw this assessment from circulation if the component or element of structure is the subject of a fire test by a test authority in accordance with the standard against which this assessment is being made and the results are not in agreement with this assessment.
- They are not aware of any information that could adversely affect the conclusions of this assessment and – if they subsequently become aware of any such information, they agree to ask the assessing authority to withdraw the assessment.

3. Description of the specimen and variations

3.1 System description

The test specimen consisted of 180 mm thick custom concrete slab extending over a 75mm Hebel Power wall panel wall penetrated by six penetration systems.

3.2 Referenced test data

The assessment of the variation to the tested system and the determination of the likely performance is based on the results of the fire test documented in the referenced test report FRT 190246.1. The test conducted on 11 November 2019 by Warringtonfire Australia Pty Ltd was sponsored jointly by Rehau Pty Ltd and Hilti Australia Pty Ltd. Further details of the tested system are described in Appendix A.

3.3 Variations to tested system

An identical system has not been subjected to a standard fire test. We have therefore assessed the system using baseline test information for similar systems. The variations to the tested system together with the referenced baseline standard fire tests are described in Table 3.

Table 3 Variation to tested system in referenced test report FRT 190246.1

System ID	Service	Encapsulation	Distance of leading edge of box from wall		Variations
			Exposed side - mm	Unexposed side - mm	
A	25 mm PE-Xa/Al/PE pipe	40 mm uPVC MD conduit	666	30	1. Service pipes may be encapsulated in the concrete slab with either uPVC MD or Rehau gas protect conduits. 2. Separating wall element can be any wall system with a minimum thickness of 75 mm and an established FRL of up to and including -/120/120 or 120/120/120. 3. The recessed cast in electrical box can be located any distance up to 30 mm from the wall provided the exit box on the other side of the wall is no closer than 666 mm from the wall. Where the box is located at 666 mm from the wall on one side the box on the other side can be up to 30mm from the wall. Maximum of two 225 mm wide boxes can be installed side by side with any adjacent box spaced at least 100 mm laterally apart.
B	16 mm PE-Xa pipe	32 mm uPVC MD conduit	666	30	
C	20 mm PE-Xa pipe	32 mm uPVC MD conduit	666	30	
D	25 mm PE-Xa pipe	40 mm uPVC MD conduit	666	30	
E	25 mm PE-Xa pipe	42 mm Rehau gas protect conduit	666	30	
F	16 mm PE-Xa/Al/PE pipe	24 mm Rehau gas protect conduit	666	30	
G	20 mm PE-Xa/Al/PE pipe	28 mm Rehau gas protect conduit	666	30	
H	25 mm PE-Xa/Al/PE pipe	42 mm Rehau gas protect conduit	666	30	

System ID	Service	Encapsulation	Distance of leading edge of box from wall		Variations
			Exposed side - mm	Unexposed side - mm	
I	16 mm PE-Xa pipe	24 mm Rehau gas protect conduit	30	666	4. The minimum concrete slab thickness is 180mm with heat exposure from either below or above the slab. 5. The service pipes can be either PE-Xa or PE-Xa/Al/PE of sizes from 16 mm to 25 mm diameter.
J	25 mm PE-Xa/Al/PE pipe	40 mm uPVC MD conduit	30	666	

Notes:

a. Service A to D and E to H were installed in separate 225 mm × 225 mm × 75 mm recessed boxes mounted side by side in the concrete slab. Maximum number of pipes to be fitted is four in the 255 mm wide box or eight pipes side by side if two boxes were installed adjacent to each other. The plastic electrical box used in for casting in the concrete slab may be optionally removed after the casting.

b. Service I and J were mounted in a 150 mm × 150 mm × 75 mm recessed box spaced at 100 mm offset laterally from the other two boxes.

c. The tested specimen wall was a 75 mm thick Hebel Power wall panel which has an established FRL of -/120/120.

d. The ceiling slab of 180 mm thick concrete.

e. All service pipes were installed embedded in the concrete with a 50 mm cover on the underside and at least 75 mm on top.

f. Each service penetration was protected by Hilti CP 611a intumescent fire sealant applied to the annular gap between the pipe and the separating wall (including the encapsulating conduit) to a depth of 20mm and finished with a 10 mm ×10 mm fillet on both the exposed and unexposed sides.

3.4 Purpose of the test

The purpose of the test was to determine the fire-resistant properties of PE-Xa and PE-Xa/Al/PE pipes embedded in a 180mm thick concrete ceiling slab and traversing over a separating element wall if tested in accordance with AS 1530.4:2014 when exposed from either above or below.

3.5 Schedule of components

Table 4 outlines the schedule of components for the assessed system/s subject to a fire test, as referenced in Appendix A.

Table 4 Schedule of components of systems as tested in FRT 190246.1

Item	Description	
Separating element		
1	Item name	Hebel Power wall panel
	Product name	75 mm thick
	Wall size	1760 mm wide × 500 mm high
	Density	517 kg/m^3 (measured)
	Installation	• The wall was positioned below the concrete floor slab at nominally 1019 mm back from the unexposed side and 1306 mm back from the exposed side of the concrete floor slab. • The panel was 500 mm high and screwed fixed to the perimeter L-angle. The L-angle were fixed to the concrete slab with Hilti HUS6 6 × 60 Masonry Anchor with the flange on the unexposed side. • The gaps between the L-angles and the panel was protected by fire-rated sealant and Hebel Mortar.
2	Item name	Concrete Floor
	Product name	2534 mm long × 1760 mm wide × 180 mm thick

Item	Description		
	Configuration	2 layers of SL81 mesh embedded at nominally 45 mm and 145 mm	
	Concrete strength	40MPa	
	Density	2325 kg/m^3 (measured)	
	Installation	The electrical boxes and the conduits were mounted between the metal reinforcement prior to the concrete being poured. The concrete floor slab was cured for 35 days before testing The Hebel Power wall panel L-angle was secured to the concrete slab with 4-off Hilti HUS6 6 × 60 Masonry Anchor	
Fire-stopping protections			
Sealant			
3	Item name	Hilti CP 611a sealant	
	Product name	Hilti Firestop Intumescent sealant CP611a	
	Density	1403 kg/m^3	
	Installation	The sealant was applied into the annular gap between pipe and the separating element to the depth of 20 mm and finished with 10 mm × 10 mm fillet on both the exposed and the unexposed sides.	
Services			
4	Item name	16 mm PE-Xa pipe	
	Manufacturer	Rehau	
	Product name	REHAU RAUTITAN platinum 16x2.2 1132300 DN/OD 16 PN 20 SDR 7.4 PE-Xa 80	
	Size	Outer diameter (OD) Thickness (t)	16.3 mm (measured) 2.4 mm (measured)
5	Item name	20 mm PE-Xa pipe	
	Manufacturer	Rehau	
	Product name	Rehau Rautitan Platinum 20x2.84 DN/OD 20 PN20 SDR7.4 PE-Xa 80	
	Size	Outer diameter (OD) Thickness (t)	20 mm (measured) 2.8 mm (measured)
6	Item name	25 mm PE-Xa pipe	
	Manufacturer	Rehau	
	Product name	Rehau Rautitan platinum 25x3.5 1132320 DN/OD 25 PN 20 SDR 7.4 PE-Xa 80	
	Size	Outer diameter (OD) Thickness (t)	25.1 mm (measured) 3.7 mm (measured)
7	Item name	16 mm PE-Xa/Al/PE pipe	
	Manufacturer	Rehau	
	Product name	Rehau Rautitan gas stabil 16.2x2.6 T3021820130611 for NG and LPG MOP 70kpa AS4176.8 Class 500 PE-Al-PEX LN75687 Germany T302 S18-2013-06-11	
	Size	Outer diameter (OD) Thickness (t)	16.1 mm (measured) 2.5 mm (measured)
8	Item name	20 mm PE-Xa/Al/PE pipe	

Item	Description		
	Manufacturer	Rehau	
	Product name	Rehau Rautitan gas stabil PE-Xa/Al/PE 20x2.9 T3031920180529 for NG and LPG MOP 70kPa AS4176.8 Class 500 PE-Al-PEX LN75687 Germany / GASTEC QA GAS MOP 100mbar ENKEL VOOR GASINSTALLATIES / TIP 442 UNI TS 11344 MOP 0.5 GAS T303 S19 2018-05-29	
	Size	Outer diameter (OD) Thickness (t)	20.0 mm (measured) 2.9 mm (measured)
9	Item name	25 mm PE-Xa/Al/PE pipe	
	Manufacturer	Rehau	
	Product name	"Rehau Rautitan gas stabil PE-Xa/Al/PE 25x3.7 T3031920180529 for NG and LPG MOP 70kPa AS4176.8 Class 500 PE-Al-PEX LN75687 Germany / GASTEC QA GAS MOP 100mbar ENKEL VOOR GASINSTALLATIES / TIP 442 UNI TS 11344 MOP 0.5 GAS T303 S19 2018-05-29"	
	Size	Outer diameter (OD) Thickness (t)	25.3 mm (measured) 4.0 mm (measured)
Conduit			
10	Item name	32 mm uPVC MD conduit	
	Manufacturer	Aussie Duct	
	Product name	AussieDuct BEP PVC uPVC Electrical AS/NZS 2053 32mm MD-T 0/60	
	Size	Outer diameter (OD) Thickness (t)	31.8 mm (measured) 2.4 mm (measured)
11	Item name	40 mm uPVC MD conduit	
	Manufacturer	Aussie Duct	
	Product name	AussieDuct BEP PVC uPVC Electrical AS/NZS 2053 40mm MD-T 0/60	
	Size	Outer diameter (OD) Thickness (t)	40.0 mm 2.5 mm
12	Item name	24 mm Rehau gas protect conduit	
	Manufacturer	Rehau	
	Size	Outer diameter (OD) Thickness (t)	23.7mm 2.5mm
13	Item name	28 mm Rehau gas protect conduit	
	Manufacturer	Rehau	
	Size	Outer diameter (OD) Thickness (t)	28.0 mm 2.7mm
14	Item name	42 mm Rehau gas protect conduit	
	Manufacturer	Rehau	
	Size	Outer diameter (OD) Thickness (t)	42.6 mm 3 mm
Spacing box			
15	Item name	225 mm Electrical box	
	Manufacture	Tripac	
	Product name	Adaptable square box 225 × 225 × 75 mm	

Item	Description	
	Wall thickness	2.2 mm
	Installation	The boxes were installed into the form work of the concrete slab with conduits installed before the concrete slab was cast. The opening side of the boxes were flush on the bottom side of the concrete slab. The boxes remained in the concrete slab after the concrete slab was cured Two pairs of 225 mm electrical boxes were installed on both the exposed and the unexposed sides of the concrete slab. On the exposed side, a pair of boxes were 666 mm from the Hebel Power wall panel. On the unexposed side, another pair of boxes were 30 mm from the Hebel Power wall panel. Eight penetrations services went through the electrical boxes.
16	Item name	150 mm Electrical box
	Manufacture	Tripac
	Product name	Adaptable square box 150 × 150 × 75 mm
	Wall thickness	2.2 mm
	Installation	The boxes were installed into the form work of the concrete slab with conduits installed before the concrete slab was cast. The opening side of the boxes were flush on the bottom side of the concrete slab. The electrical boxes remained in the concrete slab after the concrete slab was cured Two 150 mm electrical boxes were installed on both the exposed and the unexposed sides of the concrete slab. On the exposed side, a box was 30 mm from the Hebel Power wall panel. On the unexposed side, another box was 666 mm from the Hebel Power wall panel. Two penetrations service went through the electrical boxes.
Penetration system A		
A	Service	25 mm PE-Xa/AL/PE pipe (item 9)
	Encapsulation	40 mm uPVC MD conduit (item 11)
	Spacing box system	Two pair of 225 mm Electrical box (item 15)
	Service detail	• The service was inserted into the concrete slab through encapsulation after the concrete slab (item 1) was cured. • The service travelled inside the slab through the encapsulation to a nominal length of 780 mm and exited 500 mm on the exposed side of the Hebel Power wall panel (item 2) and 2000 mm on the unexposed side of the Hebel wall panel. • The service assembly travelled inside the slab to a length of 672 mm from the Hebel Power wall panel on the exposed side and 31 mm on the unexposed side. • The service was capped with pipe end cap on the exposed side only.
	Service support	The pipe was supported on the unexposed side at 1200 mm from the exit point of the concrete slab using pipe clamps fixed to the timber support.
	Aperture size	Ø 34.9 mm
	Local fire-stopping protection	
	Protection	Hilti Firestop Intumescent sealant 611a (item 3)
	Installation	The sealant was applied in the annular gap between the encapsulation and the service at the depth of 20 mm and finished with 10 mm × 10 mm fillet on both the exposed and unexposed sides. See Figure 1 to Figure 3 for more details.
Penetration system B		
B	Service	16 mm PE-Xa pipe (item 4)

Item	Description	
	Encapsulation	32 mm uPVC MD conduit (item 10)
	Spacing box system	Two pair of 225 mm Electrical box (item 15)
	Service detail	• The service was inserted into the concrete slab through encapsulation after the concrete slab (item 1) was cured. • The service travelled inside the slab through the encapsulation to a nominal length of 780 mm and exited 500 mm on the exposed side of the Hebel Power wall panel (item 2) and 2000 mm on the unexposed side of the Hebel wall panel. • The service assembly travelled inside the slab to a length of 672 mm from the Hebel Power wall panel on the exposed side and 31 mm on the unexposed side. • The service was capped with end cap on the exposed side only.
	Service support	The pipe was supported on the unexposed side at 1200 mm from the exit point of the concrete slab using pipe clamps fixed to the timber support.
	Aperture size	Ø 27.2 mm
	Local fire-stopping protection	
	Protection	Hilti Firestop Intumescent sealant 611a (item 3)
	Installation	The sealant was applied in the annular gap between the encapsulation and the service at the depth of 20 mm and finished with 10 mm × 10 mm fillet on both the exposed and unexposed sides. See Figure 1 to Figure 3 for more details.
Penetration system C		
C	Service	20 mm PE-Xa pipe (item 5)
	Encapsulation	32 mm uPVC MD conduit (item 10)
	Spacing box system	Two pair of 225 mm Electrical box (item 15)
	Service detail	• The service was inserted into the concrete slab through encapsulation after the concrete slab (item 1) was cured. • The service travelled inside the slab through the encapsulation to a nominal length of 780 mm and exited 500 mm on the exposed side of the Hebel Power wall panel (item 2) and 2000 mm on the unexposed side of the Hebel wall panel. • The service assembly travelled inside the slab to a length of 672 mm from the Hebel Power wall panel on the exposed side and 31 mm on the unexposed side. • The service was capped with end cap on the exposed side only.
	Service support	The pipe was supported on the unexposed side at 1200 mm from the exit point of the concrete slab using pipe clamps fixed to the timber support.
	Aperture size	Ø 27.2 mm
	Local fire-stopping protection	
	Protection	Hilti Firestop Intumescent sealant 611a (item 3)
	Installation	The sealant was applied in the annular gap between the encapsulation and the service at the depth of 20 mm and finished with 10 mm × 10 mm fillet on both the exposed and unexposed sides. See Figure 1 to Figure 3 for more details.
Penetration system D		
D	Service	25 mm PE-Xa pipe (item 6)
	Encapsulation	40 mm uPVC MD conduit (item 11)

Item	Description	
	Spacing box system	Two pair of 225 mm Electrical box (item 15)
	Service detail	• The service was inserted into the concrete slab through encapsulation after the concrete slab (item 1) was cured. • The service travelled inside the slab through the encapsulation to a nominal length of 780 mm and exited 500 mm on the exposed side of the Hebel Power wall panel (item 2) and 2000 mm on the unexposed side of the Hebel wall panel. • The service assembly travelled inside the slab to a length of 672 mm from the Hebel Power wall panel on the exposed side and 31 mm on the unexposed side. • The service was capped with end cap on the exposed side only.
	Service support	The pipe was supported on the unexposed side at 1200 mm from the exit point of the concrete slab using pipe clamps fixed to the timber support.
	Aperture size	Ø 34.9 mm
	Local fire-stopping protection	
	Protection	Hilti Firestop Intumescent sealant 611a (item 3)
	Installation	The sealant was applied in the annular gap between the encapsulation and the service at the depth of 20 mm and finished with 10 mm × 10 mm fillet on both the exposed and unexposed sides. See Figure 1 to Figure 3 for more details.
Penetration system E		
E	Service	25 mm PE-Xa pipe (item 6)
	Encapsulation	42 mm Rehau gas protect conduit (item 14)
	Spacing box system	Two pair of 225 mm Electrical box (item 15)
	Service detail	• The service was inserted into the concrete slab through encapsulation after the concrete slab (item 1) was cured. • The service travelled inside the slab through the encapsulation to a nominal length of 780 mm and exited 500 mm on the exposed side of the Hebel Power wall panel (item 2) and 2000 mm on the unexposed side of the Hebel wall panel. • The service assembly travelled inside the slab to a length of 672 mm from the Hebel Power wall panel on the exposed side and 31 mm on the unexposed side. • The service was capped with end cap on the exposed side only.
	Service support	The pipe was supported on the unexposed side at 1200 mm from the exit point of the concrete slab using pipe clamps fixed to the timber support.
	Aperture size	Ø 36.6 mm
	Local fire-stopping protection	
	Protection	Hilti Firestop Intumescent sealant 611a (item 3)
	Installation	The sealant was applied in the annular gap between the encapsulation and the service at the depth of 20 mm and finished with 10 mm × 10 mm fillet on both the exposed and unexposed sides. See Figure 1 to Figure 3 for more details.
Penetration system F		
F	Service	16 mm PE-Xa/Al/PE pipe (item 7)
	Encapsulation	24 mm Rehau gas protect conduit (item 12)
	Spacing box system	Two pair of 225 mm Electrical box (item 15)

Item	Description	
	Service detail	• The service was inserted into the concrete slab through encapsulation after the concrete slab (item 1) was cured. • The service travelled inside the slab through the encapsulation to a nominal length of 780 mm and exited 500 mm on the exposed side of the Hebel Power wall panel (item 2) and 2000 mm on the unexposed side of the Hebel wall panel. • The service assembly travelled inside the slab to a length of 672 mm from the Hebel Power wall panel on the exposed side and 31 mm on the unexposed side. • The service was capped with end cap on the exposed side only.
	Service support	The pipe was supported on the unexposed side at 1200 mm from the exit point of the concrete slab using pipe clamps fixed to the timber support.
	Aperture size	Ø 36.6 mm
	Local fire-stopping protection	
	Protection	Hilti Firestop Intumescent sealant 611a (item 3)
	Installation	The sealant was applied in the annular gap between the encapsulation and the service at the depth of 20 mm and finished with 10 mm × 10 mm fillet on both the exposed and unexposed sides. See Figure 1 to Figure 3 for more details.
Penetration system G		
G	Service	20 mm PE-Xa/Al/PE pipe (item 8)
	Encapsulation	28 mm Rehau gas protect conduit (item 13)
	Spacing box system	Two pair of 225 mm Electrical box (item 15)
	Service detail	• The service was inserted into the concrete slab through encapsulation after the concrete slab (item 1) was cured. • The service travelled inside the slab through the encapsulation to a nominal length of 780 mm and exited 500 mm on the exposed side of the Hebel Power wall panel (item 2) and 2000 mm on the unexposed side of the Hebel wall panel. • The service assembly travelled inside the slab to a length of 672 mm from the Hebel Power wall panel on the exposed side and 31 mm on the unexposed side. • The service was capped with end cap on the exposed side only.
	Service support	The pipe was supported on the unexposed side at 1200 mm from the exit point of the concrete slab using pipe clamps fixed to the timber support.
	Aperture size	Ø 18.7 mm
	Local fire-stopping protection	
	Protection	Hilti Firestop Intumescent sealant 611a (item 3)
	Installation	The sealant was applied in the annular gap between the encapsulation and the service at the depth of 20 mm and finished with 10 mm × 10 mm fillet on both the exposed and unexposed sides. See Figure 1 to Figure 3 for more details.
Penetration system H		
H	Service	25 mm PE-Xa/Al/PE pipe (item 9)
	Encapsulation	42 mm Rehau gas protect conduit (item 14)
	Spacing box system	Two pair of 225 mm Electrical box (item 15)
	Service detail	• The service was inserted into the concrete slab through encapsulation after the concrete slab (item 1) was cured.

Item	Description	
		• The service travelled inside the slab through the encapsulation to a nominal length of 780 mm and exited 500 mm on the exposed side of the Hebel Power wall panel (item 2) and 2000 mm on the unexposed side of the Hebel wall panel. • The service assembly travelled inside the slab to a length of 672 mm from the Hebel Power wall panel on the exposed side and 31 mm on the unexposed side. • The service was capped with end cap on the exposed side only.
	Service support	The pipe was supported on the unexposed side at 1200 mm from the exit point of the concrete slab using pipe clamps fixed to the timber support.
	Aperture size	Ø 22.6 mm
	Local fire-stopping protection	
	Protection	Hilti Firestop Intumescent sealant 611a (item 3)
	Installation	The sealant was applied in the annular gap between the encapsulation and the service at the depth of 20 mm and finished with 10 mm × 10 mm fillet on both the exposed and unexposed sides. See Figure 1 to Figure 3 for more details.
Penetration system I		
I	Service	16 mm PE-Xa pipe (item 4)
	Encapsulation	24 mm Rehau gas protect conduit (item 12)
	Spacing box system	Two 150 mm Electrical box (item 16)
	Service detail	• The service was inserted into the concrete slab through encapsulation after the concrete slab (item 1) was cured. • The service travelled inside the slab through the encapsulation to a nominal length of 780 mm and exited 500 mm on the exposed side of the Hebel Power wall panel (item 2) and 2000 mm on the unexposed side of the Hebel Power wall panel. • The service assembly travelled inside the slab to a length of 31 mm from the Hebel Power wall panel on the exposed side and 672 mm on the unexposed side. • The service was capped with end cap on the exposed side only.
	Service support	The pipe was supported on the unexposed side at 564 mm from the exit point of the concrete slab using pipe clamps fixed to the timber support.
	Aperture size	Ø 19.5 mm
	Local fire-stopping protection	
	Protection	Hilti Firestop Intumescent sealant 611a (item 3)
	Installation	The sealant was applied in the annular gap between the encapsulation and the service at the depth of 20 mm and finished with 10 mm × 10 mm fillet on both the exposed and unexposed sides. See Figure 1 to Figure 3 for more details.
Penetration system J		
J	Service	25 mm PE-Xa/Al/PE pipe (item 9)
	Encapsulation	40 mm uPVC MD conduit (item 11)
	Spacing box system	Two Adaptable square box 150 × 150 × 75 mm
	Service detail	• The service was inserted into the concrete slab through encapsulation after the concrete slab (item 1) was cured.

Item	Description	
		• The service travelled inside the slab through the encapsulation to a nominal length of 780 mm and exited 500 mm on the exposed side of the Hebel Power wall panel (item 2) and 2000 mm on the unexposed side of the Hebel Power wall panel. • The service assembly travelled inside the slab to a length of 31 mm from the Hebel Power wall panel on the exposed side and 672 mm on the unexposed side. • The service was capped with end cap on the exposed side only.
	Service support	The pipe was supported on the unexposed side at 564 mm from the exit point of the concrete slab using pipe clamps fixed to the timber support.
	Aperture size	Ø 34.9 mm
	Local fire-stopping protection	
	Protection	Hilti Firestop Intumescent sealant 611a (item 3)
	Installation	The sealant was applied in the annular gap between the encapsulation and the service at the depth of 20 mm and finished with 10 mm × 10 mm fillet on both the exposed and unexposed sides. See Figure 1 to Figure 3 for more details.

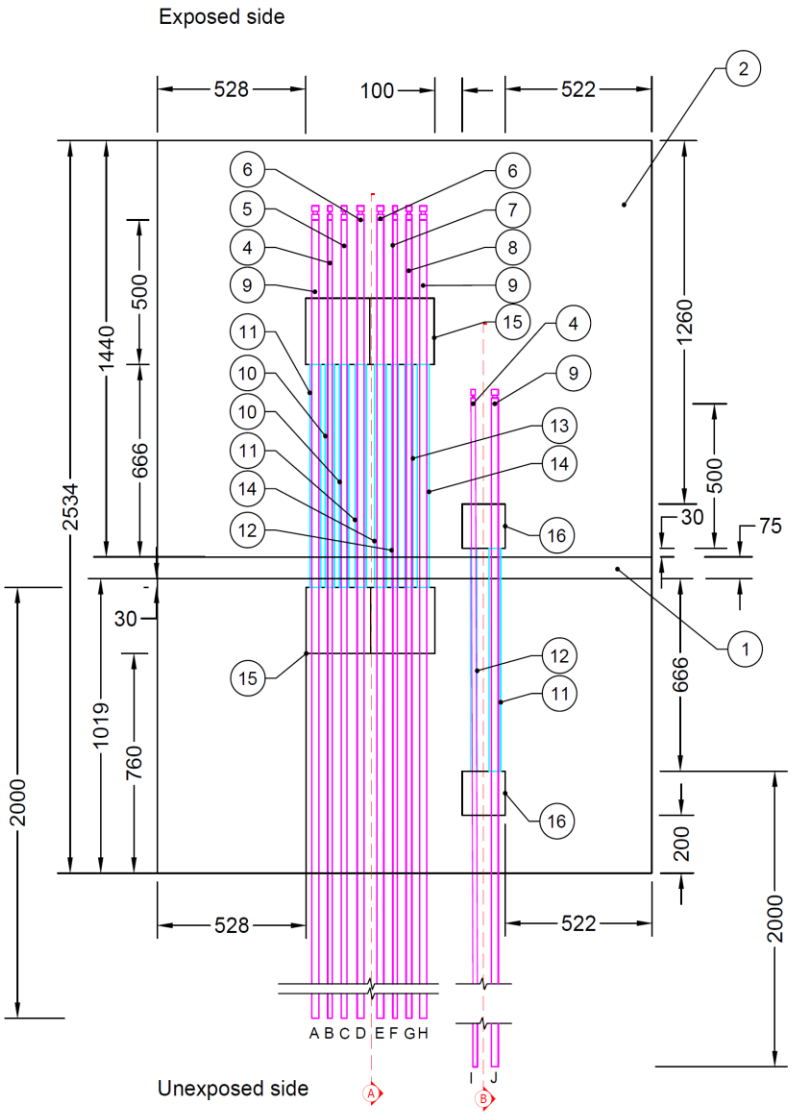

Figure 1 Plan view of test specimen

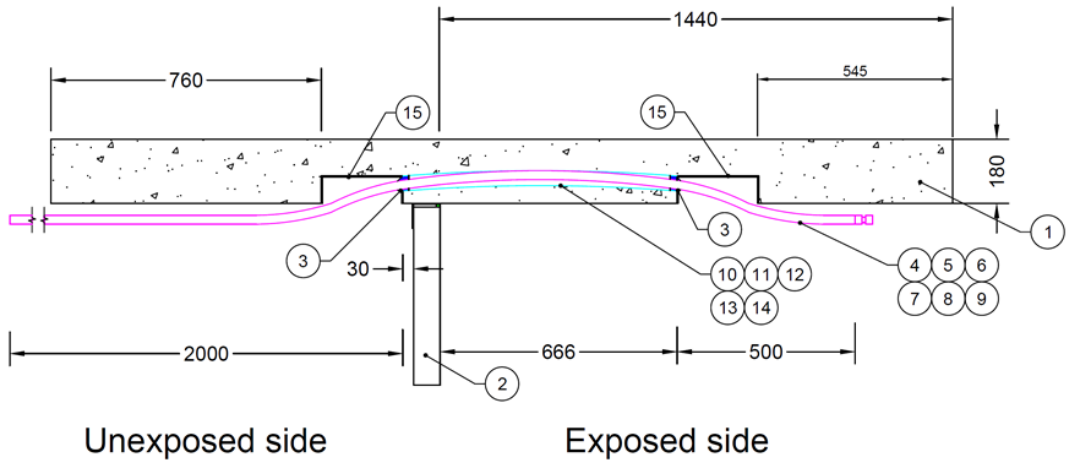

Figure 2 Cross section A-A

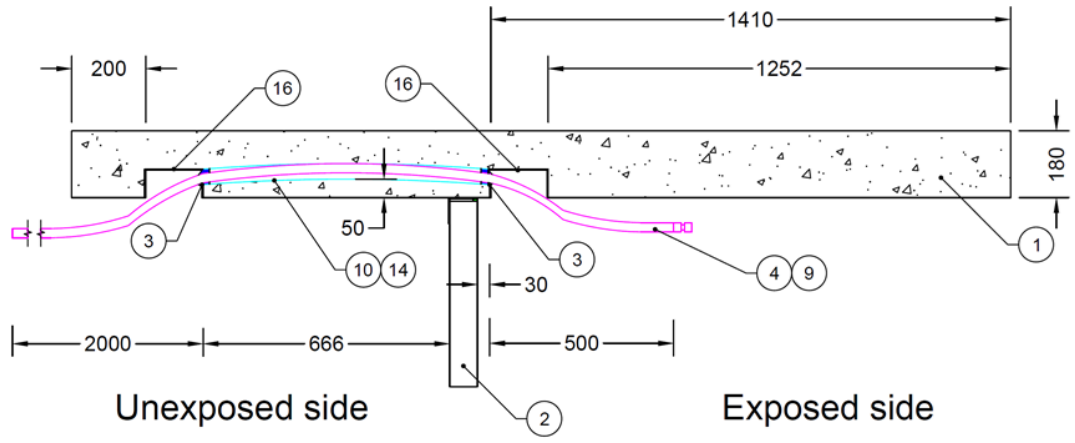

Figure 3 Cross section B-B

4. Scope, objective and assumptions

The scope, objective and assumptions for this assessment are as outlined below:

- The scope of this report is limited to an assessment of the variations to the tested systems described in section 3.3.
- This report details the methods of construction, test conditions and assessed results that would have been expected if the specific elements of construction described here had been tested in accordance with AS 1530.4:2014.
- The results of this assessment are applicable to wall and floor junctions where pipes pass over the wall embedded in the concrete ceiling or floor slab with fire exposure from above or below slab.
- This report is only valid for the assessed system/s. Any changes with respect to size, construction details, loads, stresses, edge or end conditions, other than those identified in this report, may invalidate the findings of this assessment. If there are changes to the system, a reassessment will be needed to verify consistency with the assessment in this report.
- The data, methodologies, calculations and conclusions documented in this report specifically relate to the assessed system/s and must not be used for any other purpose.

- The drawings and information that forms the basis for this report are as illustrated in Figures 1 to 3.
- This report has been prepared based on information provided by others. Warringtonfire has not verified the accuracy and/or completeness of that information and will not be responsible for any errors or omissions that may be incorporated into this report as a result.

5. Assessment

5.1 Description of variation

The proposed construction shall be as tested in FRT190246.1 on PE-Xa and PE-Xa/Al/PE pipes of 16mm, 20mm and 25mm diameter encapsulated in either uPVC MD or Rehau gas protect conduits and embedded in the concrete ceiling slab. The pipes penetrate the slab on the exposed side via cast in recessed PVC boxes of 75mm depth, traverse over the separating wall and re-emerge from the concrete slab on the unexposed side via similar recessed boxes. The exposed and unexposed boxes were placed at 771mm apart.

The proposed variations to the tested specimens are:

- Clarification of the relevance of the test results to AS 1530.4:2014.
- Service pipes may be encapsulated in the concrete slab with either uPVC MD or Rehau gas protect conduits.
- Separating wall element can be any wall system with a minimum thickness of 75 mm and an established FRL of up to and including -/120/120 or 120/120/120.
- The recessed cast in electrical box can be located any distance up to 30 mm from the wall provided the exit box on the other side of the wall is no closer than 666 mm from the wall. Where the box is located at 666 mm from the wall on one side the box on the other side can be up to 30mm from the wall. Maximum of two 225 mm wide boxes can be installed side by side with any adjacent box spaced at least 100 mm laterally apart.
- The concrete slab thickness may be 180mm or thicker with heat exposure from either below or above the slab.
- The service pipes can be either PE-Xa or PE-Xa/Al/PE of sizes from 16 mm to 25 mm diameter.

This assessment was undertaken to determine the likely performance of the system based on the favourable positive test results from referenced report FRT 190246.1.

5.2 Methodology

The approach and method of assessment used for this assessment is summarised in Table 5.

Table 5 Method of assessment

Assessment method	
Level of complexity	Simple assessment
Type of assessment	Qualitative – interpolation & Comparative

5.3 Assessment of variations

5.3.1 Relevance of the test results to AS 1530.4:2014 and AS 4072.1-2005

AS 1530.4:2014 does not specifically address the testing of penetrations with pipes that traverse over a wall embedded in the concrete ceiling slab and resurfacing from the ceiling slab on the opposite side of the wall. Applications where such a system is considered appropriate include residential buildings where services are distributed from a common corridor location within the ceiling slab to reappear within each apartment occupancy throughout the building block.

Based on the above, it is considered that the following criteria needs to be applied to the penetration systems in order to comply with the intent of AS 1530.4:2014 as outlined below:

- Insulation criteria as applied to fire resistant walls and service penetrations in AS 1530.4:2014.
- Integrity criteria as applied to fire resistant walls and service penetrations in AS 1530.4:2014.

The test assembly comprised a nominal 2534 mm long × 1760 mm wide × 180 mm thick ceiling slab constructed with an adjoining Hebel Power wall system of 1760 mm wide × 500 mm high × 75 mm thick. The slab included various conduits encapsulating pipes embedded in the slab as shown in Figures 1, 2 & 3.

In order to assess the junction of a wall and ceiling, the furnace pressure shall be set at a pressure of 20Pa at 100mm below the concrete slab in accordance with AS 1530.4:2014 requirements for horizontal elements. The furnace pressure setting is similar to that for a test on a three metres high specimen wall where the furnace pressure is set at 0Pa at 500mm from the base. This would equate to an equivalent required furnace pressure of 8 × 2.4 Pa (using the guide of 8 Pa increase with each metre rise in height) or 19.2 Pa at 100 mm from the ceiling. The specimen wall was therefore exposed to a slightly higher furnace pressure when tested to the pressure for a horizontal specimen in accordance with AS 1530.4:2014.

For all intents and purposes, the instrumentation for monitoring insulation and integrity performance was in line with those prescribed for penetrations in the walls in accordance with AS 1530.4:2014.

The purpose of the test is to determine if the concrete ceiling penetrations which incorporate the installation of the pipes and conduits connecting from the fire exposed side traversing over the separating element wall to the unexposed side, compromise the required level of fire resistance performance between the compartments separated by the wall system.

The results from the test FRT 190246.1 indicated that the maximum temperatures recorded on the unexposed side of the ceiling slab directly above the exposed electrical boxes were below 125°C after 120 minutes of heat exposure of the tested systems. There was no indication of any integrity failure throughout the test in any of the pipe penetrations.

5.3.2 Integrity performance of tested specimens

The tested systems performed adequately without any signs or recorded integrity failure for the full 120 minutes test duration.

5.3.3 Insulation performance of tested specimens

The tested specimens recorded a maximum temperature 166°C during the 120 minute test duration, except for those thermocouples located on the metal angles at the head of the separating element Hebel wall. Since all the thermocouples for the concrete ceiling slab which incorporated the embedded pipes did not record any temperatures which would cause an insulation failure and that the there was no service penetration on any section of the wall, the insulation failure would be deemed to have been caused by direct conduction along the metal angle from the exposed side. Moreover, the maximum temperature recorded at the concrete slab surface directly above the recessed boxes where the concrete was locally thinned out to no more than 105 mm was only 123°C. It is therefore fair to omit the temperature readings of the specimens on the unexposed side taken from the thermocouples attached to the surface of the metal angle along the top of the Hebel wall.

From the above discussion, it is considered that the maximum temperatures at the junction between the Hebel wall and the concrete ceiling slab would have tracked the insulation performance of a bare exposed Hebel wall without additional heat contribution from the heated ceiling slab. The concrete slab would have absorbed heat from the wall at the junction since the established FRL of the 180 mm concrete slab is very much higher than that of the 75 mm Hebel Power wall.

It is therefore considered that the thermocouples fitted to the metal angles which are part of the Hebel wall installation could be isolated or ignored when assessing the insulation performance of the specimen service penetrations protected by the Hilti intumescent fire sealants.

Insulation performance of PE-Xa/Al/PE pipes

Specimens A, H, F and G were with PE-Xa/Al/PE pipes installed with the penetrations on the exposed side in recessed electrical boxes located 666 mm from the separating Hebel wall system. Specimen J was installed with the exposed recessed box 30 mm from the wall.

Specimen A and H were of 25 mm pipes with different encapsulation conduits. The former had 40 mm uPVC MD conduit whilst the latter was encapsulated in a 42 mm Rehau gas protect conduit. Comparing the temperature time vs time graphs of both specimens, there appears to be virtually no difference in performance between them.

Specimen F and G were both encapsulated in Rehau gas protect conduits with the former being a 16 mm pipe whilst the latter was 20 mm. Specimen H is a 25mm pipe also encapsulated in a Rehau gas protect conduit. All three specimens performed adequately and similarly within a peak temperature of about 150°C. There was very little difference in the insulation performance with the order of performance from F being the best to G and lastly H which incidentally follows that the performance decrease marginally with increase in pipe size.

Specimen J was a 25 mm pipe installed in the electrical box located 30 mm from the wall on the exposed side. Comparing the performance of the 25 mm pipe in specimen H which was similarly encapsulated but with the exposed electrical box installed 666 mm away from the wall, with specimen J, it is evident that specimen J was “cooler” by about 25°C towards the end of the test. This is likely due to the fact that the majority of the embedded pipe section of specimen J was in the unexposed ceiling slab which would have absorbed a large portion of the heat transferred along the pipe. Almost the entire section of the embedded pipe in specimen H was in the ceiling slab on the exposed side of the wall.

Insulation performance of PE-Xa pipes

Specimens B, C, D and E were with PE-Xa pipes installed with the penetrations on the exposed side in recessed electrical boxes located 666 mm from the separating Hebel wall system. System I was installed with the exposed recessed box 30 mm from the wall.

Specimen D and E were of 25 mm pipes with different encapsulation conduits. The former had 40 mm uPVC MD conduit whilst the latter was encapsulated in a 42 mm Rehau gas protect conduit. Both specimens performed adequately and almost equally in insulation with specimen D marginally better when encapsulated in a uPVC MD conduit.

Similarly, the temperature vs time graphs for specimens B, C and D which were all encapsulated in uPVC MD conduits indicate a favourable overall insulation performance with performance inversely proportional to the pipe size. The variances were only marginal and the difference in temperatures between those for the 20 mm and 25 mm pipes was no more than five degrees.

5.3.4 Summary of integrity and insulation performance of the tested specimens

From the previous discussions, the performance of the tested specimens in terms of integrity and insulation can be summarised as follows:

- The specimens installed with the recessed electrical boxes located on the exposed side at 666 mm from the separating wall was more onerous when tested than those installed at 30 mm from the wall. It follows that specimens A to H would have performed equally or better if installed with the boxes located at 30 mm from the wall. It can therefore be considered that if the pipes were installed in cast in recessed electrical boxes located anywhere between 666 mm and 30 mm from one side of the wall and the total length pipe embedded in concrete is 771 mm, the penetration system will perform adequately for up to 120 minutes when tested with exposure from either side.
- It is proposed to optionally remove the plastic boxes after the casting. It was observed from the test that the recessed plastic boxes were fully consumed on the fire side at the end of the fire test. The plastic boxes were used for casting in the concrete slab to provide the recess in the slab and for locating the entry and exit points of the conduits cast in the slab. It will not have any impact on the overall fire resistance performance of the system as the plastic material of the boxes would have melted and fallen away in the initial stages of the test when the temperatures were above 450°C (above the melting point of plastic). The plastic boxes could therefore be optionally removed if required after the casting.
- The specimen pipes performed adequately and almost equally whether encapsulated in uPVC MD or in Rehau gas protect conduits.
- The PE-Xa/Al/PE and PE-Xa pipes performed adequately for up to 120 minutes in 16 mm, 20 mm and 25 mm sizes.

5.3.5 Replacing the Hebel wall system with walls of FRL's up to -/120/120 or 120/120/120.

From the previous discussions, it is evident that the service pipes embedded in the concrete ceiling slab and traversing the separating element 75 mm thick Hebel Power wall did not affect the performance of the separating Hebel Power wall.

It is proposed that the tested Hebel Power be replaced with any wall system having an FRL of up to and including -/120/120 and 120/120/120. Since the tested specimens performed adequately up 120 minutes in both integrity and insulation matching the established FRL of the 75 mm thick Hebel Power wall, the tested specimens would be capable of maintaining the FRL of any other wall systems of up to and including -/120/120 or 120/120/120 if tested in accordance with AS 1530.4:2014.

5.3.6 Heat exposure from above instead of from below concrete slab as tested

The tested specimens were with the pipes embedded in the concrete ceiling slab and traversing over the separating wall and with heat exposure from below the slab. Where the heat source is from above the concrete slab, the concrete surface is exposed to a lower pressure from the hot gases due to upward buoyancy of the burning flames. As hot gases rise, the heat transfer onto the concrete via convection will be a lot less than when exposed from below as the hot gases from below the slab would have been at its maximum temperature and imparts heat onto the soffit of the slab.

Where the fire originates from above the slab, any debris from the combustion of combustible building material would have fallen on the concrete surface and would act as a shield against radiant heat transfer. Where the slab is exposed from below, the soffit of the slab would have full radiant heat transfer without blockage from debris.

It is therefore considered that it is more onerous when the concrete slab is exposed to heat from below than from above. The results from the test in FRT 190246.1 with exposure from below the concrete slab would be applicable for the tested specimens with heat exposure from above the concrete slab.

5.3.7 Increase in concrete slab thickness

The specimens in FRT 190246.1 were tested with the pipes embedded in a 180 mm thick concrete slab. Due to the thinner of the concrete slab with the recessed electrical boxes, there was only a 100 mm top concrete cover over the embedded pipes. Allowing for the curvature when casting in the pipes, the top cover over the embedded pipes may be reduced to about 75mm. Any reduction in the concrete slab thickness may likely cause an unacceptable localised temperature rise on the unexposed side during the heat exposure and would result in failure in insulation before the required 120 minutes.

The concrete slab thickness must therefore be at least 180 mm as tested. An increase in concrete slab thickness will result in a larger thermal mass storage capacity or limit the temperature rise to maintain insulation performance for more than 120 minutes.

5.4 Conclusion

This assessment demonstrates that the Rehau PE-Xa and PE-Xa/Al/PE pipes embedded in the concrete ceiling slab traversing over a 75 mm Hebel Power wall, including variation as outlined below will likely achieve an FRL of up to -/120/120, including 120/120/120 and matching that of the separating wall element of at least 75 mm thick if it were tested in accordance with AS 1530.4:2014.

The variations that have positively assessed are:

a. Recessed boxes cast in the concrete slab for service pipes entry and exit may be installed at distances from 666 mm to as close as 30 mm to the separating wall, provided the entry and exit boxes are at least 771 mm apart. Maximum of two boxes of 225 mm × 225 mm × 75 mm deep may be installed side by side with any additional box spaced at least laterally 100 mm apart.

b. Fire exposure may be either from below concrete slab or above (with embedded pipes traversing over or under the wall system) and on either side of the separating wall element.

c. Service pipes may be cast in concrete encapsulated in with either uPVC MD or Rehau gas protect conduit

d. Service pipes embedded in the concrete must be protected at both the entry and exit from the slab with Hilti Firestop Intumescent sealant 611a the annular gap between the service pipe and the concrete hole. Fillet shall be 20mm deep finished with a 10 mm × 10 mm triangular fillet.

e. The service pipes may be either 16 mm, 20 mm or 25 mm of Rehau PE-Xa or PE-Xa/Al/PE.

f. Concrete slab thickness shall be 180 mm or thicker.

g. The separating wall element shall be at least 75 mm thick with an established FRL of up to -/120/120 or 120/120/120.

6. Validity

Warringtonfire Australia does not endorse the tested or assessed product in any way. The conclusions of this assessment may be used to directly assess fire hazard, but it should be recognised that a single test method will not provide a full assessment of fire hazard under all conditions.

Due to the nature of fire testing and the consequent difficulty in quantifying the uncertainty of measurement, it is not possible to provide a stated degree of accuracy. The inherent variability in test procedures, materials and methods of construction, and installation may lead to variations in performance between elements of similar construction.

This assessment is based on information and experience available at the time of preparation. The published procedures for the conduct of tests and the assessment of test results are subject to constant review and improvement. It is therefore recommended that this report be reviewed on or, before, the stated expiry date.

This assessment represents our opinion about the performance likely to be demonstrated on a test in accordance with AS 1530.4:2014 based on the evidence referred to in this report.

This assessment is provided to the Rehau Pty Ltd and Hilti Australia Pty Ltd for its own purposes and we cannot express an opinion on whether it will be accepted by building certifiers or any other third parties for any purpose.

Appendix A Summary of supporting test data

A.1 Test report – FRT 190246.1

Table 6 Information about test report

Item	Information about test report
Report sponsor	Rehau Pty Ltd and Hilti Australia Pty Ltd
Test laboratory	Warringtonfire Australia, Unit 2, 409-411 Hammond Road, Dandenong, Victoria 3175, Australia.
Test date	The fire resistance test was completed on 11/11/2019.
Test standards	The test was done in general accordance with AS1530.4-2014.
Variation to test standards	AS 1530.4:2014 does not include specific requirements for the testing of services which are embedded and travelling horizontal through a concrete floor. For this reason, the test is not in direct compliance with AS 1530.4:2014 and will be referenced as being tested in “general accordance” with AS 1530.4:2014. Due to the specimen layout being designed to assess the potential for horizontal flame spread through pipes in slabs and thus departing from the specimens outline in AS 1530.4:2014, there is no direct field of application
General description of tested specimen	The test specimen consisted of a Hebel wall system with an established FRL of -/120/120 with a 180mm concrete ceiling slab with a services of embedded pipes penetration from the exposed side of the wall, traversing over the top of the wall and emerging from the slab on the unexposed side. Entry and exit from the ceiling slab were via recessed cast in boxes. The top of each box was to be at least 75mm below the upper surface of the ceiling slab. The penetrating pipes and conduits in the slab were to have at lease 50mm minimum concrete cover under the pipes or conduits.
Instrumentation	The test report states that the instrumentation was in general accordance with AS 1530.4:2014.

The test specimen achieved the following result:

Table 7 Results summary for this test report

Penetration system/ control joint	Criteria	Results
A	Structural adequacy	Not applicable
	Integrity	No failure at 120 minutes
	Insulation	Failure at 111 minutes
B	Structural adequacy	Not applicable
	Integrity	No failure at 120 minutes
	Insulation	Failure at 108 minutes
C	Structural adequacy	Not applicable
	Integrity	No failure at 120 minutes
	Insulation	Failure at 113 minutes
D	Structural adequacy	Not applicable

Penetration system/ control joint	Criteria	Results
	Integrity	No failure at 120 minutes
	Insulation	Failure at 115 minutes
E	Structural adequacy	Not applicable
	Integrity	No failure at 120 minutes
	Insulation	Failure at 112 minutes
F	Structural adequacy	Not applicable
	Integrity	No failure at 120 minutes
	Insulation	Failure at 108 minutes
G	Structural adequacy	Not applicable
	Integrity	No failure at 120 minutes
	Insulation	Failure at 116 minutes
H	Structural adequacy	Not applicable
	Integrity	No failure at 120 minutes
	Insulation	Failure at 110 minutes
I	Structural adequacy	Not applicable
	Integrity	No failure at 120 minutes
	Insulation	No failure at 120 minutes
J	Structural adequacy	Not applicable
	Integrity	No failure at 120 minutes
	Insulation	No failure at 120 minutes

Table 8 Test specimen temperatures

Penetration system	T/C No.	Location of thermocouple	Temperature (°C) at t (minutes)					Limit (minutes)
			T=0	T=30	t-60	T=90	t-120	
A	011	On the L angle	22	65	101	154	219	111
	012	On the concrete slab	22	46	87	107	149	-
	013	On the electrical box	22	37	64	78	103	-
	014	On the service	23	81	107	166	132	-
B	016	On the L angle	22	65	106	162	225	108
	017	On the concrete slab	21	50	96	116	159	-
	018	On the electrical box	22	35	56	70	93	-
	019	On the service	24	71	65	85	89	-
C	021	On the L angle	22	63	103	152	214	113
	022	On the concrete slab	21	49	79	99	137	-
	023	On the electrical box	22	39	55	71	98	-
	024	On the service	24	78	63	71	85	-
D	026	On the L angle	22	62	101	145	210	115
	027	On the concrete slab	21	50	85	97	134	-
	028	On the electrical box	22	42	55	64	98	-
	029	On the service	24	80	73	70	84	-
E	031	On the L angle	22	60	105	150	217	112
	032	On the concrete slab	21	49	94	114	148	-
	033	On the electrical box	22	44	83	94	115	-
	034	On the service	24	77	74	74	90	-
F	036	On the L angle	22	62	110	158	226	108
	037	On the concrete slab	21	46	95	111	146	-
	038	On the electrical box	22	42	64	91	111	-
	039	On the service	23	74	74	90	107	-
G	041	On the L angle	21	57	92	133	211	116
	042	On the concrete slab	21	47	85	90	139	-
	043	On the electrical box	22	49	63	66	98	-
	044	On the service	23	75	77	113	115	-
H	046	On the L angle	21	62	104	153	223	110
	047	On the concrete slab	21	53	92	113	154	-
	048	On the electrical box	22	43	54	66	111	-
	049	On the service	22	95	93	103	114	-
I	051	On the L angle	21	61	99	117	184	-
	052	On the concrete slab	21	34	71	86	105	-
	053	On the electrical box	22	29	32	35	39	-
	054	On the service	23	60	38	37	40	-
J	056	On the L angle	21	64	99	108	162	-
	057	On the concrete slab	20	34	61	71	89	--

Penetration system	T/C No.	Location of thermocouple	Temperature (°C) at t (minutes)					Limit (minutes)
			T=0	T=30	t-60	T=90	t-120	
	058	On the electrical box	22	29	33	36	39	-
	059	On the service	23	51	54	53	55	-
Top of concrete. slab above the exposed boxes	101	Above the 150 mm electrical box	22	29	63	97	114	-
	102	Above the east 225 mm electrical box	23	38	#	#	#	#
	103	Above the west 225mm electrical box	22	42	79	88	123	-

Notes:

1. Limit time is the time to the nearest whole minute, rounded down to the nearest minute, at which the temperature recorded by the thermocouple does not rise by more than 180 K above the initial temperature.
2. # denotes thermocouple failure.