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Fire resistance performance of a sprayed insulation system when applied to air handling ductwork

Assessment Report

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Copyright and disclaimer

Important disclaimer

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Executive summary

This Division has re-examined the information available on the fire resistance performance of your sprayed insulation system when applied to air handling ductwork.

Based on the test data and the factors related to the construction detailed herein, it is the assessment of this Division that the Vermiduct systems as detailed in your specification listed herein and described in our reports numbered FSH 0540, FSH 0970 and FSH 1036 would achieve the fire-resistance levels (FRL's) shown in Tables 3, 4 and 5, in accordance with BS 476 Part 24.

Fire resistance performance of sprayed insulation system when applied to air handling ductwork

1 Introduction

This Division has re-examined the information available on the fire resistance performance of your sprayed insulation system when applied to air handling ductwork.

2 Supporting Data

This Division has conducted various tests and provided assessments on fire protection systems. The data from these tests and assessments are used to support this assessment. A detailed description of the tests and assessments listed below can be found in Appendix A.

- CSIRO Sponsored Investigation report numbered FSH 0092
- CSIRO Sponsored Investigation report numbered FSH 0230
- CSIRO Sponsored Investigation report numbered FSH 0236
- CSIRO Sponsored Investigation report numbered FSH 0540
- CSIRO Sponsored Investigation report numbered FSH 0970
- CSIRO Sponsored Investigation report numbered FSH 1036
- CSIRO Letter of Assessment numbered FCO-1096
- CSIRO Letter of Assessment numbered FCO-1468
- CSIRO Letter of Assessment numbered FCO-1500

3 Proposal

You have requested an assessment as to the fire performance of your tested duct protection systems based on national Standards and those conducted in accordance with BS 476 Part 24.

4 Analysis

The critical performance requirements for sprayed insulation and that of any protection method attached to ducting is the ability to restrict the temperature rise within the duct. This performance is a factor of the thermal conductivity of the protection material, the thickness of the protection material, the ability of the protection material to remain in place (called ‘stickability’) and the severity of the fire exposure.

For the test reported in FSH 1036 observations made after the completion of the test showed that the thickness of the spray at the point of insulation failure of Duct B, on duct 50mm from the wall, was due to a reduced thickness of spray over one of the support angles in the underside of the duct. If the spray had been the specified thickness then it is considered that the duct would have in fact failed insulation, at the next temperature recorded in excess of the test failure criteria which was, at 115 minutes on the wall 50mm from the duct. Based on previous test evidence if the thickness of the spray is increased to at least 30 mm where the duct exits both sides of the wall it is considered that the insulation failure would have occurred at the thermocouples positioned further away from the wall. The next insulation failures occurred at 151 minutes at 400mm from wall on duct.

Below is a summary of supporting data in table form.

TABLE 1 : Test in accordance with AS 1530.4

REPORT No.	TEST DATE	DUCT	SIZE (mm)	MODE	FIRE SIDE	THICKNESS (mm)	Fire Resistance	
							With Access Panel	Without Access Panel
FSH 0540	28/01/98	H-1	1600 x 600	HORIZ.	INT	54	120/120/90	120/120/90
FSH 0540	28/01/98	H-2	1600 x 600	HORIZ.	INT	62*	120/120/60	120/120/60
FSH 0540	28/01/98	H-3	1600 x 600	HORIZ.	EXT	43	120/120/60	120/120/60
FSH 0540	28/01/98	H-4	1600 x 600	HORIZ.	EXT	49	120/120/60	120/120/60
FSH 0540	28/01/98	V-1	1600 x 600	VERT.	INT	59	120/120/120	120/120/120
FSH 0540	28/01/98	V-2	1600 x 600	VERT.	INT	50	120/120/120	120/120/120
FSH 0649	23/12/98	H	1000 x 1000	HORIZ.	EXT	40	120/120/120	120/120/120
FSH 0972	10/05/03	H1-B	1000 x 250	HORIZ.	INT	50	240/240/185	N/A
FSH 0972	10/05/03	H2-A	1000 x 250	HORIZ.	EXT	60	180/180/16	N/A
FSH 0972	10/05/03	V1-C	1000 x 250	VERT.	INT	30	240/240/240	N/A

* Note: (FSH 0540) Spray Thickness incorporated a 10 mm layer of sacrificial/ material/ designed to vaporize during fire conditions.

TABLE 2 - Test in accordance with BS 476: 24-1987

REPORT No.	TEST DATE	DUCT	SIZE (mm)	MODE	FIRE SIDE	THICKNESS (mm)	Fire resistance	
							With Access Panel	Without Access Panel
FSH 0970	10/05/03	H1-B	1000 x 250	HORIZ.	INT	50	240/185	N/A
FSH 0970	10/05/03	H2-A	1000 x 250	HORIZ.	EXT	60	229/229	N/A
FSH 0970	10/05/03	V1-C	1000 x 250	VERT.	INT	30	240/240	N/A
FSH 1036	28/02/04	A	1000 x 250	HORIZ.	EXT	20	200/155	N/A
FSH 1036	28/02/04	B	1000 x 250	HORIZ.	INT	20	240/27	N/A

As can be seen from the results the structural adequacy and integrity of the systems were of little concern in the test reported in FSH 0540 and observation documented that no failure under these criteria were imminent at the time the testing was terminated. For the test reported in FSH 0970 observation made during and after the completion of the test show that the failures occurred for the following reasons;

(i) H1-B
   a. Insulation failure at 185 minute occurred at a thermocouple located over the joint. As the Vermiduct material had not been profiled over the joint the thickness of the Vermiduct at this point was approximately 12 mm (38_mm TDF joints).

   b. Subsequent insulation failure occurred at 227 minutes when a roving thermocouple was positioned at a point where the insulation had cracked due to the sagging of the duct at the mid-point between supports.

(ii) H2-A.
   a. At 229 minutes the portion of the duct A inside the furnace collapsed due failure of the 8-mm thick support rods. Increasing these rods to 10 mm would increase the loadbearing capacity by 56% as well as reducing the surface areas-to-mass ratio (a measure of the heat intake of the rod) 20%.

5 Conclusion

Based on the test data and the factors related to the construction detailed herein, it is the assessment of this Division that the Vermiduct systems as detailed in your specification listed herein and described in our reports numbered FSH 0540, FSH 0970 and FSH 1036 would achieve the following fire-resistance levels (FRL's) in accordance with BS 476 Part 24.

TABLE 3

Maximum SIZE (mm)	ORIENTATION	FIRE SIDE	MINIMUM THICKNESS (mm)	FRL with A/P Structural Stability and Integrity only	MINIMUM THICKNESS (mm)	FRL with A/P Structural Stability, Integrity & Insulation
1600 x 1600	Horizontal / Vertical	Internal / External	5	60/60/-	12	60/60/60
1600 x 1600	Horizontal / Vertical	Internal / External	8	90/90/-	16	90/90/90
1600 x 1600	Horizontal / Vertical	Internal / External	10	120/120/-	20	120/120/120
1600 x 1600	Horizontal / Vertical	Internal / External	15	180/180/-	45	180/180/180
1600 x 1600	Horizontal / Vertical	Internal / External	25	240/240/-	55	240/240/240

a) Ducts not to exceed the dimensions of 1600 x 1600 mm;
b) Ductwork to be manufactured in accordance with AS 4254 or BS EN 1505:1998 using minimum 0.8 mm stainless steel or galvanised sheet metal;
c) Trapeze support centres at 1200 mm maximum comprising 50 x 50 x 5 mm angles and suspension rods not less than 10 mm diameter and the stress level not to exceed that of the tested prototype;
d) Tested Joints as follows: Drive Slip@2.4m max.; Mez Joint @ 1.52 m max. centres; TDF @ 1.45 m max centres;
e) Igniseal access panels as distributed by LAF with rebated edges and non-combustible Fire seal all as per tested prototype;
f) Quikmesh reinforcement by LAF all as tested in the above assemblies and secured with adhesive pins;
g) Intermediate support to be used in accordance with Tie Rod attachments SMACNA Fig 2 & 1·3 or AS 4254 Fig 2.3(C) Tie Rod;
h) Spray thickness in all FRL levels to be increased to a minimum 30 mm for a minimum distance of 150 mm from each side of the fire wall.

TABLE 4

Maximum SIZE (mm)	ORIENTATION	FIRE SIDE	MINIMUM THICKNESS (mm)	FRL with A/P Structural Stability and Integrity only	MINIMUM THICKNESS (mm)	FRL with A/P Structural Stability, Integrity & Insulation
2400 x 2400	Horizontal / Vertical	Internal / External	8	60/60/-	16	60/60/60
2400 x 2400	Horizontal / Vertical	Internal / External	10	90/90/-	20	90/90/90
2400 x 2400	Horizontal / Vertical	Internal / External	13	120/120/-	25	120/120/120
2400 x 2400	Horizontal / Vertical	Internal / External	20	180/180/-	50	180/180/180
2400 x 2400	Horizontal / Vertical	Internal / External	30	240/240/-	55	240/240/240

a) Ducts not to exceed the dimensions of 2400 x 2400 mm;
b) Ductwork to be manufactured in accordance with AS 4254 or BS EN 1505:1998 using minimum 1.0 mm stainless steel or galvanised sheet metal;
c) Trapeze support centres at 1200 mm maximum comprising 50 x 50 x 5 mm angles and suspension rods not less than 10 mm diameter and the stress level not to exceed that of the tested prototype;
d) Tested Joints as follows: Mez Joint @ 1.52 m max. centres; TDF @ 1.45 m max centres; Angle Flange @ 1.5 max. centres;
e) Igniseal access panels as distributed by LAF with rebated edges and non-combustible Fire seal all as per tested prototype;
f) Quikmesh reinforcement by LAF all as tested in the above assemblies and secured with adhesive pins;
g) Intermediate support to be used in accordance with Tie Rod attachments SMACNA Fig 2 & 1·3 or AS4254 Fig 2.3(C) Tie Rod;
h) Spray thickness in all FRL levels to be increased to a minimum 30 mm for a minimum distance of 150 mm from each side of the fire wall.

TABLE 5

Maximum SIZE (mm)	ORIENTATION	FIRE SIDE	MINIMUM THICKNESS (mm)	FRL with A/P Structural Stability and Integrity only	MINIMUM THICKNESS (mm)	FRL with A/P Structural Stability, Integrity & Insulation
10,000 x 3600	Horizontal / Vertical	Internal / External	10	60/60/-	16	60/60/60
10,000 x 3600	Horizontal / Vertical	Internal / External	13	90/90/-	20	90/90/90
10,000 x 3600	Horizontal / Vertical	Internal / External	15	120/120/-	25	120/120/120
10,000 x 3600	Horizontal / Vertical	Internal / External	25	180/180/-	55	180/180/180
10,000 x 3600	Horizontal / Vertical	Internal / External	35	240/240/-	65	240/240/240

a) Ducts not to exceed the dimensions of 10,000mm x 3600 mm;
b) Ductwork to be manufactured in accordance with AS 4254 or BS EN 1505:1998 using minimum 1.0 mm stainless steel or galvanised sheet metal;
c) Trapeze support centres at 1200 mm maximum comprising 50 x 50 x 5 mm angles and suspension rods not less than 12 mm diameter and the stress level not to exceed that of the tested prototype;
d) Tested Joints as follows: TDF @ 1.45 m max centres; Angle Flange @ 1.5 max. centres;
e) Igniseal access panels as distributed by LAF with rebated edges and non-combustible Fire seal all as per tested prototype;
f) Quikmesh reinforcement by LAF all as tested in the above assemblies and secured CD welded pins @ 1600 mm c's and adhesive pins thereafter;
g) Intermediate support to be used in accordance with Tie Rod attachments SMACNA Fig 2 & 1·3 or AS 4254 Fig 2.3(C) Tie Rod; and Figure 2.6 (A), tie rod extend to structure above;
h) Spray thickness in all FRL levels to be increased to a minimum 30 mm for a minimum distance of 150 mm from each side of the fire wall.
i) Expansion allowance at the perimeter to be 50mm each end and 36mm at top.

6 Term of validity

This assessment report will lapse on 31 May 2027. Should you wish us to re-examine this report with a view to the possible extension of its term of validity, would you please apply to us three to four months before the date of expiry. This Division reserves the right at any time to amend or withdraw this assessment in the light of new knowledge.

Appendix A – Supporting data

CSIRO SPONSORED INVESTIGATION REPORT NUMBERED FSH 0092

On 23 August 1990 this Division conducted a fire-resistance test on a specimen consisting of two vertical and four horizontal ducts protected with Vermitex 'AF' sprayed insulation. Each duct was fabricated from 1.0-mm thick galvanised sheet steel and was 1200-mm x 600-mm in cross section. Pins 2.7 diameter and 50-mm long were welded in a grid at 300 mm centres. Speed clips were used to secure the 25-mm x 25-mm x 1-mm thick wire mesh to the pins.

On ducts H3, H2 and V2 the Vermitex 'AF' was sprayed to two third of the final depth before the mesh was fixed. On ducts H4, H1 and V1 the mesh was fixed at two third of the final sprayed thickness.

The duct V1 was 2300-mm long and was fixed vertically into a 650-mm x 1250-mm opening in the 200-mm thick concrete slab with 100-mm of ductwork projecting into the furnace and 2000-mm outside the furnace. The duct was protected on the outside with 97-mm thick Vermitex 'AF' and was exposed to the fire from the inside. The duct failed with respect to insulation at 178 minutes but did not fail with respect to integrity or structural adequacy at the test termination time of 241 minutes.

The duct V2 was 2300-mm long and was fixed vertically into a 650-mm x 1250-mm opening in the 200-mm thick concrete slab with 100-mm of ductwork projecting into the furnace and 2000-mm outside the furnace. The duct was protected on the outside with 68-mm thick Vermitex 'AF' and was exposed to the fire from the inside. The duct failed with respect to insulation between 120 minutes and 180 minutes but did not fail with respect to integrity or structural adequacy at the test termination time of 241 minutes.

The duct H1 was 2400-mm long and was fixed horizontally into a 650-mm x 1250-mm opening in the 230-mm thick brick wall with 100-mm of ductwork projecting into the furnace and 2000-mm outside the furnace. The duct was protected on the outside with 96-mm thick Vermitex 'AF' and was exposed to the fire from the inside. The duct did not fail at the test termination time of 241 minutes.

The duct H2 was 2400-mm long and was fixed horizontally into a 650-mm x 1250-mm opening in the 230-mm thick brick wall with 100-mm of ductwork projecting into the furnace and 2000-mm outside the furnace. The duct was protected on the outside with 71-mm thick Vermitex 'AF' and was exposed to the fire from the inside. The duct failed with respect to insulation at 220 minutes but did not fail with respect to integrity or structural adequacy at the test termination time of 241 minutes.

The duct H3 was 5220-mm long and was fixed horizontally at both ends into 650-mm x 1250-mm openings in the 230-mm thick brick wall with 100-mm of ductwork projecting outside and with 4560-mm inside the furnace. The duct was protected on the outside with 64-mm thick Vermitex 'AF' and was exposed to the fire from the outside. The duct failed with respect to insulation at 175 minutes but did not fail with respect to integrity or structural adequacy at the test termination time of 241 minutes.

The duct H4 was 5220-mm long and was fixed horizontally at both ends into 650-mm x 1250-mm openings in the 230-mm thick brick wall with 100-mm of ductwork projecting outside and with 4560-mm inside the furnace. The duct was protected on the outside with 89-mm thick Vermitex 'AF' and was exposed to the fire from the outside. The duct did not fail at the test termination time of 241 minutes.

CSIRO SPONSORED INVESTIGATION REPORT NUMBERED FSH 0230

On 20 August 1992 this Division conducted a fire-resistance test on a specimen consisting of three steel ducts protected with Vermitex 'AF' sprayed insulation. Pins 2.7 diameter and 50-mm to 60-mm long were welded in a grid at 300-mm centres. The sprayed insulation was reinforced with "Spraylok" expanded steel mesh fixed at 40-mm from the surface of the duct. Each duct was fabricated from 1.0-mm thick galvanised sheet steel. On ducts H1 the Vermitex 'AF' was sprayed to two third of the final depth before the mesh was fixed. On ducts H2 and V1 the mesh was fixed at two third of the final sprayed thickness.

The duct V1 was 2300-mm long and was fixed vertically into a 2450-mm x 650-mm opening in a concrete slab. The 2400-mm x 600-mm ductwork projected 100-mm into the furnace and 2000-mm above the slab. The duct was protected on the outside with 66-mm thick Vermitex 'AF' and was exposed to the fire from the inside. The duct failed with respect to insulation at 82 minutes but did not fail with respect to integrity or structural adequacy at the test termination time of 226 minutes.

The duct H1 was 5220-mm long and was fixed horizontally at both ends into 650-mm x 1650-mm openings in the 230-mm thick brick wall with 100-mm of ductwork projecting outside and with 4560-mm inside the furnace. The duct was protected on the outside with 61-mm thick Vermitex 'AF' and was exposed to the fire from the outside. The duct failed with respect to insulation at 138 minutes but did not fail with respect to integrity or structural adequacy at the test termination time of 226 minutes.

The duct H2 had a horizontal leg 2600-mm long and was installed through a 650-mm x 2450-mm opening in the 230-mm thick brick wall. The duct was 2400-mm x 600-mm in cross section and incorporated a right angle bend. The duct was protected on the outside with 63-mm thick Vermitex 'AF' and was exposed to the fire from the inside. The duct failed with respect to insulation at 66 minutes and with respect to integrity at 223 minutes but did not fail with respect to structural adequacy at the test termination time of 226 minutes.

Penetration F comprised Vermitex 'AF' cast insitu within the slab opening. Spraylok-C mesh was fixed at the bottom of the slab opening by concrete nails. Two Rondo furring channels were placed spanning the 1250-mm side of the opening and supported by Z clips at 300-mm centres. Another layer of steel mesh was placed over the Rondo channel and fixed in place. Vermitex 'AF' was poured into the opening to a total depth of 65-mm.

CSIRO SPONSORED INVESTIGATION REPORT NUMBERED FSH 0236

On 18 December 1992 this Division conducted a fire-resistance test on a specimen consisting of two steel ducts and two PVC ducts protected with Vermitex 'AF' sprayed insulation reinforced with steel mesh.

Steel duct was fabricated from 1.0 mm thick galvanised sheet steel. Pins 2.7 diameter and 55-mm long were welded in a grid at 300-mm centres. Steel square mesh 25-mm x 25-mm x 1.0-mm thick was held at a distance of 40-mm from the surface and was lapped 100-mm at joints. PVC ducts were installed using a surrounding frame of Rondo 308 furring channels spaced at 380 mm and attached to two Rondo 222 main runners with Rondo 281 clips. The steel square mesh was wrapped around the duct framework and held in place by screws. The mesh was fixed at two third of the final sprayed thickness.

The duct V1 was 2300-mm long and was fixed vertically into a 2450-mm x 650-mm opening in a concrete slab. The 2400-mm x 600-mm ductwork projected 100-mm into the furnace and 2000-mm above the slab. The duct was protected on the outside with 77-mm thick Vermitex 'AF' and was exposed to the fire from the inside. The duct failed with respect to insulation at 133 minutes but did not fail with respect to integrity or structural adequacy at the test termination time of 188 minutes.

The duct H1 had a horizontal leg 2600-mm long and was installed through a 650-mm x 2450-mm opening in the 230-mm thick brick wall. The duct was 2400-mm x 600-mm in cross section and incorporated a right angle bend. The duct was protected on the outside with 68-mm thick Vermitex 'AF' and was exposed to the fire from the inside. The duct failed with respect to insulation at 56 minutes but did not fail with respect to integrity or structural adequacy at the test termination time of 188 minutes.

The PVC duct H2 was 5220-mm long and was installed horizontally through 800 mm x 650 mm opening in the 230-mm brickwork. The gap between the duct and the brickwork was packed using 25-mm thick Bradford Fibretex-350 mineral fibre. The duct was protected on the outside with 78-mm thick Vermitex 'AF' and was exposed to the fire from the outside. The duct did not fail at the test termination time of 188 minutes.

The PVC duct H3 was 750-mm x 570-mm x 2200-mm long and was installed horizontally. It protruded 100 mm into the spray-protected box at the furnace end of the duct and was bolted to a steel elbow at the fluing end of the duct. The duct was protected on the outside with 75-mm thick Vermitex 'AF' and was exposed to the fire from the inside. The duct failed with respect to insulation at 127 minutes but did not fail with respect to integrity or structural adequacy at the test termination time of 188 minutes.

CSIRO SPONSORED INVESTIGATION REPORT NUMBERED FSH 0540

On 28 January 1998 this Division conducted a full-scale fire-resistance test on duct systems. The specimen comprised six ducts fabricated from galvanised sheet steel 0.8 mm thick and protected with Vermiduct sprayed insulation reinforced with square steel mesh and two steel ducts protected with Vermiduct sprayed insulation without the aid of mechanical reinforcement.

Duct V1 was 2300 mm long and was fixed vertically into a 1650 mm x 650 mm opening in the 200 mm thick Hebel slab. The duct projected 100 mm into the furnace chamber and 2000 mm above the Hebel panel. The duct was fixed to the slab with 8 mm masonry anchors through 1.6 mm steel angles which were in turn fixed to the ducts with self tapping screws at 300 mm centres as shown in drawings numbered 0197-003 and 0197-004. The duct incorporated slip on propriety flange (SPF) joints and specifically TDF joints, had 10 mm polystyrene sheeting adhered to its perimeter by means of self-adhesive double-sided tape, as well as 25 mm x 25 mm x 1 mm square mesh wrapped to its perimeter.

The duct was protected on the outside with Vermiduct sprayed insulation and was exposed to the fire from the inside. The average sprayed thickness of Vermiduct on the duct (including polystyrene sheeting) ranged from 50 mm to 65 mm with an average of 58.6 mm.

Duct V2 was of similar construction to Duct V1 except for the following differences. Duct V2 incorporated Integrated Machine Rolled Flange (IMRF) joints and specifically 25 mm MEZ joints.

The duct was protected on the outside with Vermiduct sprayed insulation and was exposed to the fire from the inside. The average sprayed thickness of Vermiduct on 50 mm. The duct was clad with 0.55 mm thick galvanised steel sheeting, which was fixed to the duct with self tapping hex screws at 200 mm centres.

Duct H1 was 2350 mm long and was fixed horizontally into a 1650 mm x 650 mm opening in a 230 mm thick brick wall with 100 mm of ductwork projecting into the furnace chamber and 2250 mm outside the furnace. The duct was fixed to the wall with 8 mm masonry anchors through 1.6 mm steel angles which were in turn fixed to the ducts with self tapping screws at 300 mm centres as shown in drawings numbered 0197-001, 0197-002 and 0197-003. The duct had appended, at the end of the horizontal run, a vertical riser duct, this portion of the duct was not sprayed as shown on drawing numbered 0197-003. The duct incorporated slip on propriety flange (SPF) joints and specifically 25 mm MEZ joints, had 25 mm x 25 mm x 1 mm square mesh wrapped to its perimeter tensioned by means of plastic inserts. The duct was supported by trapeze hangers with 8 mm diameter threaded rods and 40 mm x 40 mm x 5 mm steel angle, and incorporated one access panel measuring 600 mm x 600 mm.

The duct was protected on the outside with Vermiduct sprayed insulation and was exposed to the fire from the inside. The average sprayed thickness of Vermiduct on the duct ranged from 45 mm to 62 mm with an average of 53.9 mm.

Duct H2 was of similar construction to Duct H1 except the following differences. The duct had 10 mm thick polystyrene sheeting adhered to its perimeter by means of self-adhesive double-sided tape, as well as 25 mm x 25 mm x 1 mm square mesh wrapped to its perimeter and fixed with self tapping screws.

The duct was protected on the outside with Vermiduct sprayed insulation and was exposed to the fire from the inside. The average sprayed thickness of Vermiduct on the duct (including polystyrene sheeting) ranged from 52 mm to 67 mm with an average of 61.2 mm.

Duct H3 was 5220 mm long and was fixed horizontally at both ends into 1650 mm x 650 mm openings in a 230 mm thick brick wall with 100 mm of ductwork projecting outside the furnace on each end. The duct was fixed to the wall with 6 mm masonry anchors through 1.6 mm steel angles which were in turn fixed to the ducts with self tapping screws at 300 mm centres as shown in drawings numbered 0197-001and 0197-004. The duct incorporated Drive Slip (DS) joints, one access panel measuring 600 mm x 600 mm, and was supported by trapeze hangers with 10 mm diameter threaded rods and 40 mm x 40 mm x 5 mm steel angle.

The duct was protected on the outside with Vermiduct sprayed insulation sprayed directly to contour without any mechanical reinforcement and was exposed to the fire from the outside. The average sprayed thickness of Vermiduct on the duct ranged from 35 mm to 49 mm with an average of 42.5 mm.

Duct H4 was of similar construction to Duct H3 except the following differences. Duct H4 had 25 mm x 25 mm x 1 mm square mesh wrapped to its perimeter and tensioned by means of plastic inserts.

The duct was protected on the outside with Vermiduct sprayed insulation and was exposed to the fire from the outside. The average sprayed thickness of Vermiduct on the duct ranged from 35 mm to 59 mm with an average of 48.5 mm.

CSIRO SPONSORED INVESTIGATION REPORT NUMBERED FSH 0970

On 10 May 2003 this Division conducted a full-scale fire-resistance test in accordance with BS 476 Part 24 on three duct systems.

The three ducts consisted of two horizontal ducts, Duct H1-B was subjected to internal fire exposure and H2-A and V1-C were subjected to external fire exposure.

The ducts were constructed from nominal 0.8-mm thick galvanized steel sheeting with all longitudinal seams of the Pittsburgh lock type. The transverse joint consisted of Integrated Machine Rolled Flange (IMRF), or 38-mm TDF. The IMRF joints were sealed with closed cell fire retarded foam tape. Each duct section was of variable length and nominally 1000-mm wide x 250-mm deep.

Duct V1 consisted of a nominal 4500-mm high duct with nominally 2000-mm above the furnace roof. The hole in the roof was nominally 1050-mm wide x 300-mm deep and did not have any packing except for the Vermiduct® spray.

The duct was secured to the furnace roof, above and below, with nominal angles 75 mm x 75 mm x 1.6-mm thick along all sides. The angle was secured to the roof with 12 masonry anchors and to the duct with self tapping screws.

Duct H1-B was nominally 6340-mm long and installed horizontally into a 1050-mm wide x 800-mm high opening in a brickwork wall. The length of duct inside the furnace was nominally 3610 mm and outside the furnace was nominally 2500 mm. The end of the duct was then connected into a transition piece which then fed into an exhaust fan. The flow rate through the duct was set to 3 m/s before the start of the test. Inside the furnace the duct had an opening in accordance with BS476:24 for internal exposure for type B ducts.
The duct was supported by trapeze hangers with 8-mm diameter threaded rods and 40 mm x 40 mm x 5 mm angles. The duct also had two access panels measuring nominally 198-mm x 332-mm, one inside the furnace the other outside the furnace.

Duct H2-A was of similar construction to Duct H1-B except it had a T-Junction and a 90° bend as shown in drawing HA-1073-1 and was closed to the furnace. Before the start of the test the pressure was set inside the duct to minus 300 Pa below laboratory pressure.

The Vermiduct® Fire Spray material was then applied as per the manufactures instructions in layers up to 20-mm thick until the required thickness was achieved. The applied density of the Vermiduct® was nominally 293kg/m^3. The ducts were sprayed at the following thickness:

- Duct V1-C spayed to 30-mm thickness
- Duct H1-B sprayed to 50-mm thickness
- Duct H2-A sprayed to 60-mm thickness.

The spray was applied so that the joints were not visible i.e. the thickness over the joints was of reduced thickness.

CSIRO SPONSORED INVESTIGATION REPORT NUMBERED FSH 1036

On 28 February 2004 this Division conducted a full-scale fire-resistance test in accordance with BS 476 Part 24 on two duct systems.

Duct A subjected to external fire exposure and Duct B was subjected to internal fire exposure.

The ducts were constructed from nominal 0.8-mm thick galvanized steel sheeting with all longitudinal seams of the Pittsburgh lock type. The transverse joint consisted of Integrated Machine Rolled Flange (IMRF), or 38-mm TDF. The IMRF joints were sealed with closed cell fire retarded foam tape. Each duct section was of variable length and nominally 1000-mm wide x 250-mm deep.

Duct B was nominally 6340-mm long and installed horizontally into a 1050-mm wide x 300-mm high opening in a brickwork wall. The length of duct inside the furnace was nominally 3610 mm and outside the furnace was nominally 2500 mm. The end of the duct was then connected into a transition piece which then fed into an exhaust fan. The flow rate through the duct was set to 3 m/s before the start of the test. Inside the furnace the duct had an opening in accordance with BS476:24 for internal exposure for type B ducts.

The duct was supported by trapeze hangers with 12-mm diameter threaded rods and 40 mm x 40 mm x 5 mm angles. The duct also had two access panels measuring nominally 198-mm x 332-mm, one inside the furnace the other outside the furnace

Duct A was of similar construction to Duct B except it had a T-Junction and a 90° bend and was closed to the furnace. Before the start of the test the pressure was set inside the duct to minus 300 Pa below laboratory pressure.

The Vermiduct® Fire Spray material was then applied as per the manufactures instructions in a single layer at least 20-mm thick. The applied density of the Vermiduct® was nominally 293kg/m^3. Duct B failed insulation over one of the support hangers due to a reduced thickness in spray in this area. If the spray had the specified minimum 20 mm thickness over the support bracket then it is considered insulation failure would not have occurred until the next temperature recorded, in excess of the test failure criteria, at 115 minutes.

CSIRO ASSESSMENT REPORT NUMBERED FCO-1026

On 20 August 2013 this Division re-assessed the fire performance of roof/ceiling systems incorporating different thicknesses of sprayed insulation. Data from various full scale these results was used to assess the fire resistance performance of the ceiling systems when considering the Incipient Spread of Fire criterion. Using a regression analysis on the relevant data resulted in a table for the thickness required to achieve incipient spread of fire.

The proposed systems use various thicknesses of sprayed material to achieve the required fire-resistance levels. These thicknesses range from 25-mm for 60/60/60 to 60-mm for 240/240/240. The system reported in SI 1589 achieved 240/240/240 with the stipulated 60-mm of sprayed material. Comparing this result with the results of the ductwork tests shows that there is also a significant conservatism in the proposed systems. This conservatism is considered appropriate to an extrapolation process.

CSIRO ASSESSMENT REPORT NUMBERED FCO-1468

On 15 March 2011 this Division re-assessed the fire performance of Vermiduct fire protection systems based on the requirements of AS 1530.4-2005, test data obtained during CSIRO fire test FS 2979/1574 and LAF Specification dated 28 January 1998.

CSIRO ASSESSMENT REPORT NUMBERED FCO-1500

On 26 August 2014 this Division re-assessed the fire performance of unprotected steel duct systems The assessment concluded that the steel duct systems detailed in Sponsored Investigation reports numbered FSH 0230, FSH 0236 and FSH 0540 installed without any spray protection, would be capable of achieving fire-resistance levels of 120/120/0 if tested in accordance with AS 1530.4-1997 and BS 476 Part 24-1987 for internal fire exposure in both horizontal and vertical orientation provided that :-

1. An agent of L & A Fazzini Manufacturing or a suitably qualified engineering consultant appointed by L & A Fazzini Manufacturing as their representative, must ensure that LAF Group's duct construction specifications are complied with in relation to:-

(a) Metal Duct Construction Specification;

- the ductwork is constructed in strict accordance with specifications of the tested prototypes;
- the maximum size of the overall duct system is restricted to 4800-mm x 3000-mm constructed in modules not exceeding 1600-mm x 1500-mm and incorporate internal tie-rods supports at maximum 1600 centres;
- all support structural elements are protected to a level of 120/-/- and are increased in size in line with accepted structural design principles to carry the additional dead load bearing imposed.

(b) on-site installation methodology

2. Any departures and modifications from the nominated standards must be approved in writing before construction and erection of the ductwork.

3. The trapeze angles and hanging rod dimensions must be verified by a qualified structural engineer to ensure their safe working load is not exceeded.

References

The following informative documents are referred to in this Report:

FSH 0092	CSIRO Sponsored Investigation report on a fire-resistance test on a specimen consisting of two vertical and four horizontal ducts protected with Vermitex 'AF' sprayed insulation conducted on 23 August 1990.
FSH 0230	CSIRO Sponsored Investigation report on a fire-resistance test on a specimen consisting of three steel ducts protected with Vermitex 'AF' sprayed insulation conducted on 20 August 1992.
FSH 0236	CSIRO Sponsored Investigation report on a fire-resistance test on a specimen consisting of two steel ducts and two PVC ducts protected with Vermitex 'AF' sprayed insulation reinforced with steel mesh conducted on 18 December 1992.
FSH 0540	CSIRO Sponsored Investigation report on a full-scale fire-resistance test on duct systems conducted on 28 January 1998.
FSH 0970	CSIRO Sponsored Investigation report on a full-scale fire-resistance test in accordance with BS 476 Part 24 on three duct systems conducted on 10 May 2003.
FSH 1036	CSIRO Sponsored Investigation report on a full-scale fire-resistance test in accordance with BS 476 Part 24 on two duct systems conducted on 28 February 2004.
British Standard 476: Part 20	Fire Tests on Building materials and structures. Part 20 Method of test for determination of the fire resistance of elements of construction (General Principles)
British Standard 476: Part 24	Fire Tests on Building materials and structures, Part 24 Method for the determination of the fire-resistance of ventilation ducts

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