

# Performance of Vermitex TH insulation when applied to solid and hollow core concrete structural elements (vertical and/or horizontal) used for construction in tunnel applications

## Assessment Report

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**Report number:** FCO-2819

**Date:** 30/6/2022

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Commercial-in-confidence

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### Report Details:

Report CSIRO Reference number: FCO-2819/4666

### Report Status and Revision History:

VERSION	STATUS	DATE	DISTRIBUTION
Revision A	Draft for internal review	16/02/2016	CSIRO
Revision B	Final for issue	24/02/2016	CSIRO/LAF
Revision C	Amend for re-issue	05/12/2018	CSIRO/LAF
Revision C	Final for issue	1/6/2021	CSIRO/LAF
Revision d	Final for issue	30/6/2022	CSIRO/LAF

### Report Authorization:

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30/6/2022	30/6/2022	30/6/2022

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# Contents

Executive summary .....	4
1 Introduction .....	5
2 Supporting Data .....	5
3 Proposal .....	5
4 Analysis.....	6
5 Conclusion.....	7
6 Term of validity .....	10
Appendix A .....	11
CSIRO test numbered FS 3049/1696.....	11
CSIRO Sponsored Investigation report numbered SI 1589 .....	11
CSIRO Sponsored Investigation report numbered FSP 0836 .....	11
CSIRO Sponsored Investigation report numbered FSP 0837 .....	11
CSIRO Sponsored Investigation report numbered FSP 0981 .....	11
CSIRO Sponsored Investigation report numbered FSP 1070 .....	12
CSIRO Sponsored Investigation report numbered FSP 1071 .....	12
CSIRO Sponsored Investigation report numbered FSV 1198 .....	12
CSIRO Sponsored Investigation report numbered FSZ 1206 .....	13
CSIRO Sponsored Investigation report numbered FSP 1305 .....	13
CSIRO Sponsored Investigation report numbered FSH 1345 .....	14
CSIRO Sponsored Investigation report numbered FSV 1374 .....	14
CSIRO Sponsored Investigation report numbered FSV 1375 .....	15
CSIRO Sponsored Investigation report numbered FSZ 1406 .....	16
CSIRO Sponsored Investigation report numbered FSH 1468.....	16
L & A Fazzini post-test analysis numbered DOC- HCM/JUNE 2010/TEST .....	16
References.....	17

## Executive summary

This Division has re-analysed the available information on the likely performance of Vermitex TH insulation when applied to various concrete structural elements (vertical and/or horizontal) used for construction in tunnel applications.

Based on the observed performance of your Vermitex TH sprayed protection systems for horizontal ceilings and vertical wall membranes during standard fire tests to many fire curves including Eurocode 1 & 2, EN 1363 -1 & 2, it is the opinion of this Division that the Vermitex TH spray, applied over shotcrete, precast slabs, or other concrete elements normally constructed to have AS 3600 thicknesses covering the reinforcement, for use as tunnel linings and separations to a thickness specified in Tables 1 & 2 to obtain the temperature resistance given in the tables. You may also use the combination of the Trimesh and Vermitex<sup>®</sup> TH to construct walls and air plenums for the conveying of fresh air or smoke spill systems.

This opinion is for either new or existing systems where the Vermitex<sup>®</sup> TH is used to reinstate the fire-resistance level of the slab where, previous protective coatings have been removed and the substrate sealed.

You have also advised that specific tunnels may be used to accommodate heavy vehicular traffic powered by LPG or CNG with a potential exposure of the Vermitex TH to flame impingement if the tanks were to be pierced or the PRD were to release bursts of high pressure gas. The tanks vary in capacity from 50 to 250 litres capacity.

It is our opinion that the potential duration and impingement effect on the Vermitex TH sprayed onto a concrete element by an ignited jet flame of combustible gases (LPG or CNG) would be negligible and would not have a detrimental effect on the fire performance of the Vermitex TH.

# Performance of Vermitex TH insulation when applied to solid and hollow core concrete structural elements (vertical and/or horizontal) used for construction in tunnel applications

## 1 Introduction

This Division has re-analysed the available information on the likely fire performance of Vermitex TH insulation when applied to various concrete structural elements (vertical and/or horizontal) used for construction in tunnel applications.

## 2 Supporting Data

This Division has conducted various tests and provided assessments on fire protection systems. The data from these tests and assessments are used to support this assessment.

- CSIRO test numbered FS 3049/1696
- CSIRO Sponsored Investigation report numbered SI 1589
- CSIRO Sponsored Investigation report numbered FSP 0836
- CSIRO Sponsored Investigation report numbered FSP 0837
- CSIRO Sponsored Investigation report numbered FSP 0981
- CSIRO Sponsored Investigation report numbered FSP 1070
- CSIRO Sponsored Investigation report numbered FSP 1071
- CSIRO Sponsored Investigation report numbered FSV 1198
- CSIRO Sponsored Investigation report numbered FSZ 1206
- CSIRO Sponsored Investigation report numbered FSP 1305
- CSIRO Sponsored Investigation report numbered FSH 1345
- CSIRO Sponsored Investigation report numbered FSV 1374
- CSIRO Sponsored Investigation report numbered FSV 1375
- CSIRO Sponsored Investigation report numbered FSZ 1406
- CSIRO Sponsored Investigation report numbered FSH 1468
- L & A Fazzini post-test analysis numbered DOC- HCM/JUNE 2010/TEST

## 3 Proposal

You propose to apply designated thicknesses of your Vermitex TH sprayed insulation material to various permanent concrete elements to achieve specified fire performances when exposed to the various fire curves commonly adopted in the construction of tunnels including the most severe heating conditions of the HC modified (HC inc) curve.

## 4 Analysis

As indicated by the supporting documentation listed above, this Division has conducted numerous fire-resistance tests incorporating your sprayed insulation system applied to various elements. The applied thicknesses in these tests varied approximately from 15 mm to 75 mm.

As a result of this series of hose stream tests, fire tests and fire-resistance tests the 'stickability' of your spray insulation to the concrete elements has been demonstrated and the insulation performance established. The test results, particularly from the many hollow core precast slabs, have enabled us to approximate your spray to an equivalent thickness of concrete (approximately 0.55%).

In June of 2010 and in 19 December 2008 this Division conducted fire-resistance tests numbered FSH 1420 (HC inc Mod) and FSH 1345 (ASTM E1529) on the Vermitex TH sprayed directly (unreinforced) to concrete elements and to a suspended membrane ceiling system comprising your Vermitex TH and Trimesh sprayed over a compressed fibre cement (CFC) panel as well as a further portion of suspended membrane ceiling system comprising your Vermitex TH and Trimesh only.

The above systems represent the Vermitex TH as a standalone spray applied coating or the Vermitex TH and Trimesh prefabricated as a sprayed panel system. Your Vermitex TH system has been extensively tested in various configurations. The materials and construction systems adopted above have been originally tested as a ceiling system since 1982 and were successfully tested and reported in fire test report SI 1589.

Your Trimesh panels have been capable of supporting both your ceiling as well as wall separating construction for periods up to 4 hours. The wall was supported off 10mm rods placed at 600 mm centres whilst the ceiling was supported at 1200 x 1200 mm centres with 12mm rods centres without the aid of a suspended sub-frame.

On the 15 of October this Division completed tests FSV 1374 and FSV 1375 which were carried out to comply with TNO Report 1998-CVB-R1161-rev 1 and included a non-loadbearing wall system and your Vermitex TH panel and panel jointing system with numerous penetrating elements suitable for bearing loads from electrical and mechanical services.

As required under NFPA 5000 the wall was instrumented to comply with ASTM E-119 and heated to the requirements of the RWS curve.

On completion, the wall was subjected to and passed the required Hose Stream Test required by NFPA and ASTM wall tests to comply with ASTM E 2226.

Since the original issue of this assessment AS 1530.4 has been revised. CSIRO has reviewed the relevance of these changes and confirmed that the fire exposure to protection on the fireside of concrete elements is not tested any differently when tested in accordance with the previous or 2014 version of AS1530.4-2014.

## 5 Conclusion

Based on the observed performance of your Vermitex TH sprayed protection systems for horizontal ceilings and vertical wall membranes during standard fire tests and too many fire curves including Eurocode 1 & 2, EN 1363 -1 & 2; it is the opinion of this Division that Vermitex TH can be sprayed over shotcrete, precast slabs, or other concrete elements normally constructed to have AS 3600 thicknesses covering the reinforcement, for use as tunnel linings and separations to a thickness specified in Table 1 & 2 below to obtain the temperature resistance given in these tables. You may also use the combination of the Trimesh and Vermitex® TH to construct walls and air plenums for the conveying of fresh air or smoke spill systems.

This opinion is for either new or existing systems where the Vermitex® TH is used to reinstate the fire-resistance level of the slab where previous protective coatings have been removed and the substrate sealed.

**Table 1**

HC modified (HC <sub>inc</sub> ) FRP/FRL	VERMITEX® TH Thickness (21 mm) - Specimen 3 – Solid Slab					
	Concrete Interface temperature	25 mm from the interface	50 mm from the interface	70 mm from the interface	Spalling	
					Insulation	Concrete
30/30/30	90 °C	55 °C	35 °C	25 °C	No	No
60/60/60	135 °C	100 °C	100 °C	95 °C	No	No
90/90/90	185 °C	101 °C*	101 °C*	101 °C*	No	No
120/120/120	190 °C	101 °C*	101 °C*	101 °C*	No	No

Note: Neither Vermitex® TH nor concrete layers are delaminated or spalled.

\* Temperature plateau due to latent heat of evaporation of the water.

**Table 2**

HC modified (HC <sub>inc</sub> ) FRP/FRL	VERMITEX® TH Thickness (26 mm) - Specimen 1 – Hollow Core Slab					
	Concrete Interface temperature	25 mm from the interface	50 mm from the interface	70 mm from the interface	Spalling	
					Insulation	Concrete
30/30/30	100 °C	75 °C	40 °C	30 °C	No	No
60/60/60	180 °C	105 °C	90 °C	70 °C	No	No
90/90/90	285 °C	155 °C*	105 °C*	100 °C*	No	No
120/120/120	365 °C	215 °C*	120 °C*	120 °C*	No	No

Note: Neither Vermitex® TH nor concrete layers are delaminated or spalled.

**Table 3**

HC modified (HC <sub>inc</sub> ) FRP/FRL	VERMITEX® TH Thickness (23mm) - Specimen 2 – Hollow Core Slab					
	Concrete Interface temperature	25 mm from the interface	50 mm from the interface	70 mm from the interface	Spalling	
					Insulation	Concrete
30/30/30	115 °C	75 °C	40 °C	30 °C	No	No
60/60/60	225 °C	115 °C	95 °C	85 °C	No	No
90/90/90	335 °C	190 °C*	110 °C*	110 °C*	No	No
120/120/120	415 °C	255 °C*	145 °C*	120 °C*	No	No

Note: Neither Vermitex® TH nor concrete layers are delaminated or spalled.

The above data comes from FSH 1468 for the testing to the HC inc time-temperature curve conducted on 7 April 2011 and demonstrated that a 20-mm thickness or greater is sufficient to keep the surface temperature of a solid slab to less than 380°C when subjected to the HC inc time-temperature curve. For hollow core slabs the required thickness will depend on the thickness of the outer skins.

THICKNESS OF UNREINFORCED VERMITEX TH SPRAY APPLIED DIRECTLY TO BOTH VERTICAL AND HORIZONTAL CONCRETE TUNNEL ELEMENTS OF CONSTRUCTION WITH CONCRETE COVER TO REINFORCEMENT AND TENDONS TO COMPLY WITH AS3600, AS WELL AS BS 8110 AND EUROCODE 1 & 2

- (a) Fire Test to ISO 834, ASTM E119, AS 1530-4, BS 476 20&21, EN 1363-1 (Reference Test-FSP 1070)

<b>SOLID CONCRETE / VERMITEX TH INTERFACE TEMP</b>	<b>200°C</b>	<b>250°C</b>	<b>300°C</b>	<b>350°C</b>	<b>380°C</b>
REINFORCEMENT TEMP @ 25-mm cover	< 110°C	< 150°C	< 180°C	< 200°C	< 215°C
60 minutes	10mm	10mm	10mm	10mm	10mm
120 minutes	25mm	22mm	15mm	13mm	10mm
180 minutes	35mm	30mm	20mm	18mm	15mm
240 minutes	45mm	40mm	25 mm	23mm	20mm

- (b) Hydrocarbon Fire Test to BS 476 20&21, EN 1363-1 and UL 1709 (Reference Test-FSP 1071)

<b>SOLID CONCRETE / VERMITEX TH INTERFACE TEMP</b>	<b>200°C</b>	<b>250°C</b>	<b>300°C</b>	<b>350°C</b>	<b>380°C</b>
REINFORCEMENT TEMP @ 25-mm cover	< 110°C	< 150°C	< 180°C	< 200°C	< 215°C
60 minutes	28mm	15mm	10mm	10mm	10mm
120 minutes	35mm	25mm	18mm	15mm	12mm
180 minutes	45mm	35mm	22mm	20mm	18mm
240 minutes	55mm	45mm	26mm	24mm	22mm

- (c) RABT Train (Reference Test-FSP 1305)

<b>SOLID CONCRETE / VERMITEX TH INTERFACE TEMP</b>	<b>200°C</b>	<b>250°C</b>	<b>300°C</b>	<b>350°C</b>	<b>380°C</b>
REINFORCEMENT TEMP @25-mm cover	< 110°C	< 150°C	< 180°C	< 200°C	< 215°C
60 minutes	30mm	25mm	20mm	15mm	10mm
120 minutes	40mm	30mm	25mm	23mm	20mm



- (d) RWS (BS 476 20&21, EN 1363-1), UL 1709  
(Reference Test – FSH 1374, FSH 1375, FSH 1420 and FSH 1468)

SOLID CONCRETE / VERMITEX TH INTERFACE TEMP	200°C	250°C	300°C	380°C
REINFORCEMENT TEMP @ 50-mm cover	< 110°C	< 150°C	< 180°C	< 215°C
60 minutes	20mm	18mm	12mm	10mm
120 minutes	30mm	25mm	22mm	18mm

- (e) HC inc (Modified)- Eurocode 1 & 2 ,EN 1363 -1&2  
(Reference Tests – FSP FSH 1374, FSH 1375, FSH 1420 & FSH 1468)

SOLID CONCRETE / VERMITEX TH INTERFACE TEMP	200°C	250°C	300°C	380°C
REINFORCEMENT TEMP @ 50-mm cover	< 110°C	< 150°C	< 180°C	< 215°C
60 minutes	23mm	20mm	15mm	12mm
120 minutes	35mm	28mm	25mm	20mm

During test FSH 1420 it was recorded that the Vermitex TH, when sprayed unreinforced to the underside of a concrete pre-cast panel, to a thickness of 17mm, performed well and totally prevented spalling on the concrete face.

Such performance may be beneficial where the interface temperature between the concrete face and the spray can be overlooked even if the first 5-10 mm of concrete undergoes a potential chemical change. Notwithstanding the potential chemical change, which may reduce the compressive strength of the first 10-15 mm of concrete, it proved inconsequential to the stickability of the Vermitex TH leaving the coating well adhered to the concrete face for the duration of 2 hour test.

The maximum temperature recorded at 25 mm from the concrete face, did not exceed 379 °C, whilst the maximum temperature recorded at the steel reinforcement level of 50 mm from the concrete face, did not exceed 209 °C. At this temperature, the steel reinforcement would not exhibit any significant loss of strength.

- (f) HCinc (Modified)- Eurocode 1 & 2 ,EN 1363 -1&2  
(Reference Tests – FSH 1374 & FSH 1420)

VERMITEX TH thickness required for 120/120/120	30mm	25mm	20mm	17mm
TEMPERATURE @ 25mm FROM CONCRETE FACE	200 °C	250° C	300° C	379° C
REINFORCEMENT TEMP @ 50-mm cover	< 140 °C	< 145 °C	< 155°C	< 165 °C
CONCRETE / VERMITEX TH surfaces	NO SPALLING	NO SPALLING	NO SPALLING	NO SPALLING

You have also advised that specific Tunnels may be used to accommodate heavy vehicular traffic powered by LPG or CNG with potential exposure of the Vermitex TH to flame impingement if the tanks

were to be pierced or the PRD were to release bursts of high pressure gas. The tanks vary in capacity from 50 to 250 litres capacity.

It is our opinion that the potential duration and impingement effect on the Vermitex TH sprayed onto a concrete element by an ignited jet flame of combustible gases (LPG or CNG) would be negligible and would not have a detrimental effect on the fire performance of the Vermitex TH.

The performance of Trimesh barriers is now covered in FCO 2913.

## 6 Term of validity

This assessment report will lapse on 30<sup>th</sup> June 2027. Should you wish us to re-examine this report with a view to the possible extension of its term of validity, would you please apply to us three to four months before the date of expiry. This Division reserves the right at any time to amend or withdraw this assessment in the light of new knowledge.

# Appendix A

## CSIRO test numbered FS 3049/1696

On 30 July 1998, an indicative fire test was conducted on Vermiduct and Rein Panel in accordance with the guidelines provided in AS 1530.4-1990. The specimen comprised a five (5) sided cube protected with Vermiduct, Vermiduct WP and Vermitex 7WP sprayed insulation. The cube had a 1050 x 1050 mm clear opening on the underside.

## CSIRO Sponsored Investigation report numbered SI 1589

On 14 July 1982 this Division conducted a fire resistance test on a 4600 mm x 3700 mm low-slope metal-deck roof comprising steel purlins and bracing and steel roof sheeting. The underside of the roof sheeting was insulated with fibreglass insulation supported on a steel wire mesh. A ceiling system was suspended beneath the roof on steel hanger rods. The ceiling membrane comprised a 60-mm thick 'Vermitex 7' a Vermiculite base product. The spray was applied in two layers. The first layer on to expanded steel lath fixed to a grid of steel channels. A galvanised steel mesh was fixed beneath the first layer and the second layer was sprayed over it. Some sections of the lower layer of the spray were lost within the first 15 minutes. The roof/ceiling structure did not fail at the test termination time of 242 minutes.

## CSIRO Sponsored Investigation report numbered FSP 0836

The specimen comprised a 1150-mm x 1150-mm x 125-mm thick concrete slab supported on all four sides by a 500-mm high steel frame. The specimen was protected by Vermitex TH sprayed insulation. The test was conducted on 19 December 2000 in accordance with AS 1530.4-1997 and British Standard 476, Part 20, Appendix D.

## CSIRO Sponsored Investigation report numbered FSP 0837

The specimen comprised a 1150-mm x 1150-mm x 125-mm thick concrete slab supported on all four sides by a 500-mm high steel frame. The specimen was protected by Vermitex TH sprayed insulation. The test was conducted on 22 December 2000 in accordance with AS 1530.4-1997 and British Standard 476, Part 20, Appendix D.

## CSIRO Sponsored Investigation report numbered FSP 0981

The sponsor identified the specimen as three loadbearing beam sections, three reinforced concrete panels and one partially exposed timber joist sample. The specimen was protected by Vermitex TH and AF sprayed insulation. The test was conducted on 28 June 2003 in accordance with BS 476, Parts 20 & 21, Appendix D, Hydrocarbon curve.

## CSIRO Sponsored Investigation report numbered FSP 1070

The sponsor identified the specimen as Vermitex TH surface adhered cementitious compound used to fire protect various construction elements. Test 1, comprising a concrete slab, steel beam, metal cable tray and electrical cables, CFRP strip and Trimesh perimeter walls was conducted on 30 June 2004 in accordance with ISO 834-1:1999– Part 1, 6.1.1 Heating Curve and AS/NZS 3013:1995, Appendix A. Test 2 comprising a concrete slab, steel beam, metal cable tray and electrical cables, CFRP strip and Trimesh perimeter walls was conducted on 2 July 2004 in accordance with AS/NZS 3013:1995, Appendix A.

## CSIRO Sponsored Investigation report numbered FSP 1071

The fire tests were conducted on 9 July 2004 (Test1) and 14 July 2004 (Test 2) under the guidelines specified in British Standard 476: Part 20: 1987, Fire tests on building materials and structures, Part 20, Appendix D, Method for determination of fire resistance of elements of construction (general principles)

The specimens comprised an 1150-mm x 1150-mm x 150-mm thick concrete slab protected by Vermitex “TH” cementitious compound. The Vermitex “TH” spray material was applied to the exposed face of the concrete slabs in successive coats until the final levelled target thickness was achieved. A single layer of texture was then applied to the specimen surface.

### Spray Application

Test Number:	TARGET THICKNESS (mm)
Test 1:	25
Test 2:	10

Vermitex ‘TH’ had a dry density of 400 kg/m<sup>3</sup> (± 10 %).

Test 1: The test specimen did not qualify for Fire Resistance due to the reduced size of the test specimen. The specimen fulfilled the Integrity and Insulation criteria of BS476: Part 20 for the duration of the test period.

Test 2: The test specimen did not qualify for Fire Resistance due to the reduced size of the test specimen. The specimen fulfilled the Integrity and Insulation criteria of BS476: Part 20 for the duration of the test period

## CSIRO Sponsored Investigation report numbered FSV 1198

The specimen comprised Trimesh wall panels sprayed with Vermitex TH cementitious compound to form a non-loadbearing partition with overall nominal dimensions of 3020-mm high x 3000-mm wide x 70-mm thick in accordance with ASTM E119 – 2005, Standard Test Methods for Fire Tests of Building Construction and Materials on 15 June 2006.

Performance observed in respect of the following ASTM E119 - 2005 criteria for fire-resistance:

Structural stability	Not applicable
Integrity	No failure at 241 minutes
Insulation	No failure at 241 minutes

Therefore the specimen provides an ASTM E119 classification period for fire-resistance of 4-hours. The fire-resistance classification is applicable for fire exposure from the direction tested.

## CSIRO Sponsored Investigation report numbered FSZ 1206

The specimen comprised Trimesh wall panels sprayed with Vermitex TH cementitious compound to form a non-loadbearing partition with overall nominal dimensions of 3020-mm high x 3020-mm wide x 70-mm thick. Specimen construction comprised a steel perimeter track section (Rondo Part No. 661C) bolted to the top, bottom and one vertical side of the specimen containing frame using M12 bolts at 600-mm centres. The steel perimeter track used on the remaining vertical edge of the specimen was fixed to the top and bottom track only. A 50-mm wide x 10-mm thick strip of Insufoam was inserted within the steel bottom perimeter track section. Hilti CP611A fire rated mastic was used to provide a seal between the steel perimeter frame and the specimen containing frame. The top perimeter track incorporated five vertical M12 threaded rods located at nominally 600-mm centres extending to nominally 300-mm above the bottom perimeter track. The wall panel system incorporated Trimesh R100 wall panels measuring 1200-mm wide x 2200-mm long x 30-mm thick. These Trimesh panels incorporated a layer of aluminium foil fixed to one face of the panel using speed clips at 300-mm and 400-mm centres. The Trimesh R100 wall panels were installed inside the steel perimeter frame and incorporated the vertical M12 threaded rods located within the panels. The M12 threaded rods were wire tied to the Trimesh panels on the side opposite to the aluminium foil backing. All butt joints between the Trimesh panels of the partition system were reinforced using 300-mm wide RG1 lapping strip installed centrally over the joint and wire tied to the Trimesh panels using 1.25-mm diameter tie wire at 300-mm centres. The Vermitex TH cementitious based spray compound was spray applied directly to the foil backing of the Trimesh R100 wall panels. Construction is detailed in drawings numbered 01 and 02 by L & A Fazzini Manufacturing Pty Ltd.

Performance observed in respect of the following ASTM E119 - 2005 criteria for fire-resistance:

Integrity – no failure at 241 minutes

Insulation – no failure at 241minutes

The element of construction described above also satisfied the ASTM –E119, Section 11 Hose Stream Test criteria for a duration of 5 minutes.

The element of construction described above satisfied the Conditions of Acceptance of ASTM –E119, for a 4-hours fire rated non-loadbearing wall system. The fire endurance test was conducted on 15 June 2006 and the hose stream test was conducted on 3 July 2006.

## CSIRO Sponsored Investigation report numbered FSP 1305

The specimen comprised an 1150-mm x 1150-mm x 150-mm thick reinforced concrete slab protected by Vermitex 'TH' cementitious compound on the exposed face. The testing was conducted under the guidelines specified in:

Australian Standard 1530, Methods for fire tests on building materials, components and structures, Part 4-2005, Fire-resistance tests of elements of building construction.

British Standard 476: Part 20: 1987, Fire tests on building materials and structures, Part 20, Appendix D, Method for determination of fire resistance of elements of construction (general principles).

European Standard EN 1363-1:1999, Fire Resistance Tests – Part 1: General requirements.

The testing was conducted following the heating conditions specified by the RABT (train) time/temperature curve.

The fire-resistance test was conducted on 29 November 2007.

## CSIRO Sponsored Investigation report numbered FSH 1345

The specimen tested on the 20th April 2009 comprised of a Trimesh ceiling which spanned 3020-mm x 6020-mm constructed using Trimesh R200 panels. The panel thickness was 50-mm and incorporated a layer of aluminium foil fixed on external face. The foil was secured with 5mm speed clips at 300 and 400-mm centres.

One coat of Vermitex TH was sprayed to a thickness of 30-35 mm over the Trimesh plane and allowed to dry. The final thickness was then built up with Vermitex TH to provide an overall cover of 60-mm. The ceiling system was instrumented in accordance with ASTM E119-08a, Standard Test Methods for Fire Tests of Building Construction and Materials. The ceiling was exposed to the heating conditions specified in Figure 3.1 of UL 1709 – 2005, Rapid Rise Fire Tests of Protection Materials for Structural Steel, for the first half of the fire endurance test, and as specified in Section 4 of ASTM E1529-06, Standard Test Methods for Determining Effects of Large Hydrocarbon Pool Fire on Structural Members and Assemblies, for the second half of the fire endurance test.

The tested satisfied the integrity and insulation criteria as specified in ASTM E119 – 2008a criteria for fire endurance for the 241 minute duration of the test.

## CSIRO Sponsored Investigation report numbered FSV 1374

The specimen comprised Trimesh wall panels sprayed with Vermitex TH cementitious compound to form a non-loadbearing wall with overall nominal dimensions of 3020-mm high x 3000-mm wide x 90-mm (average) thick. Specimen construction comprised a steel perimeter track section bolted to the top, bottom and one vertical side of the specimen containing frame using M12 bolts at 600-mm centres. The steel perimeter track used on the remaining vertical edge of the specimen was fixed to the top and bottom track only. A 75-mm wide x 10-mm thick strip of Insufoam was inserted within the steel bottom perimeter track section. Hilti CP611A fire rated mastic was used to provide a seal between the steel perimeter frame and the specimen containing frame on two vertical sides and the bottom. The top perimeter track incorporated five vertical M12 threaded rods 1800-mm long located at nominally 600-mm centres extending to nominally 300-mm above the bottom perimeter track. The wall panel system incorporated Trimesh R200 wall panels measuring 1200-mm wide x 2280-mm long x 50-mm thick. These Trimesh panels incorporated a layer of aluminium foil fixed to one face of the panel using speed clips at 300-mm and 400-mm centres. The Trimesh R200 wall panels were installed inside the steel perimeter frame and incorporated the vertical M12 threaded rods located within the panels. The M12 threaded rods were wire tied to the Trimesh panels on the side opposite to the aluminium foil backing. All butt joints between the Trimesh panels of the wall system were reinforced using 300-mm wide RG1 lapping strip installed centrally over the joint and wire tied to the Trimesh panels using 1.25-mm diameter tie wire at 300-mm centres. The Vermitex TH cementitious based spray compound was spray applied directly to the foil backing of the Trimesh R200 wall panels. Construction is detailed in drawings numbered 001 and 004 by L & A Fazzini Manufacturing Pty Ltd. The fire endurance test was conducted on 13 October 2009 in accordance with ASTM E119-2008a, Standard Test Methods for Fire Tests of Building Construction and Materials. Heating curve specified in TNO Report 1998-R116-rev 1 (RWS curve).

The element of construction described above satisfied the following criteria for fire endurance for the period stated when subjected to the RWS heating curve.

Loadbearing capacity	not applicable
Integrity	93 minutes
Insulation	No failure at 120 minutes

## CSIRO Sponsored Investigation report numbered FSV 1375

The specimen comprised two horizontal panels ceiling with overall dimensions of 1800 mm long x 600-mm wide built from Trimesh R100 panel. Each panel was nominally 65 mm thick to include the 6 mm “Vitrapanel” CFC panel bolted to the bottom face. The panels were supported by a 50-mm x 25-mm x 2.5-mm RHS steel frame to the panel perimeter. The two panels were installed leaving a 30-mm gap. The gap as well as the space between the two RHS sections (approximately 75 mm wide) running along the longitudinal joint of the two adjoining panels was later filled to a depth of 80 mm with Vermitex THc. The panel was terminated 75 mm away from the central spandrel panel. A 100-mm x 100-mm x 1.0-mm angle was fixed into the lightweight concrete spandrel panel and lightweight AAC blocks at 600-mm centres. The angle was then back filled from the top with “Vermitex THc” and finished with a 90-mm coving onto the wall. A number of services were then cut into the LAF composite panel with a hole-saw and these included;

- a) 65 mm galvanised malleable iron pipe,
- b) 38 mm galvanised malleable iron pipe;
- c) CCTV camera enclosure, and
- d) 8-mm, 12-mm and 16-mm galvanised threaded rods.

A mesh cage was placed around all penetrations and “Vermitex TH” mixture was used to seal the entire depth of the penetration whilst Hilti 611 A was used to provide a 10-mm deep smoke seal around the penetration through the CFC board.

The camera enclosure had internal clearances of 250-mm by 300-mm high and was manufactured from Trimesh and secured with 1.0-mm galvanised tie wire to the upper layer of the Trimesh panel with Quikmesh (25-mm x 25-mm x 1.0-mm). The Quikmesh was later hand patched with Vermitex THc to form a 90-mm thick coving around the perimeter of the enclosure.

All penetrations were finished with a 90-mm coving around the penetration.

The element of construction described above satisfied the following criteria for fire-resistance for the period stated when subjected to the RWS heating curve.

Loadbearing capacity	-	not applicable
Integrity	-	No failure at 120 minutes
Insulation	-	No failure at 120 minutes

The test was conducted on 13 October 2009 in accordance with EN 1363-1:1999 – Fire resistance tests. General requirements, EN 1363-2:1999 – Fire resistance tests. Alternative and additional procedures, EN 1366-3:2009 – Fire resistance tests for service installations. Penetration seals and EN 1366-4:1999 – Fire resistance tests for service installations. Linear joint seals.

## CSIRO Sponsored Investigation report numbered FSZ 1406

The specimen comprised Trimesh wall panels sprayed with Vermitex TH cementitious compound to form a non-loadbearing wall with overall nominal dimensions of 3020-mm high x 3000-mm wide x 90-mm (average) thick. Specimen construction comprised a steel perimeter track section bolted to the top, bottom and one vertical side of the specimen containing frame using M12 bolts at 600-mm centres. The steel perimeter track used on the remaining vertical edge of the specimen was fixed to the top and bottom track only. A 75-mm wide x 10-mm thick strip of Insufoam was inserted within the steel bottom perimeter track section. Hilti CP611A fire rated mastic was used to provide a seal between the steel perimeter frame and the specimen containing frame on two vertical sides and the bottom. The top perimeter track incorporated five vertical M12 threaded rods 1800-mm long located at nominally 600-mm centres extending to nominally 300-mm above the bottom perimeter track. The wall panel system incorporated Trimesh R200 wall panels measuring 1200-mm wide x 2280-mm long x 50-mm thick. These Trimesh panels incorporated a layer of aluminium foil fixed to one face of the panel using speed clips at 300-mm and 400-mm centres. The Trimesh R200 wall panels were installed inside the steel perimeter frame and incorporated the vertical M12 threaded rods located within the panels. The M12 threaded rods were wire tied to the Trimesh panels on the side opposite to the aluminium foil backing. All butt joints between the Trimesh panels of the wall system were reinforced using 300-mm wide RG1 lapping strip installed centrally over the joint and wire tied to the Trimesh panels using 1.25-mm diameter tie wire at 300-mm centres. The Vermitex TH cementitious based spray compound was spray applied directly to the foil backing of the Trimesh R200 wall panels. Construction is detailed in drawing numbered 004 by L & A Fazzini Manufacturing Pty Ltd.

The element of construction described above satisfied the ASTM – E119, Section 11 Hose Stream Test criteria for duration of 2 minutes and 30 seconds.

The test was conducted on 13 October 2009 in accordance with ASTM E119 – 2005 Standard Test Methods for Fire Tests of Building Construction and Materials – Section 11 Hose Stream Test.

## CSIRO Sponsored Investigation report numbered FSH 1468

The specimens comprised nominally two 5000-mm x 900-mm x 300-mm thick hollow core concrete slabs and one 5000-mm x 1200-mm x 150-mm thick solid concrete slab, all protected on the underside with Vermitex TH, spray applied, cementitious compound insulation material. The test was conducted in accordance with Heating conditions specified in “Specification and Guidelines for Testing of Passive Fire Protection for Concrete Tunnel Linings”, Appendix A Modified Hydrocarbon Curve (HCM) on 7 April 2011.

## L & A Fazzini post-test analysis numbered DOC- HCM/JUNE 2010/TEST

On 3 June 2010, L & A Fazzini Manufacturing conducted a post-test analysis on hollow core precast slab test to HC modified curve. The fire-resistance test conducted on 3 June 2010 in accordance with Eurocode 1 & 2 and EN 1363-1 & 2 and reported on in CSIRO Sponsored Investigation report numbered FSH 1420.



# References

The following informative documents are referred to in this Report:

ISO 834-1 :1999	Fire-resistance tests --Elements of building construction --Part 1: General requirements
BS 476 Part 24: 1987	Fire tests on building materials and structures, Method for the determination of the fire resistance of ventilation ducts
BS 476 Part 20: 1987	Fire tests on building materials and structures, Method for the determination of the fire resistance of elements of construction (general principles);
AS 1530.4-2014	Methods for fire tests on building materials, components and structures, Fire-resistance tests of elements of building construction
AS 3600	
British Standard 8110 Parts 1 & 2	
Euro code 1 & 2	
EN 1363 -1 & 2	
CSIRO test numbered FS 3049/1696	Test conducted on 30 July 1998.
SI 1598	Full-scale fire-resistance report conducted on 14 July 1982.
FSP 0836	Vermitex TH to HC in test numbered FS 3356/2110 (19 December 2000)
FSP 0837	(Vermitex TH to HC)
FSP 0981	
FSP 1070	(1st Test Vermitex TH to ISO 4 hour), (2nd Test Vermitex TH to modified French HC peaks at 1350°C)
FSP 1071	(3rd Test Vermitex TH to BS EN 1363 Parts 1 and 2, FSP 1071 (4th Test Vermitex TH to BS EN 1363 HC)
FSV 1198	4 hour fire-resistance test to ASTM E 119 carried out on 15 June 2006, on a sprayed Vermitex TH non-loadbearing wall element
FSZ 1206	Hose stream test (4 hour fire exposure) according to ASTM E 2226 and ASTM E 119 (on 3 July 2006), on a sprayed Vermitex TH non-loadbearing wall element.
FSP 1305	Report on test conducted on 29 November 2007 to the RABT Train Curve.
FSH 1345	4 hour fire-resistance test to ASTM E 1529 (Hydrocarbon Pool Fire –Rapid Rise) carried out on 18 December 2008, on a sprayed ceiling and structural steel elements.
FSV 1374	2 hour fire-resistance test to RWS (TNO Report 1998-R116-rev1) carried out on 13 October 2009, on a sprayed Vermitex TH non-loadbearing wall element.
FSV 1375	2 hour fire-resistance test to RWS (TNO Report 1998-R116-rev1) carried out on 13 October 2009, on a sprayed Vermitex TH non-loadbearing ceiling element, inclusive of pipe and other services penetrations.
FSZ 1406	Hose stream test (for 2 hour fire exposure) according to ASTM E 2226 and ASTM E 119 however with a 2 hour fire-resistance test to RWS (TNO Report 1998-R116-rev1) carried out on 13 October 2009, on a sprayed Vermitex TH non-loadbearing wall element.
FSH 1468	2 hour fire-resistance test to HC <sub>inc</sub> carried out on 7 April 2011 on three concrete elements.
DOC- HCM/JUNE 2010/TEST	Post-test analysis on a fire-resistance test to the HC inc (MOD) fire curve and reported in FSH 1420 conducted on 3 June 2010, on a hollow core precast slab element.

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