The fire resistance of 3M Fire Barrier Duct Wrap 615+ protection system for internal fire exposure

Assessment Report

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1 Introduction

This report is an assessment of the fire resistance of the 3M Fire Barrier Duct Wrap 615+ protection system in accordance with AS 1530.4-2014 for internal fire exposure.

This report is prepared for the purpose of meeting the requirements of NCC 2019 Volume 1 Schedule 5 clauses 2b) and 2 c) or NCC 2022 Volume 1 Clauses S1C2 (b) and (c) as appropriate for FRL.

This report reviews and confirms the extent to which the reference fire resistance tests listed in Section 2 meet the requirements of the fire test standards listed in Section 4 of the report. The proposed variations to the tested construction presented in Section 3 are subject to an analysis in Appendix B and the conclusions are presented in Section 5 of this report.

The field of applicability of the results of this assessment report is presented in Section 6 and subject to the requirements, validity and limitations of Sections 7, 8 and 9.

2 Supporting Data

This assessment report refers to various test reports to support the analysis and conclusions of this report. They are listed below;

Report Reference	Test Standard	Outline of Test Specimen
FSV 1844	AS 1530.4-2014	Horizontally orientated duct protected with 3M Fire Barrier Duct Wrap 615+ for internal fire exposure.
FSP 2015	AS 1530.4-2014	Vertically orientated duct protected with 3M Fire Barrier Duct Wrap 615+ for internal fire exposure.
BTC 18644FA	BS EN 13381-4:2013	Supplementary data on Glasroc F encased steel column sections.
FSP 2247	AS 1530.4-2014	Vertically orientated duct protected with 3M Fire Barrier Duct Wrap 615+ for internal fire exposure, with access panels
FSH 2299	AS 1530.4-2014	Horizontally orientated duct protected with 3M Fire Barrier Duct Wrap 615+ for external fire exposure

The test report FSV 1844, FSP 2015, FSP 2247 and FSH 2299 were undertaken by CSIRO North Ryde and sponsored by 3M Australia Pty Ltd.

The test report BTC 18644FA was undertaken by The Building Test Centre, Loughborough. CSR limited has given permission on behalf of British Gypsum for the use of this report for assessment purposes.

3 Proposed Variations

3.1 Horizontal Ducts – Internal exposure

The proposed construction for horizontal ducts for internal exposure only and shall be as tested in FSV 1844 and subject to the following variations:

- Inclusion of 150mm wide third layer of wrap at collar for 120-minute applications.
- Simultaneous variation of duct size and length of each wrap layer based on design
- Duct construction shall vary up to 3600mm x 3600mm in size and be in accordance with AS 4254-2012 Pressure Class 1000.
- Duct hanger rod size, hanger spacing, support, duct BMT, stiffeners and jointing shall be in accordance with AS 4254.2-2012 as appropriate for Pressure Class 1000 and do not require fire protection.
- Inclusion of access panels as tested in FSP 2247 as per Figure 12
- The opening for the access panel system to be at least 600mm away from the separating wall element and 400mm from the duct joint
- Variation to support construction to include concrete, masonry, plasterboard, Speedpanel, and AAC panel walls.
- The inclusion of a minimum 100 mm width of 3M Venture 1520-CW - 50µm thick aluminium foil tape with Acrylic pressure-sensitive adhesive with temperature resistance at least 121° C
- The inclusion of 3M Fire Barrier CP25WB+ sealant
- The inclusion of Glasroc F as an alternative wall collar material
- The proposed construction is summarised in Table 1 and Figures 1 to 14.

3.2 Vertical Ducts – Internal exposure

The proposed construction for vertical ducts for internal exposure only and shall be as tested in FSP 2015 and subject to the following variations:

- Duct wrap to be above slab as per Figure 15 only
- Removal of plasterboard build-up on the unexposed side (topside) & angle on the exposed (underside)
- Variation of 2nd and 3rd layers of wrap for 60 minute and 120 minute applications duct construction shall vary up to 3600mm x 3600mm in size and be in accordance with AS 4254-2012 Pressure Class 1500.
- Duct hanger rod size, hanger spacing, support, duct BMT, stiffeners and jointing shall be in accordance with AS 4254.2-2012 as appropriate for Pressure Class 1500 and do not require fire protection.
- Duct support & spacing between stiffeners/joints in accordance with AS 4254.2-2012 as appropriate for Pressure Class 1500
- Inclusion of access panels as tested in FSP 2247 as per Figure 12
- The opening for the access panel system to be at least 1450mm of separating slab element and 400mm from the duct joint
- The proposed construction is summarised in Table 1 and Figures 8 -11, 12-17

3.3 Horizontal and vertical Ducts – External exposure

The proposed construction for horizontal ducts for external exposure only and shall be as tested in FSH 2299 and subject to the following variations:

- Wall support construction shall be as tested in FSH 2299
- Duct to be wrapped the entire length with two layers of wrap
- Variation in duct sizes up to 3000mmx 3000mm
- Ducts to be straight, joints to be tapped with Aluminum foil tape, and duct wrapped with 12mm x 0.5 mm stainless or carbon steel bands at a maximum of 300mm ctrs. Corners wrap to be pinned to the duct with capacitive discharge pins at 300mm ctrs.
- Duct orientation to vary to include vertical ducts based on FSH 2299
- Duct slab detail is to be based on FSH 2299 and FSP 2247 as shown in Figure 18
- Duct hanger rod size, hanger spacing, support, duct BMT, stiffeners and jointing shall be in accordance with AS 4254.2-2012 as appropriate for Pressure Class 1000 and designed to support the weight of duct under external exposure for up to 120 minutes
- The proposed construction is summarised in Table 1 and Figures 7, 10, 11, 13, 14, 16, 17, 18

Table 1 – Construction Specification

Item #	Description
1	***Retaining angle*** **INTERNAL EXPOSURE** • **Horizontally orientated ducts** 2 mm steel retaining angle on each side of the wall, refer to Tables 2 & 3 for size • **Vertically orientated ducts** 1.6mm steel retaining angle on the top side of the floor, refer to Tables 4 & 5 for size **EXTERNAL EXPOSURE** • **Horizontally orientated ducts** 1.6 mm steel retaining angle on each side of the wall, refer to Table 6 for the size • **Vertically orientated ducts** 1.6 mm steel retaining angle on the top and bottom side of the slab, refer to Table 6 for the size
2	***Collar Fixing Screws*** **Plasterboard wall** - 8 gauge x 100 mm plasterboard/wood screw @ 200 mm centres **Concrete & Masonry Wall** - 8 gauge x 100 mm masonry screw @ 200 mm centres **Speedpanel wall** –10 gauge x 115 mm flat top screw, 20TPI **Autoclaved Aerated Concrete (AAC) panel wall** –14 gauge x 100mm flat top screw, 17TPI
3	***Steel Angle Fixing (to walls)*** **Plasterboard wall** - 8 gauge x 50mm flat-head plasterboard screw @ 200 mm centres (countersunk into steel angle). **Concrete & Masonry -** 8 gauge x 50mm flat-head masonry screw @ 400 mm centres (countersunk into steel angle). **Speedpanel –** 10 gauge x 30 mm flat head screw, 16TPI, @ 200 mm centres (countersunk into steel angle). **Autoclaved Aerated Concrete (AAC) –**14 gauge x 50 mm flat top screw, 17TPI, @ 200 mm centres (countersunk into steel angle) **Steel Angle Fixing to concrete slab** - 8 gauge x 50mm flat-head masonry screw @ 400 mm centres (countersunk into steel angle).

4	**Steel angle to duct Fixing** 5mm ø x 10mm length blind steel rivets @ 200 mm centres.
5	**Plasterboard collar for 60 minutes application** • Four layers of 16mm fire grade plasterboard or 2 layers of 30 mm Glasroc F as per Figure 1 or 2 additional layers of 150mm wide wrap as per Figure 1a **Plasterboard collar for 120 minutes application** • Four layers of 16mm fire grade plasterboard or 2 layers of 30 mm Glasroc F with an additional layer of 150mm wide wrap as per Figure 2 All gaps sealed with 3M fire barrier 2000+ sealant or 3M Fire Barrier CP25WB+
6	**Sealant around duct and wall/floor gap packing** • 3M Fire Barrier 2000+ Sealant or 3M Fire Barrier CP25WB+ • 15mm minimum depth or a depth of 50% of the joint width
7	**Seal around plasterboard collar (item 5)** 10mm fillet of either 3M Fire Barrier 2000+ Sealant or 3M Fire Barrier CP25WB+
8	**Duct and wall/floor gap packing** 90mm wide compressed un-foiled contents of 3M Fire Barrier 615+ Duct Wrap fill the full width of the gap
9	**Separating element** **INTERNAL EXPOSURE** The wall shall be tested or assessed as a wall and designed to include an aperture for the duct o Plasterboard wall – Min thickness 116mm o Concrete & Masonry Wall – Min thickness 100mm o Speedpanel wall – Min thickness 78mm o Autoclaved Aerated Concrete (AAC) panel wall – Min thickness 75mm The floor shall be tested or assessed as a floor and designed to include an aperture for the duct o Concrete slab – Min. thickness 150mm **EXTERNAL EXPOSURE**The wall shall be tested or assessed as a wall and designed to include an aperture for the duct o Concrete & Masonry Wall – Min thickness 230mm o Plasterboard wall – Min thickness 126mm • The floor shall be tested or assessed as a floor and designed to include an aperture for the duct o Concrete slab – Min. thickness 150mm
10	**Duct** **INTERNAL EXPOSURE** Horizontal ducts: Steel duct constructed to AS 4254, pressure class 1000 pa or higher. Vertical ducts: Steel duct constructed to AS 4254, pressure class 1500 pa or higher. **EXTERNAL EXPOSURE** Steel duct constructed to AS 4254, pressure class 1000 pa or higher.
11	**Duct Wrap** 3M Fire Barrier 615+ Duct Wrap. The first layer is continuously applied to the whole duct. The length of the other layers of the wrap is to be as per Tables 2-5.

12	**Duct wrap collar -** 3M Fire Barrier 615+ Duct Wrap collar 150mm wide. **INTERNAL EXPOSURE** Required for 120-minute applications when installed in walls only. **EXTERNAL EXPOSURE** Required for when installed in walls and slabs.
13	**Access panel Opening for internal exposure only** **An o**pening cut in the ductwork to suit the appropriate size of the access door.
14	**Vertical duct access panel options for internal exposure only** 1. Skamo Tech calcium silicate board design • Install 25mm thick steel frame of up to 548mm x 420mm in an opening size of up to 465mm x 330mm at min.400mm above the duct joint and min.1450mm above slab using 5mm steel rivets and sealed with 3MCP25WB+ sealant to the duct. • Fit two 12.7mm wide 3M Expantrol flexible intumescent strips to the 30mm wide flange of the access cover frame • Bond a 1.6mm steel sheet to a 40mm Skamo Tech calcium silicate board • Mechanically fix 40mm Skamo Tech calcium silicate board to the frame using M6 x 50mm wing screws. 2. 3M 615+ duct wrap design • Install 80mm thick steel frame of up to 654mm x 540mm in an opening size of up to 534mm x 420mm at min.400mm above the duct joint and min.1450mm above slab using 5mm steel rivets at 110mm spacings and sealed with 3MCP25WB+ sealant to the duct. • Apply 3M Fire Barrier CP25WB+ between the 3M 615+ Duct Wrap and the access panel frame. • Apply 2 x 12.7mm wide 3M Expantrol flexible intumescent strips (e-FIS) to the flange of the access cover frame. • Fasten a 1.6mm steel sheet to the frame using M6 x 10mm cap-head screws. • Fix 2 layers of 80mm thick 3M 615+ duct wrap of up to 609mm x 620mm and one layer of 10mm non-fire rated plasterboard to the steel plate using four M6 x 100mm screws into M6 rivet nut inserts. **Refer to Figure 12**
15	**Seal around duct wrap for 2& 3 side protection** 30mm x 30mm fillet, continuous 3M Fire Barrier 2000+ Sealant or 3M Fire Barrier CP25WB+
16	**Horizontal duct support for external fire exposure** 30mm x 30mm steel angle trapeze supports suspended on threaded M16 rods • To be located at 1150mm from plasterboard walls • To be located at 1350mm from masonry walls **Vertical duct support for external fire exposure** Duct hanger rod size, hanger spacing, support, duct BMT, stiffeners and jointing shall be in accordance with AS 4254.2-2012 as appropriate for Pressure Class 1000 and designed to support the weight of the duct under external exposure for up to 120 minutes
17	**Insulation Bands** • 12mm x 0.5mm stainless steel bands at max. 300 mm spacing
18	**Insulation pins** Capacitive discharge pins with washers fixed at 300mm centres on the duct to fix insulation on the underside only for horizontally orientated ducts and on each side for vertically orientated ducts.
19	**Joint Tape** • 3M 425 Aluminium Foil Tape Or • 3M Venture 1520-CW - 3M Venture Aluminium Foil Tape, 100 mm width (minimum 50µm thick foil with Acrylic adhesive, temperature resistance > 120°C).

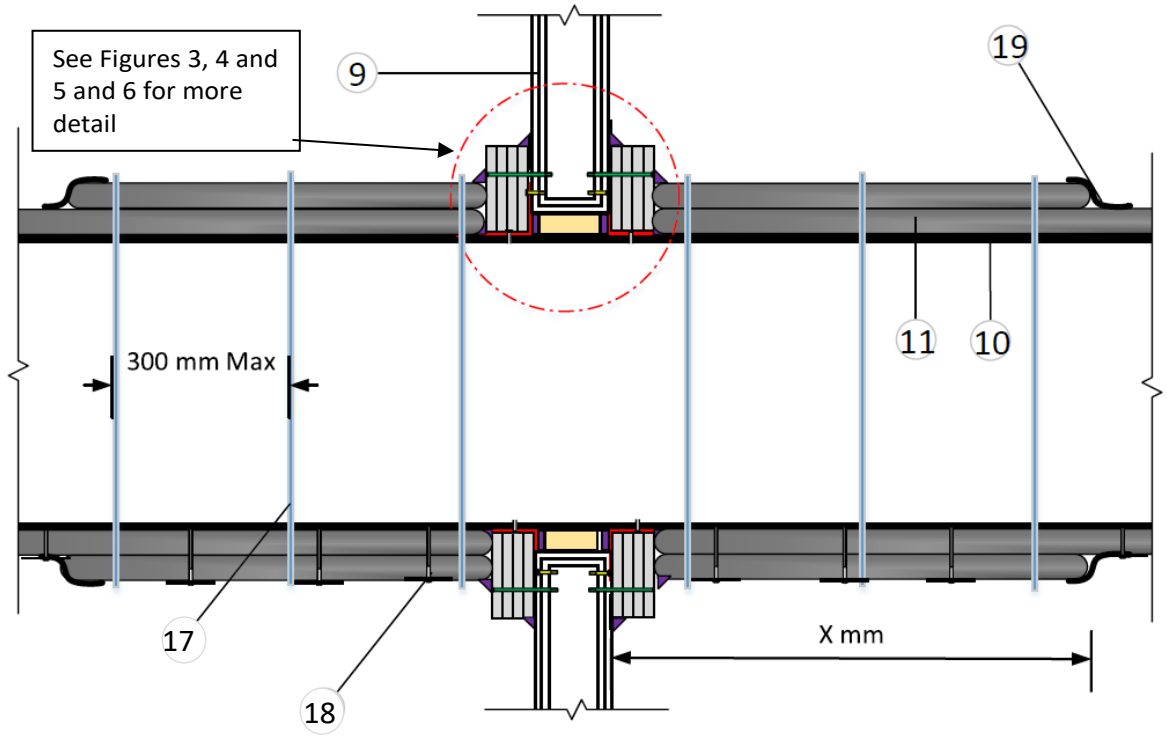


Figure 1 – General arrangement of 3M Fire Barrier 615+ Duct Wrap for 60-minute applications – internally exposed horizontally orientated duct

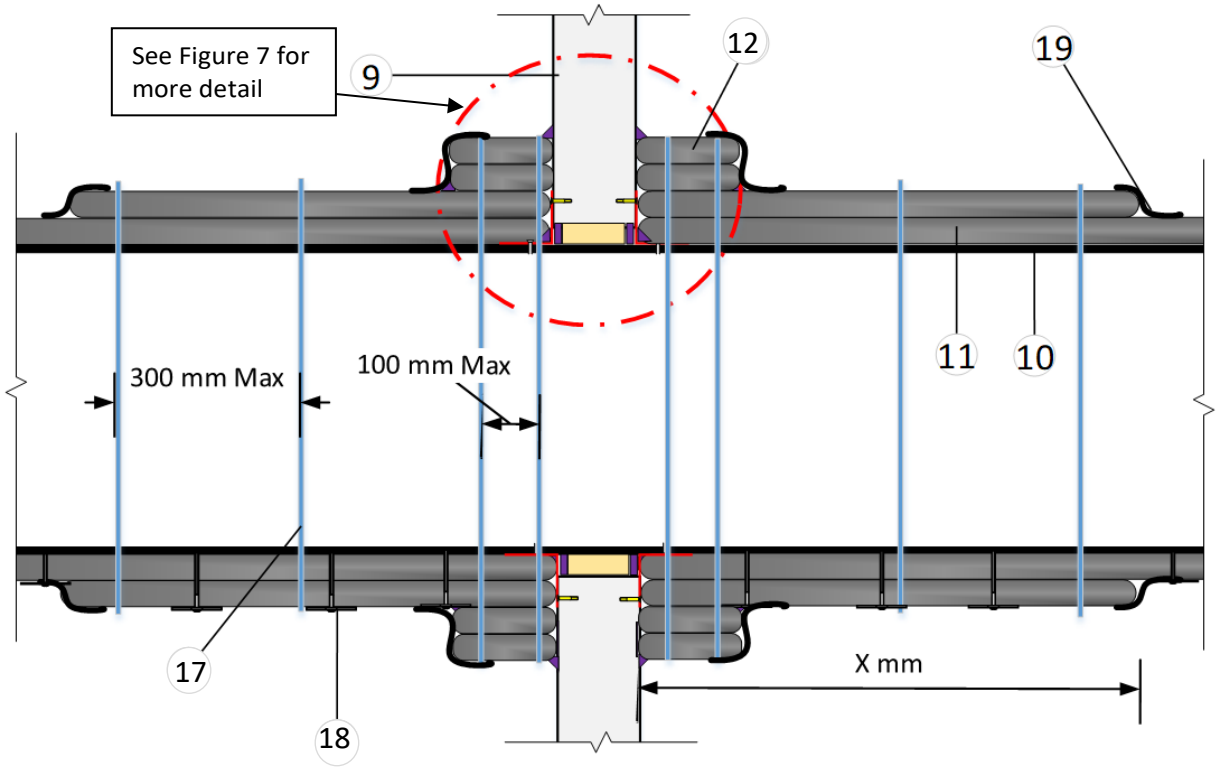


Figure 1a– Alternative arrangement of 3M Fire Barrier 615+ Duct Wrap with Duct Wrap collar for 60-minute applications – internally exposed horizontally orientated duct

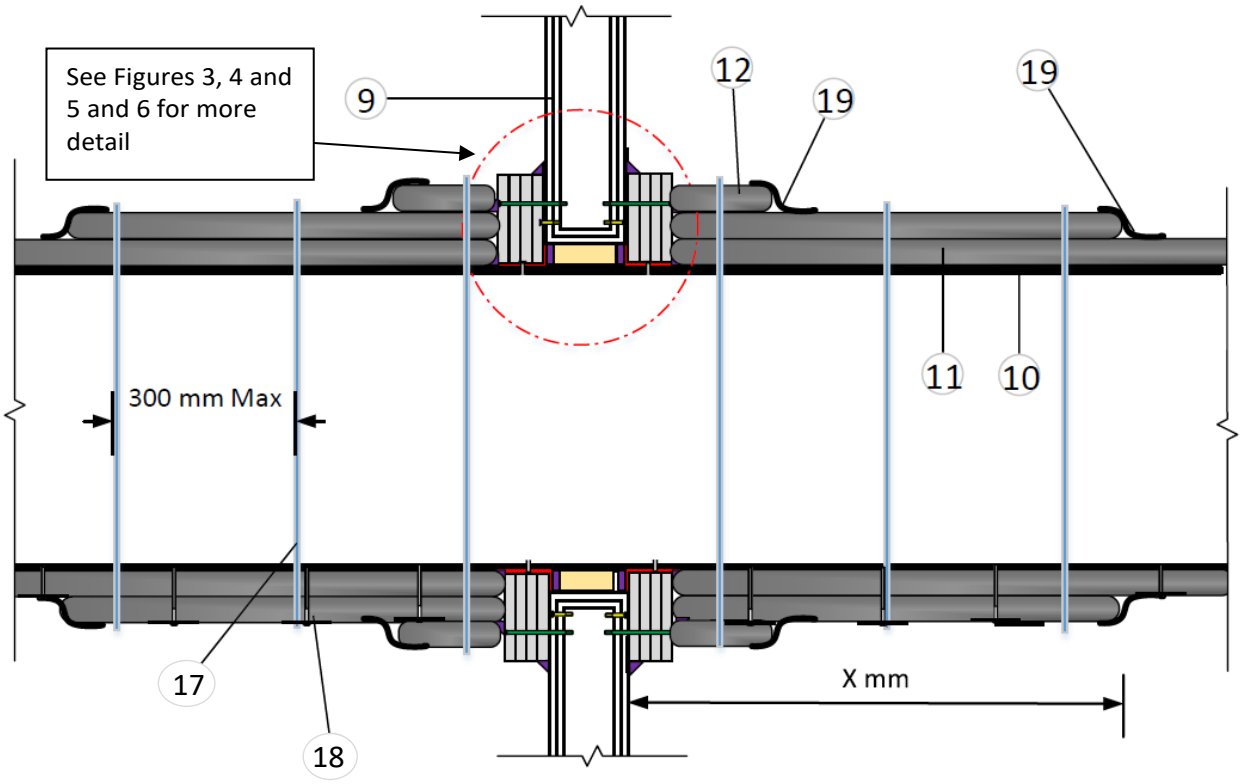


Figure 2 – General arrangement of 3M Fire Barrier 615+ Duct Wrap with plasterboard collar for 120-minute applications – internally exposed horizontally orientated duct

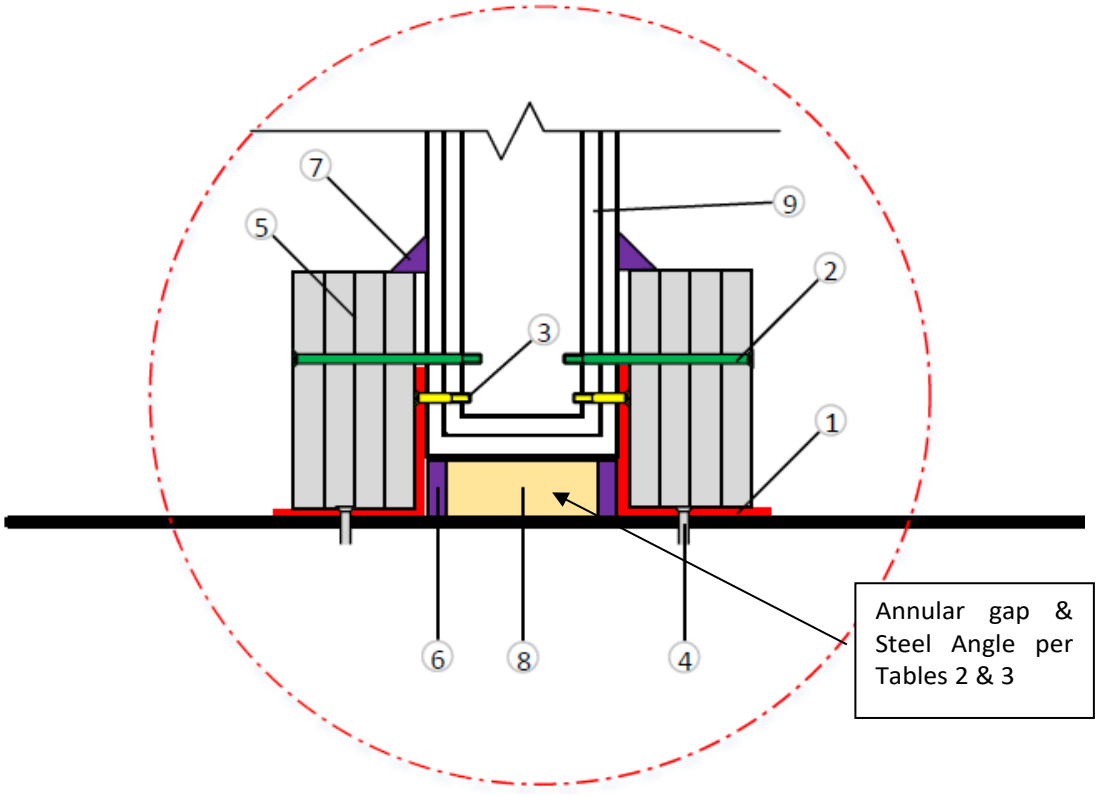


Figure 3 – Duct to wall junction for plasterboard – internally exposed horizontally orientated duct

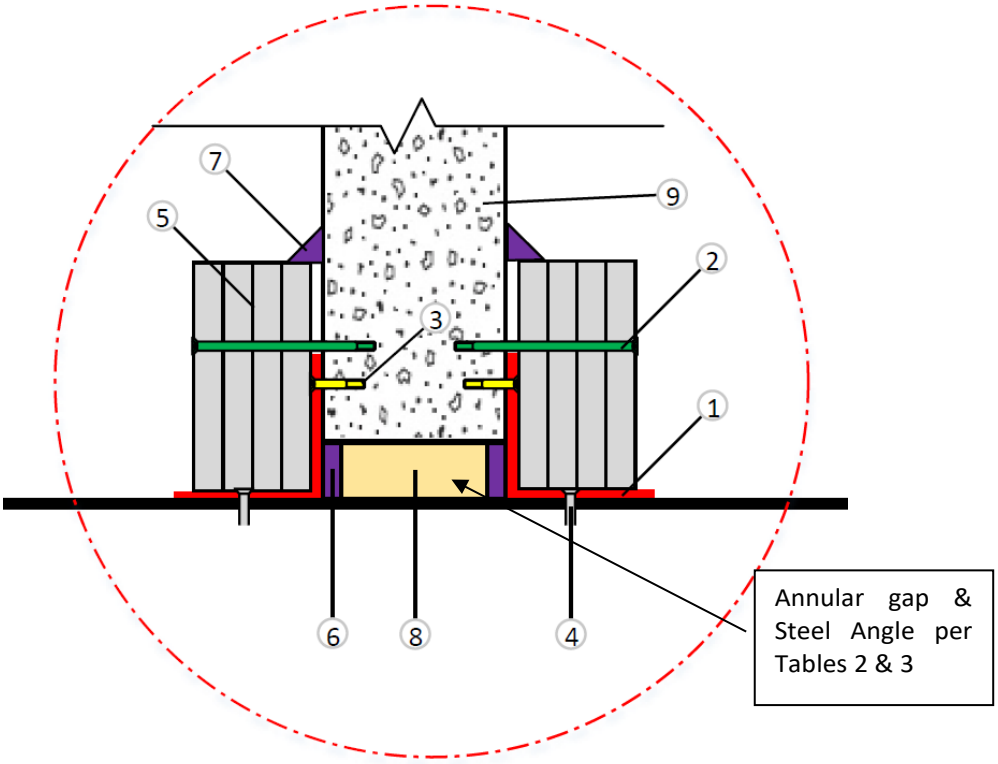


Figure 4 – Duct to wall junction for concrete/masonry wall penetration – internally exposed horizontally orientated duct

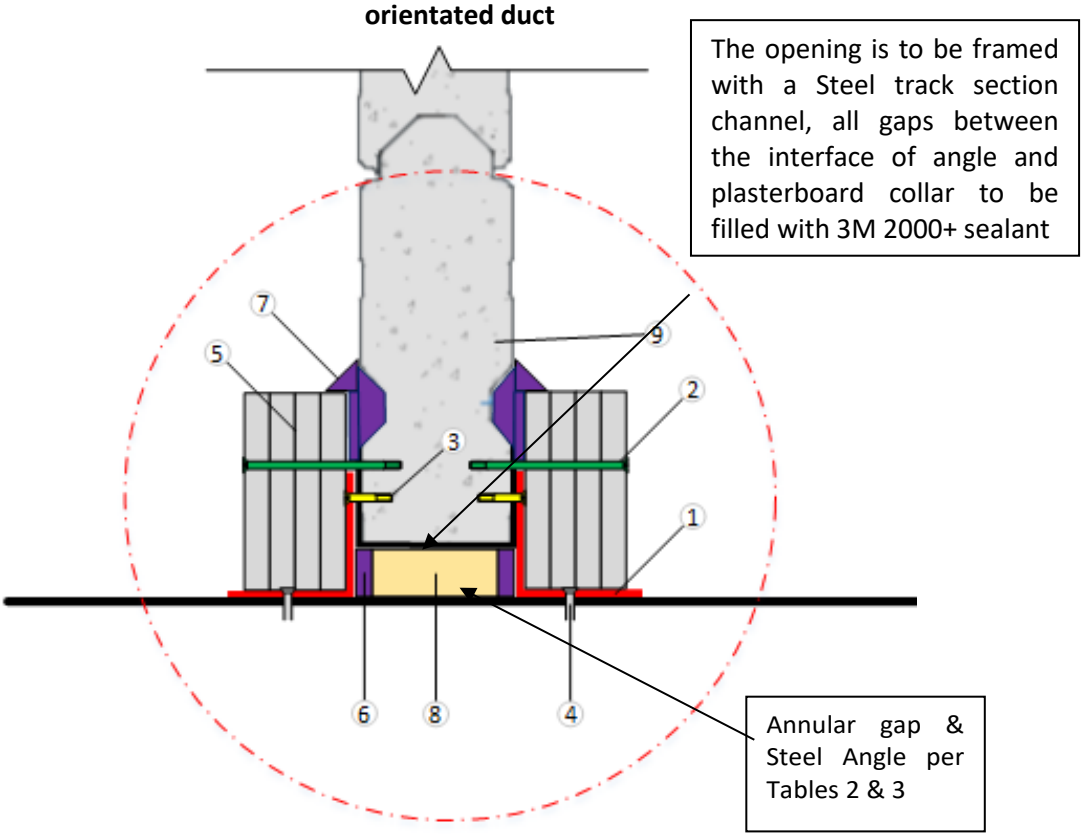


Figure 5 – Duct to wall junction for Speedpanel penetration – internally exposed horizontally orientated duct

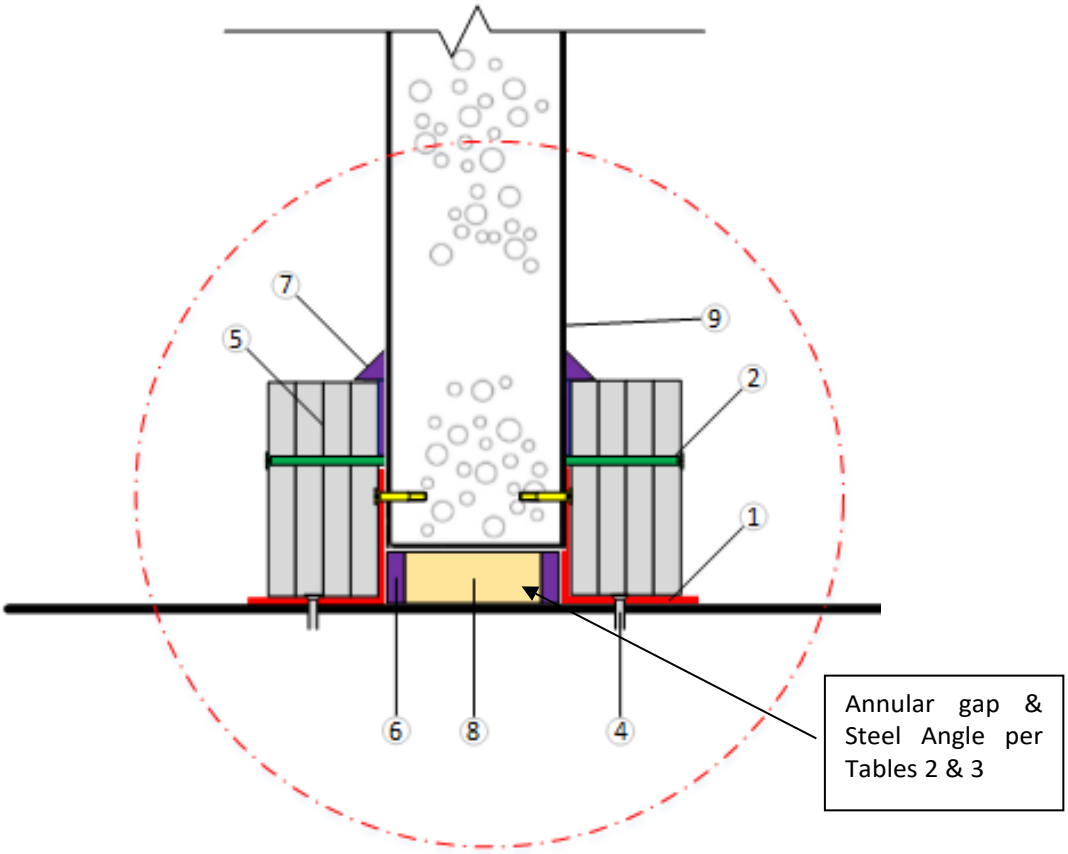


Figure 6 – Duct to wall junction for AAC panel penetration – internally exposed horizontally orientated duct

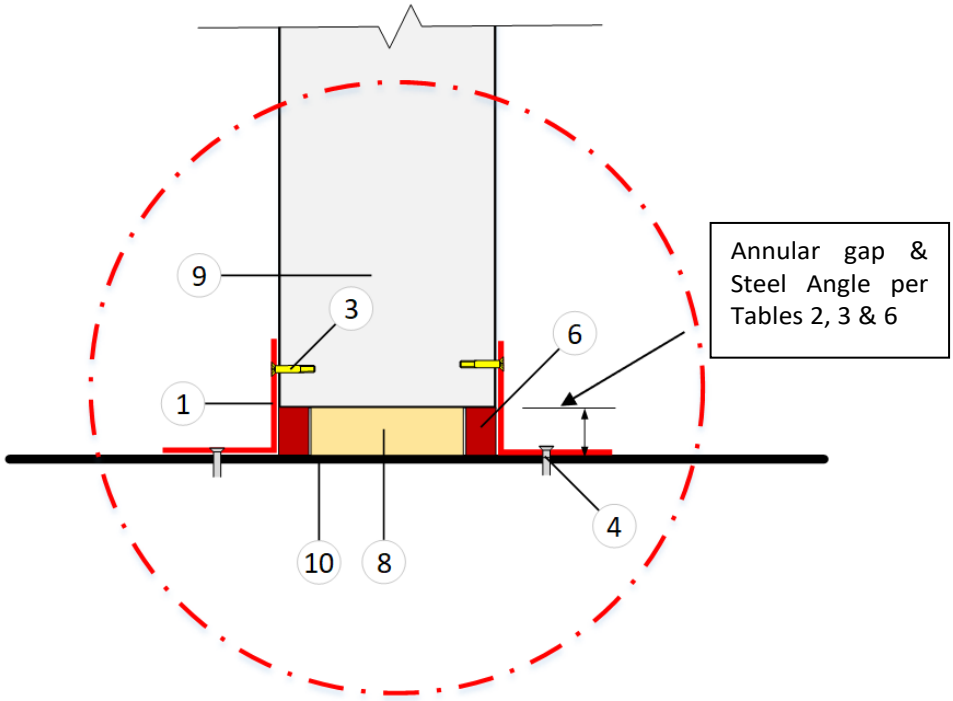


Figure 7 – Detail of Gap at the perimeter of the duct – internally and externally exposed horizontally orientated duct

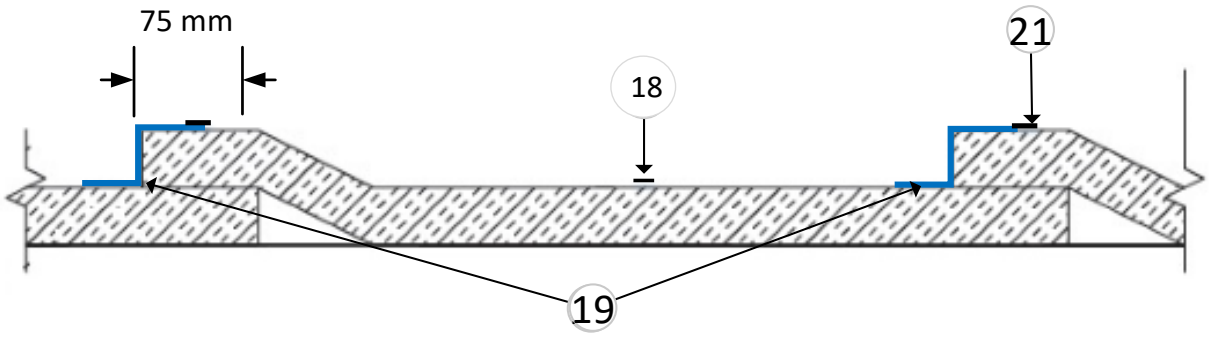


Figure 8 – Joints for single layer sections (Telescoping Method)

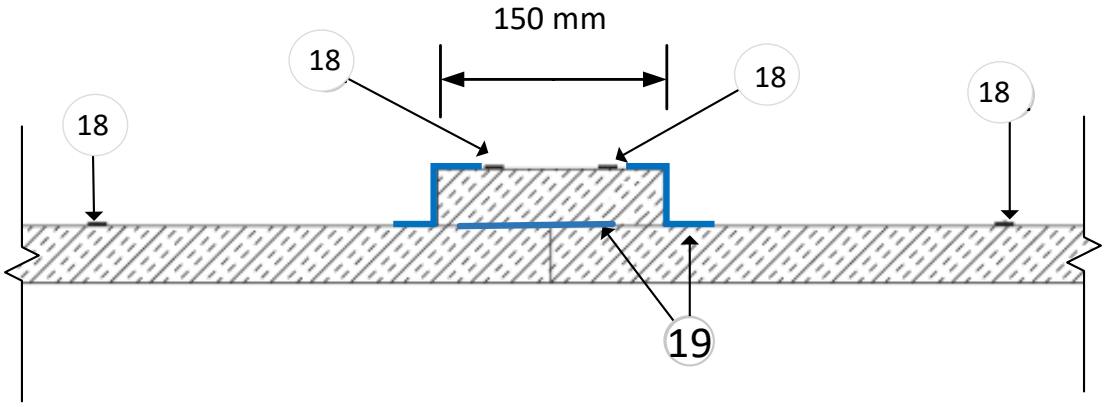


Figure 9 – Joints for a single layer (Butt Joint with Wrap Collar Method)

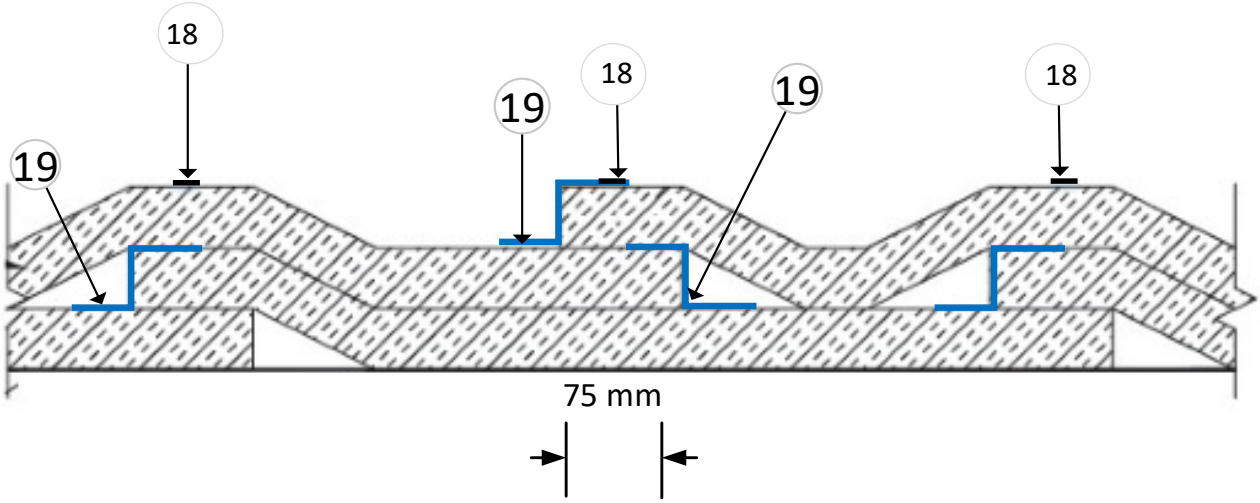


Figure 10 – Joints/wrap overlaps and taping (sealing) of joints for double layer sections (Telescoping Method)

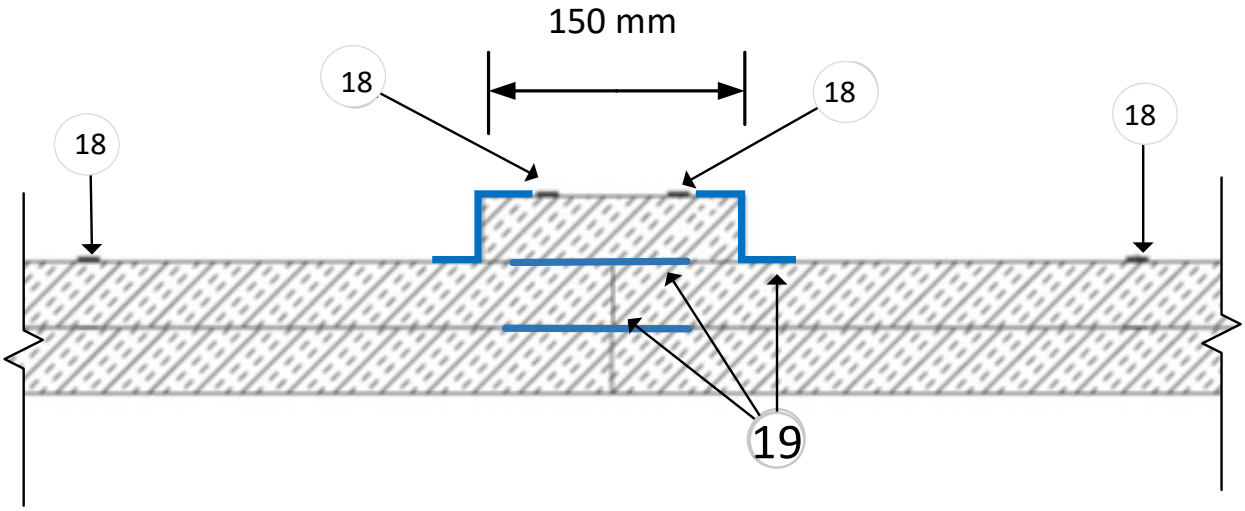


Figure 11 –Joints/wrap overlaps and taping (sealing) of joints for double layer sections (Butt Joint with Wrap collar Method)

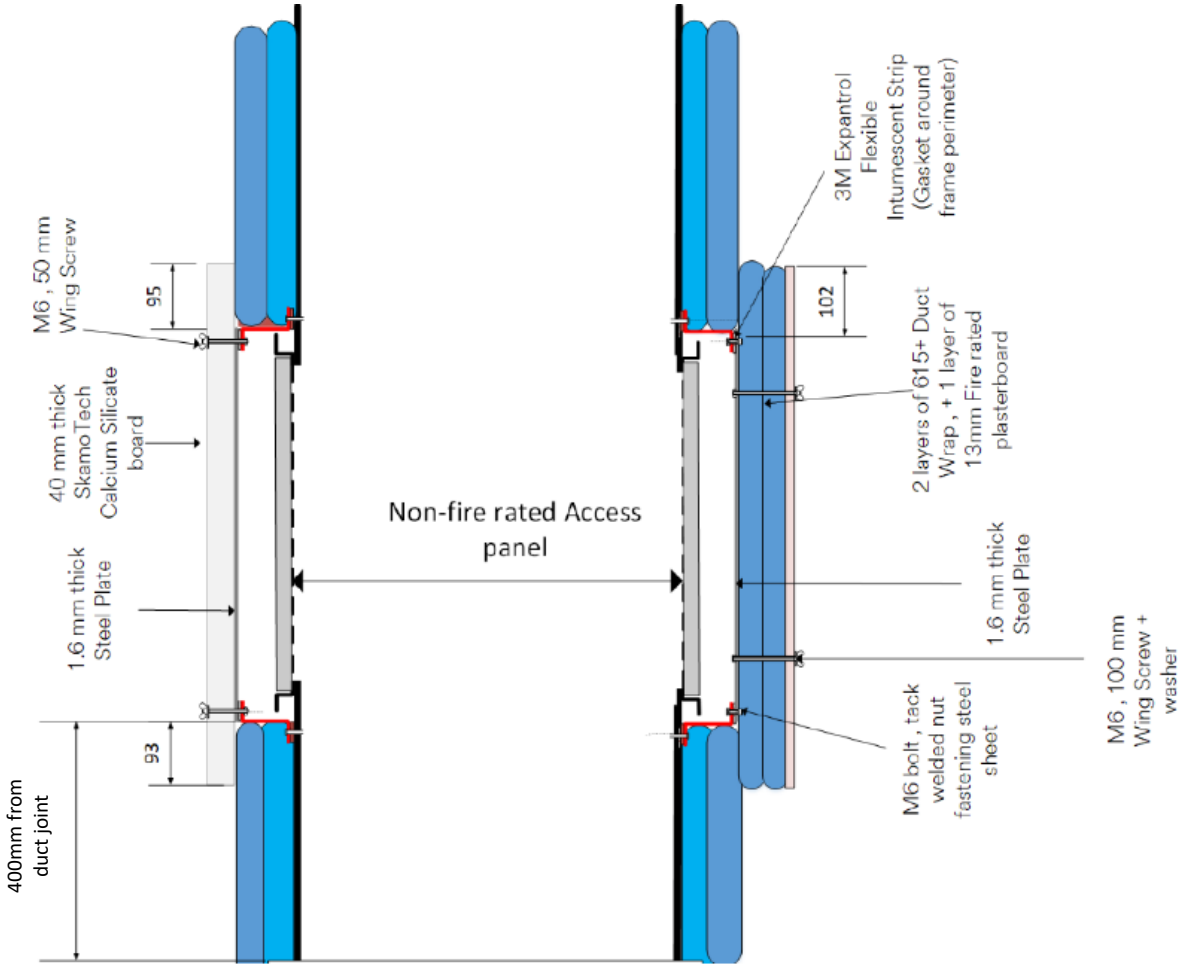


Figure 12 – Installation of an internally exposed vertically or horizontally orientated duct with duct access door system as tested in FSP 2247 for 1 or 2-layer wrap sections

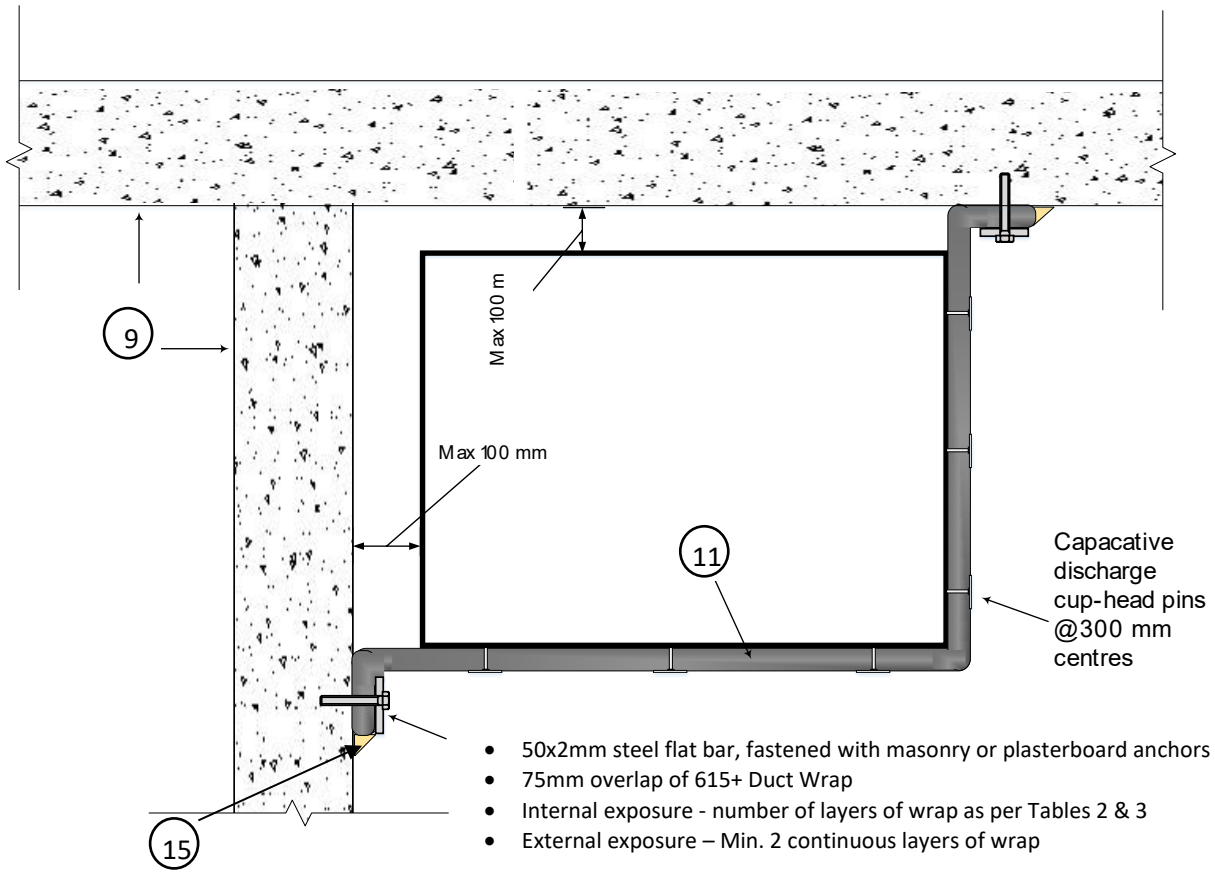


Figure 13– 2-sided protection detail (horizontal or vertical oriented ducts)

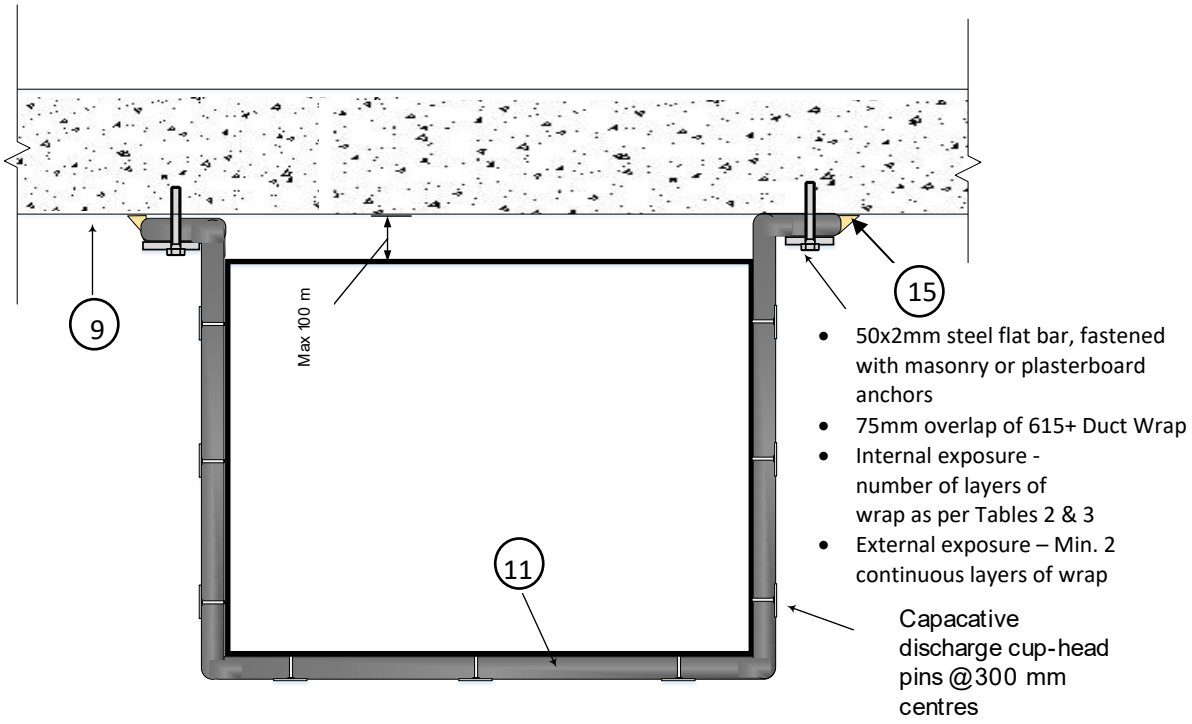


Figure 14– 3-sided protection detail (horizontal or vertical oriented ducts)

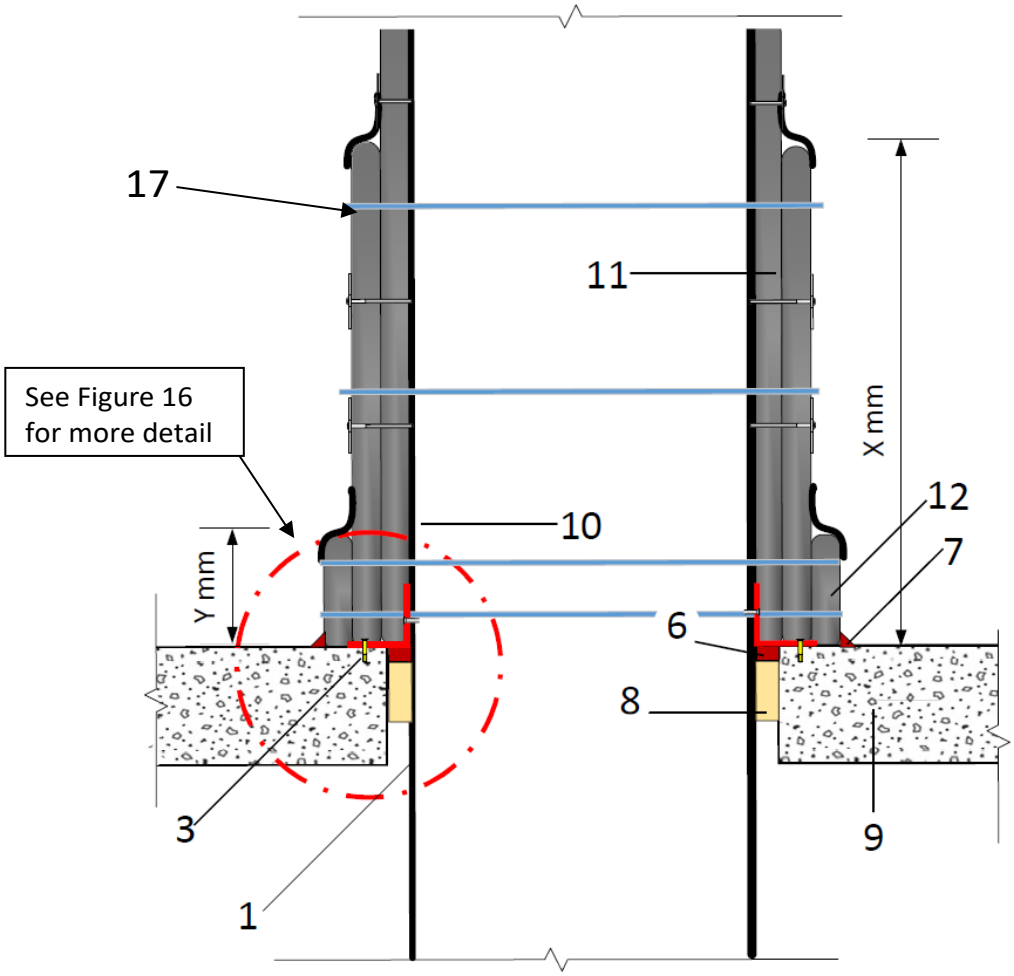


Figure 15- General arrangement of 3M Fire Barrier 615+ Duct Wrap for 60 & 120 minute applications (internally exposed vertical oriented ducts)

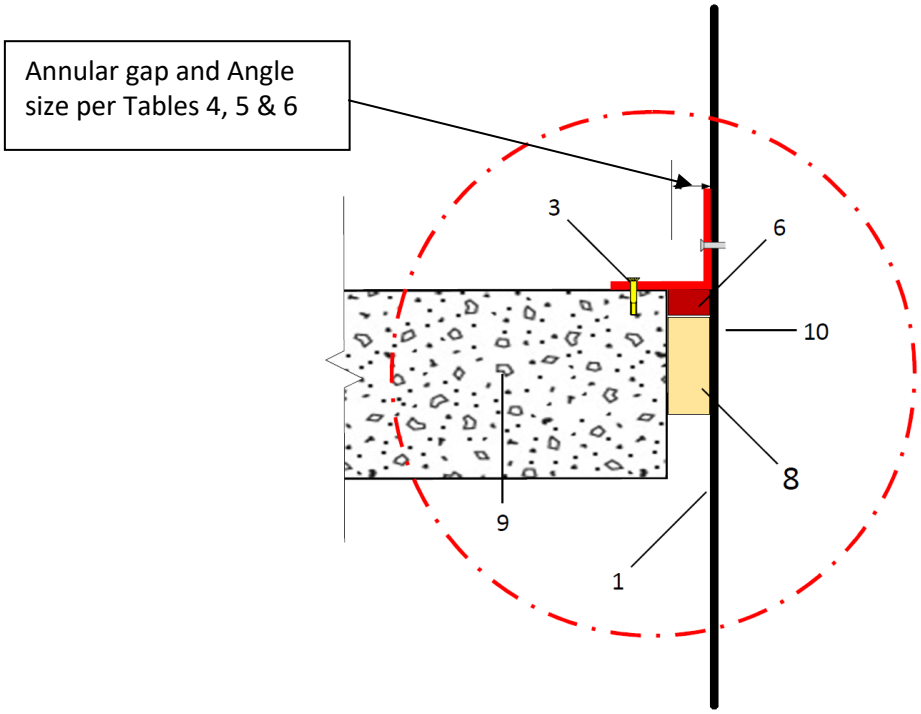


Figure 16 - Detail of Gap at the perimeter of the vertically orientated duct (internally or externally exposed)

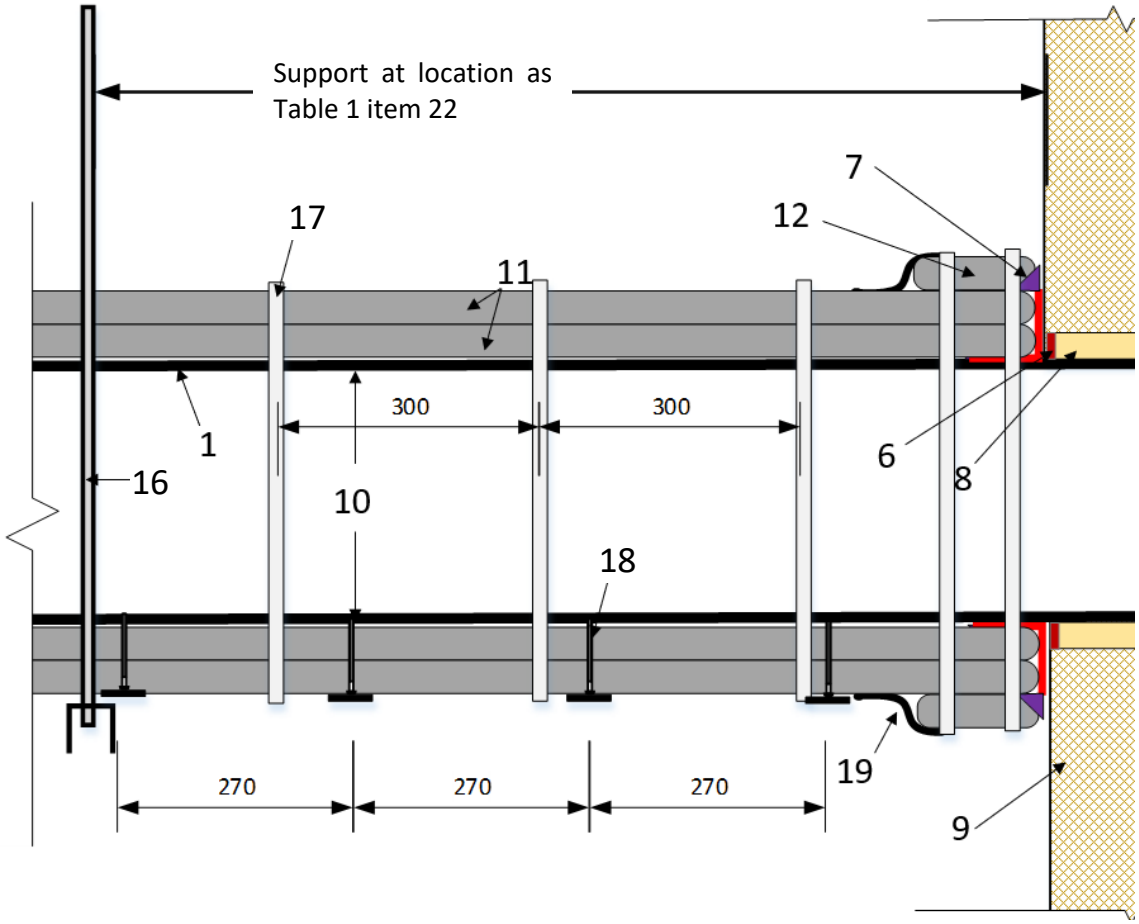


Figure 17 – General arrangement of 3M Fire Barrier 615+ Duct Wrap for up to 120-minute applications – externally exposed horizontally orientated duct (symmetrically detailed on the other side of the wall)

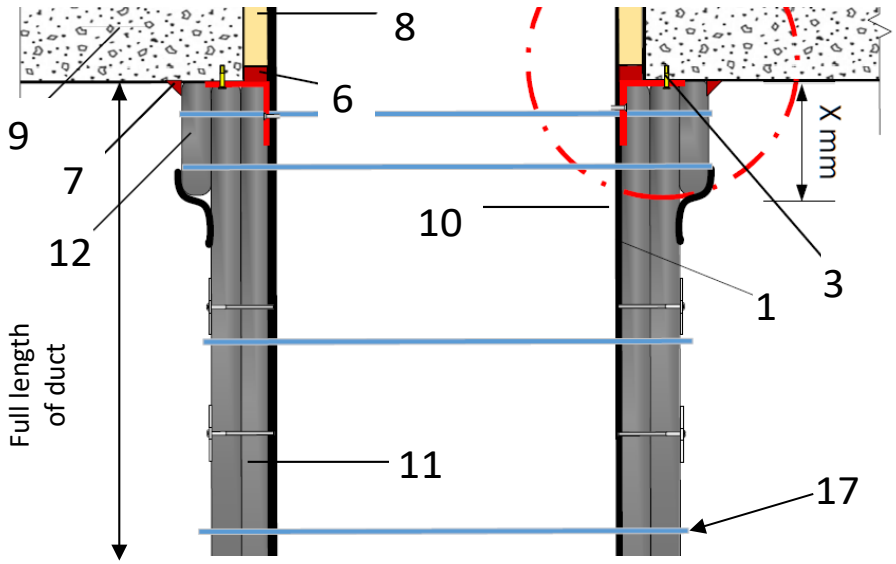


Figure 18 – General arrangement of 3M Fire Barrier 615+ Duct Wrap for up to 120-minute applications – externally exposed vertically orientated duct (symmetrically detailed on the topside of the slab)

4 Referenced Standards

Standards:

AS 1530.4-2014	Methods for fire tests on building materials, components and structures Part 4: Fire resistance tests of elements of building construction, Section 9 as appropriate for Duct protection for inside exposure. Section 9 – As appropriate for ducts exposed to internal and external exposure

5 Conclusion

On the basis of the analysis presented in this report, it is the opinion of this Accredited Testing Laboratory that the tested prototypes described in Section 2 when varied as described in Section 3 will achieve the performance below when submitted to a test in accordance with the test methods referenced in Section 4, and subject to the requirements of Section 7, the validity of Section 8 and limitation of Section 9.

Table 2 – Horizontal Duct configuration for FRL for internal exposure of 60/60/60

Duct Width (mm)	Duct Height (mm)	Minimum Annular Gap (mm)	Maximum Annular Gap (mm)	Angle Size (mm) (Item 1)		Plasterboard Collar Width (mm) (Item 5)	"X" Refer to Figures 1 and 1a	Relevant Figures
				Duct Side Flange	Wall side Flange			
600	600	20	35	50	75	125	1000	Figures 1, 1a, 3 - 14
600	900	20	35				1100	
600	1200	20	35				1100	
900	900	20	35				1200	
600	1800	30	45	50	100	150	1200	
900	1200	20	35				1200	
1200	1000	20	35				1200	
600	2400	35	50				1200	
1200	1200	20	35				1300	
900	1800	30	45				1300	
600	3000	40	55				1300	
600	3600	45	60				1300	
900	2400	35	50				1400	
1200	1800	30	45				1400	
900	3000	40	55				1400	
1200	2400	35	50				1400	
900	3600	45	60				1500	
1800	1800	30	45				1500	
1200	3000	40	55				1500	
1200	3600	45	60				1500	
1800	2400	35	50				1500	
1800	3000	40	55				1600	
2400	2400	40	50				1600	
1800	3600	45	60				1600	
2400	3000	40	55				1600	
2400	3600	45	60				1700	
3000	3000	50	55				1700	
3000	3600	50	60				1700	
3600	3600	60	60				1700	

Table 3 – Horizontal Duct configuration for FRL for internal exposure of 120/120/120

Duct Width (mm)	Duct Height (mm)	Minimum Annular Gap (mm)	Maximum Annular Gap (mm)	Angle Size (mm) (Item 1)		Plasterboard Collar Width (mm) (Item 5)	"X" Refer to Figure 2	Relevant Figures
				Duct Side Flange	Wall side Flange			
600	600	20	35	50	75	125	1500	Figures 2-6, 8 -14
600	900	20	35				1700	
600	1200	20	35				1800	
900	900	20	35				1900	
600	1800	30	45	50	100	150	2000	
900	1200	20	35				2000	
1200	1000	20	35				2000	
600	2400	35	50				2100	
1200	1200	20	35				2100	
900	1800	30	45				2200	
600	3000	40	55				2200	
600	3600	45	60				2200	
900	2400	35	50				2300	
1200	1800	30	45				2300	
900	3000	40	55				2400	
1200	2400	35	50				2500	
900	3600	45	60				2500	
1800	1800	30	45				2500	
1200	3000	40	55				2600	
1200	3600	45	60				2600	
1800	2400	35	50				2700	
1800	3000	40	55				2800	
2400	2400	40	50				2900	
1800	3600	45	60				2900	
2400	3000	40	55				3000	
2400	3600	45	60				3100	
3000	3000	50	55				3100	
3000	3600	50	60				3200	
3600	3600	60	60				3300	

Table 4 – Vertical Duct configuration for FRL for internal exposure of 60/60/60

Duct Width (mm)	Duct Height (mm)	Minimum Annular Gap (mm)	Maximum Annular Gap (mm)	Angle Size (mm) (Item 1)		"X" (2nd Layer) Refer to Figure 16	"Y" (3rd Layer) Refer to Figure 16	Relevant Figures
				Duct Side Flange	Floor side Flange			
600	600	20	35	50	75	1100	150	Figures 8 -16
600	900	20	35			1200	150	
600	1200	20	35			1300	150	
900	900	20	35			1400	150	
600	1800	30	45	50	100	1400	150	
900	1200	20	35			1400	150	
1200	1000	20	35			1500	150	
600	2400	35	50			1500	150	
1200	1200	20	35			1500	150	
900	1800	30	45			1600	150	
600	3000	40	55			1500	150	
600	3600	45	60			1600	150	
900	2400	35	50			1600	150	
1200	1800	30	45			1700	150	
900	3000	40	55			1700	150	
1200	2400	35	50			1700	150	
900	3600	45	60			1700	150	
1800	1800	30	45			1800	150	
1200	3000	40	55			1800	150	
1200	3600	45	60			1900	150	
1800	2400	35	50			1900	150	
1800	3000	40	55			2000	150	
2400	2400	40	50			2000	150	
1800	3600	45	60			2000	150	
2400	3000	40	55			2000	150	
2400	3600	45	60			2100	150	
3000	3000	50	55			2100	150	
3000	3600	50	60			2100	150	
3600	3600	60	60			2200	150	

Table 5 – Vertical Duct configuration for FRL for internal exposure of 120/120/120

Duct Width (mm)	Duct Depth (mm)	Minimum Annular Gap (mm)	Maximum Annular Gap (mm)	Angle Size (mm) (Item 1)		"X" (2nd Layer) Refer to Figure 16	"Y" (3rd Layer) Refer to Figure 16	Relevant Figures
				Duct Side Flange	Floor side Flange			
600	600	20	35	50	75	2300	1000	Figures 8 -16
600	900	20	35			2500	1100	
600	1200	20	35			2600	1200	
900	900	20	35			2700	1200	
600	1800	30	45	50	100	2900	1300	
900	1200	20	35			2900	1300	
1200	1000	20	35			3000	1300	
600	2400	35	50			3100	1300	
1200	1200	20	35			3100	1400	
900	1800	30	45			3200	1400	
600	3000	40	55			3200	1400	
600	3600	45	60			3300	1400	
900	2400	35	50			3400	1500	
1200	1800	30	45			3400	1500	
900	3000	40	55			3600	1500	
1200	2400	35	50			3700	1600	
900	3600	45	60			3700	1600	
1800	1800	30	45			3800	1600	
1200	3000	40	55			3800	1600	
1200	3600	45	60			4000	1700	
1800	2400	35	50			4100	1700	
1800	3000	40	55			4200	1700	
2400	2400	40	50			4300	1700	
1800	3600	45	60			4400	1800	
2400	3000	40	55			4500	1800	
2400	3600	45	60			4700	1800	
3000	3000	50	55			4800	1800	
3000	3600	50	60			5000	1900	
3600	3600	60	60			5200	1900	

Table 6 – Horizontal and vertical duct configuration for FRL for external exposure of 120/120/60

Duct Width (mm)	Duct Height (mm)	Minimum Annular Gap (mm)	Maximum Annular Gap (mm)	Angle Size (mm) (Item 1)		"X" (3rd Layer) Refer to Figures 18 and 19	Relevant Figures
				Duct Side Flange	Wall side Flange		
600	600	20	35	50	75	150	Figures 7, 10, 11, 13, 14, 16, 17, 18
600	900	20	35				
600	1200	20	35				
900	900	20	35				
600	1800	30	45	50	100		
900	1200	20	35				
1200	1000	20	35				
600	2400	35	50				
1200	1200	20	35				
900	1800	30	45				
600	3000	40	55				
900	2400	35	50				
1200	1800	30	45				
900	3000	40	55				
1200	2400	35	50				
1800	1800	30	45				
1200	3000	40	55				
1800	2400	35	50				
1800	3000	40	55				
2400	2400	40	50				
2400	3000	40	55				
3000	3000	50	55				

6 Direct Field of Application of Results

The results of this assessment apply to ducts exposed to fire from inside or outside of the duct.

For vertically orientated ducts exposed to fire from inside, the relevant duct performance applies to the sections of the duct above the slab.

For vertically orientated ducts exposed to fire from outside, the relevant duct performance applies to the sections of the duct above or below the slab.

For ducts wrapped on one side only, the relevant duct performance applies to fire exposure on the unwrapped side of the duct only.

7 Requirements

It is required that the supporting construction be load bearing or non-load bearing and tested or assessed with the required size of the aperture to achieve the required FRL in accordance with AS 1530.4.

Any variations with respect to size, and construction details other than those identified in this report, may invalidate the conclusions drawn in this report.

8 Term of Validity

This assessment report will lapse on 31st July 2025. 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.

9 Limitations

The conclusions of this assessment report may be used to directly assess the fire resistance performance under such conditions, but it should be recognised that a single test method will not provide a full assessment of the fire hazard under all fire conditions.

Because of the nature of fire resistance 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 report does not provide an endorsement by CSIRO of the actual products supplied to industry. The referenced assessment can therefore only relate only to the actual prototype test specimens, testing conditions and methodology described in the supporting data, and does not imply any performance abilities of construction of subsequent manufacture.

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

The information contained in this assessment report shall not be used for the assessment of variations other than those stated in the conclusions above. The assessment is valid provided no modifications are made to the systems detailed in this report. All details of construction should be consistent with the requirements stated in the relevant test reports and all referenced documents.

Appendix A Supporting Test Data

A.1 CSIRO Report FSV 1844

On 29 June 2017, CSIRO North Ryde conducted a fire resistance test of a steel duct protected with 3M 615+ Duct Wrap in accordance with AS 1530.4- 2014, Section 9 as appropriate for internal fire exposure.

Wall system

The penetrated wall system comprised a 116mm thick plasterboard lined frame wall system comprising two layers of 13mm thick Fyrchek plasterboard on each side of 64mm thick metal studs, with an established FRL of -/120/120, report reference FAR2357.

Steel duct and supports

The steel duct comprised two single pieces of 1200mm wide x 1000mm high x 1400mm long x 1.2mm BMT galvanised steel duct, joined via a TDF TJ-13 transverse duct joint, sealed with 3M 2000+ Fire Barrier Silicone Sealant as the gasket. The unexposed end of the steel duct was capped with a screw-fastened galvanised steel plate (sealed using 3M 2000+ Silicone around the perimeter) with a 50mm aperture in the centre. The exposed end of the duct was left open to the furnace chamber.

The duct extended 153mm into the furnace chamber on the exposed side and extended approximately 2539mm on the non-fire side of the wall. The duct was supported by Unistrut trapeze supports located approximately 390mm, 1540mm and 2530mm from the wall on the non-fire side only.

Insulation

3M Fire Barrier Duct Wrap 615+ is a flexible fire-resistant wrap, consisting of an inorganic fibre blanket encapsulated with a scrim-reinforced foil. The product is 38mm thick, with 96 kg/m^3 density.

The duct was insulated on both sides of the wall with two layers of 3M 615+ Duct Wrap insulation, apart from the end 250mm of the duct on the exposed side only, which was lagged using a single layer of 3M 615+ Duct Wrap insulation. The insulation for each layer was applied around the duct with a 75-100mm wide overlap which was sealed using 3M 425 Aluminium foil tape. The 3M 615+ Duct Wrap insulation was supported using 12mm x 0.5mm stainless steel bands which were applied to each layer at 300mm spacing. The two layers of insulation were then secured with capacitive discharge pins fixed at 300mm centres on the underside only.

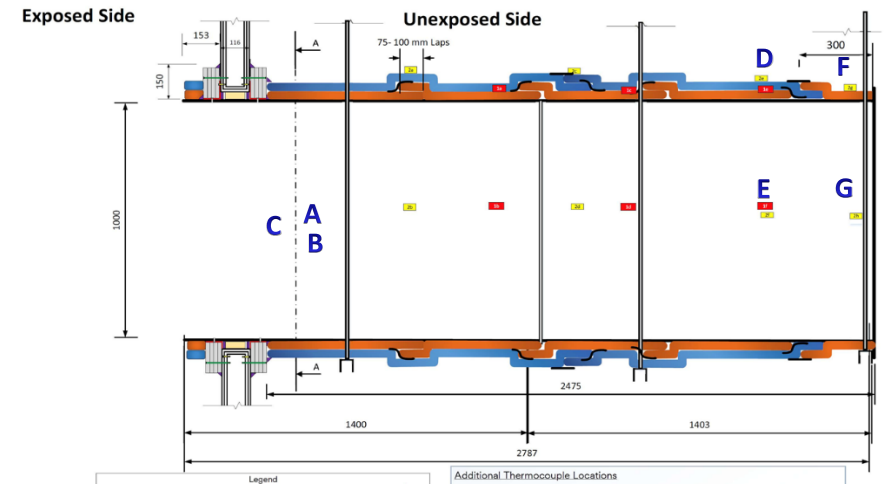
Duct penetration collar detail

The steel duct penetrated the plasterboard wall through a 1260mm wide x 1060mm high opening which was lined using two layers of 13mm thick fire grade plasterboard. Within the wall opening, the gap between the penetrating steel duct and the wall opening was filled using 30mm thick and 90mm wide silicate wool (the un-foiled content of 615+ Duct Wrap), compressed to 30%. The gap between the insulation and wall opening was then sealed using 3M Fire Barrier 2000+ Sealant to a depth of 15mm. The duct was retained on both sides of the wall using 75mm x 75mm x 2mm thick steel retaining angles. The angles were secured at 200mm centres, to the wall with 8 g x 50mm screws and to the duct using 5mm, 10mm shell length steel pop rivets. A plasterboard collar, comprising of 4 layers of 16mm thick x 150mm wide CSR Fyrchek plasterboard was then attached to the wall using 8 g x 100mm plasterboard screws at 300mm centres.

The furnace pressure was maintained at 15Pa ± 2Pa after the first five minutes at the centre of the duct inlet.

Test Results

Time (Minutes)	Distance from Collar (mm)	Location of Reading	Temperature
85	350	The roving thermocouple on top of insulation – 350mm from the collar (64mm thick) – left side see “A” below	176°C
86	350	The roving thermocouple on top of insulation – 350mm from the collar (64mm thick) – left side see “B” below	186°C
112	25	The fixed thermocouple S7 on top of insulation – 25mm from the collar see “C” below	>180°K Rise over ambient.
120	2000	Fixed thermocouple S20 on top of insulation – 2000mm from the collar – top see “D” below	135°C
120	2000	Fixed thermocouple S21 on top of insulation – 2000mm from the collar – right side see “E” below	107°C
120	2400	Fixed thermocouple S22 on top of insulation – 2400mm from the collar – top see “F” below	176°C
120	2400	Fixed thermocouple S23 On top of insulation – 2400mm from the collar – right side see “G” below	173°C



Criteria	Duct Performance
Structural Adequacy	No failure at 130 minutes
Integrity	Integrity Failure of Specimen – Flaming for the duration of greater than 10 seconds of the sealant between the duct flange and end plate observed along the top right-hand edge of the endplate
Integrity at wall junction	No failure at 130 minutes
The integrity of the duct other than at the cover plate	No failure at 130 minutes
Insulation	112 minutes- 25mm from collar (location C)

A.2 CSIRO Report FSP 2015

On 24 June 2019, CSIRO North Ryde conducted a fire resistance test of a steel duct protected with 3M 615+ Duct Wrap in accordance with AS 1530.4- 2014, Section 9 as appropriate for internal fire exposure.

Floor system

The penetrated floor comprised a 150mm thick concrete slab reinforced with a double layer of steel reinforcement providing a Fire Resistance Period (FRP) for insulation of 180 minutes in accordance with table 5.5.1 of AS 3600:2018 - Concrete Structures.

Steel duct and supports

The steel duct comprised two single pieces of 560mm wide x 560mm high x 1400mm long x 0.8mm BMT galvanised steel duct, joined via a J5 TDF 25 x 0.8 mm transverse duct joint, sealed with 3M 2000+ Fire barrier Silicone Sealant as the gasket. The unexposed end of the steel duct was capped with a screw-fastened galvanised steel plate (sealed using ceramic fibre around the perimeter) with a 50mm diameter aperture at the centre. The exposed end of the duct was left open to the furnace chamber.

The duct extended 153mm into the furnace chamber on the exposed side and extended approximately 2470mm on the non-fire side of the floor. The duct was supported at the screw-fastened endplate via a welded support frame, which was fixed to the unexposed face of the slab.

Duct insulation

3M Fire Barrier Duct Wrap 615+ is a flexible fire-resistant wrap, consisting of an inorganic fibre blanket encapsulated with a scrim-reinforced aluminium foil. The product was 38mm thick, with a stated density of 96kg/m^3.

The duct was insulated on both sides of the concrete floor with two layers of 3M 615+ Duct Wrap insulation, with the exception of the end 700mm of the duct on the unexposed side only, which was lagged using a single layer of 3M 615+ Duct Wrap insulation. Each insulation layer was applied around the duct incorporating a 75-100mm wide overlap which was sealed using 3M Venture 1520CW Aluminium foil tape. The 3M 615+ Duct Wrap insulation was supported using 12mm x 0.5 mm stainless steel bands which were applied to each layer at 300mm spacing. The two layers of insulation were then secured with capacitive discharge pins fixed at nominal 300mm centres on two opposite sides only.

Duct penetration collar detail

The steel duct penetrated the concrete slab through a 600mm x 600mm opening. Within the slab opening the gap between the penetrating steel, the duct was filled using 20 mm thick and 90mm wide silicate wool (the un-foiled content of the 3M 615+ Duct Wrap), with a 15mm recess on the top side, compressed to approximately 30%. The gap between the insulation and top opening was then sealed using a 3M Fire Barrier CP25WB+ Sealant flush to a depth of 15mm (top side only).

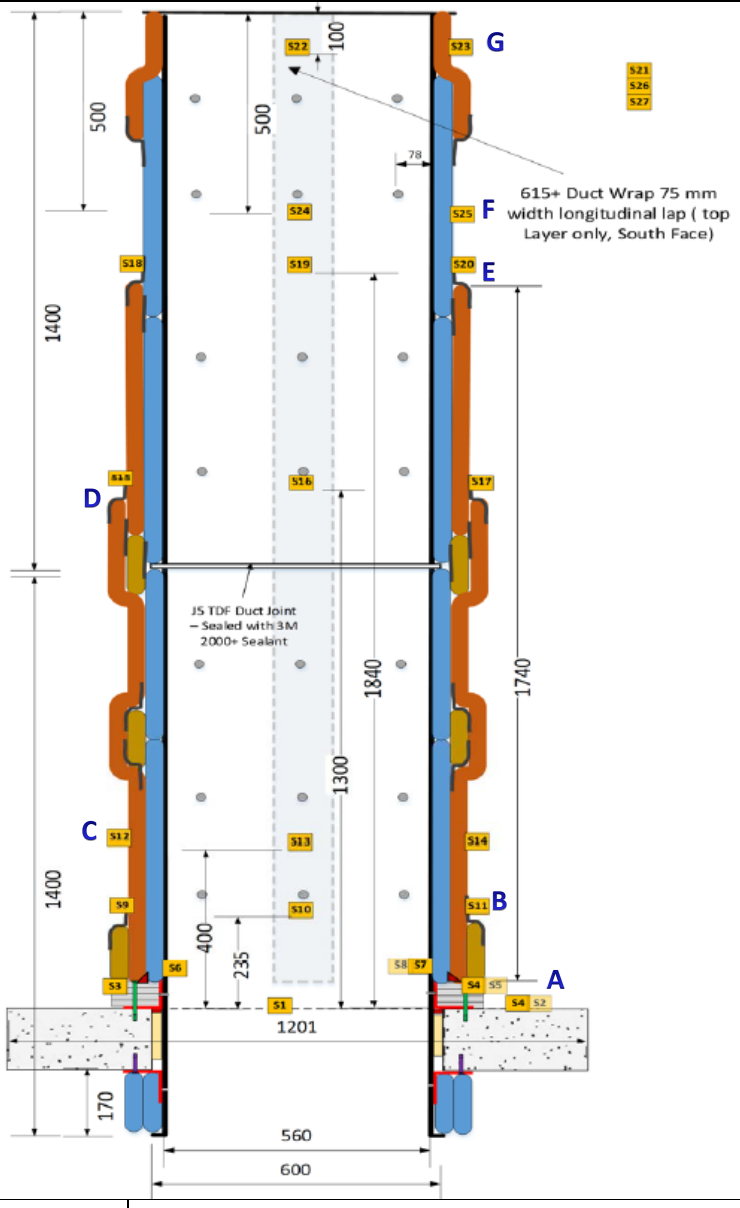
The duct was retained on the top side of the slab using 75mm x 75 mm x 1.6mm thick steel retaining angles covered by a plasterboard collar. The plasterboard collar comprised 4 layers of 16 mm thick x 100mm wide CSR Fyrchek plasterboard. Both the plasterboard and the steel angles were fastened through to the slab using 100mm long x 8g masonry screws and washers.

The duct was additionally retained on the underside side of the slab using 75mm x 75mm x 2 mm thick steel retaining angles, fastened to the slab at 250mm spacing with 50mm long x 8g masonry expansion bolts. The angles on both sides were secured to the duct at 200mm centres using 5mm dia. x 10mm shell length steel pop rivets.

The furnace pressure was in excess of the tolerances of the requirements of AS 1530.4-2014. It is confirmed that the minor departure in furnace pressure measured would not have significantly affected the results of this test.

Test Results

Wrap layer	From slab	TC	Temperature (°C)				Position
			30min.	60min.	90min.	120min.	
2 layers	89	7	-	-	-	68	A
	235	11	32	91	148	181	B
	400	12	41	145	205	230	C
	1300	15	25	72	104	147	D
1 layer	1840	20	70	129	177	189	E
	1980	25	73	144	181	191	F
	2380	23	70	118	137	146	G



Criteria	Duct Performance
Structural Adequacy	No failure at 181 minutes
Integrity	No failure at 181 minutes
Insulation	83 minutes- on the duct wrap 400mm from the slab (location C)

A.3 FSP 2247

On 23 September 2021, CSIRO North Ryde conducted a fire resistance test of a steel duct protected with 3M 615+ Duct Wrap in accordance with AS 1530.4- 2014, Section 9 as appropriate for internal fire exposure.

Floor System

The penetrated floor system comprised a 150mm thick concrete slab reinforced with a double layer of steel reinforcement providing a Fire Resistance Period (FRP) for insulation of 180 minutes in accordance with table 5.5.1 of AS 3600:2018 - Concrete Structures.

Steel duct and supports

The steel duct comprised two single pieces of 560mm wide x 710mm deep x 1400mm long x 1.2 mm BMT galvanised steel duct, joined via a J5TDF 25 x 1.2mm transverse duct joint, sealed with 3M Fire Barrier CP25WB+ as the gasket. The unexposed end of the steel duct was capped with a screw fastened galvanised steel plate (sealed using ceramic fibre around the perimeter) with a 50mm diameter aperture at the centre. The exposed end of the duct was left open to the furnace chamber.

The duct extended approximately 220mm into the furnace chamber on the exposed side and extended approximately 2430mm on the non-fire side of the slab. The duct was supported at the screw-fastened end plate via a welded support frame, which was fixed to the unexposed face of the slab.

Duct insulation

3M Fire Barrier Duct Wrap 615+ is a flexible fire-resistant wrap, consisting of an inorganic fibre blanket encapsulated with a scrim-reinforced aluminium foil. The product was 38mm thick, with a stated density of 96kg/m^3.

The duct was insulated above the concrete slab with two layers of 3M 615+ Duct Wrap insulation. Each insulation layer was applied around the duct incorporating a 75-100mm wide overlap which was sealed using 3M Venture 1520CW Aluminium foil tape. The 3M 615+ Duct Wrap insulation was supported using 12mm x 0.5 mm stainless steel bands which were applied to each layer at 300mm spacings. The two layers of insulation were then secured with capacitive discharge pins fixed at nominal 300mm centres on two opposite sides only.

Duct penetration collar detail

The steel duct penetrated the concrete slab through a 605mm x 750mm opening. Within the slab opening the gap between the penetrating steel duct was filled using 20 mm thick and 90mm wide ceramic fibre, with a 20mm recess on the top side. The gap between the insulation and top opening was then sealed using a 3M Fire Barrier CP25WB+ Sealant flush to a depth of 20mm (top side only).

The duct was retained on the top side of the slab using 50mm x 75 mm x 1.6mm thick steel retaining angles fastened to the duct using 6mm steel rivets and fastened to the slab using M8 Expansion bolts. 3M CP25WB+ sealant was applied to the interface of the wrap and the concrete slab.

Access panel 1

Access panel # one consisted of a steel frame 548mm x 420mm x 25mm with an opening size of 465mm x 330mm (manufactured by Ductware). The access door frame was installed 400mm above the duct joint using 5mm steel rivets and sealed with 3MCP25WB+ sealant to the duct.

The 30mm wide flange of the access cover frame was fitted with two 12.7mm wide 3M Expantrol flexible intumescent strips. A 1.6mm steel sheet was bonded to a 40mm Skamo Tech calcium silicate board which was mechanically fixed to the frame using M6 x 50mm wing screws.

Access panel 2

Access panel # two consisted of a steel frame 654mm x 540mm x 80mm with an opening size of 534mm x 420mm. The retro fit access door frame was installed 370mm above the duct joint using 5mm steel rivets at 110mm spacings and sealed with 3MCP25WB+ sealant to the duct. 3M Fire Barrier CP25WB+ was applied between the 3M 615+ Duct Wrap and the access panel frame.

3M Expantrol flexible intumescent strips (e-FIS) measuring 2 x 12.7mm wide, were applied to the flange of the access cover frame. A 1.6mm steel sheet was fastened to the frame using M6 x 10mm cap-head screws. 2 layers of 3M 615+ duct wrap 609mm x 620mm x 80mm and one layer of 10mm non-fire rated plasterboard were fixed to the steel plate using four M6 x 100mm screws into M6 rivet nut inserts.

Structural support

A 1.6mm thick 40mm x 40mm x 560mm (nominal width of the duct) square steel hollow section (SHS) was secured to the duct using three 12g x 20mm self-drilling screws, 680mm above the concrete slab. A 30mm x 30mm x 1.6mm SHS was inserted through the 40mm SHS sleeve which was cut so that 275mm was extended from the duct wrap on both sides. 3M CP25WB+ sealant was applied to the interface of the wrap and sleeve to the full depth. One side of the 30mm SHS was wrapped with one layer, 150mm wide of 3M 615+ duct wrap, which was held in place with steel banding.

Test Results

When tested, the duct failed insulation on the wrap at 1225mm from the slab. The access panel 1 failed insulation at 126 minutes on the duct wrap 25mm below the SkamoTech calcium silicate board while access panel 2 failed insulation at 131 minutes on the duct wrap 25mm below the access panel 2. Both access panels maintain integrity for the 183 minutes duration of the test. The wrap temperatures at various locations are shown in the table below.

Wrap layer	From slab	TC	Temperature (°C)
			120 min.
3 layers	25	26	66
2 layers	175	29	145
	400	31	185
	800	32	158
	1200	35	115
	1225	36	192
	1600	39	141

A.4 FSH 2299

The specimen comprised a horizontal air duct tested for external fire exposure. The steel duct sections were insulated using two layers of 3M Fire Barrier 615+ Duct Wrap insulation blanket. For this test, two different duct systems were tested. Duct A is the subject of this report.

Specimen supporting construction

The 3040mm wide x 4300mm long specimen frame was lined with a supporting wall construction comprising approximately a 900mm high x 230mm thick masonry wall system (on three sides) and a 126mm thick Fyrchek plasterboard wall system at one opposite end. The plasterboard system comprised a double layer of 13mm Fyrchek plasterboard on both sides of a 74mm wide steel stud (the wall cavity was left uninsulated). The top of the supporting brick walls was enclosed using ceramic fibre lined AAC panels attached to steel framing to form a soffit above the specimen duct.

The 4300mm long walls of the perimeter incorporated two 1040mm long x 303 mm high apertures to facilitate the installation of the penetrating ductwork. The apertures were located opposite each other

at approximately the centre of the supporting walls and 250mm up from the base of the specimen frame. The top of the brickwork aperture was formed using a concrete lintel. The duct penetrated the plasterboard wall on one end and penetrated the brick wall at the opposite end.

Ductwork

The specimen comprised a straight length of horizontal ducting measuring nominally 4200mm long x 1000mm wide x 300mm high, fabricated using 1.2mm thick galvanized steel. The longitudinal duct seams were formed using a Pittsburgh lock seam. The ducting comprised three 1400 mm long sections with the transverse duct joints incorporating bolted flange joints. Each duct section was bolted together using M8 x20mm bolts and nuts at each corner of the flange joint. The duct sections were also held together using 25mm Transverse Duct Flange (TDF) Clips around the perimeter of the connecting flanges at nominal 100mm centres (see photo below). A bead of 3M Fire Barrier 3000WT was applied to the flanges of each duct section prior to the fixings. The flange joints are located 780 mm and 870mm from the plasterboard and brick wall respectively within the furnace chamber.

The duct system was supported using hangers comprising 30mm x 30mm steel angle trapeze supports suspended on threaded M16 rods fixed through the soffit panels. The uninsulated trapeze supports were placed at a nominal 1150mm from the exposed face of the plasterboard wall and a nominal 1365mm from the exposed face of the brick wall. (See Appendix D - drawing titled 'Duct and wall assembly', sheet 1 of 4 by 3M Australia Pty Ltd).

The duct penetrated wall openings in the brick wall and plasterboard wall system, resulting in a 20 mm annular gap around the duct perimeter on both ends. The duct protruded approximately 500 mm beyond the unexposed face of each respective wall system.

Wall penetration seal

Prior to the duct being insulated with the 3M Fire Barrier 615+ insulation blanket, the perimeter gap where the duct passed through the aperture in the wall systems was sealed using a combination of steel angles, unfoiled 3M Fire Barrier 615+ insulation blanket and 3M Fire barrier CP25WB+ sealant.

The resulting gap between the wall systems and steel duct was first sealed using unfoiled 3M Fire Barrier 615+ insulation. The unfoiled insulation was then covered with 3M Fire barrier CP25WB+ sealant to a depth of 20mm prior to being covered on all four sides of the duct with 75mm x 75 mm x 1.6mm steel angles at both wall penetrations.

At the brick wall penetration, the steel angles were fixed using 10G x 32mm masonry screws at nominal 200mm centres with a bead of 3M Fire Barrier CP25WB+ sealant. For the plasterboard wall penetration, the steel angle was fixed to the wall using 19g x 50mm metal screws at 150mm centres. The steel perimeter angles were also fixed to the duct using 10g x 50mm metal screws at nominal 160mm centres.

Duct insulation

The entire length of the duct both inside and outside the furnace chamber was wrapped with two layers of a 3M Fire Barrier 615+ Duct Wrap insulation blanket. The first layer consists of a 38mm thick x 610 mm wide Fire Barrier 615+ and the second layer of a 38 mm thick x 1220mm wide 3M Fire Barrier 615+ Duct Wrap insulation blanket (stated density of 96kg/m^3).

The insulation blankets were pinned to the face of the steel duct using capacity discharge welded cupped head pins. The pins comprised a 30mm diameter head was 78 mm in length. Along the top, bottom and sides of the duct, the pins were spaced at a maximum of 275mm grid centres. The duct insulation blanket was then supported using 12mm x 0.5mm crimped stainless-steel bands at 300 mm centres.

The first layer of the insulation blanket was wrapped around the duct with a 100mm overlap at the longitudinal and circumferential joints. The insulation blanket joints were held in place with 3M Venture 1520CW aluminium foil tape. The first layer of the blanket fully covered the two transverse duct joins inside the furnace chamber.

A second layer of insulation blanket was applied over the first layer ensuring that the joints were staggered by at least 200mm. The second layer comprised of 100mm overlaps longitudinally and circumferentially and the joints were held in place with 3M Venture 1520CW aluminium foil tape.

At the junction of the wall collar, a 150mm wide 3M Fire Barrier 615+ duct wrap insulation blanket was wrapped around the two layers and held in place with two crimped stainless-steel bands. The gap between the brick wall system and the insulation blanket was sealed with 3M Fire Barrier 3000WT sealant with a 25mm fillet. (No bead of sealant was applied at the plasterboard wall junction).

The 500mm length of duct positioned outside of the furnace chamber was also wrapped with two layers of insulation blanket, finishing 150mm from the unexposed face of the brick wall and was used to cover the steel angles. Two layers of insulation blanket were also used along the full unexposed length of the steel duct at the opposite end. No sealant was applied to the gap between the wall and the sealant on both sides.

Orientation

The duct specimen positioned penetrating the brick and plasterboard wall system perimeter above the furnace chamber opening. The 3050mm exposed length of duct and wall collar penetrations were subjected to external fire exposure conditions.

Test result

When tested, the wrap at the centre of the duct on the top side failed insulation at 88 minutes while the duct was able to maintain integrity for the 122 minutes duration of the test. Post-test observations revealed no significant reduction in the cross-sectional area of the air duct

A.5 Supplementary test data - BTC 18644FA

On 28th March 2014, The Building Test Centre, Loughborough carried out a fire resistance test in accordance with BS EN 13381-4:2013, which follows the standard temperature/time curve specified in EN 1363-1, on various steel columns encased on all four sides with either a 15mm thick or 30mm thick layer of Glasroc F. The temperature under the Glasroc F layer on the 1m long reference columns was measured and recorded as per the table below.

Specimen ID	The thickness of Glasroc F (mm)	Surface density (kg/m2)	Time to 180°K Rise (min)
RC1	15	13.6	37
RC2	30	26.9	72

Appendix B Analysis of Variations

B.1 Structural adequacy of horizontal ducts of varied size – internal exposure

The proposed construction shall be for ducts for internal exposure only and shall be as tested FSV 1844 and subject to the following variations;

- Duct construction shall vary up to 3600mm x 3600mm in size and be in accordance with AS 4254-2012 Pressure Class 1000.

Table B1 – Duct Size and Clearance Details

Duct Width (mm)	Duct Height (mm)	Minimum Annular Gap (mm)	Maximum Annular Gap (mm)
600	600	20	35
600	900	20	35
600	1200	20	35
900	900	20	35
600	1800	30	45
900	1200	20	35
1200	1000	20	35
600	2400	35	50
1200	1200	20	35
900	1800	30	45
600	3000	40	55
600	3600	45	60
900	2400	35	50
1200	1800	30	45
900	3000	40	55
1200	2400	35	50
900	3600	45	60
1800	1800	30	45
1200	3000	40	55
1200	3600	45	60
1800	2400	35	50
1800	3000	40	55
2400	2400	40	50
1800	3600	45	60
2400	3000	40	55
2400	3600	45	60
3000	3000	50	55
3000	3600	50	60
3600	3600	60	60

Structural Adequacy

By inspection of FSV 1844, the density of 3M Fire Barrier Duct Wrap 615+ is nominally 96kg/m^3 making the mass of one layer of 38mm thick wrap nominally 3.7kg/m^2 (37Pa) and supported a maximum span of 1150mm.

The duct design was 1.2mm steel with proprietary slip-on flanges with a 1200mm x 1000mm cross-section and a maximum of 1400mm between joints. With reference to AS 4254.2-2012 Table 2.3(E), the tested duct construction meets the Pressure Class of 1000 (1000Pa).

Based on inspection of the duct requirements of AS 4254-2012 Table 2.3(E), these tables include guidance on how duct construction shall vary for larger ducts including:

- The decrease in rib spacing ribs or reinforcing of ducts, which means shorter duct sections between joints or ribs.
- Closer supports spacing.
- The Higher base metal thickness of the duct wall.
- Joints of an alternate design of greater or better strength.

The structural resistance to internal pressure for the duct construction in AS 4254-2012 is related in some way to the yield stress of the steel and it is reasonable to consider that the stress state of larger ducts in accordance with AS 4254-2012 with more reinforcement and thicker wall construction will have a similar stress state to smaller ducts with less reinforcement and thinner duct wall thickness.

In this assessment, it is considered reasonable and conservative that the pressure rating including the allowable support spacing is directly related to the structural adequacy of the duct when exposed to heat and no pressure when tested.

The weight of the single wrap tested, and the proposed double wrap was 37Pa and 73Pa respectively. This represents 3.7% and 7.3% of the pressure rating of the duct and therefore does not have a considerable impact on the structural adequacy of the duct system.

The structural adequacy of the duct, when tested, is based on the ability of the duct to resist the effects of fire and support its own weight and that of the duct wrap protection without internal pressure or suction. The structural adequacy criteria of AS 1530.4-2014 clause 9.6.1 is as follows:

> **9.6.1 Structural adequacy**
>
> Structural adequacy failure of the duct shall be deemed to have occurred when the duct collapses in such a manner that the duct no longer fulfils its intended function.

When tested in FSV 1844 the pressure class 1000 duct tested met the structural adequacy criteria without any signs of impending failure or collapse.

Based on this and the above discussion, it is considered reasonable and conservative that smaller ducts that have a pressure class of 1000Pa in accordance with AS 4254.2-2012 will also meet this structural adequacy criterion as they will have a metal thickness, joint reinforcement, and support spacing making them as strong as the tested duct in its ability to span between supports and resist internal positive or negative pressure many times the weight of the wrap.

Based on the above discussion it is confirmed the proposed variation to the size of the duct construction will meet the structural adequacy requirements of AS 1530.4-2014 for 120 minutes if wrapped with one or two layers of 3M Fire Barrier Duct Wrap 615+.

Integrity and Insulation at the wall

The proposed variation in size also has consequences for the detailing of the seal of the duct protection system to the wall and the size of gaps between the duct and wall to allow for expansion.

The proposed clearances between the duct and the wall are listed in Table B1 and the proposed clearances range from 1.3% to 10% of the maximum duct cross section.

The furnace temperature at 120 minutes is 1050˚C and the calculated thermal expansion from 20˚C to 1050˚C is between 1.5-1.6%. It is confirmed there are sufficient gaps to allow for expansion of the duct when conservatively calculated on the furnace temperature.

The maximum proposed gap also represents a 30mm increase in the size of the gap between the ducting and the aperture in the wall. When tested this was filled with a layer of 3M Fire Barrier Duct Wrap 615+ with the foil removed and faced with sealant and fire grade plasterboard.

When tested there was no indication of integrity or insulation weakness associated with the seal.

Based on the above discussion it is considered reasonable and conservative that the fire resistance of the proposed duct to aperture seals will be maintained if the gap size is increased to a maximum of 60mm provided the depth of sealant is at least half the width of the joint.

Based on the above discussion it is confirmed that the proposed variation to the gaps around the ducts will not detrimentally affect the integrity performance when tested in accordance with AS 1530.4-2014, Section 9 as appropriate for internal exposure for up to 120 minutes

B.2 Internally exposed horizontal duct - Insulation performance and length of the second layer of wrap

The proposed construction shall be for ducts for internal exposure only and shall be as tested FSV 1844 and subject to the following variations;

- For 120-minute applications include a 150mm wide third layer of wrap at the wall collar refer to Figure 2.
- For 60 and 120 minutes applications, the length of the second layer of wrap varied based on duct size, refer to Figures 1 and 2.

With reference, the specimen tested in FSV 1844 which comprised a nominally 3m x 3m plasterboard lined wall supporting a 1200mm(W) × 1000mm(H) steel duct protected externally with a layer of 3M Fire Barrier Duct Wrap 615+ that projected away from the unexposed side of the wall 2787mm.

1200mm(W) x 1000mm(H) ducts for 60 minutes insulation

When tested in FSV 1844, the insulation performance of the wrapped part of the duct was 112 minutes. Additional measurements were taken on the wrap at other locations and roving thermocouple readings were taken at various distances down the duct.

The proposed construction includes two layers of wrap that extends along the duct from the wall for 1200mm as tested and shown in Figure 1. Based on the tested performance it is expected the proposed construction will also achieve at least 60 minutes of insulation with some margin.

Based on the above discussion it is confirmed an insulation performance of 60 minutes will be maintained for a wrap length extension of 2m when tested in accordance with AS 1530.4-2014 as appropriate for internal fire exposure.

1200mm(W) x 1000mm(H) ducts for 120 minutes insulation

When tested in FSV 1844, the insulation performance of the wrapped part of the duct was 112 minutes where the specimen failed insulation 25mm from the collar at the wall.

The proposed construction for 120 minutes includes an additional wrap 150mm wide adjacent to the collar as shown in Figure 2. It is considered the addition of another layer of 38mm 3M Fire Barrier Duct Wrap 615+ will maintain the insulation performance at that location for an additional 8 minutes.

Based on the above discussion it is confirmed an insulation performance of 120 minutes will be maintained for the constriction shown in Figure 2 when tested in accordance with AS 1530.4-2014 as appropriate for internal fire exposure.

Larger ducts for 60 and 120 minutes of insulation

When tested, the 1000mm x 1200mm duct was exposed to convective heat transfer from the air moving through the duct and due to the air being a particularly poor conductor, the temperature measured at the inlet to the duct when compared to the outlet to the duct was nominally hotter.

The proposed duct systems described in Figures 1 to 11 include a gas-tight seal at the junction with the wall construction and include all external joints taped as tested.

To evaluate the impact of duct size on the insulation performance it is considered reasonable and conservative to calculate the required duct length based on the "configuration factor" of the opening of the duct to the furnace. The configuration factor at any point along the duct can be calculated in accordance with AS 1530.4-2014 Appendix A4 equation A4 (2), where W and H are the duct dimensions and D is the distance from the opening to the furnace. This approach is strongly linked to the duct opening and potentially makes the required duct length related to the radiant energy entering the duct which may be reradiated and or reflected within the duct.

The calculation was undertaken using the following steps;

a) For the tested 1200mm x 1000mm duct, interpolate the critical distance from the wall so that the insulation performance is just maintained. This was found to be 1.2m and 2.0m for 60 and 120 respectively.
b) Derive the configuration factor for the tested duct at the distance down the duct at which the insulation criteria are just being maintained, this is the benchmark configuration factor.
c) Repeat this calculation for ducts of increased size, and increase the extent of wrap for the larger duct until the calculated configuration factor is less than or equal to the benchmark configuration factor.
d) The outcome of this calculation is shown below in Table B2.

Table B2– Wrap Length VS Duct Size and FRL for Horizontal Ducts

Duct Width (mm)	Duct Height (mm)	60 min "X" Refer to Figure 1	120 min "X" Refer to Figure 2
600	600	1000	1500
600	900	1100	1700
600	1200	1100	1800
900	900	1200	1900
600	1800	1200	2000
900	1200	1200	2000
1200	1000	1200	2000
600	2400	1200	2100
1200	1200	1300	2100
900	1800	1300	2200
600	3000	1300	2200
600	3600	1300	2200
900	2400	1400	2300
1200	1800	1400	2300
900	3000	1400	2400
1200	2400	1400	2500
900	3600	1500	2500
1800	1800	1500	2500
1200	3000	1500	2600
1200	3600	1500	2600
1800	2400	1500	2700
1800	3000	1600	2800
2400	2400	1600	2900
1800	3600	1600	2900
2400	3000	1600	3000
2400	3600	1700	3100

Duct Width (mm)	Duct Height (mm)	60 min "X" Refer to Figure 1	120 min "X" Refer to Figure 2
3000	3000	1700	3100
3000	3600	1700	3200
3600	3600	1700	3300

Based on the above discussion it is confirmed that the insulation performance for the proposed construction is maintained for 60 and 120 minutes for the extent of the double wrap shown in Figures 1 and 2 when tested in accordance with AS 1530.4-2014, Section 9 as appropriate for internal exposure.

B.3 Structural adequacy of vertical ducts of varied size – internal exposure

The proposed construction shall be for ducts for internal exposure only and shall be as tested FSP 2015 and subject to the following variations;

- Duct construction shall vary up to 3600mm x 3600mm in size and be in accordance with AS 4254-2012 Pressure Class 1500.

Table B3 – Duct Size and Clearance Details

Duct Width (mm)	Duct Height (mm)	Minimum Annular Gap (mm)	Maximum Annular Gap (mm)
600	600	20	35
600	900	20	35
600	1200	20	35
900	900	20	35
600	1800	30	45
900	1200	20	35
1200	1000	20	35
600	2400	35	50
1200	1200	20	35
900	1800	30	45
600	3000	40	55
600	3600	45	60
900	2400	35	50
1200	1800	30	45
900	3000	40	55
1200	2400	35	50
900	3600	45	60
1800	1800	30	45
1200	3000	40	55
1200	3600	45	60
1800	2400	35	50
1800	3000	40	55
2400	2400	40	50
1800	3600	45	60
2400	3000	40	55
2400	3600	45	60
3000	3000	50	55
3000	3600	50	60
3600	3600	60	60

Structural Adequacy

By inspection of FSH 2015, the density of 3M Fire Barrier Duct Wrap 615+ is nominally 96kg/m^3 making the mass of one layer of 38mm thick wrap nominally 3.7kg/m^2 (37Pa) and supported a maximum span of 2470mm.

The duct design was 0.8mm steel with proprietary slip-on flanges with a 560mm x 560mm cross-section with a maximum of 1400mm between joints. With reference to AS 4254.2-2012 Table 2.3(F), the tested duct construction meets the Pressure Class of 1500 (1500Pa).

Based on inspection of the duct requirements of AS 4254-2012 Table 2.3(F), these tables include guidance on how duct construction shall vary for larger ducts including:

- The decrease in rib spacing ribs or reinforcing of ducts, which means shorter duct sections between joints or ribs.
- Closer supports spacing.
- The Higher base metal thickness of the duct wall.
- Joints of an alternate design of greater or better strength.

The structural resistance to internal pressure for the duct construction in AS 4254-2012 is related in some way to the yield stress of the steel and it is reasonable to consider that the stress state of larger ducts in accordance with AS 4254-2012 with more reinforcement and thicker wall construction will have a similar stress state to smaller ducts with less reinforcement and thinner duct wall thickness.

In this assessment, it is considered reasonable and conservative that the pressure rating including the allowable support spacing is directly related to the structural adequacy of the duct when exposed to heat and no pressure when tested.

The weight of the single wrap tested, and the proposed double wrap was 37Pa and 73Pa respectively. This represents 2.5% and 4.9% though as it acts axially on a vertical duct rather than perpendicular to the duct surface as for horizontal ducts, therefore does not have a considerable impact on the structural adequacy of the duct system.

The structural adequacy of the duct, when tested, is based on the ability of the duct to resist the effects of fire and support its own weight and that of the duct wrap protection without internal pressure or suction. The structural adequacy criteria of AS 1530.4-2014 clause 9.6.1 is as follows:

> **9.6.1 Structural adequacy**
>
> Structural adequacy failure of the duct shall be deemed to have occurred when the duct collapses in such a manner that the duct no longer fulfils its intended function.

When tested in FSP 2015 the pressure class 1500 duct tested met the structural adequacy criteria without any signs of impending failure or collapse.

Based on this and the above discussion, it is considered reasonable and conservative that smaller ducts that have a pressure class of 1500Pa in accordance with AS 4254.2-2012 will also meet this structural adequacy criterion as they will have a metal thickness, joint reinforcement, and support spacing making them as strong as the tested duct in its ability to span between supports and resist internal positive or negative pressure many times the weight of the wrap.

Based on the above discussion it is confirmed the proposed variation to the size of the duct construction will meet the structural adequacy requirements of AS 1530.4-2014 for 120 minutes if wrapped with one or two layers of 3M Fire Barrier Duct Wrap 615+.

Integrity and Insulation at the floor junction

The proposed variation in size also has consequences for the detailing of the seal of the duct protection system to the floor and the size of gaps between the duct and floor to allow for expansion.

The proposed clearances between the duct and the floor are listed in Table B3 and the proposed clearances range from 1.3% to 10% of the maximum duct cross section.

The furnace temperature at 120 minutes is 1050˚C and the calculated thermal expansion from 20˚C to 1050˚C is between 1.5-1.6%. It is confirmed there are sufficient gaps to allow for expansion of the duct when conservatively calculated on the furnace temperature.

The maximum proposed gap also represents a 40mm increase in the size of the gap between the ducting and the aperture in the floor. When tested this was filled with a layer of 3M Fire Barrier Duct Wrap 615+ with the foil removed and faced with sealant and fire grade plasterboard.

When tested there was no indication of integrity or insulation weakness associated with the seal.

Based on the above discussion it is considered reasonable and conservative that the fire resistance of the proposed duct to aperture seals will be maintained if the gap size is increased to a maximum of 60mm provided the depth of sealant is at least half the width of the joint.

Based on the above discussion it is confirmed that the proposed variation to the gaps around the ducts will not detrimentally affect the integrity performance when tested in accordance with AS 1530.4-2014 Section 9 as appropriate for internal exposure for up to 120 minutes.

B.4 Internally exposed vertical duct - Insulation performance and length of the second layer of wrap

The proposed construction shall be for ducts for internal exposure only and shall be as tested FSP 2015 and subject to the following variations;

- For 60 and 120 minutes applications, the length of the second and third layers of wrap varied based on duct size, refer to Figure 15.
- Duct wrap to be above slab as per Figure 15 only
- Removal of plasterboard build-up on the unexposed side (topside) & angle on the exposed (underside)

With reference, the specimen tested in FSP 2015 which comprised a 150mm thick concrete slab supporting a 560mm(W) × 560mm(H) steel duct protected externally with a layer of 3M Fire Barrier Duct Wrap 615+ that projected 2470mm away from the unexposed side of the floor.

560mm(W) × 560mm (H) ducts for 60 minute insulation applications

When tested in FSP 2015, the insulation performance of the wrapped part of the 560mm x 560mm duct with 1 layer of wrap maintains insulation for 120 minutes at just under 2000mm away from the slab. The second layer of wrap failed insulation at 83 minutes at 400mm way from the slab. The third layer was able to maintain insulation for more than 120 minutes.

The proposed construction includes the second layer of wrap that extends along a 560mm(W) × 560mm (H) duct from the slab for 1000mm as shown in Figure 15. Based on the tested performance it is expected the proposed construction will also achieve at least 60 minute insulation performance with some margin.

Based on the above discussion it is confirmed an insulation performance of 60 minutes will be maintained for a wrap length extension of 1000mm when tested in accordance with AS 1530.4-2014 Section 9 as appropriate for internal exposure.

560mm(W) × 560mm (H) ducts for 120 minute insulation performance

When tested in FSP 2015, the insulation performance of the wrapped part of the 560mm x 560mm duct with 1 layer of wrap maintains insulation for 120 minutes at just under 2000mm away from the slab. The second layer of wrap failed insulation at 83 minutes at 400mm way from the slab, while it maintained insulation for 120 minutes at 900mm away from the slab. The 150mm width third layer had a measured temperature of 68°C at 120 minutes.

The proposed construction includes the second layer of wrap that extends along a 560mm(W) × 560mm (H) duct from the slab for 2000mm and an additional third layer of wrap extends along the duct from the slab for 900mm as shown in Figure 15. It is expected that when the third layer is extended to a distance of 900mm from the slab, it will maintain insulation for 120 minutes.

Based on the above discussion it is confirmed an insulation performance of 120 minutes will be maintained for the constriction shown in Figure 15 when tested in accordance with AS 1530.4-2014 Section 9 as appropriate for internal exposure.

Removal of Fire rated plasterboard collar and underside angle

The proposed construction comprises the removal of the 4 x 16mm Fire rated plasterboard collar and angle on the exposed side as tested in FSP 2015 so as to reflect the detail shown in Figure 15.

With reference to FSP 2247 a 560mm wide x 710mm deep x 1400mm long x 1.2 mm BMT galvanised steel duct protected with two layers of continuous 3M Fire Barrier Duct Wrap 615+ and an additional layer of wrap at 150mm above the slab. The duct only had an angle on the top side of the slab. The slab did not fail insulation for the 183 minutes duration of the test. The 2nd layer of wrap at 25mm from the 3rd layer of wrap did not fail insulation until 172 minutes.

Since the tested duct in FSP 2247 is slightly bigger than that tested in FSP 2015, and so would expose the area of ducting closer to the furnace opening with more furnace heat, FSP 2247 This demonstrates the proposed wrap configuration is sufficient to allow the duct to maintain insulation for at least 120 minutes.

Based on the above discussion it is confirmed an insulation performance of 120 minutes will be maintained for the constriction shown in Figure 15 when tested in accordance with AS 1530.4-2014 Section 9 as appropriate for internal exposure.

Larger ducts for 60 and 120 minute insulation performance

When tested, the 560mm x 560mm duct was exposed to convective heat transfer from the air moving through the duct and due to the air being a particularly poor conductor, the temperature measured at the inlet to the duct when compared to the outlet to the duct was nominally hotter.

The proposed duct systems described in Figures 8 to 11 and Figures 16 to 17 include a gas-tight seal at the junction with the slab construction and include all external joints taped as tested.

To evaluate the impact of duct size on the insulation performance it is considered reasonable and conservative to calculate the required duct length based on the “configuration factor” of the opening of the duct to the furnace. The configuration factor at any point along the duct can be calculated in accordance with AS 1530.4-2014 Appendix A4 equation A4 (2), where W and H are the duct dimensions and D is the distance from the opening to the furnace. This approach is strongly linked to the duct opening and potentially makes the required duct length related to the radiant energy entering the duct which may be reradiated and or reflected within the duct.

The calculation was undertaken using the following steps;

e) For the tested 560mm x 560mm duct, interpolate the critical distance from the slab so that the insulation performance is just maintained. This was found to be 1m and 2m for 60 and 120 respectively.
f) Derive the configuration factor for the tested duct at the distance down the duct at which the insulation criteria are just being maintained, this is the benchmark configuration factor.
g) Repeat this calculation for ducts of increased size, and increase the extent of wrap for the larger duct until the calculated configuration factor is less than or equal to the benchmark configuration factor.
h) The outcome of this calculation is shown below in Table B4

Table B4– Wrap Length VS Duct Size and FRL for vertical Ducts

Duct Width (mm)	Duct Height (mm)	60 min "X" Refer to Figures 16 and 17	60 min "Y" Refer to Figures 16 and 17	120 min "X" Refer to Figure 16	120 min "Y" Refer to Figure 16
600	600	1100	150	2300	1000
600	900	1200	150	2500	1100
600	1200	1300	150	2600	1200
900	900	1400	150	2700	1200
600	1800	1400	150	2900	1300
900	1200	1400	150	2900	1300
1200	1000	1500	150	3000	1300
600	2400	1500	150	3100	1300
1200	1200	1500	150	3100	1400
900	1800	1600	150	3200	1400
600	3000	1500	150	3200	1400
600	3600	1600	150	3300	1400
900	2400	1600	150	3400	1500
1200	1800	1700	150	3400	1500
900	3000	1700	150	3600	1500
1200	2400	1700	150	3700	1600
900	3600	1700	150	3700	1600
1800	1800	1800	150	3800	1600
1200	3000	1800	150	3800	1600
1200	3600	1900	150	4000	1700
1800	2400	1900	150	4100	1700
1800	3000	2000	150	4200	1700
2400	2400	2000	150	4300	1700
1800	3600	2000	150	4400	1800
2400	3000	2000	150	4500	1800
2400	3600	2100	150	4700	1800
3000	3000	2100	150	4800	1800
3000	3600	2100	150	5000	1900
3600	3600	2200	150	5200	1900

Based on the above discussion it is confirmed an insulation performance of 60 and 120 minutes will be maintained for the construction shown in Figure 16 when tested in accordance with AS 1530.4-2014 Section 9 as appropriate for internal exposure.

B.5 Performance of ducts exposed on two or three sides – internal exposure

The proposed construction shall be for ducts for internal exposure only and shall be as tested in FSV 1844 and FSP 2015 and subject to the following variations;

- Variations previously discussed in a section B1-B4 of this report.
- Optional protection on 2 or 3 sides when adjacent to fire resistant non-combustible construction refers to Figures 13 and 14.
- Adjacent construction shall be either non-combustible walls or floors, or for walls that include combustible framing, they shall be protected by 1 x 16mm or 2 x 13mm fire grade plasterboard for 60 and 120-minute applications respectively.

Ducts exposed on two or three sides only

Where ducts are installed adjacent to the wall and floor construction that has an equal FRL to that required of the duct, it is proposed that the wrap extend to the face and be sealed to this construction as shown in Figure 13 and Figure 14.

The principle of this variation is that the duct affords protection from the wall or floor construction and that construction performs the role of duct protection at this location. The proposed requirement of non-combustible construction or combustible construction protected with various layers of fire grade plasterboard provides confidence that the adjacent construction will not interact with the duct construction, create a cavity and support potential fires, or otherwise, behave in a manner that differs from the tested construction.

The detail of the seal of the wrap to the underside of a floor above Figure 13 and Figure 14 includes the following features;

- The maximum separation of the duct from the floor is 100mm.
- Fixing each layer of the wrap to the floor construction via a 50 x 2mm flat steel bar, bolted to the floor with concrete anchors at 300mm centres.
- Edge of wrap sealed to the floor with a 30mm x 30mm fillet of 3M Fire Barrier 2000+ sealant.

The proposed construction includes a robust seal that mechanically presses the wrap in contact with the support construction, additional confidence in a continuous high temp gas seal is afforded by the fillet of sealant on the edge of the wrap, which will act to fill gaps at imperfections in the shape of the underside of the floor.

The gaps between the duct and floor/wall are limited to 100mm will mean the wrap is only spanning 100mm unsupported which is considered to not detrimentally affect the ability of the laps and joints to be formed.

Based on the above it is considered that the proposed details will not introduce gaps or additional venting and are of sufficient robustness to support the wrap when the duct is exposed to internal fire exposure.

Based on the above discussion it is expected that the structural adequacy, integrity or insulation performance of the proposed construction will be at least 120 minutes if tested in accordance with AS 1530.4-2014 Section 9 as appropriate for internal exposure.

B.6 Variation to the support systems for the ducts – internal exposure

The proposed construction shall be for ducts for internal exposure only and shall be as tested in FSV 1844 and FSP 2015 and subject to the following variations;

- Variations previously discussed in Sections B1-B5 of this report.
- Duct hanger rod size, hanger spacing, support, duct BMT, stiffeners, and duct jointing shall be in accordance with AS 4254.2-2012 as appropriate for Pressure Class 1000 and do not require fire protection.
- The weight used to calculate the force on hangers shall make due allowance for the wrapped weight and all overlaps.

The proposed construction includes hangers and supports that are specified in accordance with AS 4254-2012 as appropriate for ambient temperatures.

The test construction was exposed to internal fire exposure only and the variations described in this report confirm that the proposed construction will meet the insulation requirements of AS 1530.4-2014 at 60 and 120 minutes and thereby the maximum temperature on the outside of the duct wrap is expected to be around 200°C.

By reference to AS 4100-1998 (Amdt. 1) clause 12.4.1, the yield stress is not reduced until the steel temperature exceeds 215°C. It is considered based on this that there are no special requirements for the hanging rods for ducts exposed to internal fire exposure for the period that they maintain insulation.

Based on the above it is confirmed the proposed construction of duct supports will maintain the structural adequacy of the duct system for 60 and 120 minutes based on the wrap designs for 60 and 120 minutes of insulation in accordance with AS 1530.4-2014 Section 9 as appropriate for internal exposure.

B.7 The inclusion of access panels for ducts with internal exposure

The proposed construction shall be for ducts for internal exposure only and shall be as tested in FSV 1844 and FSP 2015 and subject to the following variations;

- Variations previously discussed in Sections B1-B5 of this report.
- The inclusion of the access panels as tested in FSP 2247 for vertically or horizontally orientated ducts as per Figure 12

Access panel for vertically orientated ducts

The proposed construction in Figure 12 includes access panel assemblies as tested in FSP 2247 into the proposed vertically orientated ducts as discussed above.

With reference to FSP 2247, two types of access panels were installed in the vertically orientated duct wrapped with 2 layers of wrap, with their frame located at 370 and 400mm above a duct joint and at approximately 1450mm from the slab. Both access panels were able to maintain integrity for the 183 minutes duration of the test and also maintain insulation for at least 120 minutes.

It is observed that the hot spots in the vertical duct are approximately 400mm and at 1225mm above the slab. Further above the 1225mm location, the next points of failure were 25mm below the access panel. At 1600mm, the temperature is much cooler than at 1225mm at 120 minutes.

This temperature profile is expected as it is similar to the duct tested in FSP 2015 and is consistent with the discussion above in Section B4 on the expected performance of additional layers at various locations.

Therefore, provided that the access panel is installed into the proposed vertically orientated duct at a distance of at least 1450mm above the slab, it is expected to maintain insulation for up to 60 and 120 minutes based on the design

Based on the above discussion it is considered the performance of the proposed access panels as tested in FSP 2247 will be at least 120 minutes when tested in accordance with AS 1530.4-2014 Section 9 as appropriate for internal exposure.

Access panel for horizontally orientated ducts

The proposed construction in Figure 12 includes an access panel assembly as tested in FSP 2247 into the proposed horizontally orientated ducts as discussed above.

With reference to the above comparison of vertical and horizontal ducts and the wrap arrangements required to achieve the same performance, it can be seen that they both require at least two layers of wrap for a certain distance from the separating element to maintain insulation for 60 and 120 minutes. It also demonstrates that as differs from a vertically orientated duct, horizontal ducts have their hot spots at the location of the opening and the temperature profile away from the opening decrease with distance.

With reference to FSV 1844, the temperature measurement on two layers of wrap at 600mm from the plasterboard collar measured a temperature rise of 127°C at 120 minutes. Therefore, it is expected at

when the duct is located at least 600mm from the wall, the wrap around the access panel will also maintain insulation for up to 120 minutes.

Based on the above discussion it is considered the performance of the proposed access panels as tested in FSP 2247 will be at least 120 minutes when tested in accordance with AS 1530.4-2014 Section 9 as appropriate for internal exposure.

Impact of an access panel on horizontal duct Structural Adequacy

The proposed access panel locations shall be within 600mm of the barrier walls. In such cases, the shear force and compression in the duct walls are increased around the access panels.

Due to the robust construction of the access panel construction compared to that of the duct, it is confirmed the bucking capacity of the duct wall is likely to be increased in the vicinity of the access panel due to the multiple layers of steel used in the access panel construction.

Based on the above discussion it is considered the structural adequacy of the duct will not be detrimentally affected by an opening in the duct up to 510mm x 510mm for applications up to 120 minutes when tested in accordance with AS 1530.4-2014 Section 9 as appropriate for internal exposure.

B.8 Variation to collar material for internally exposed horizontal ducts

The proposed construction comprises replacing the tested 4 x 16mm Fire rated plasterboard collar tested in FSV 1844 with 2 layers of 30mm Glasroc F.

Fire grade plasterboard is primarily comprised of comprised from plaster, with minor quantities of vermiculate and glass fibre mixed throughout. Glasroc F is primarily comprised of comprised from plaster with a glass fibre tissue immediately below the surface of the board on both sides and a core reinforced with glass fibre rovings and other minor constituents.

On the non-fire side it is considered that due to the similar chemistry of Glasroc F to CSR fire grade plasterboard, the proposed Glasroc F will perform similarly in regard to insulation performance to Fire grade plasterboard in FSV 1844.

Confidence in its integrity performance is provided by the supplementary test BTC 18644FA where columns were encased on all four sides with either a 15mm thick or 30mm thick layer of Glasroc F, in which the Glasroc F layers were able to stay intact for up to 180 minutes.

Based on the above, it is considered that the proposed variation will not detrimentally affect the integrity and insulation performance of the specimen in FSV 1844 when tested in accordance with AS 1530.4-2014 Section 9 as appropriate for internal exposure for up to 120 minutes.

B.9 Variation to wall construction – internal exposure

The proposed construction shall be for ducts for internal exposure only and shall be as tested in FSV 1844 and subject to the following variations;

- Variations previously discussed in Sections B1, B2, B5 – B7 of this report.
- The support construction is varied to include Speedpanel, Hebel, masonry (solid and hollow) and plasterboard lined walls as shown in Figure 1 to Figure 7
- The support wall shall be tested or assessed by others to be suitable for the aperture size required by the duct installation.

With reference, the specimen tested in FSV 1844, which comprised a nominally 3m × 3m plasterboard lined wall 118mm wide which supported a 600mm × 600mm steel duct protected externally with 3M

Fire Barrier Duct Wrap 615+ duct insulation that projected away from the unexposed side of the wall 2475mm from the face of the collar.

The steel duct penetrated the plasterboard wall through a 1260mm wide x 1060mm high opening which was lined using two layers of 13mm thick fire grade plasterboard. Within the wall opening, the gap between the penetrating steel duct and the wall opening was filled using 30mm thick and 90mm wide silicate wool (the un-foiled content of 615+ Duct Wrap), compressed to 30%. The gap between the insulation and wall opening was then sealed using 3M Fire Barrier 2000+ Sealant to a depth of 15mm. The duct was retained on both sides of the wall using 75mm x 75mm x 2mm thick steel retaining angles. The angles were secured at 200mm centres, to the wall with 8 g x 50mm screws and to the duct using 5mm, 10mm shell length steel pop rivets. A plasterboard collar, comprising of 4 layers of 16mm thick x 150mm wide CSR Fyrchek plasterboard was then attached to the wall using 8 g x 100mm plasterboard screws at 300mm centres.

The proposed variation to the support wall construction includes a variation in the thickness of the barrier wall. The tested construction comprises a duct that protrudes 100mm into the furnace on the exposed side, meaning the wall thickness does not provide a significant impact on the thermal shielding of the duct.

The proposed wall construction is required to have been tested or assessed to maintain the required FRL with apertures big enough to accommodate the ducts.

The interface of the plasterboard collar with the proposed wall types is shown in Figures 1 to Figure 7. For all types, the interface includes a bead of 3M Fire Barrier 2000+ Sealant between the collar and duct wrap and the collar and wall. This will tolerate the variations in the surface shape of masonry, AAC, and Speedpanel and is expected to perform similarly to the tested plasterboard wall system.

Further confidence in this proposal is based on the addition of the 3M Fire Barrier 2000+ Sealant over the duct gasket under the collar.

Based on the above discussion it is confirmed the proposed variation to the support construction as shown in Figure 1 to Figure 7 will not detrimentally affect the integrity and insulation performance when tested in accordance with AS 1530.4-2014 Section 9 as appropriate for internal exposure for up to 120 minutes.

B.10 Structural adequacy of horizontal ducts of varied size – external exposure

The proposed construction for horizontal ducts for external exposure only and shall be as tested in FSH 2299 and subject to the following variations:

- Ducts to be straight, joints to be tapped with Aluminum foil tape, and duct wrapped with 12mm x 0.5 mm stainless or carbon steel bands at a maximum of 300mm ctrs. Corners wrap to be pinned to the duct with capacitive discharge pins at 300mm ctrs.
- Duct hanger rod size, hanger spacing, support, duct BMT, stiffeners and jointing shall be in accordance with AS 4254.2-2012 as appropriate for Pressure Class 1000 and designed to support the weight of duct under external exposure for up to 120 minutes
- The proposed construction is summarised in Table 1 and Figures 7, 10, 11, 13, 14, 17

The proposed construction shall be for ducts for external exposure only and shall be as tested FSH 2299 and subject to the following variations;

- Duct construction shall vary up to 3000mm x 3000mm in size and be in accordance with AS 4254-2012 Pressure Class 1000.

Table B5 – Duct Size and Clearance Details

Duct Width (mm)	Duct Height (mm)	Minimum Annular Gap (mm)	Maximum Annular Gap (mm)
600	600	20	35
600	900	20	35
600	1200	20	35
900	900	20	35
600	1800	30	45
900	1200	20	35
1200	1000	20	35
600	2400	35	50
1200	1200	20	35
900	1800	30	45
600	3000	40	55
900	2400	35	50
1200	1800	30	45
900	3000	40	55
1200	2400	35	50
1800	1800	30	45
1200	3000	40	55
1800	2400	35	50
1800	3000	40	55
2400	2400	40	50
2400	3000	40	55
3000	3000	50	55

Structural Adequacy

By inspection of FSH 2299, the density of 3M Fire Barrier Duct Wrap 615+ is nominally 96kg/m^3 making the mass of one layer of 38mm thick wrap nominally 3.7kg/m^2 (37Pa) and supported a span of 1150mm to 1350mm

The duct design was 1.2mm steel with proprietary slip-on flanges with a 300mm x 1000mm cross-section and a maximum of 1400mm between joints. With reference to AS 4254.2-2012 Table 2.3(E), the tested duct construction meets the Pressure Class of 1000 (1000Pa).

Based on inspection of the duct requirements of AS 4254-2012 Table 2.3(E), these tables include guidance on how duct construction shall vary for larger ducts including:

- The decrease in rib spacing ribs or reinforcing of ducts, which means shorter duct sections between joints or ribs.
- Closer supports spacing.
- The Higher base metal thickness of the duct wall.
- Joints of an alternate design of greater or better strength.

The structural resistance to internal pressure for the duct construction in AS 4254-2012 is related in some way to the yield stress of the steel and it is reasonable to consider that the stress state of larger ducts in accordance with AS 4254-2012 with more reinforcement and thicker wall construction will have a similar stress state to smaller ducts with less reinforcement and thinner duct wall thickness.

In this assessment, it is considered reasonable and conservative that the pressure rating including the allowable support spacing is directly related to the structural adequacy of the duct when exposed to heat and no pressure when tested.

The weight of the proposed double wrap was 73Pa respectively. This represents 7.3% of the pressure rating of the duct and therefore does not have a considerable impact on the structural adequacy of the duct system.

The structural adequacy of the duct, when tested, is based on the ability of the duct to resist the effects of fire and support its own weight and that of the duct wrap protection without internal pressure or suction. The structural adequacy criteria of AS 1530.4-2014 clause 9.6.1 is as follows:

> **9.6.1 Structural adequacy**
>
> Structural adequacy failure of the duct shall be deemed to have occurred when the duct collapses in such a manner that the duct no longer fulfils its intended function.

When tested in FSH 2299 the pressure class 1000 duct tested met the structural adequacy criteria without any signs of impending failure or collapse.

Based on this and the above discussion, it is considered reasonable and conservative that smaller ducts that have a pressure class of 1000Pa in accordance with AS 4254.2-2012 will also meet this structural adequacy criterion as they will have a metal thickness, joint reinforcement, and support spacing making them as strong as the tested duct in its ability to span between supports and resist internal positive or negative pressure many times the weight of the wrap.

Based on the above discussion it is confirmed the proposed variation to the size of the duct construction will meet the structural adequacy requirements of AS 1530.4-2014 for 120 minutes if wrapped with two layers of 3M Fire Barrier Duct Wrap 615+.

Integrity and Insulation at the wall

The proposed variation in size also has consequences for the detailing of the seal of the duct protection system to the wall and the size of gaps between the duct and wall to allow for expansion.

The proposed clearances between the duct and the wall are listed in Table B1 and the proposed clearances range from 1.3% to 10% of the maximum duct cross section.

The furnace temperature at 120 minutes is 1050˚C and the calculated thermal expansion from 20˚C to 1050˚C is between 1.5-1.6%. It is confirmed there are sufficient gaps to allow for expansion of the duct when conservatively calculated on the furnace temperature.

The maximum proposed gap also represents a 30mm increase in the size of the gap between the ducting and the aperture in the wall. When tested this was filled with a layer of 3M Fire Barrier Duct Wrap 615+ with the foil removed and faced with sealant and fire grade plasterboard.

When tested there was no indication of integrity or insulation weakness associated with the seal.

Based on the above discussion it is considered reasonable and conservative that the fire resistance of the proposed duct to aperture seals will be maintained if the gap size is increased to a maximum of 60mm provided the depth of sealant is at least half the width of the joint.

Based on the above discussion it is confirmed that the proposed variation to the gaps around the ducts will not detrimentally affect the integrity performance when tested in accordance with AS 1530.4-2014, Section 9 as appropriate for external exposure for up to 120 minutes.

B.11 External exposed horizontal duct - Insulation performance

The proposed construction shall be for ducts for external exposure only and shall be as tested FSH 2299 and subject to the following variations;

- Variation in duct sizes up to 3000mmx 3000mm

The proposed construction comprises increasing the size of the duct from the tested size to 3000mmx 3000mm. It is expected that the increase in duct surface area will be balanced out by the increase in the amount of airflow through the larger cross section of the duct from one side of the furnace to the other side.

Based on the above discussion it is confirmed that the proposed construction will maintain insulation for up to 60 minutes when tested in accordance with AS 1530.4-2014, Section 9 as appropriate for external exposure.

B.12 Inclusion of vertical ducts of varied sizes – external exposure

The proposed construction for horizontal ducts for external exposure only and shall be as tested in FSH 2299 and subject to the following variations:

- Duct orientation to vary to include vertical ducts based on FSH 2299
- Variation in duct sizes up to 3000mmx 3000mm
- Ducts to be straight, joints to be tapped with Aluminum foil tape, and duct wrapped with 12mm x 0.5 mm stainless or carbon steel bands at a maximum of 300mm ctrs. Corners wrap to be pinned to the duct with capacitive discharge pins at 300mm ctrs.
- Duct slab detail is to be based on FSH 2299 and FSP 2247 as shown in Figure 18
- Duct hanger rod size, hanger spacing, support, duct BMT, stiffeners and jointing shall be in accordance with AS 4254.2-2012 as appropriate for Pressure Class 1000 and designed to support the weight of duct under external exposure for up to 120 minutes
- The proposed construction is summarised in Table 1 and Figures 10, 11, 13, 14, 16, 18

The proposed construction shall be for ducts for external exposure only and shall be as tested FSH 2299 and subject to the following variations;

- Duct construction shall vary up to 3000mm x 3000mm in size and be in accordance with AS 4254-2012 Pressure Class 1000.

Table B5 – Duct Size and Clearance Details

Duct Width (mm)	Duct Height (mm)	Minimum Annular Gap (mm)	Maximum Annular Gap (mm)
600	600	20	35
600	900	20	35
600	1200	20	35
900	900	20	35
600	1800	30	45
900	1200	20	35
1200	1000	20	35
600	2400	35	50
1200	1200	20	35
900	1800	30	45
600	3000	40	55
900	2400	35	50
1200	1800	30	45
900	3000	40	55
1200	2400	35	50
1800	1800	30	45
1200	3000	40	55
1800	2400	35	50
1800	3000	40	55
2400	2400	40	50
2400	3000	40	55
3000	3000	50	55

The proposed vertical ducts would be subject to less sheer stress at duct joints when under fire exposure compared to horizontal ducts. This decreases the tendency for joints opening up and for the

sagging of wraps. Therefore, a vertically orientated duct, when constructed and supported in the same manner as the proposed horizontal duct, would be able to able to perform better than the tested horizontal duct in FSH 2299. When tested to AS 1530.4 -2014 section 9, the hot air inside the duct will flow out of the open end of the duct at the top of the separating element through the chimney effect, it is expected that the temperature inside the duct would be cooler than that tested in FSH 2299.

Therefore, it is expected that the discussion for horizontal ducts is also applicable to vertical ducts to maintain structure adequacy for up to 120 minutes. The proposed aperture filling around the duct and slab as shown in Figure 18 comprises the same detail as that tested in FSH 2299 in walls. The furnace pressure at the underside of the slab would be greater than that experienced by the aperture seal in FSH 2299. Therefore, it is expected that this junction may be a location of integrity and insulation weakness.

With reference to FSH 2247, the same detail was tested, though with an angle on the top side of the slab instead of on the underside of the slab. The packing material and sealant were exposed to direct furnace heat and did not cause integrity or insulation failure on the unexposed side of the duct or slab for up to 120 minutes.

The proposed detail would have an extra angle on the fireside, therefore reducing the heat exposure of the aperture seal, which would lead to better integrity and insulation performance of this joint.

Based on the above discussion it is confirmed the proposed variation to the size of the duct construction and the proposed variation to the gaps around the ducts will allow the ducts to meet the structural adequacy and integrity requirements of AS 1530.4-2014 for 120 minutes if wrapped with two layers of 3M Fire Barrier Duct Wrap 615+ and allow the duct to maintain insulation for up to 60 minutes.

B.13 Performance of ducts exposed on two or three sides – internal exposure

The proposed construction shall be for ducts for external exposure only and shall be as tested in FSH 299 and subject to the following variations;

- Variations previously discussed in sections B9-B11 of this report.
- Optional protection on 2 or 3 sides when adjacent to fire resistant non-combustible construction refers to Figure 13 and Figure 14.
- Adjacent construction shall be either non-combustible walls or floors, or for walls that include combustible framing, they shall be protected by 1 x 16mm or 2 x 13mm fire grade plasterboard for 60 and 120-minute applications respectively.

Ducts exposed on two or three sides only

Where ducts are installed adjacent to the wall and floor construction that has an equal FRL to that required of the duct, it is proposed that the wrap extend to the face and be sealed to this construction as shown in Figure 13 and Figure 14.

The principle of this variation is that the duct affords protection from the wall or floor construction and that construction performs the role of duct protection at this location. The proposed requirement of non-combustible construction or combustible construction protected with various layers of fire grade plasterboard provides confidence that the adjacent construction will not interact with the duct construction, create a cavity and support potential fires, or otherwise, behave in a manner that differs from the tested construction.

The detail of the seal of the wrap to the underside of a floor above Figure 13 and Figure 14 includes the following features;

- The maximum separation of the duct from the floor is 100mm.
- Fixing each layer of the wrap to the floor construction via a 50 x 2mm flat steel bar, bolted to the floor with concrete anchors at 300mm centres.
- Edge of wrap sealed to the floor with a 30mm x 30mm fillet of 3M Fire Barrier 2000+ sealant.

The proposed construction includes a robust seal that mechanically presses the wrap in contact with the support construction, additional confidence in a continuous high temp gas seal is afforded by the fillet of sealant on the edge of the wrap, which will act to fill gaps at imperfections in the shape of the underside of the floor.

The gaps between the duct and floor/wall are limited to 100mm will mean the wrap is only spanning 100mm unsupported which is considered to not detrimentally affect the ability of the laps and joints to be formed.

Based on the above it is considered that the proposed details will not introduce gaps or additional venting and are of sufficient robustness to support the wrap when the duct is exposed to internal fire exposure.

Based on the above discussion it is expected that the structural adequacy and integrity performance of the proposed construction will be at least 120 minutes and or insulation performance will be at least 60 minutes if tested in accordance with AS 1530.4-2014 Section 9 as appropriate for internal exposure.

B.14 Variation to sealants and foil

The proposed construction shall be for ducts for internal exposure only and shall be as tested in FSV 1844 and subject to the following variations;

- The inclusion of a minimum 100 mm width of 3M Venture 1520-CW - 50µm thick aluminium foil tape with Acrylic pressure-sensitive adhesive with temperature resistance at least 121°C
- The inclusion of 3M Fire Barrier CP25WB+ sealant

3M Fire Barrier CP25WB+ Sealant was tested in FSP 2015 and did not introduce any flaming failure for up to 181 minutes despite being in contact with a hotter duct than that tested in FSV 1844. It is expected it will perform similarly to the tested 3M Fire Barrier 2000+ sealant.

3M Venture 1520-CW - 50µm thick aluminium foil tape was tested in FSP 2015, without introducing any insulation weakness in the wrap overlap for up to 120 minutes despite the wrap and duct being hotter than that in FSV 1844. It is expected it will perform similarly to the tested 3M 425 Aluminium foil tape.

Based on the above, it is expected that the proposed variation will not detrimentally affect the integrity and insulation performance of the specimen in FSV 1844 when tested in accordance with AS 1530.4-2014 Section 9 as appropriate for internal exposure for up to 120 minutes.

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