A Jensen Hughes Company

Fire assessment report

FulaFlex FR Hybrid sealant in wall and floor control and head joints in accordance with AS 1530.4:2014 and AS 4072.1:2005

Sponsor: H.B. Fuller Australia Pty Ltd

Report number: FAS190359 Revision: R1.2

Issued date: 25 June 2024 Expiry date: 30 June 2029

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			Prepared by	**Reviewed by**	**Authorised by**
		Name	Hon Wong	Mahmoud Akl	Omar Saad
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			Prepared by	**Reviewed by**	**Authorised by**
		Name	Zak Awad	Omar Saad	Omar Saad
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		Signature			

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Executive summary

This report presents the findings of the assessment of the expected fire resistance performance of H.B. Fuller FulaFlex FR Hybrid sealant protecting control joints in floors or walls and head joints as tested and described in reports FRT190354 R1.0, FRT220290 R1.0 and FRT200213 R1.0 when modified as detailed in section 5 of this report.

The analysis in section 5 of this report found that the proposed variations are likely to achieve the fire resistance performance presented in Table 1 to Table 5 if tested in a similar manner in accordance with AS 1530.4:2014. The variations are assessed based on the requirements of AS 4072.1:2005.

Table 1 Control joints in concrete walls with sealant on both sides flush to the wall surfaces

Control joint width	Local fire-stopping protection	Sealant depth on both sides	Sealant application	FRL Minimum separating element effective thickness*		
				120 mm	150 mm	175 mm
50 mm	H.B. Fuller FulaFlex FR hybrid	25 mm	Applied on both sides as illustrated in Figure 1	-/120/120	-/180/180	-/240/240
40 mm		20 mm				
30 mm		15 mm				
20 mm		10 mm				
10 mm		10 mm				

*The stipulated separating element thickness is applicable to solid block concrete, hollow core and masonry construction. The effective thickness must be as per AS 3600:2018 and AS 3700:2018 respectively. Hollow core masonry cores must be filled with concrete where the joint is present to ensure insulation is preserved.

The sealant is applied with a 20 mm × 20 mm or 28 mm × 20 mm rectangular section open cell backer rod.

Table 2 Control joints in concrete floors with sealant on both sides flush to the floor surfaces

Control joint width	Local fire-stopping protection	Sealant depth on both sides	Sealant application	FRL Minimum separating element effective thickness*	
				150 mm	175 mm
35 mm	H.B. Fuller FulaFlex FR hybrid	20 mm	Applied on both sides as illustrated in Figure 2	-/180/180	-/180/180
30 mm		15 mm		-/180/180	-/240/240
20 mm		10 mm		-/180/180	-/240/240
10 mm		10 mm		-/180/180	-/240/240

*The stipulated separating element thickness is applicable to solid block concrete, hollow core and masonry construction. The effective thickness must be as per AS 3600:2018 and AS 3700:2018 respectively. Hollow core masonry cores must be filled with concrete where the joint is present to ensure insulation is preserved.
The sealant is applied with a 20 mm × 30 mm rectangular section open cell backer rod.

Table 3 Double caulked control joints in concrete walls or floors

Control joint width	Local fire-stopping protection	First layer sealant depth	Second layer sealant depth	Distance between sealant	FRL Minimum separating element effective thickness**	
					150 mm	175 mm
26 mm – 35 mm		20 mm	30 mm	Minimum 25 mm with an airgap as	-/180/180*	-/240/180*

Control joint width	Local fire-stopping protection	First layer sealant depth	Second layer sealant depth	Distance between sealant	FRL: Minimum separating element effective thickness** 150 mm	FRL: Minimum separating element effective thickness** 175 mm
	H.B. Fuller FulaFlex FR hybrid			shown in Figure 3		
11 mm – 25 mm		15 mm	25 mm	Applied back-to-back or with an airgap as shown in Figure 3	-/180/180	-/240/180
10 mm		10 mm	10 mm	Applied back-to-back or with an airgap as shown in Figure 3	-/180/180	-/240/180
*Sealant application must have a minimum 25 mm airgap between layers **The stipulated separating element thickness is applicable to solid block concrete, hollow core and masonry construction. The effective thickness must be as per AS 3600:2018 and AS 3700:2018 respectively. Hollow core masonry cores must be filled with concrete where the joint is present to ensure insulation is preserved. The sealant is applied with a 20 mm × 30 mm rectangular section open cell backer rod. The sealant shall be flush with the wall or floor surface where fire exposure direction is expected. FRL of control joints in floors is only applicable from the underside FRL of control joints in walls is applicable from both directions						

Table 4 Head joints in concrete walls with sealant on both sides

<table>
<tr><th rowspan="3">Head joint width</th><th rowspan="3">Local fire-stopping protection</th><th rowspan="3">Sealant depth</th><th rowspan="3">Sealant application</th><th colspan="3">FRL</th></tr>
<tr><th colspan="3">Minimum separating element effective thickness*</th></tr>
<tr><th>120 mm</th><th>150 mm</th><th>175 mm</th></tr>
<tr><td>50 mm</td><td rowspan="6">H.B. Fuller Fulaflex FR hybrid</td><td>25 mm</td><td rowspan="6">Applied on both sides as illustrated in Figure 4</td><td rowspan="6">-/120/120</td><td rowspan="6">-/180/180</td><td rowspan="4">-/240/240</td></tr>
<tr><td>40 mm</td><td>20 mm</td></tr>
<tr><td>30 mm</td><td>15 mm</td></tr>
<tr><td>20 mm</td><td>15 mm</td></tr>
<tr><td>20 mm</td><td>10 mm</td><td>-/240/180</td></tr>
<tr><td>10 mm</td><td>10 mm</td><td>-/240/240</td></tr>
<tr><td colspan="7">*The stipulated separating element thickness is applicable to solid block concrete, hollow core and masonry construction. The effective thickness must be as per AS 3600:2018 and AS 3700:2018 respectively. Hollow core masonry cores must be filled with concrete where the joint is present to ensure insulation is preserved.
The backing rod and the sealant must be sandwiched between rigid surfaces only.</td></tr>
</table>

Table 5 Double caulked head joints in concrete walls

<table>
<tr><th rowspan="3">Head joint width</th><th rowspan="3">Local fire-stopping protection</th><th rowspan="3">First layer sealant depth</th><th rowspan="3">Second layer sealant depth</th><th rowspan="3">Distance between sealant</th><th colspan="2">FRL</th></tr>
<tr><th colspan="2">Minimum separating element effective thickness*</th></tr>
<tr><th>150 mm</th><th>175 mm</th></tr>
<tr><td>26 mm – 35 mm</td><td rowspan="3">H.B. Fuller FulaFlex FR hybrid</td><td>30 mm</td><td>20 mm</td><td>Minimum 25 mm airgap as shown in Figure 5</td><td>-/180/180</td><td>-/240/180</td></tr>
<tr><td>11 mm – 25 mm wide</td><td>30 mm</td><td>20 mm</td><td rowspan="2">Applied back-to-back or with an air gap as shown in Figure 5</td><td>-/180/120</td><td>-/240/120</td></tr>
<tr><td>10 mm wide</td><td>10 mm</td><td>10 mm</td><td>-/180/180</td><td>-/240/180</td></tr>
<tr><td colspan="7">*The stipulated separating element thickness is applicable to solid block concrete, hollow core and masonry construction. The effective thickness must be as per AS 3600:2018 and AS 3700:2018 respectively. Hollow core masonry cores must be filled with concrete where the joint is present to ensure insulation is preserved.
The sealant is applied with a 20 x 30 mm rectangular section open cell backer rod.
The sealant shall be flush with the wall surface where fire exposure direction is expected.</td></tr>
</table>

The assessment is relevant only to the fire resistance performance of the control joints.

The outcome of this assessment is subject to the limitations and requirements described in sections 2, 3 and 6 of this report. The outcome of this report is valid until 30 June 2029.

Contents

1. Introduction

This report presents the findings of the assessment of the expected fire resistance performance of H.B. Fuller FulaFlex FR Hybrid sealant protecting control joints in floors, walls and head joints as tested and described in FRT190354 R1.0, FRT220290 R1.0 and FRT200213 R1.0 when modified as detailed in section 5 of this report and tested in a similar manner in accordance with AS 1530.4:2014. The proposed variations are assessed based on the requirements of AS 4072.1:2005.

This assessment was carried out at the request of H.B. Fuller Australia Pty Ltd. The sponsor details are included in Table 6.

Table 6 Sponsor details

Sponsor	Address
H.B. Fuller Australia Pty Ltd	16~22 Red Gum Drive Dandenong South VIC 3175 Australia

2. Framework for the assessment

2.1 Assessment approach

An assessment is a professional opinion about the expected performance of a component or element of structure subjected to a fire test.

No specific framework, methodology, standard or guidance documents exists in Australia for undertaking these assessments. We have therefore followed the ‘Guide to undertaking technical assessments of the fire performance of construction products based on fire test evidence’ prepared by the Passive Fire Protection Forum (PFPF) in the UK in 2021[1].

This guide provides a framework for undertaking 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
- The 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 can 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.

This assessment uses established empirical methods and our experience of fire testing similar products to extend the scope of application by determining the limits for the design and performance based on the tested constructions and performances obtained. The assessment is an evaluation of the potential fire resistance performance of the elements in accordance with AS 1530.4:2014.

[1] Passive Fire Protection Forum (PFPF), 2021, Guide to undertaking technical assessments of the fire performance of construction products based on fire test evidence, Passive Fire Protection Forum (PFPF), UK.

This assessment has been written in accordance with the general principles outlined in EN 15725:2023[2] for extended application on the fire performance of construction products and building elements: Principle of EXAP standards and EXAP reports.

The expected performance of the systems with the variations documented in this assessment report has been determined by assessing the performance of tested systems against the expected impact of each variation. The systems tested in accordance with AS 1530.4:2014 and detailed within Appendix A, are generally considered to be comparable to the listed system variations which are generally expected to yield a performance equivalent to the tested systems.

2.2 Compliance with the National Construction Code

This assessment report has been prepared to meet the evidence of suitability requirements of the NCC 2022[3] under A5G3(1)(d). It references test evidence for meeting deemed-to-satisfy (DTS) provisions of the NCC under A5G5 for fire resistance level that apply to the assessed systems based on Specifications 1 and 2 for fire resistance for building elements.

The proposed details and systems (building elements) in this report are confirmed to be assessed, without the aid of an active fire suppression system, based on prototype tests that are equivalent to or more severe than a standard fire test as specified in section 4.2, in accordance with NCC 2022 S1C2(b). It is also confirmed that the differences between the proposed systems and details compared to the tested prototypes are considered minor in accordance with NCC 2022 S1C2(c).

This assessment report may also be used to demonstrate compliance with the requirements for evidence of suitability under the relevant sections of previous versions of the NCC.

2.3 Declaration

The ‘Guide to undertaking technical assessments of the fire performance of construction products based on fire test evidence’ prepared by the PFPF in the UK requires a declaration from the client. By accepting our fee proposal on 9 February 2022, H.B. Fuller Australia Pty Ltd confirmed that:

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

- The scope of this report is limited to an assessment of the variations to the tested systems described in section 4.3.
- This report details the methods of construction, test conditions and assessed results that are expected in accordance with AS 1530.4:2014.
- This assessment is applicable to floor systems exposed to fire from below in accordance with the requirements of AS 1530.4:2014 where horizontal elements must be exposed to

[2] European Committee for Standardization, 2023, Extended application on the fire performance of construction products and building elements: Principle of EXAP standards and EXAP reports, EN 15725:2023, European Committee for Standardization, Brussels, Belgium

[3] National Construction Code Volumes One and Two - Building Code of Australia 2022, Australian Building Codes Board, Australia

heat from the underside only. Applicability of fire exposure direction for walls is specified in each assessed variation.

- This report is only valid for the assessed systems and must not be used for any other purpose. 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. Changes to the system other than those identified in this report shall be reassessed by an Accredited Testing Laboratory (ATL), accredited to the test standards included in this report.
- The documentation that forms the basis for this report is listed in Appendix A.
- 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.
- This assessment is based on the proposed systems being constructed under comprehensive quality control practices and following appropriate industry regulations and Australian Standards on quality of materials, design of structures, guidance on workmanship and expert handling, placing and finishing of the products on site. These variables are beyond the control and consideration of this report.
- The applications of the sealant must be as per the tables and figures listed above as the systems are not symmetrical and would not be applicable for heat exposure from either side.
- The FRL of the joints assessed, based on the reference tests, is limited to the FRL of the separating elements they are installed into, and the integrity and insulation performance of the joints cannot exceed that of the separating element.

4. Description of the specimen and variations

4.1 Description of assessed systems

This assessment is based on reference tests FRT190354 R1.0, FRT220290 R1.0 and FRT200213 R1.0, which include control joints in a concrete wall and floor protected by H.B. Fuller FulaFlex FR Hybrid sealant, tested in accordance with AS 1530.4:2014. The system includes control joints on walls and floors with various widths and methods of sealant application.

Refer to Appendix A for a full summary of the test data.

4.2 Referenced test data

The assessment of the variation to the tested system is based on the data provided in the reports listed in Table 7. Further details of the tested system are included in Appendix A.

Table 7 Referenced test data

Report number	Test sponsor	Test date	Testing authority
FRT220290 R1.0	H.B. Fuller Aust Co P/L	14 June 2023	Warringtonfire Australia
FRT200213 R1.0		25 August 2020	
FRT190354 R1.0		18 November 2019	

4.3 Variations to the tested systems

The proposed construction shall be as tested and described in FRT190354 R1.0, FRT220290 R1.0 and FRT200213 R1.0 with control joints on walls or floors of various widths protected by H.B. Fuller FulaFlex FR Hybrid sealant, which may vary in various applications as follows:

- Control joints in concrete walls with thicknesses greater than 120 mm with sealant applied on both sides flush to the wall surfaces supported by FRT 190354 R1.0
- Control joints in concrete floors with thicknesses 150 and 175 mm with sealant on both sides flush to the floor surfaces are supported by FRT220290 R1.0 and FRT200213 R1.0
- Double caulked control joints in concrete walls or floors supported by FRT220290 R1.0
- Head joints in concrete walls with sealant on both sides supported by FRT190354 R1.0
- Double caulked head joints in concrete walls supported by FRT220290 R1.0

4.4 Schedule of components

The proposed control joints and their protection with H.B. Fuller FulaFlex Fr sealant relative to the direction of exposure is illustrated in Figure 1 - Figure 5

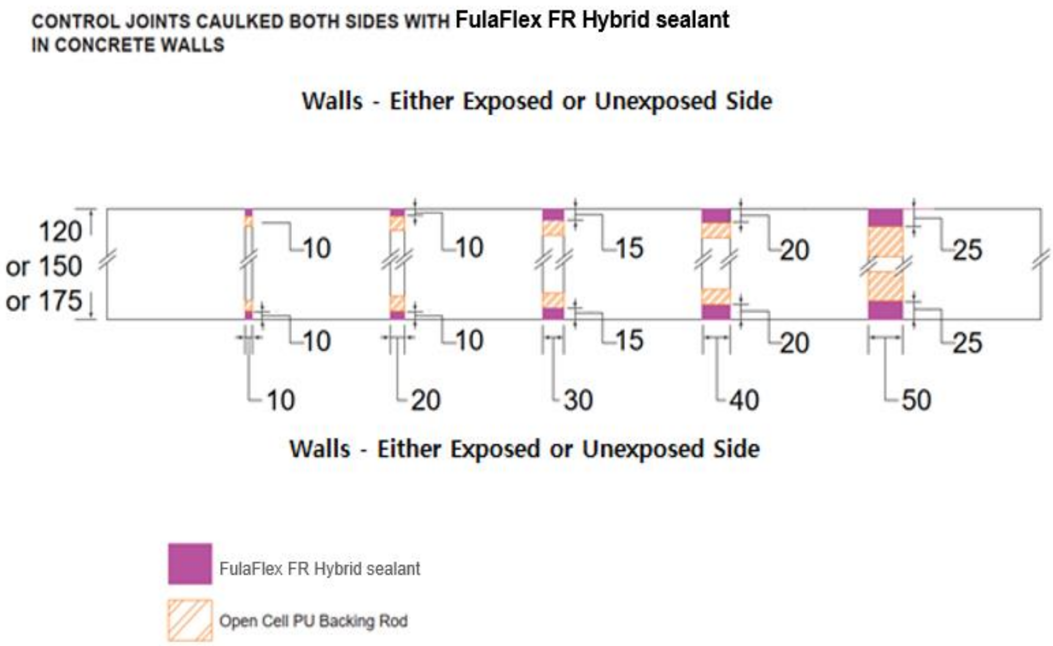

Figure 1 Control joints with H.B. Fuller FulaFlex FR sealant caulked flush on both sides in concrete walls

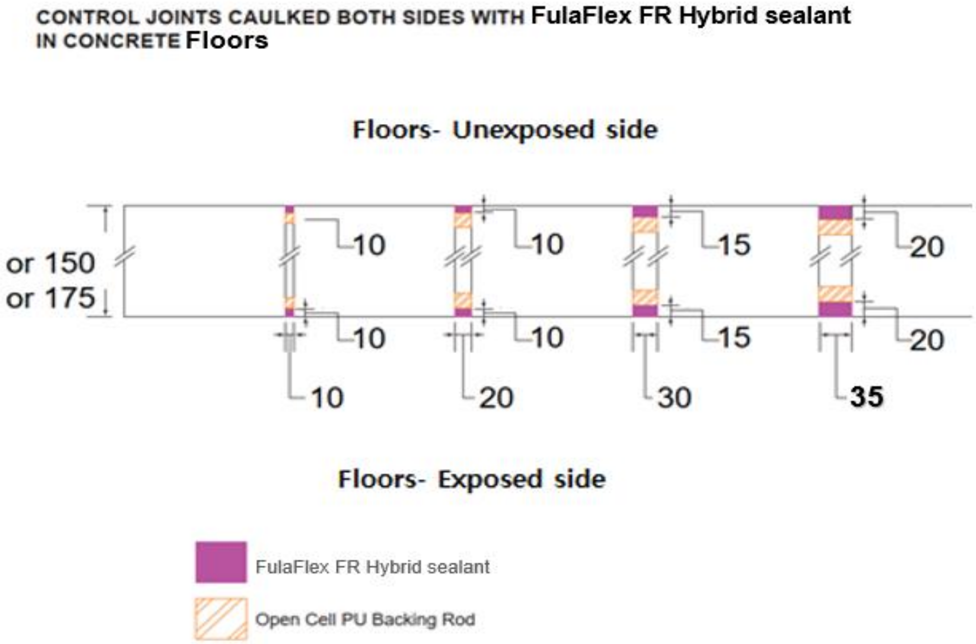

Figure 2 **Control joints with H.B. Fuller FulaFlex FR sealant caulked on both sides in concrete floors**

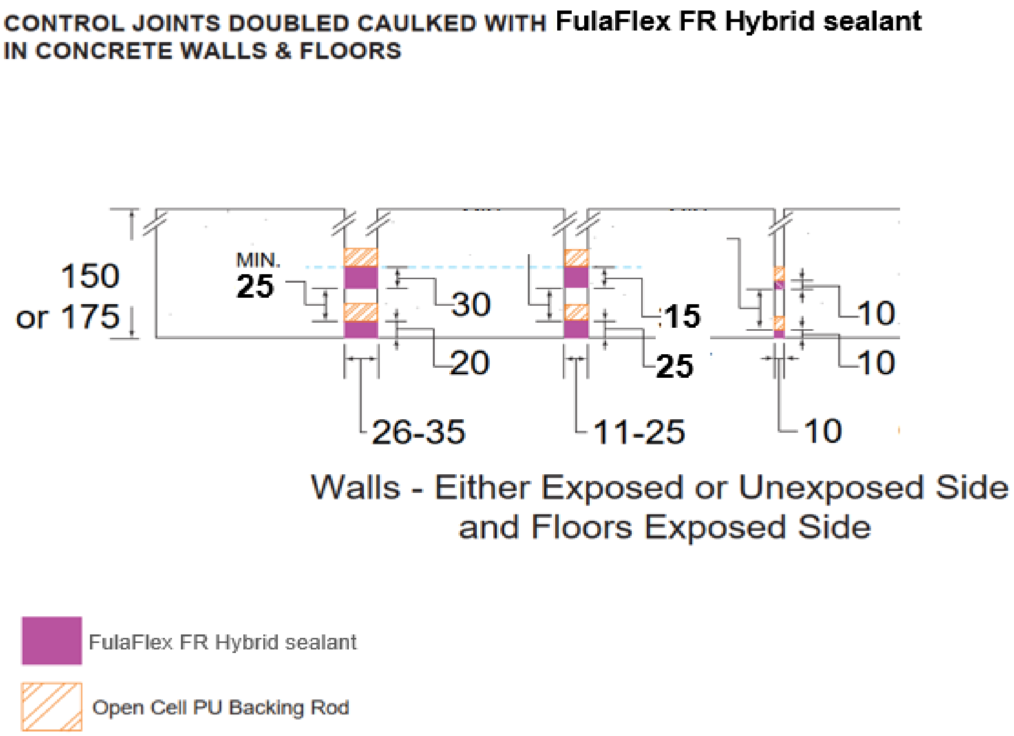

Figure 3 **Double caulked control joints in concrete walls or floors**

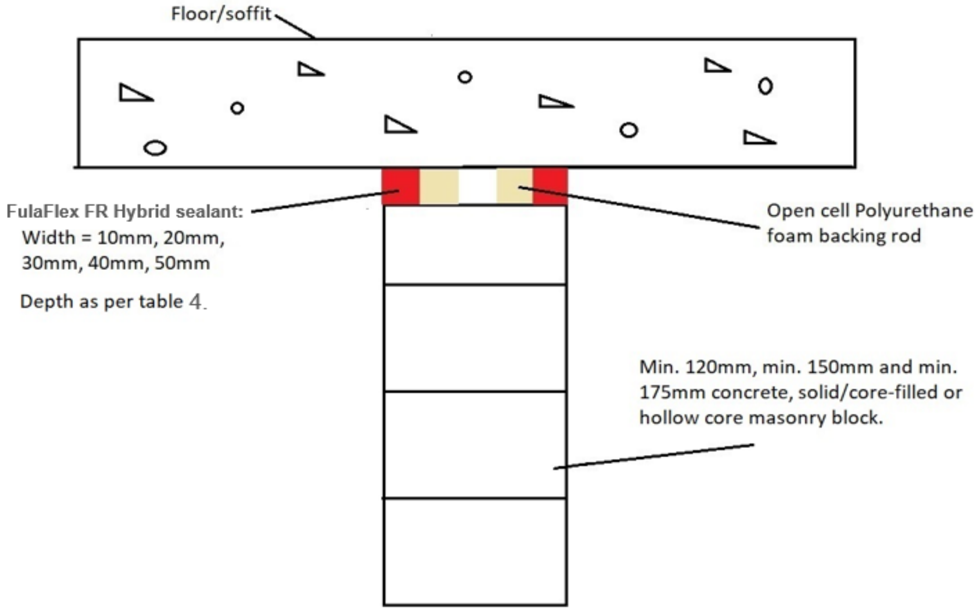

Figure 4 Head joints in concrete walls with sealant flush on both sides

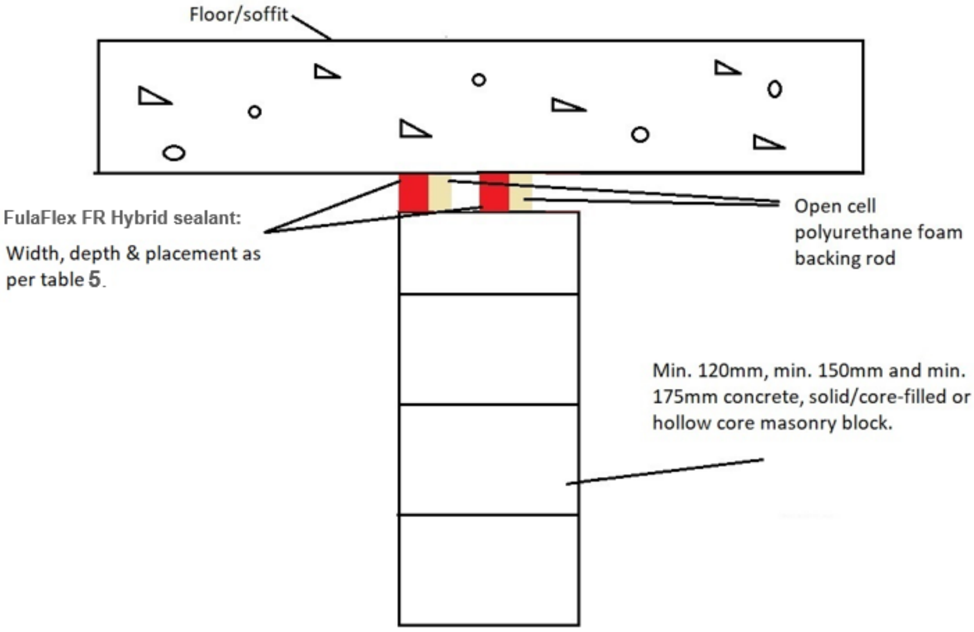

Figure 5 Double caulked head joints in concrete walls

5. Assessment of variations to control joints and head joints protected by H.B. Fuller FulaFlex FR Hybrid sealant

5.1 Description of variations

The proposed construction shall be as tested in FRT190354 R1.0 in accordance with AS 1530.4:2014 with control joints in 120 mm thick concrete wall of a series of widths protected by H.B. Fuller FulaFlex FR Hybrid sealant with consideration for the following minor variations:

- Varying the concrete wall thickness from 120 mm as tested to 150 mm
- Varying the concrete wall thickness from 120 mm as tested to 170 mm
- Replacing the 120 mm, 150 mm and 170 mm thick concrete walls with equivalent concrete masonry block walls of equivalent established FRL's to those of the corresponding concrete walls
- Adding a 30 mm wide control joint with sealant applied to both sides each to a depth of 15 mm
- Control joints in concrete walls with sealant on both sides flush to the wall surfaces
- Control joints in concrete floors with sealant on both sides flush to the floor surfaces
- Double caulked control joints in concrete walls or floors
- Head joints in concrete walls with sealant on both sides
- Double caulked head joints in concrete walls

This assessment was undertaken to determine the expected performance of the system in accordance with AS 1530.4:2014 and AS 4072.1:2005.

5.2 Methodology

The method of assessment used is summarised in Table 8.

Table 8 Method of assessment

Assessment method	
Level of complexity	Intermediate assessment
NCC procedure for determining FRL	Differs in only a minor degree from a tested prototype S1C2(c)
Type of assessment	Quantitative – interpolation and comparative

5.3 Assessment of variations to control joints protected by H.B. Fuller FulaFlex FR Hybrid sealant

The control joints incorporating the H.B. Fuller FulaFlex FR Hybrid sealant in test FRT190354 R1.0 were tested in a 120 mm thick concrete wall for an exposure duration of 241 minutes. The concrete wall held integrity for the full duration but tended towards heat saturation after 135 minutes exposure. The wall temperature had a steeper temperature and failed insulation performance after about 165 minutes into the test. It is evident that the 120 mm concrete will not hold its insulation performance beyond 165 minutes. The following discussion will address the insulation performance and review the results to form an opinion on the expected performance of sealant in the control joints.

5.3.1 Varying the concrete wall thickness to 150 mm

Test specimen control joint A did not have a thermocouple installed in the sealant within the joint gap as it could not be physically fitted. The temperatures recorded were therefore only those on the concrete wall surface adjacent to the control joint. The temperatures recorded in control joints B, C and D showed the temperatures in the sealant on the unexposed side were all below 200°C (or within the insulation performance for 180 minutes exposure) after 180 minutes of exposure. The temperatures on the concrete surface adjacent to the joints, however, exceeded 200°C. This is due to the fact that the 120 mm concrete wall has an established FRL of -/120/120. It is evident that the sealant continued to perform to at least 180 minutes in insulation, uninfluenced by the higher surrounding temperature of the concrete.

Temperatures recorded for control joint A were only those for the concrete wall surface adjacent to the joint. From observations of the temperatures for control joints B, C and D, the temperatures recorded in the sealant on the unexposed side were all below the concrete surface temperatures. It is fair to deduce that the temperature in the sealant on the unexposed side of control joint A will be either equal to or lower than the temperature on the wall surface adjacent to the joint.

If the concrete wall were to be increased in thickness to at least 150 mm, the expected temperature of the concrete would be within the limits for insulation performance for 180 minutes. The reason is that the 150 mm thick concrete wall is expected to perform to its established FRL or -/180/180.

From the above discussion, it is considered that the control joints A, B, C and D will perform to at least 180 minutes in integrity and insulation or an FRL of -/180/180.

5.3.2 Varying the concrete wall thickness to 175 mm

The sealant temperature in control joint C after 240 minutes exposure was less than 200°C but increased to more than 200°C as the joint gap decreased in control joints C and B. It appears that as the control joint is reduced in width from 50 mm in control joint D to 20 mm in control joint B, the influence of the higher concrete temperature along the side walls within the joint gap becomes more dominant as the gap narrows. The effects are shown with the narrowing of the temperature difference between the temperature graph for the sealant and that for the concrete surface reduces as the control joint width decreases.

It is therefore reasonable to consider that if the concrete temperature were held to within 200°C, there would be reduced heat transfer from the concrete to the sealant, as the temperature of the sealant would be only slightly lower than that of the concrete. Increasing the concrete wall thickness to 170 mm would result in having a concrete temperature (on the unexposed side) to no more than 200°C, ie the concrete will maintain its insulation performance for up to 240 minutes as 170 mm thick concrete has an established FRL of -/240/240.

Control joints B, C and D would therefore have an insulation performance of at least that of the 170 mm thick concrete and adding to the tested integrity performance of 240 minutes, the control joints would have an FRL of -/240/240.

Similarly, as the sealant temperatures are expected to be no more than the concrete surface temperature, the control joint A is expected to have a sealant temperature on the unexposed side after 240 minutes of exposure of less than 200°C in a 170 mm thick wall system. It is therefore considered that control joint A to perform up to an FRL of -/240/240 in a 170 mm thick concrete wall system.

5.3.3 Replacing each of the concrete wall system with a solid concrete masonry block wall of equivalent FRL

As per AS 1530.4:2014, the results of a test conducted on control joints in concrete walls may be applied to solid concrete masonry block walls, provided that the wall system has an equivalent FRL to the concrete wall and that the wall thickness is equal to or thicker.

The test data indicates that the FulaFlex FR Hybrid sealant achieved an integrity performance of up to 240 minutes when applied to both sides of the control joints in a 120 mm thick concrete wall. The insulation performance of the sealant appears to track that of the wall system. The sealant is therefore expected to perform equally in a similar type of construction, such as solid concrete masonry block walls, provided the walls are not less than 120 mm thick and that the walls would perform to the required FRL, ie. -/120/120, -/180/180 and -/240/240.

5.3.4 30 mm control joint protected by the FulaFLex FR Hybrid sealant applied on both sides

From the analysis of the overall performance of the sealants in the control joints tested in FRT190354 R1.0, it is evident that the minimum required sealant depth in order to maintain the required FRL is half the joint width, i.e. a depth of 25 mm for a 50 mm wide joint and 10 mm for a 20 mm wide joint. The minimum sealant depth is held at 10 mm as there is insufficient test data to interpolate for joint widths less than 20 mm.

The addition of a 30 mm wide control joint protected by the FulaFlex FR Hybrid sealant applied to both sides to a depth of 15 mm would therefore perform similarly to the control joints tested in FRT190354 R1.0 and assessed positively in the above discussion.

Table 9 Control joints in concrete walls with sealant on both sides flush to the wall surfaces

Control joint width	Local fire-stopping protection	Sealant depth on both sides	Sealant application	FRL Minimum separating element effective thickness* 120 mm	 150 mm	 175 mm
50 mm	H.B. Fuller FulaFlex FR hybrid	25 mm	Applied on both sides as illustrated in Figure 1	-/120/120	-/180/180	-/240/240
40 mm		20 mm				
30 mm		15 mm				
20 mm		10 mm				
10 mm		10 mm				
*The stipulated separating element thickness is applicable to solid block concrete, hollow core and masonry construction. The effective thickness must be as per AS 3600:2018 and AS 3700:2018 respectively. Hollow core masonry cores must be filled with concrete where the joint is present to ensure insulation is preserved. The sealant is applied with a 20 mm × 20 mm or 28 mm × 20 mm rectangular section open cell backer rod.						

5.3.5 Control joints in concrete floors with sealant on both sides flush to the floor surfaces

In the fire resistance test report FRT200213 R1.0, three control joints under penetration systems C, D and E were tested with H.B. Fuller FulaFlex FR sealant. The sealant was applied to the control joint to the depth of the backing rod and finished flush with the face of the separating element on both the unexposed and exposed sides in all three penetrating systems. Control joints C, D and E were 10 mm, 20 mm and 30 mm respectively. All 3 control joints achieved an FRL of -/240/180.

In FRT220290 R1.0, control joint A, a 35 mm wide control joint, was tested in a 150 mm thick concrete slab with H.B. Fuller FulaFlex FR sealant. The first layer of sealant was at a depth between 65 mm and 95 mm from the exposed side. The second layer was to a depth of 20 mm and finished flush on the exposed side of the separating element. Control joint A achieved an FRL of -/180/180. It is expected that a 35 mm wide control joint with sealant on both sides flush to the floor will also achieve an FRL of -/180/180 due to the increased insulation provided by the larger airgap.

Table 10 Control joints in concrete floors with sealant on both sides flush to the floor surfaces

Control joint width	Local fire-stopping protection	Sealant depth on both sides	Sealant application	FRL Minimum separating element effective thickness* 150 mm	 175 mm
35 mm		20 mm		-/180/180	-/180/180
30 mm		15 mm		-/180/180	-/240/240

Control joint width	Local fire-stopping protection	Sealant depth on both sides	Sealant application	FRL	
				Minimum separating element effective thickness*	
				150 mm	175 mm
20 mm	H.B. Fuller FulaFlex FR hybrid	10 mm	Applied on both sides as illustrated in Figure 2	-/180/180	-/240/240
10 mm		10 mm		-/180/180	-/240/240

*The stipulated separating element thickness is applicable to solid block concrete, hollow core and masonry construction. The effective thickness must be as per AS 3600:2018 and AS 3700:2018 respectively. Hollow core masonry cores must be filled with concrete where the joint is present to ensure insulation is preserved.
The sealant is applied with a 20 mm × 30 mm rectangular section open cell backer rod.

5.3.6 Double caulked control joints in concrete walls or floors

In test FRT220290 R1.0, a 35 mm wide double caulked control joint with 30 mm and 20 mm deep sealant installed in a 150 mm concrete wall was tested in accordance with AS 1530.4:2014. The sealants were applied 25 mm apart and installed using backing rods. This construction achieved an FRL of -/240/180.

Additionally, a 25 mm wide double caulked control joint with 15 mm and 25 mm deep sealant installed in a 150 mm concrete wall was tested in accordance with AS 1530.4:2014. The sealants were applied back-to-back with no air gap and installed using backing rods. This construction achieved an FRL of
-/240/120. The reduction in insulation performance can be attributed to back-to-back installation of the sealant, as it offers heat transfer through conduction in addition to radiation and convection.

In test FRT200213 R1.0, a 10 mm wide control joint with H.B. Fuller FulaFlex FR sealant applied to the depth of the backing rod and finished flush with the face of the separating element on both the unexposed and exposed sides was tested in accordance with AS 1530.4:2014. This construction achieved an FRL of -/240/180. It is proposed that the sealants will be applied with a minimum 25 mm air gap between layers. This is expected to eliminate the primary mode of heat transfer through conduction. For the 35 mm wide control joint in FRT220290 R1.0, 50 mm of sealant is used, which provides an approximate ratio of 1:1.4 for control joint width to sealant depth. For the 10 mm wide control joint in FRT200213 R1.0, 20 mm of sealant is used, which provides a ratio of 1:2 for control joint width to sealant depth which is higher than the 35 mm control joint. According to AS 1530.4:2014, clause 10.5.3 states that *'thermocouples shall only be fitted to the seal when the joint width is greater than or equal to 12 mm.'* This means that a 10 mm control joint is not expected to fail insulation.

The above observations establish the ability of 35 mm, 25 mm and 10 mm double caulked joints with sealant depth as discussed above to achieve up to 240 minutes of integrity and up to 180 minutes of insulation performance in concrete floors. It is proposed that the joints be installed in walls. As joints in floors are considered more onerous, it is expected that the observed performance will be replicated in concrete walls.

In practical application, the FRL of the joints will be dictated by the separating element they are installed into. As per AS 3600:2018, 120 mm, 150 mm and 175 mm concrete walls and floors are stipulated to achieve an FRL of -/120/120, -/180/180 and -/240/240, respectively, if appropriate design conditions are met.

It is further proposed that the intermediate sizes between 35 mm, 25 mm and 10 mm joints – specifically, 11 mm – 25 mm and 26 mm – 35 mm – are assessed. The proposal includes replicating the sealant depth of the widest joint of the range which is either tested or assessed for an FRL up to
-/240/180. As the widest joint with the same sealant depth has achieved an FRL of up to -/240/180, it is reasonable to conclude that the narrower joint in the range will also achieve the same FRL. Based on the above, the joints listed in Table 11 are positively assessed for the shown FRL.

Table 11 Double caulked control joints in concrete walls or floors

Control joint width	Local fire-stopping protection	First layer sealant depth	Second layer sealant depth	Distance between sealant	FRL	
					Minimum separating element effective thickness**	
					150 mm	175 mm
26 mm – 35 mm	H.B. Fuller FulaFlex FR hybrid	20 mm	30 mm	Minimum 25 mm with an airgap as shown in Figure 3	-/180/180*	-/240/180*
11 mm – 25 mm		15 mm	25 mm	Applied back-to-back or with an airgap as shown in Figure 3	-/180/180	-/240/180
10 mm		10 mm	10 mm	Applied back-to-back or with an airgap as shown in Figure 3	-/180/180	-/240/180

*Sealant application must have a minimum 25 mm airgap between layers
**The stipulated separating element thickness is applicable to solid block concrete, hollow core and masonry construction. The effective thickness must be as per AS 3600:2018 and AS 3700:2018 respectively. Hollow core masonry cores must be filled with concrete where the joint is present to ensure insulation is preserved.

The sealant is applied with a 20 mm × 30 mm rectangular section open cell backer rod.

The sealant shall be flush with the wall or floor surface where fire exposure direction is expected.

FRL of control joints in floors is only applicable from the underside

FRL of control joints in walls is applicable from both directions

5.4 Assessment of variations to Head joints protected by H.B. Fuller FulaFlex FR Hybrid sealant

5.4.1 Application of control joint data to head joints

When head joint details span horizontally across the head of a vertical wall system, it is considered that the pressure would be highest at the top of the furnace when tested in accordance with AS 1530.4:2014. In consideration of this phenomenon, test data for control joints spanning vertically in vertical wall systems needs to be analysed with caution when assessing them for head joint applications. The location at which the pressure is measured within the furnace must be identified and approximations made to correlate these pressures with what would be present at the top of the furnace. It is considered, for vertical specimens, that for every 1 m rise within the furnace, the pressure would rise by 8 Pa. Accordingly, it is considered that the expected pressure conditions can be calculated from the control joint test data.

FRT190354 R1.0 consisted of a 120 mm thick wall specimen with vertical control joints. For the purpose of this assessment, all four control joints are considered. For this test specimen, with a height of 1600 mm, the furnace pressure was measured at 130 mm below the mid-height of the control joint and corrected to 15 Pa at the mid-height of the control joint. Based on the approximation of pressure increase per meter increase in height, detailed above, the corrected furnace pressure for the top of the specimen is 19 Pa. Inspection of the test images post-test reveals no clear difference between the sealant at mid-height and at the top of the specimen. The furnace pressure was not consistent throughout the test and jumped to 23 Pa from 25 – 35 minutes at mid-height, then 20 Pa between 35 – 40 minutes. Therefore, the test results for integrity and insulation of the control joints can be deemed applicable to the 19 Pa conditions.

Additionally, the fire tests FRT200213 R1.0 and FRT220290 R1.0 are also used for the assessment of the proposed head joints in this report. These tests consisted of control joints in

150 mm thick concrete floor slabs. For the duration of these tests, the furnace pressure measurements ranged from 18 Pa to 22 Pa, measured at 150 mm and 100 mm below the underside of the slabs and corrected to 100 mm below the underside of the slab for each test. The pressure condition matches that of the corrected FRT190354 R1.0 pressure condition and provides confidence for the floor specimen test results to be applied to the proposed head joint details.

Confidence can be gained in the application of control joint test data from floors to the proposed head joint details in walls due to floor elements providing a more onerous condition for sealant protection details than that of walls. When pressure conditions are comparable, as has been established above, the floor specimen would present a more onerous case than that of walls due to the gravitational effect that can cause the sealant to detach and fall off the floor elements. Such behaviour would largely depend on the fire resistance properties of the sealant and their ability to maintain a connection with the separating element. This is not the case for sealant in the horizontal or vertical joints in the vertical wall element.

5.4.2 Head joints in concrete walls with sealant on both sides

In test FRT190354 R1.0, control joint A consisted of a 10 mm wide control joint with 10 mm deep H.B. Fuller FulaFlex FR hybrid sealant on both sides, installed in a 120 mm concrete wall and tested in accordance with AS 1530.4:2014. The sealant was applied using 20 mm × 20 mm backing rod. This construction achieved an FRL of -/240/120. The insulation failure at 171 minutes was recorded on the separating element as there was no thermocouple placed on the control joint itself. Since the separating element was the cause of the insulation failure, the H.B. Fuller FulaFlex FR hybrid sealant is not expected to cause insulation failure. Based on the above and the analysis in section 5.4.1, a 10 mm wide head joint with 10 mm wide sealant applied on both sides is positively assessed for the FRL's as listed in Table 12.

Control joint B consisted of a 20 mm wide control joint with 10 mm deep H.B. Fuller FulaFlex FR hybrid sealant on both sides, installed in a 120 mm concrete wall and tested in accordance with AS 1530.4:2014. The sealant was applied using 28 mm × 20 mm backing rod. This construction achieved an FRL of -/240/120. It is proposed that a 20 mm head joint with 10 mm wide FulaFlex FR hybrid sealant applied flush on both sides will perform similarly. The insulation failure at 165 minutes was recorded on the separating element, while the control joint failed at 204 minutes. Therefore, based on the above and the analysis in section 5.4.1, a 20 mm head joint with a 10 mm wide sealant applied on both sides is positively assessed for the FRL's as listed in Table 12.

Control joint C consisted of a 40 mm wide control joint with 20 mm deep H.B. Fuller FulaFlex FR hybrid sealant on both sides, installed in a 120 mm concrete wall and tested in accordance with AS 1530.4:2014. The sealant was applied using 28 mm × 20 mm and 20 mm × 20 mm backing rods. This construction achieved an FRL of -/240/120. It is proposed that a 40 mm head joint with 20 mm wide FulaFlex FR hybrid sealant applied flush on both sides will perform similarly. The insulation failure at 166 minutes was recorded on the separating element, while the control joint maintained insulation for up to 240 minutes. Therefore, based on the fact that the control joint maintained an integrity and insulation of up to 240 minutes, it is expected that a 40 mm head joint with a 20 mm wide sealant applied flush on both sides is positively assessed for the FRL's as listed in Table 12.

Control joint D consisted of a 50 mm wide control joint with 25 mm deep H.B. Fuller FulaFlex FR hybrid sealant flush on both sides, installed in a 120 mm concrete wall and tested in accordance with AS 1530.4:2014. The sealant was applied using 2 × 28 mm × 20 mm backing rods. This construction achieved an FRL of -/240/120. It is proposed that a 50 mm head joint with 25 mm wide FulaFlex FR hybrid sealant applied flush on both sides will perform similarly. The insulation failure at 173 minutes was recorded on the separating element while the control joint maintained insulation for up to 240 minutes. Therefore, since the control joint maintained an integrity and insulation for up to 240 minutes, a 50 mm head joint with a 25 mm wide sealant applied flush on both sides is positively assessed for the FRL's as listed in Table 12.

It is proposed that a 30 mm wide head joint with 15 mm deep H.B. Fuller Fulaflex FR hybrid sealant flush on both sides is expected to achieve an FRL of up to -/240/240 in a 175 mm concrete separating element. In FRT190354 R1.0, the 40 mm and 50 mm wide control joints with half their width in sealant achieved an FRL of -/240/120, with insulation failing due to the separating element rather than the control joint in both cases. This is likely because the control joints were tested in a 120 mm concrete wall. Based on the above information, it is expected that a 30 mm wide head joint with 15 mm wide H.B. Fuller FulaFlex FR hybrid sealant flush on both sides is positively assessed for the FRL's as listed in Table 12.

It is proposed that a 20 mm head joint with 15 mm of H.B. Fuller FulaFlex FR hybrid sealant applied flush on both sides is expected to achieve an FRL of up to -/240/240 in a 175 mm concrete separating element. This is a reasonable proposition, as a 30 mm wide head joint with 15 mm deep sealant was positively assessed and that is a more onerous position than a 20 mm head joint with 15 mm deep sealant. Therefore, a 20 mm head joint with 15 mm deep FulaFlex FR hybrid sealant is positively assessed for the FRL's as listed in Table 12.

The expected performance of the sealant in isolation was discussed above. However, in practice, the FRL of the joints will be governed by the FRL of the separating element they are installed into. As per AS/NZS 3600:2018, 120 mm, 150 mm and 175 mm concrete walls and floors are indicated to achieve FRLs of -/120/120, -/180/180 and -/240/240, respectively, if appropriate design conditions are met. Based on the above, the applicable FRLs of the head joints are summarised in Table 12.

Table 12 Head joints in concrete walls with sealant on both sides

<table>
<tr><th rowspan="3">Head joint width</th><th rowspan="3">Local fire-stopping protection</th><th rowspan="3">Sealant depth</th><th rowspan="3">Sealant application</th><th colspan="3">FRL</th></tr>
<tr><th colspan="3">Minimum separating element effective thickness*</th></tr>
<tr><th>120 mm</th><th>150 mm</th><th>175 mm</th></tr>
<tr><td>50 mm</td><td rowspan="6">H.B. Fuller Fulaflex FR hybrid</td><td>25 mm</td><td rowspan="6">Applied on both sides as illustrated in Figure 4</td><td rowspan="6">-/120/120</td><td rowspan="6">-/180/180</td><td rowspan="4">-/240/240</td></tr>
<tr><td>40 mm</td><td>20 mm</td></tr>
<tr><td>30 mm</td><td>15 mm</td></tr>
<tr><td>20 mm</td><td>15 mm</td></tr>
<tr><td>20 mm</td><td>10 mm</td><td>-/240/180</td></tr>
<tr><td>10 mm</td><td>10 mm</td><td>-/240/240</td></tr>
<tr><td colspan="7">*The stipulated separating element thickness is applicable to solid block concrete, hollow core and masonry construction. The effective thickness must be as per AS 3600:2018 and AS 3700:2018 respectively. Hollow core masonry cores must be filled with concrete where the joint is present to ensure insulation is preserved.

The backing rod and the sealant must be sandwiched between rigid surfaces only.</td></tr>
</table>

5.4.3 Double caulked head joints in concrete walls

In test FRT220290 R1.0, specimen A consisted of a 35 mm wide double caulked control joint with 30 mm and 20 mm deep H.B. Fuller FulaFlex FR hybrid installed in a 150 mm thick concrete floor slab and tested in accordance with AS 1530.4:2014. The sealants were applied 25 mm apart and installed using backing rods. This construction achieved an FRL of -/240/180.

Specimen B consisted of a 25 mm wide double caulked control joint with 15 mm and 25 mm deep H.B. Fuller FulaFlex FR hybrid installed in a 150 mm thick concrete floor slab and tested in accordance with AS 1530.4:2014. The sealants were applied back-to-back and installed using backing rods. This construction achieved an FRL of -/240/120. The reduction in insulation performance can be attributed to back-to-back installation of the sealant, as it offers heat transfer through conduction in addition to radiation and convection.

In test FRT200213 R1.0, specimen C consisted of a 10 mm wide control joint with 10 mm deep H.B. Fuller FulaFlex FR sealant applied to the depth of the backing rod and finished flush with the face of the separating element on both the unexposed and exposed sides. It was tested in a 150 mm thick concrete slab in accordance with AS 1530.4:2014. This construction achieved an FRL of -/240/180. As discussed in section 5.3.6, since a 10 mm control joint is not expected to fail insulation, it is reasonable to consider that a 10 mm wide double caulked head joint will maintain integrity and insulation if the sealant is applied flush with the separating element from the exposed side.

The above observations establish the ability of 35 mm, 25 mm and 10 mm double caulked joints with sealant depth as discussed above to achieve the FRLs listed in Table 13 in a 150 mm thick concrete floor. It is proposed that the joints be installed in head joints. As joints in the floor are considered comparable to head joints due to the pressure conditions and gravitational force, it is expected that the observed performance will be replicated in concrete head joints.

In practical application, the FRL of the joints will be dictated by the separating element they are installed into. As per AS/NZS 3600:2018, 120 mm, 150 mm and 175 mm concrete walls and floors are stipulated to achieve an FRL of -/120/120, -/180/180 and -/240/240, respectively, if appropriate design conditions are met.

It is further proposed that the intermediate sizes between 35 mm, 25 mm and 10 mm joints – specifically, 11 mm – 25 mm and 26 mm – 35 mm – are assessed. The proposal includes replicating the sealant depth of the widest joint of the range, which is either tested or assessed for an FRL up to -/240/180. As the widest joint with the same sealant depth has achieved an FRL of up to -/240/180, it is reasonable to conclude that the narrower joint of the range will also achieve the same FRL. Based on the above, the joints listed in Table 13 are positively assessed for the shown FRL.

Table 13 Double Caulked head joints in concrete walls

<table>
<tr><th rowspan="3">Head joint width</th><th rowspan="3">Local fire-stopping protection</th><th rowspan="3">First layer sealant depth</th><th rowspan="3">Second layer sealant depth</th><th rowspan="3">Distance between sealant</th><th colspan="2">FRL</th></tr>
<tr><th colspan="2">Minimum separating element effective thickness*</th></tr>
<tr><th>150 mm</th><th>175 mm</th></tr>
<tr><td>26 mm – 35 mm</td><td rowspan="3">H.B. Fuller FulaFlex FR hybrid</td><td>30 mm</td><td>20 mm</td><td>Minimum 25 mm airgap as shown in Figure 5</td><td>-/180/180</td><td>-/240/180</td></tr>
<tr><td>11 mm – 25 mm wide</td><td>30 mm</td><td>20 mm</td><td rowspan="2">Applied back-to-back or with an air gap as shown in Figure 5</td><td>-/180/120</td><td>-/240/120</td></tr>
<tr><td>10 mm wide</td><td>10 mm</td><td>10 mm</td><td>-/180/180</td><td>-/240/180</td></tr>
<tr><td colspan="7">*The stipulated separating element thickness is applicable to solid block concrete, hollow core and masonry construction. The effective thickness must be as per AS 3600:2018 and AS 3700:2018 respectively. Hollow core masonry cores must be filled with concrete where the joint is present to ensure insulation is preserved.

The sealant is applied with a 20 x 30 mm rectangular section open cell backer rod.

The sealant shall be flush with the wall surface where fire exposure direction is expected.</td></tr>
</table>

5.5 Conclusion

This assessment demonstrates that the control joints as tabled above are expected to achieve the FRLs listed in accordance with AS 1530.4:2014 and AS 4072.1:2005. The applications of the sealant must be as per the tables and figures listed above as the systems are not symmetrical and would not be applicable for heat exposure from either side.

6. Validity

Warringtonfire does not endorse the tested or assessed products and systems in any way. The conclusions of this assessment may be used to directly assess fire resistance, but it should be recognised that a single test method will not provide a full assessment of fire resistance 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 test data, information and experience available at the time of preparation. If contradictory evidence becomes available to the assessing authority, the assessment will be unconditionally withdrawn and the report sponsor will be notified in writing. Similarly, the assessment should be re-evaluated, if the assessed construction is subsequently tested since actual test data is deemed to take precedence.

The sponsor is responsible for formally notifying Warringtonfire of any additional testing performed on their product/system. This obligation applies regardless of where the test was conducted, the results of the test, or whether it was initially considered part of Warringtonfire's ongoing assessment. The primary goal of this notification is to allow Warringtonfire to review the changes and determine whether they require re-evaluation or re-testing to determine whether the changes have affected the product's performance. It is important that the client promptly notify Warringtonfire if any such changes are implemented.

The procedures for the conduct of tests and the assessment of test results are subject to constant review and improvement. The sponsor is therefore recommended that this report be reviewed on, or before, the stated expiry date.

This assessment represents our opinion about the performance of the proposed systems that is expected to be demonstrated when subjected to test conditions in accordance with AS 1530.4:2014, based on the evidence referred to in this report.

This assessment is provided to H.B. Fuller Australia Pty Ltd for their own specific purposes. This report may be used as evidence of suitability in accordance with the requirements of the relevant National Construction Code. Building certifiers and other third parties must determine the suitability of the systems described in this report for a specific installation.

Appendix A Summary of supporting test data

A.1 Test report – FRT190354 R1.0

Table 14 Information about test report

Item	Details
Report sponsor	H.B. Fuller Australia Pty Ltd
Test laboratory	Warringtonfire Australia, Unit 2, 409-411 Hammond Road, Dandenong, Victoria 3175, Australia.
Test date	18/11/2019.
Test standards	AS1530.4-2014
Test Duration	241 minutes
Variation to test standards	The pressure varied up to 23 Pa from the prescribed test standard limits during the first 90 minutes of the test but was within the limits for the remainder of the test. Due to the nature of the specimen and the fact that no significant events occurred during these time periods, the variances in pressure are unlikely to have invalidated the test result. The temperature was up to 25 °C above the limits prescribed in the standard during the 45-46 minute period. The temperature was within the limits for the rest of the test. This over temperature resulted in the test conditions being more onerous and would not have invalidated the test result.
General description of tested specimen	The test specimen control joints were constructed from five concrete strips of 1600mm long and 120mm thick. Three of the strips were 200mm wide mounted centrally and the remaining two were 600mm and 570mm place on each side. The central strips were spaced at 10mm, 20mm, 40mm and 50mm apart forming the four specimen control joints. The strips were held together in a 1900mm wide by 1600mm frame.
Instrumentation	The test report states that the instrumentation was in accordance with AS1530.4:2014.

The test specimen achieved the following result:

Table 15 Results summary for this test report

Control joint	Criteria	Results	Fire resistance level (FRL)
A	Structural adequacy	Not applicable	**-/240/120**
	Integrity	No failure at 241 minutes	
	Insulation	Failure at 171 minutes	
B	Structural adequacy	Not applicable	**-/240/120**
	Integrity	No failure at 241 minutes	
	Insulation	Failure at 165 minutes	
C	Structural adequacy	Not applicable	**-/240/120**
	Integrity	No failure at 241 minutes	
	Insulation	Failure at 166 minutes	
D	Structural adequacy	Not applicable	**-/240/120**
	Integrity	No failure at 241 minutes	
	Insulation	Failure at 173 minutes	

A.2 Test report – FRT220290 R1.0

Table 16 Information about test report

Item	Details
Report sponsor	H.B. Fuller Australia Pty Ltd
Test laboratory	Warringtonfire Australia, Unit 2, 409-411 Hammond Road, Dandenong, Victoria 3175, Australia.
Test date	14/06/2023
Test standards	AS1530.4-2014
Test Duration	241 minutes
Variation to test standards	None
General description of tested specimen	The test specimen consisted of three control joints (35 mm × 1000 mm, 25 mm × 1000 mm, 50 mm × 1000 mm) that were tested in a 150 mm thick concrete floor slab in accordance with sections 2 and 10 of AS 1530.4:2014.
Instrumentation	The test report states that the instrumentation was in accordance with AS1530.4:2014.

The test specimen achieved the following result:

Table 17 Results summary for this test report

Control joint	Criteria	Results	Fire resistance level (FRL)
A	Structural adequacy	Not applicable	**-/180/180***
	Integrity	No failure at 241 minutes	
	Insulation	Failure at 226 minutes	
B	Structural adequacy	Not applicable	**-/180/120***
	Integrity	No failure at 241 minutes	
	Insulation	Failure at 135 minutes	
C	Structural adequacy	Not applicable	**-/180/90***
	Integrity	No failure at 241 minutes	
	Insulation	Failure at 116 minutes	
Note: * The assigned FRL is limited by the expected FRL of the separating element into which it is installed.			

A.3 Test report – FRT200213 R1.0

Table 18 Information about test report

Item	Details
Report sponsor	H.B. Fuller Australia Pty Ltd
Test laboratory	Warringtonfire Australia, Unit 2, 409-411 Hammond Road, Dandenong, Victoria 3175, Australia.
Test date	25/08/2020
Test standards	AS1530.4-2014
Test Duration	241 minutes

Item	Details
Variation to test standards	The pressure was up to 2 Pa below the limits prescribed in the standard during the 215-220 minute period. The pressure and temperature were within the limits for the rest of the test. Due to the nature of the specimen and the fact that no significant events occurred during this time period, this under pressure is unlikely to have invalidated the test results.
General description of tested specimen	The test specimen consisted of five control joints (30 mm × 1000 mm, 20 mm × 1000 mm, 50 mm × 1000 mm, 10 mm × 1000 mm, 30 mm × 1000 mm) that were tested in a 150 mm thick concrete floor slab in accordance with sections 2 and 10 of AS 1530.4:2014.
Instrumentation	The test report states that the instrumentation was in accordance with AS1530.4:2014.

The test specimen achieved the following result:

Table 19 Results summary for this test report

Control joint	Criteria	Results	Fire resistance level (FRL)
A	Structural adequacy	Not applicable	**-/240/180**
	Integrity	No failure at 241 minutes	
	Insulation	Failure at 215 minutes	
B	Structural adequacy	Not applicable	**-/240/180**
	Integrity	No failure at 241 minutes	
	Insulation	Failure at 213 minutes	
C	Structural adequacy	Not applicable	**-/240/180**
	Integrity	No failure at 241 minutes	
	Insulation	Failure at 225 minutes	
D	Structural adequacy	Not applicable	**-/240/180**
	Integrity	No failure at 241 minutes	
	Insulation	Failure at 218 minutes	
E	Structural adequacy	Not applicable	**-/240/180**
	Integrity	No failure at 241 minutes	
	Insulation	Failure at 217 minutes	