Bodycote

Test Report

Title:

Fire-resistance test of various diameter pipes protected by retrofit collars fitted both sides, penetrating a 128mm thick steel framed plasterboard partition tested in accordance with AS 1530.4-2005.

BWA Report No:

2257300

Test Applicant:

Promat Australia P/L
1 Scotland Road
Mile End
SA 5031.

Test Date:

16th June 2008

Bodycote

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1 CONSTRUCTION DETAILS

TEST ASSEMBLY

The test assembly comprised a nominal 1200mm long × 1200mm wide × 128mm thick steel stud plasterboard wall penetrated by various diameter pipes.

TEST SPECIMENS

The partition was penetrated by nine pipe systems that were protected by various retrofit collars that were designated as Services A – I. Further details are provided in Figures A1.1 to A1.4 and the 'Schedule of Components' in Section 2.

ASSEMBLY AND INSTALLATION METHODS

The services were installed by authorized representatives of the test applicant into the plasterboard wall at BWA Melbourne on the 12th and 13th of June 2008, under the supervision of a BWA representative. The plasterboard wall was supplied by BWA.

ORIENTATION

The fire protection devices were symmetric and installed on both sides of the wall.

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2 SCHEDULE OF COMPONENTS

Item	Description
	SERVICE A
Pipe System	
Product name	16.2 x 2.6 PE-X/AL/PE pipe.
Pipe dimensions	16.4 mm (measured) diameter (OD) × 3.0 mm thick (measured) pipe that protruded nominal 525 mm on the exposed side past the wall and minimum 2000 mm on the unexposed side, capped on the exposed side with kaowool and sealant to a depth of 25mm.
Pipe Support	The pipe was supported on the unexposed side with 25mm wide steel strapping 500mm and 1500mm from the unexposed face.
Collar	
Product Name	PROMASTOP® Unicollar® CFC 32
Collar location	One on the exposed side and one on the unexposed side.
Collar size	Overall dimension of the collar was nominal 54 mm in diameter × nominal 51 mm high with an internal diameter to the intumescent of nominal 32 mm. The outer shell of the collar is made from 0.55 mm thick stainless steel with perforated edged segments 15 mm wide × 51 mm long. At every second segment a nominal 11 mm wide × 9 mm long lip is turned 90° to the outer shell, in order to secure the intumescent strip (dimensions measured).
Intumescent	The intumescent on both of the collars were nominal 50 mm high × 10 mm thick, with an average approximate density of 900±50 kg/m^3 (as specified by the collar manufacturer).
Fixing	Collar fixed to both sides of the wall with 10g × 40 mm course threaded stitching screws at two points.
Sealant	
Product name	PROMASEAL® AN Acrylic sealant.
Location	The annular gap between the separating element and pipe (on both sides) was sealed to a minimum depth (nominal) of 10 mm.
Hole Size in Wall	Nominally 19 mm diameter.

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Item	Description
	SERVICE B
Pipe System	
Product name	20 x 2.8 PE-X-a pipe.
Pipe dimensions	20.2 mm (measured) diameter (OD) × 3.2 mm thick (measured) pipe that protruded nominal 525 mm on the exposed side past the wall and minimum 2000 mm on the unexposed side, capped on the exposed side with kaowool and sealant to a depth of 25mm.
Pipe Support	The pipe was supported on the unexposed side with 25mm wide steel strapping 500mm and 1500mm from the unexposed face.
Collar	
Product Name	PROMASTOP® Unicollar® CFC 32
Collar location	One on the exposed side and one on the unexposed side.
Collar size	Overall dimension of the collar was nominal 54 mm in diameter × nominal 51 mm high with an internal diameter to the intumescent of nominal 32 mm. The outer shell of the collar is made from 0.55 mm thick stainless steel with perforated edged segments 15 mm wide × 51 mm long. At every second segment a nominal 11 mm wide × 9 mm long lip is turned 90° to the outer shell, in order to secure the intumescent strip (dimensions measured).
Intumescent	The intumescent on both of the collars were nominal 50 mm high × 10 mm thick, with an average approximate density of 900±50 kg/m^3 (as specified by the collar manufacturer).
Fixing	Collar fixed to both sides of the wall with 10g × 40 mm course threaded stitching screws at two points.
Sealant	
Product name	PROMASEAL® AN Acrylic sealant.
Location	The annular gap between the separating element and pipe (on both sides) was sealed to a minimum depth (nominal) of 10 mm.
Hole Size in Wall	Nominally 23 mm diameter.

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Item	Description
	SERVICE C
Pipe System	
Product name	20 x 2.9 PE-X/AL/PE pipe.
Pipe dimensions	19.8 mm (measured) diameter (OD) × 3.0 mm thick (measured) pipe that protruded nominal 525 mm on the exposed side past the wall and minimum 2000 mm on the unexposed side, capped on the exposed side with kaowool and sealant to a depth of 25mm.
Pipe Support	The pipe was supported on the unexposed side with 25mm wide steel strapping 500mm and 1500mm from the unexposed face.
Collar	
Product Name	PROMASTOP® Unicollar® CFC 32
Collar location	One on the exposed side and one on the unexposed side.
Collar size	Overall dimension of the collar was nominal 54 mm in diameter × nominal 51 mm high with an internal diameter to the intumescent of nominal 32 mm. The outer shell of the collar is made from 0.55 mm thick stainless steel with perforated edged segments 15 mm wide × 51 mm long. At every second segment a nominal 11 mm wide × 9 mm long lip is turned 90° to the outer shell, in order to secure the intumescent strip (dimensions measured).
Intumescent	The intumescent on both of the collars were nominal 50 mm high × 10 mm thick, with an average approximate density of 900±50 kg/m^3 (as specified by the collar manufacturer).
Fixing	Collar fixed to both sides of the wall with 10g × 40 mm course threaded stitching screws at two points.
Sealant	
Product name	PROMASEAL® AN Acrylic sealant.
Location	The annular gap between the separating element and pipe (on both sides) was sealed to a minimum depth (nominal) of 10 mm.
Hole Size in Wall	Nominally 23 mm diameter.

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Item	Description
	SERVICE D
Pipe System	
Product name	25 x 3.5 PE-X-a pipe.
Pipe dimensions	25.4 mm (measured) diameter (OD) × 4.0 mm thick (measured) pipe that protruded nominal 525 mm on the exposed side past the wall and minimum 2000 mm on the unexposed side, capped on the exposed side with kaowool and sealant to a depth of 25mm.
Pipe Support	The pipe was supported on the unexposed side with 25mm wide steel strapping 500mm and 1500mm from the unexposed face.
Collar	
Product Name	PROMASTOP® Unicollar® CFC 32
Collar location	One on the exposed side and one on the unexposed side.
Collar size	Overall dimension of the collar was nominal 54 mm in diameter × nominal 51 mm high with an internal diameter to the intumescent of nominal 32 mm. The outer shell of the collar is made from 0.55 mm thick stainless steel with perforated edged segments 15 mm wide × 51 mm long. At every second segment a nominal 11 mm wide × 9 mm long lip is turned 90° to the outer shell, in order to secure the intumescent strip (dimensions measured).
Intumescent	The intumescent on both of the collars were nominal 50 mm high × 10 mm thick, with an average approximate density of 900±50 kg/m^3 (as specified by the collar manufacturer).
Fixing	Collar fixed to both sides of the wall with 10g × 40 mm course threaded stitching screws at two points.
Sealant	
Product name	PROMASEAL® AN Acrylic sealant.
Location	The annular gap between the separating element and pipe (on both sides) was sealed to a minimum depth (nominal) of 10 mm.
Hole Size in Wall	Nominally 28 mm diameter.

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Item	Description
	SERVICE E
Pipe System	
Product name	25 x 3.7 PE-X/AL/PE pipe.
Pipe dimensions	25.2 mm (measured) diameter (OD) × 4.0 mm thick (measured) pipe that protruded nominal 525 mm on the exposed side past the wall and minimum 2000 mm on the unexposed side, capped on the exposed side with kaowool and sealant to a depth of 25mm.
Pipe Support	The pipe was supported on the unexposed side with 25mm wide steel strapping 500mm and 1500mm from the unexposed face.
Collar	
Product Name	PROMASTOP® Unicollar® CFC 32
Collar location	One on the exposed side and one on the unexposed side.
Collar size	Overall dimension of the collar was nominal 54 mm in diameter × nominal 51 mm high with an internal diameter to the intumescent of nominal 32 mm. The outer shell of the collar is made from 0.55 mm thick stainless steel with perforated edged segments 15 mm wide × 51 mm long. At every second segment a nominal 11 mm wide × 9 mm long lip is turned 90° to the outer shell, in order to secure the intumescent strip (dimensions measured).
Intumescent	The intumescent on both of the collars were nominal 50 mm high × 10 mm thick, with an average approximate density of 900±50 kg/m^3 (as specified by the collar manufacturer).
Fixing	Collar fixed to both sides of the wall with 10g × 40 mm course threaded stitching screws at two points.
Sealant	
Product name	PROMASEAL® AN Acrylic sealant.
Location	The annular gap between the separating element and pipe (on both sides) was sealed to a minimum depth (nominal) of 10 mm.
Hole Size in Wall	Nominally 28 mm diameter.

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Item	Description
	SERVICE F
Pipe System	
Product name	32 x 4.7 PE-X/AL/PE pipe.
Pipe dimensions	31.7 mm (measured) diameter (OD) × 5.0 mm thick (measured) pipe that protruded nominal 525 mm on the exposed side past the wall and minimum 2000 mm on the unexposed side, capped on the exposed side with kaowool and sealant to a depth of 25mm.
Pipe Support	The pipe was supported on the unexposed side with 25mm wide steel strapping 500mm and 1500mm from the unexposed face.
Collar	
Product Name	PROMASTOP® Unicollar® CFC 32
Collar location	One on the exposed side and one on the unexposed side.
Collar size	Overall dimension of the collar was nominal 54 mm in diameter × nominal 51 mm high with an internal diameter to the intumescent of nominal 32 mm. The outer shell of the collar is made from 0.55 mm thick stainless steel with perforated edged segments 15 mm wide × 51 mm long. At every second segment a nominal 11 mm wide × 9 mm long lip is turned 90° to the outer shell, in order to secure the intumescent strip (dimensions measured).
Intumescent	The intumescent on both of the collars were nominal 50 mm high × 10 mm thick, with an average approximate density of 900±50 kg/m^3 (as specified by the collar manufacturer).
Fixing	Collar fixed to both sides of the wall with 10g × 40 mm course threaded stitching screws at two points.
Sealant	
Product name	PROMASEAL® AN Acrylic sealant.
Location	The annular gap between the separating element and pipe (on both sides) was sealed to a minimum depth (nominal) of 10 mm.
Hole Size in Wall	Nominally 35 mm diameter.

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Item	Description
	SERVICE G
Pipe System	
Product name	40 x 5.5 PE-X-a pipe.
Pipe dimensions	40.6 mm (measured) diameter (OD) × 6.1 mm thick (measured) pipe that protruded nominal 525 mm on the exposed side past the wall and minimum 2000 mm on the unexposed side, capped on the exposed side with kaowool and sealant to a depth of 25mm.
Pipe Support	The pipe was supported on the unexposed side with 25mm wide steel strapping 500mm and 1500mm from the unexposed face.
Collar	
Product Name	PROMASTOP® Unicollar®
Collar location	One on the exposed side and one on the unexposed side.
Collar size	Overall dimension of the collar was nominal 64 mm in diameter × nominal 51 mm high with an internal diameter to the intumescent of nominal 42 mm. The outer shell of the collar is made from 0.55 mm thick stainless steel with perforated edged segments 15 mm wide × 51 mm long. At every second segment a nominal 11 mm wide × 9 mm long lip is turned 90° to the outer shell, in order to secure the intumescent strip (dimensions measured).
Intumescent	The intumescent on both of the collars were nominal 50 mm high × 10 mm thick, with an average approximate density of 900±50 kg/m^3 (as specified by the collar manufacturer).
Fixing	Collar fixed to both sides of the wall with 10g × 40 mm course threaded stitching screws at two points.
Sealant	
Product name	PROMASEAL® AN Acrylic sealant.
Location	The annular gap between the separating element and pipe (on both sides) was sealed to a minimum depth (nominal) of 10 mm.
Hole Size in Wall	Nominally 43 mm diameter.

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Item	Description
	SERVICE H
Pipe System	
Product name	40 x 6.0 PE-X/AL/PE pipe.
Pipe dimensions	39.8 mm (measured) diameter (OD) × 6.4 mm thick (measured) pipe that protruded nominal 525 mm on the exposed side past the wall and minimum 2000 mm on the unexposed side, capped on the exposed side with kaowool and sealant to a depth of 25mm.
Pipe Support	The pipe was supported on the unexposed side with 25mm wide steel strapping 500mm and 1500mm from the unexposed face.
Collar	
Product Name	PROMASTOP® Unicollar®
Collar location	One on the exposed side and one on the unexposed side.
Collar size	Overall dimension of the collar was nominal 64 mm in diameter × nominal 51 mm high with an internal diameter to the intumescent of nominal 42 mm. The outer shell of the collar is made from 0.55 mm thick stainless steel with perforated edged segments 15 mm wide × 51 mm long. At every second segment a nominal 11 mm wide × 9 mm long lip is turned 90° to the outer shell, in order to secure the intumescent strip (dimensions measured).
Intumescent	The intumescent on both of the collars were nominal 50 mm high × 10 mm thick, with an average approximate density of 900±50 kg/m^3 (as specified by the collar manufacturer).
Fixing	Collar fixed to both sides of the wall with 10g × 40 mm course threaded stitching screws at two points.
Sealant	
Product name	PROMASEAL® AN Acrylic sealant.
Location	The annular gap between the separating element and pipe (on both sides) was sealed to a minimum depth (nominal) of 10 mm.
Hole Size in Wall	Nominally 43 mm diameter.

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Item	Description
	SERVICE I
Pipe System	
Product name	50 x 6.9 PE-X-a pipe.
Pipe dimensions	50.7 mm (measured) diameter (OD) × 7.5 mm thick (measured) pipe that protruded nominal 525 mm on the exposed side past the wall and minimum 2000 mm on the unexposed side, capped on the exposed side with kaowool and sealant to a depth of 25mm.
Pipe Support	The pipe was supported on the unexposed side with 25mm wide steel strapping 500mm and 1500mm from the unexposed face.
Collar	
Product Name	PROMASTOP® Unicollar®
Collar location	One on the exposed side and one on the unexposed side.
Collar size	Overall dimension of the collar was nominal 76 mm in diameter × nominal 51 mm high with an internal diameter to the intumescent of nominal 52 mm. The outer shell of the collar is made from 0.55 mm thick stainless steel with perforated edged segments 15 mm wide × 51 mm long. At every second segment a nominal 11 mm wide × 9 mm long lip is turned 90° to the outer shell, in order to secure the intumescent strip (dimensions measured).
Intumescent	The intumescent on both of the collars were nominal 50 mm high × 10 mm thick, with an average approximate density of 900±50 kg/m^3 (as specified by the collar manufacturer).
Fixing	Collar fixed to both sides of the wall with 10g × 40 mm course threaded stitching screws at two points.
Sealant	
Product name	PROMASEAL® AN Acrylic sealant.
Location	The annular gap between the separating element and pipe (on both sides) was sealed to a minimum depth (nominal) of 10 mm.
Hole Size in Wall	Nominally 54 mm diameter.
	SEPARATING ELEMENT
Product name	Rondo.
Size	64mm wide steel studs and 65mm wide steel tracks.
Fixing	Top and Bottom tracks were fixed at three locations using 6.5mm × 30mm long masonry anchors to the concrete block header and concrete block sill respectively. The side studs were fixed into the steel restraint frame with 40mm long self tapping hex head screws at three locations. The studs were fixed to the bottom track only, on both sides with 15mm long self tapping screws.
Cladding	2-off layers of 16mm thick fire-rated plasterboard, screw fixed to both faces of the frame with 50mm long plasterboard screws.

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3 TEST PROCEDURE

STATEMENT OF COMPLIANCE

The test was performed in accordance with the requirements of AS 1530.4-2005 Sections 2 & 10 .

VARIATIONS TO TEST METHOD

For the period of 160 to 170 minutes of the test duration the furnace pressure was above the limits prescribed by AS 1530.4-2005. The higher pressure may have caused more furnace gases to be forced to the unexposed face however no flaming or cotton pad ignition occurred during this period. The results of the test are considered to be valid and not significantly affected by the variation to the procedure.

PRE-TEST CONDITIONING

Sealant applied around pipes was allowed to cure for a minimum of 24 hours prior to testing.

SAMPLING / SPECIMEN SELECTION

The laboratory was not involved in the selection of the test specimen for test.

AMBIENT TEMPERATURE

The ambient temperature at the start of the test was 17°C and varied between 14°C and 17°C during the test.

TEST DURATION

The test was terminated after approximately 193 minutes after agreement between the test laboratory and applicant.

INSTRUMENTATION AND EQUIPMENT

The instrumentation was provided in accordance with AS 1530.4-2005 as detailed below:

The furnace temperature was measured by 4-off mineral insulated metal sheathed Type K thermocouples with wire diameters not greater than 1mm and overall diameter of 3mm with the measuring junction insulated from the sheath. The thermocouples protruded a minimum of 25mm from steel supporting tubes.

The non-fire side specimen temperatures were measured by Type K thermocouples with wire diameters less than 0.5mm diameter soldered to 12mm diameter × 0.2mm thick copper discs covered by a 30mm × 30mm × 2.0 mm inorganic insulating pads.

The thermocouples positions are described in Table A4.1, and are shown on Figure A4.1 in Appendix 4. A roving thermocouple was available to measure temperatures at positions that appear hotter than the positions monitored by fixed thermocouples.

The furnace pressure was measured at a position level with the centreline of the lowest penetration.

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4 TEST MEASUREMENTS

FURNACE TEMPERATURE AND PRESSURE MEASUREMENTS

Furnace temperature and pressure data are provided in A5.1 and A5.2 in Appendix 5.

SPECIMEN TEMPERATURES

Specimen temperature data is provided in A5.3 and Table A5.1 in Appendix 5.

OBSERVATIONS

A table that includes observations of the significant behaviour of the specimen and details of the occurrence of the various performance criteria specified in AS 1530.4-2005 is provided in Appendix 2. Photographs of the specimen are included in Appendix 6.

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5 TEST RESULTS

The specimen achieved the following performance when tested in accordance with AS 1530.4-2005, Section 2 & 10.

Service	Criteria	Result
A	Structural Adequacy	Not applicable
	Integrity	No failure at 193 minutes
	Insulation	183 minutes
	FRL	**-/180/180**
B	Structural Adequacy	Not applicable
	Integrity	No failure at 193 minutes
	Insulation	186 minutes[1]
	FRL	**-/180/180**
C	Structural Adequacy	Not applicable
	Integrity	No failure at 193 minutes
	Insulation	67 minutes
	FRL	**-/180/60**
D	Structural Adequacy	Not applicable
	Integrity	No failure at 193 minutes
	Insulation	147 minutes
	FRL	**-/180/120**
E	Structural Adequacy	Not applicable
	Integrity	No failure at 193 minutes
	Insulation	59 minutes
	FRL	**-/180/30**
F	Structural Adequacy	Not applicable
	Integrity	No failure at 193 minutes
	Insulation	70 minutes
	FRL	**-/180/60**
G	Structural Adequacy	Not applicable
	Integrity	No failure at 193 minutes
	Insulation	151 minutes
	FRL	**-/180/120**
H	Structural Adequacy	Not applicable
	Integrity	No failure at 193 minutes
	Insulation	47 minutes
	FRL	**-/180/30**
I	Structural Adequacy	Not applicable
	Integrity	No failure at 193 minutes
	Insulation	121 minutes
	FRL	**-/180/120**

Note 1: No insulation failure occurred on the service pipe or collar for the duration of the test.

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6 APPLICATION OF TEST RESULTS

TEST LIMITATIONS

The results of this fire test may be used to directly assess fire hazard, but it should be recognized that a single test method will not provide a full assessment of fire hazard under all fire conditions. The results only relate to the behaviour of the specimen of the element of the construction under the particular conditions of the test; they are not intended to be the sole criteria for assessing the potential fire performance of the element in use nor do they necessarily reflect the actual behaviour in fires.

VARIATIONS FROM THE TESTED SPECIMENS

This report details the methods of construction, the test conditions and the results obtained when the specific element of construction described herein was tested following the procedure outlined in AS 1530.4. Any significant variation with respect to size, constructional details, loads, stresses, edge or end conditions, other than those allowed under the field of direct application in the relevant test method, is not addressed by this report. It is recommended that any proposed variation to the tested configuration other than as permitted under the field of direct application specified in Appendix 3 should be referred to the test sponsor in the first instance to obtain appropriate documentary evidence of compliance from Bodycote Warringtonfire (Aus) Pty Ltd or another Registered Testing Authority.

UNCERTAINTY OF MEASUREMENT

Because of the nature of fire resistance testing and the consequent difficulty in quantifying the uncertainty of measurement of fire resistance, it is not possible to provide a stated degree of accuracy of the result.

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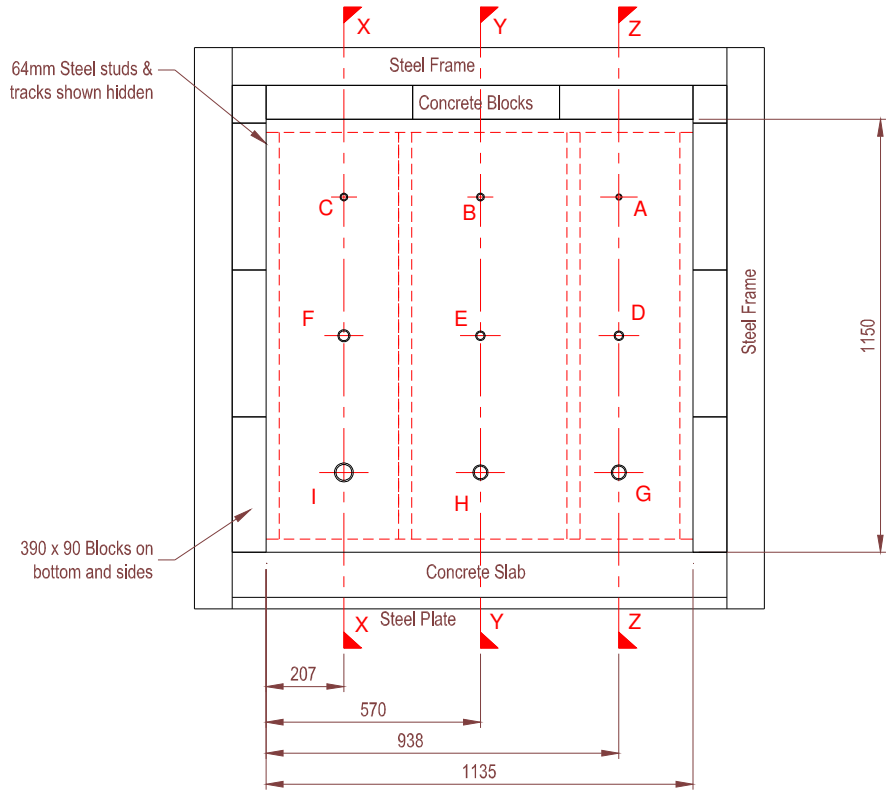
APPENDIX 1 DRAWINGS OF TEST ASSEMBLY

REFER SCHEDULE OF COMPONENTS (SECTION 2)

All pipes extend a minimum of 2000mm non fire side, 500mm on fire side (excluding cap on fire exposed side)

A. PE-X/AL/PE 16.2 x 2.6 (1 off PROMASTOP® Unicollar® CFC 32 retrofit collar either side)
B. PE-X-a 20 x 2.8 (1 off PROMASTOP® Unicollar® CFC 32 retrofit collar either side)
C. PE-X/AL/PE 20 x 2.9 (1 off PROMASTOP® Unicollar® CFC 32 retrofit collar either side)
D. PE-X-a 25 x 3.5 (1 off PROMASTOP® Unicollar® CFC 32 retrofit collar either side)
E. PE-X/AL/PE 25 x 3.7 (1 off PROMASTOP® Unicollar® CFC 32 retrofit collar either side)
F. PE-X/AL/PE 32 x 4.7 (1 off PROMASTOP® Unicollar® CFC 32 retrofit collar either side)
G. PE-X-a 40 x 5.5 (1 off PROMASTOP® Unicollar® retrofit collar either side)
H. PE-X/AL/PE 40 x 6.0 (1 off PROMASTOP® Unicollar® retrofit collar either side)
I. PE-X-a 50 x 6.9 (1 off PROMASTOP® Unicollar® retrofit collar either side)



UNEXPOSED FACE ELEVATION

Figure A1.1: Plan view of Test Specimen

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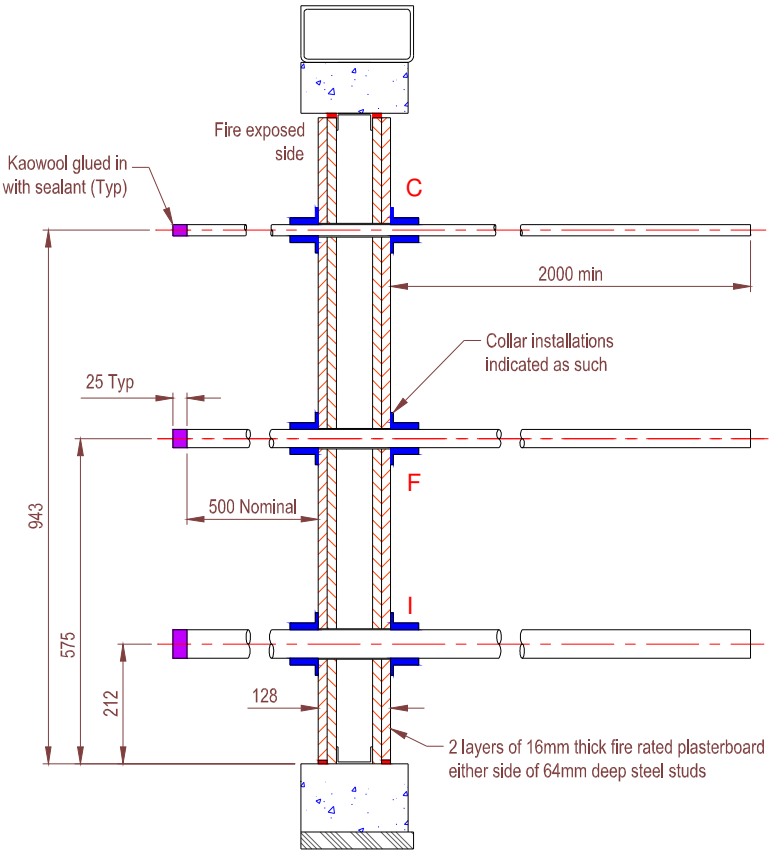

SECTIONAL ELEVATION X-X

Figure A1.2: Sectional Elevation X-X

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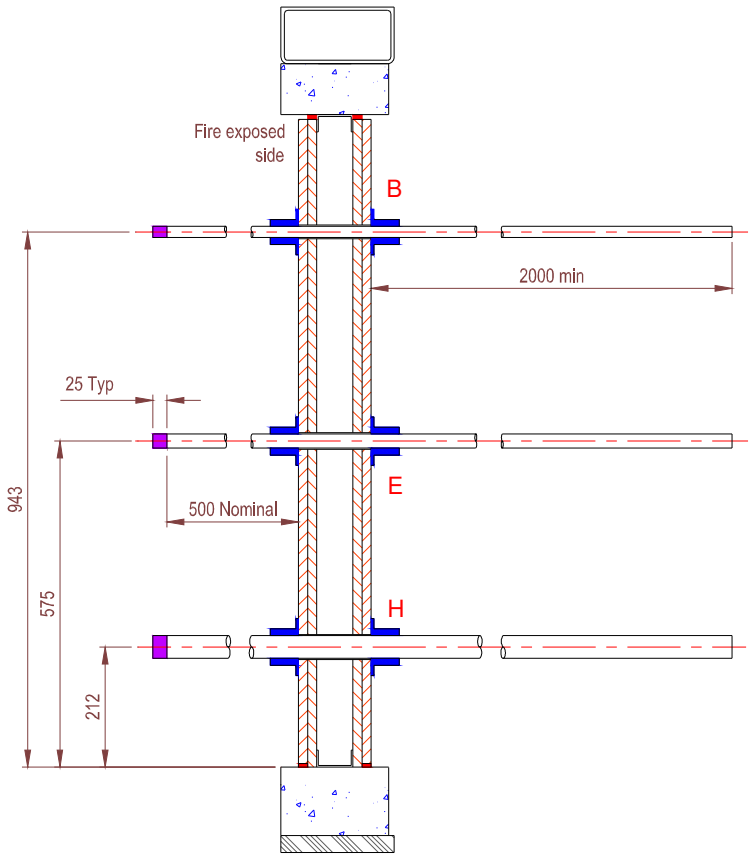

Figure A1.3: Sectional Elevation Y-Y

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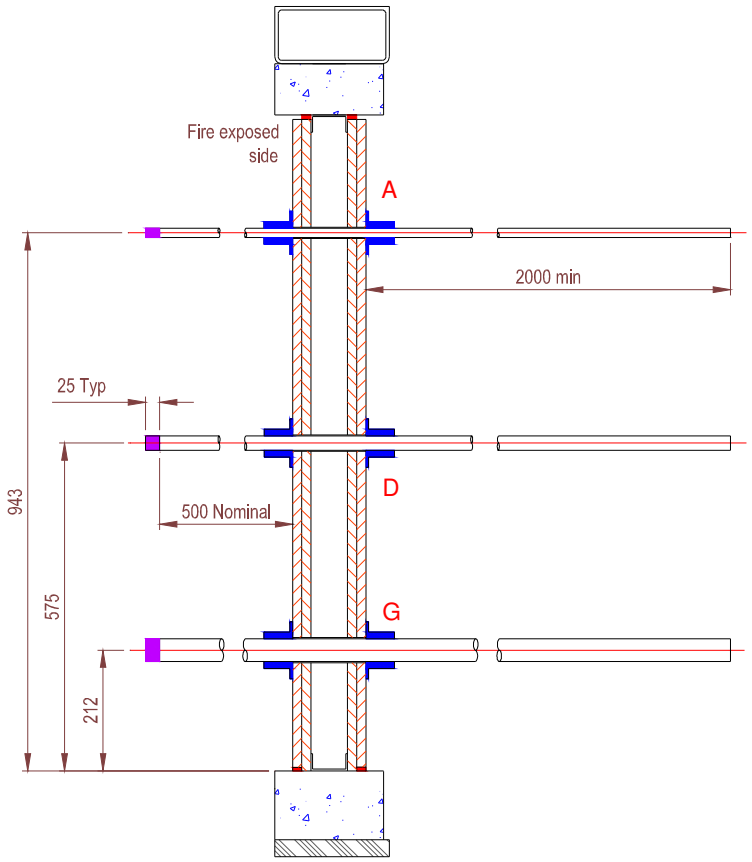

SECTIONAL ELEVATION Z-Z

Figure A1.4: Sectional Elevation Z-Z

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APPENDIX 2 TEST OBSERVATIONS

The following include observations of the significant behaviour of the specimen.

Time Min	Time Sec	Observation
		Service A
0	00	Fire Resistance Test was commenced and ambient service temperature was approximately 16℃.
4	27	Smoke emission was evident from the end of the pipe.
5	36	Smoke emission was evident from the end of the pipe.
6	23	Smoke emission from the end of the pipe had ceased.
8	10	Smoke emission was evident from the end of the pipe.
9	08	Smoke emission from the end of the pipe had ceased.
30	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
33	40	Smoke emission (slight) was evident from the end of the pipe.
43	51	Smoke emission was evident from the end of the pipe.
60	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
90	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
120	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
177	49	Smoke emission (wisps) was evident from the end of the pipe.
180	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
183	**00**	**Failure on insulation occurred in accordance with AS 1530.4-2005, where an individual temperature on the unexposed face (on the collar) exceeded the initial temperature by more than 180℃.**
193	32	Service had continued to maintain integrity in accordance with AS 1530.4-2005. Test was stopped upon agreement between the laboratory and test applicant.
		Service B
0	00	Fire Resistance Test was commenced and ambient service temperature was approximately 17℃.
4	14	Smoke emission was evident from the end of the pipe.
8	56	Heavy blow of smoke was evident from the end of the pipe.
9	08	Smoke emission from the end of the pipe had ceased.
9	30	Heavy smoke emission was evident from the end of the pipe.
11	07	Smoke emission from the end of the pipe had ceased.
11	38	Smoke emission (slight) was evident from the end of the pipe.
14	21	Smoke emission from the end of the pipe had ceased.
23	12	Smoke emission was evident from the end of the pipe.
30	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.

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Time Min	Time Sec	Observation
31	44	Pipe had bent in shape.
43	51	Smoke emission was evident from the end of the pipe.
56	16	Liquid emission was evident from the end of the pipe.
60	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
90	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
120	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
167	05	Smoke emission was evident from the end of the pipe.
180	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
186	**00**	**Failure on insulation occurred in accordance with AS 1530.4-2005, where an individual temperature on the unexposed face (on the wall) exceeded the initial temperature by more than 180°C.**
193	32	Service had continued to maintain integrity in accordance with AS 1530.4-2005. Test was stopped upon agreement between the laboratory and test applicant.
Service C		
0	00	Fire Resistance Test was commenced and ambient service temperature was approximately 17°C.
3	17	Smoke emission was evident from the end of the pipe.
5	32	Smoke emission was evident from the end of the pipe.
8	56	Heavy blow of smoke was evident from the end of the pipe.
9	08	Smoke emission from the end of the pipe had ceased.
9	30	Heavy smoke emission was evident from the end of the pipe.
11	07	Smoke emission from the end of the pipe had ceased.
30	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
45	50	Smoke emission was evident from the end of the pipe.
60	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
67	**00**	**Failure on insulation occurred in accordance with AS 1530.4-2005, where an individual temperature on the unexposed face (on the pipe) exceeded the initial temperature by more than 180°C.**
90	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
91	00	The intumescent material within the collar (on the unexposed side) had begun to expand. Plastic sheathing had begun to melt.
120	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
180	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
183	23	Wall had darkened in colour above service.
193	32	Service had continued to maintain integrity in accordance with AS 1530.4-2005. Test was stopped upon agreement between the laboratory and test applicant.

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Time Min	Time Sec	Observation
Service D		
0	00	Fire Resistance Test was commenced and ambient service temperature was approximately 18°C.
3	23	Smoke emission was evident from the end of the pipe.
3	38	Smoke emission had ceased.
5	39	Smoke emission was evident from the end of the pipe.
7	57	Smoke emission was evident from the end of the pipe.
8	56	Heavy blow of smoke was evident from the end of the pipe.
9	08	Smoke emission from the end of the pipe had ceased.
9	30	Heavy smoke emission was evident from the end of the pipe.
11	07	Smoke emission from the end of the pipe had ceased.
11	38	Smoke emission (slight) was evident from the end of the pipe.
13	43	Smoke emission from the end of the pipe had ceased.
30	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
31	01	Smoke emission was evident from the end of the pipe.
43	51	Smoke emission was evident from the end of the pipe.
60	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
120	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
147	**00**	**Failure on insulation occurred in accordance with AS 1530.4-2005, where an individual temperature on the unexposed face (on the pipe) exceeded the initial temperature by more than 180°C.**
180	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
189	59	Bending of pipe was observed.
193	32	Service had continued to maintain integrity in accordance with AS 1530.4-2005. Test was stopped upon agreement between the laboratory and test applicant.
Service E		
0	00	Fire Resistance Test was commenced and ambient service temperature was approximately 17°C.
3	20	Smoke emission was evident from the end of the pipe then stopped momentarily after.
9	30	Heavy smoke emission was evident from the end of the pipe.
11	07	Smoke emission from the end of the pipe had ceased.
11	38	Smoke emission (slight) was evident from the end of the pipe.
14	21	Smoke emission from the end of the pipe had ceased.
27	56	Smoke emission was evident from the end of the pipe.
30	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.

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Time Min	Time Sec	Observation
31	01	Smoke emission was evident from the end of the pipe.
43	51	Smoke emission was evident from the end of the pipe.
58	26	The intumescent material within the collar (on the unexposed side) had begun to expand. Plastic sheathing had begun to melt.
59	**00**	**Failure on insulation occurred in accordance with AS 1530.4-2005, where an individual temperature on the unexposed face (on the collar) exceeded the initial temperature by more than 180°C.**
60	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
64	37	Plastic sheathing near wall had begun to soften.
90	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
120	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
180	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
183	23	Wall had darkened in colour above service.
193	32	Service had continued to maintain integrity in accordance with AS 1530.4-2005. Test was stopped upon agreement between the laboratory and test applicant.
Service F		
0	00	Fire Resistance Test was commenced and ambient service temperature was approximately 16°C.
4	22	Smoke emission was evident from the end of the pipe.
6	38	Smoke emission from the end of the pipe had ceased.
7	35	Heavy smoke emission was evident from the end of the pipe.
8	56	Heavy blow of smoke was evident from the end of the pipe.
9	08	Smoke emission from the end of the pipe had ceased.
9	30	Heavy smoke emission was evident from the end of the pipe.
11	07	Smoke emission from the end of the pipe had ceased.
13	19	Heavy smoke emission was evident from the end of the pipe.
14	32	There was a significant reduction in the amount of smoke emission from the end of the pipe.
15	12	Smoke emission from the end of the pipe had ceased.
18	06	Heavy smoke emission was evident from the end of the pipe.
19	45	There was an increase in the amount of smoke emission from the end of the pipe.
22	06	There was a slight reduction in the amount of smoke emission from the end of the pipe.
30	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
31	01	Smoke emission was evident from the end of the pipe.

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Time Min	Time Sec	Observation
43	51	Smoke emission was evident from the end of the pipe.
60	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
65	33	Plastic sheathing near wall had begun to soften.
70	**00**	**Failure on insulation occurred in accordance with AS 1530.4-2005, where an individual temperature on the unexposed face (on the collar and pipe) exceeded the initial temperature by more than 180°C.**
90	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
91	00	The intumescent material within the collar (on the unexposed side) had begun to expand. Plastic sheathing had begun to melt.
120	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
180	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
182	26	Wall had darkened in colour above service.
193	32	Service had continued to maintain integrity in accordance with AS 1530.4-2005. Test was stopped upon agreement between the laboratory and test applicant.
Service G		
0	00	Fire Resistance Test was commenced and ambient service temperature was approximately 18°C.
2	36	Smoke emission was evident from the end of the pipe.
3	07	Smoke emission from the end ceased then restarted momentarily after.
8	56	Heavy blow of smoke was evident from the end of the pipe.
9	08	Smoke emission from the end of the pipe had ceased.
9	30	Heavy smoke emission was evident from the end of the pipe.
10	18	Smoke emission from the end of the pipe had ceased.
24	35	Smoke emission (slight) was evident from the end of the pipe.
30	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
31	01	Smoke emission was evident from the end of the pipe.
43	51	Smoke emission was evident from the end of the pipe.
60	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
90	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
120	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
151	**00**	**Failure on insulation occurred in accordance with AS 1530.4-2005, where an individual temperature on the unexposed face (on the pipe) exceeded the initial temperature by more than 180°C.**
180	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
193	32	Service had continued to maintain integrity in accordance with AS 1530.4-2005. Test was stopped upon agreement between the laboratory and test applicant.

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Time Min	Time Sec	Observation
		Service H
0	00	Fire Resistance Test was commenced and ambient service temperature was approximately 17°C.
5	20	Smoke emission was evident from the end of the pipe.
7	06	Smoke emission from the end of the pipe had ceased.
8	56	Heavy blow of smoke was evident from the end of the pipe.
9	08	Smoke emission from the end of the pipe had ceased.
9	30	Heavy smoke emission was evident from the end of the pipe.
11	07	Smoke emission from the end of the pipe had ceased.
11	38	Smoke emission (slight) was evident from the end of the pipe.
12	34	Smoke emission from the end of the pipe had ceased.
14	52	Heavy smoke emission was evident from the end of the pipe.
19	45	There was an increase in the amount of smoke emission from the end of the pipe.
22	06	There was a slight reduction in the amount of smoke emission from the end of the pipe.
30	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
31	01	Smoke emission was evident from the end of the pipe.
43	51	Smoke emission was evident from the end of the pipe.
46	53	The intumescent material within the collar (on the unexposed side) had begun to expand. Plastic sheathing had begun to melt.
47	**00**	**Failure on insulation occurred in accordance with AS 1530.4-2005, where an individual temperature on the unexposed face (on the pipe and collar) exceeded the initial temperature by more than 180°C.**
60	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
61	11	Smoke emission was evident from the pipe/collar interface.
90	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
115	28	Wall had darkened in colour above service.
120	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
177	13	Smoke emission was evident from the end of the pipe.
180	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
183	23	There was an increase in the amount of darkening of the wall above service.
186	36	Slight amount of smoke emission was evident from the intumescent of the collar on the unexposed side.
193	32	Service had continued to maintain integrity in accordance with AS 1530.4-2005. Test was stopped upon agreement between the laboratory and test applicant.

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Time Min	Time Sec	Observation
Service I		
0	00	Fire Resistance Test was commenced and ambient service temperature was approximately 14°C.
1	38	Smoke emission was evident from the pipe/collar interface.
2	18	Smoke emission from the pipe/collar interface had ceased.
5	20	Smoke emission was evident from the end of the pipe.
8	22	Intumescent material was emitted from the end of the pipe for a period of approximately 60 seconds.
8	56	Heavy blow of smoke was evident from the end of the pipe.
9	08	Smoke emission from the end of the pipe had ceased.
9	30	Heavy smoke emission was evident from the end of the pipe.
11	07	Smoke emission from the end of the pipe had ceased.
16	01	Heavy smoke emission was evident from the end of the pipe.
19	45	There was an increase in the amount of smoke emission from the end of the pipe.
20	35	Smoke emission (slight) was evident from the pipe/collar interface.
22	06	There was a slight reduction in the amount of smoke emission from the end of the pipe.
26	30	Smoke emission from the pipe/collar interface had ceased.
30	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
31	01	Smoke emission was evident from the end of the pipe.
36	04	Pipe had drooped and bent out of shape.
39	06	Liquid emission was evident from the end of the pipe.
43	51	Smoke emission was evident from the end of the pipe.
60	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
120	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
121	**00**	**Failure on insulation occurred in accordance with AS 1530.4-2005, where an individual temperature on the unexposed face (on the pipe) exceeded the initial temperature by more than 180°C.**
124	38	There was an increase in the amount of deformation of the pipe.
126	37	Intumescent material had fallen from the collar to the floor.
136	24	Smoke emission was evident from the intumescent material that had expanded in the collar at the base of the service.
137	15	A 30 second cotton pad test was carried out at the pipe/collar interface. No glowing or flaming of the cotton pad had become evident (discolouration only).
138	50	A 30 second cotton pad test was carried out at the pipe/collar interface. No glowing or flaming of the cotton pad had become evident (discolouration only).

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Time Min	Time Sec	Observation
140	15	Furnace can be seen through small hole in side of pipe near collar interface.
140 - 156	36 - 23	A 30 second cotton pad test (5 times) was carried out at the pipe/collar interface. No glowing or flaming of the cotton pad had become evident (discolouration only).
157	50	There was a pulse flaming at the hole mentioned at 140min15sec but was not continuous flaming.
158 – 163	41 – 23	A 30 second cotton pad test (3 times) was carried out at the pipe/collar interface. No glowing or flaming of the cotton pad had become evident (discolouration only).
165	02	Significant amount of smoke emission was evident from hole in side of pipe.
172	10	Smoke emission from the hole in the pipe had ceased and it appeared the collar had “closed” the pipe.
180	00	Service had continued to maintain integrity in accordance with AS 1530.4-2005.
193	32	Service had continued to maintain integrity in accordance with AS 1530.4-2005. Test was stopped upon agreement between the laboratory and test applicant.
General Observations		
0	00	Fire Resistance Test was commenced and ambient temperature was approximately 17°C.
182	26	Screw fixings in wall had begun to darken.
193	32	Service had continued to maintain integrity in accordance with AS 1530.4-2005. Test was stopped upon agreement between the laboratory and test applicant.

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APPENDIX 3 DIRECT FIELD OF APPLICATION

A 3.1 GENERAL

The results of the fire test contained in the test report are directly applicable, without reference to the testing authority, to similar constructions where one or more of the following changes have been made, provided no individual component is removed or reduced:

A 3.2 PLASTIC PIPES

A 3.3.1 In addition to the requirements of Clause A 3.2, test results may be directly applied to masonry and concrete elements thicker than the tested prototype when installed in accordance with Figure 10.11.5 – AS 1530.4-2005.
Results obtained from a particular test shall not be applied to plastic pipes of different diameters, wall thicknesses or material types, except for the following applications:

(a) The fire protection system shall be subjected to the fire-resistance test when protecting 40 mm, 50 mm, 65 mm, 80 mm and 100 mm nominal size PVC-U DWV for separating elements and all sizes shall achieve the required FRL.

(b) For other types of plastic pipes and pipe wall thicknesses, if the maximum and minimum sizes have also been tested and achieved, the required FRL in the subject separating element, a registered testing authority may provide an opinion of the performance of intermediate sizes provided the outside diameter of the largest pipe does not exceed 120 mm and the outside diameter of the smallest pipe is not less than 40 mm.

Results obtained from tests on penetrations through vertical separating elements shall not be used to assess performance in horizontal elements, and vice versa.
As penetration seals for plastic pipes are dependent for activation upon exposure to fire conditions, they shall always be installed with the same orientation and fire exposure as was established in the fire-resistance test.

A 3.3.2 *Services not perpendicular to the fire separation*
Penetrations not perpendicular to the plane of the element are acceptable provided that the fire-stopping system has similar exposure and dimensions to the tested prototype.

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APPENDIX 4 INSTRUMENTATION POSITIONS

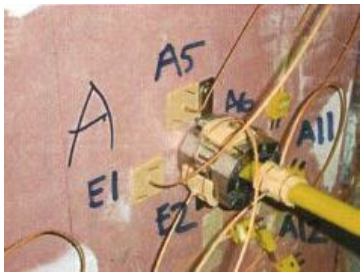
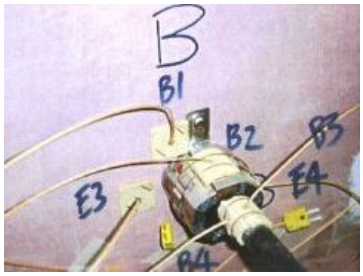
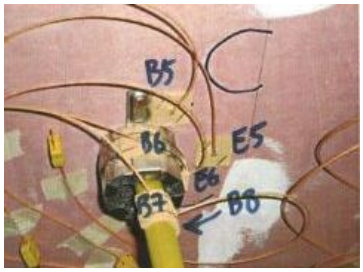
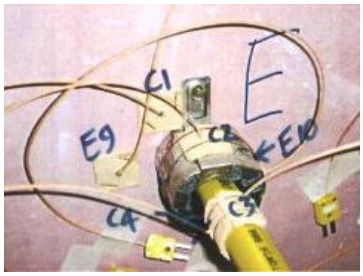
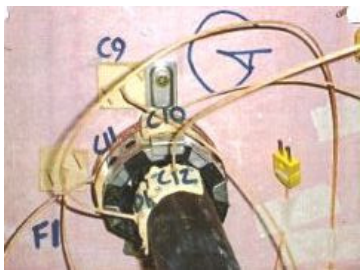
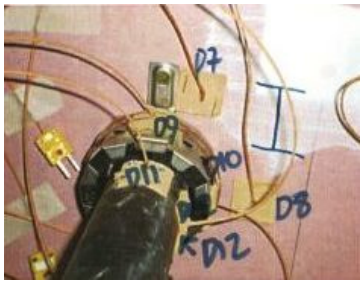
		
Service A	**Service B**	**Service C**
		
Service D	**Service E**	**Service F**
		
Service G	**Service H**	**Service I**

Figure A4.1: Thermocouple Locations on Un-exposed Face

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Table A4.1 Thermocouple Locations

Service	T/C	Description
A	A5	25 mm from collar on the wall
	E1	25 mm from collar on the wall
	A6	25 mm from wall on the collar
	E2	25 mm from wall on the collar
	A11	25 mm from collar on the pipe
	A12	25 mm from collar on the pipe
B	B1	25 mm from collar on the wall
	E3	25 mm from collar on the wall
	B2	25 mm from wall on the collar
	E4	25 mm from wall on the collar
	B3	25 mm from collar on the pipe
	B4	25 mm from collar on the pipe
C	B5	25 mm from collar on the wall
	E5	25 mm from collar on the wall
	B6	25 mm from wall on the collar
	E6	25 mm from wall on the collar
	B7	25 mm from collar on the pipe
	B8	25 mm from collar on the pipe
D	B9	25 mm from collar on the wall
	E7	25 mm from collar on the wall
	B10	25 mm from wall on the collar
	E8	25 mm from wall on the collar
	B11	25 mm from collar on the pipe
	B12	25 mm from collar on the pipe
E	C1	25 mm from collar on the wall
	E9	25 mm from collar on the wall
	C2	25 mm from wall on the collar
	E10	25 mm from wall on the collar
	C3	25 mm from collar on the pipe
	C4	25 mm from collar on the pipe
F	C5	25 mm from collar on the wall
	E11	25 mm from collar on the wall
	C6	25 mm from wall on the collar
	E12	25 mm from wall on the collar
	C7	25 mm from collar on the pipe
	C8	25 mm from collar on the pipe
G	C9	25 mm from collar on the wall
	F1	25 mm from collar on the wall
	C10	25 mm from wall on the collar
	C11	25 mm from wall on the collar
	C12	25 mm from collar on the pipe
	D1	25 mm from collar on the pipe
H	D2	25 mm from collar on the wall
	F1	25 mm from collar on the wall
	D3	25 mm from wall on the collar
	D4	25 mm from wall on the collar
	D5	25 mm from collar on the pipe
	D6	25 mm from collar on the pipe
I	D7	25 mm from collar on the wall
	D8	25 mm from collar on the wall
	D9	25 mm from wall on the collar
	D10	25 mm from wall on the collar
	D11	25 mm from collar on the pipe
	D12	25 mm from collar on the pipe

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APPENDIX 5 TEST DATA

A 5.1 FURNACE TEMPERATURE

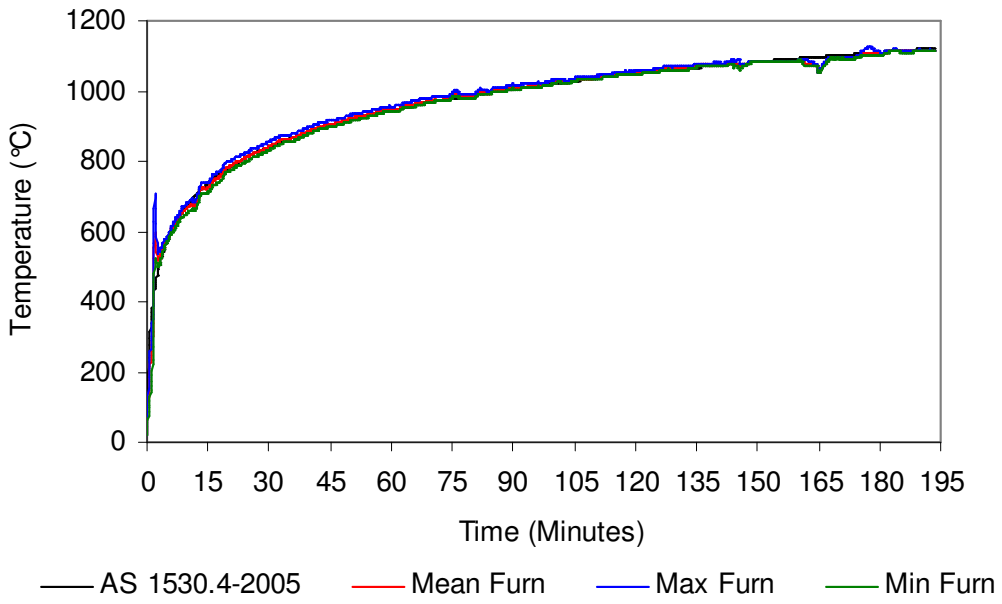

Figure A5.1: Furnace Temperatures vs. Time

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A 5.2 FURNACE PRESSURE

Time (minutes)	Pressure (Pa)	Time (minutes)	Pressure (Pa)
	Avg		Avg
5-10	**12**	100-105	**14**
10-15	**12**	105-110	**13**
15-20	**13**	110-115	**13**
20-25	**15**	115-120	**14**
25-30	**13**	120-125	**13**
30-35	**14**	125-130	**15**
35-40	**17**	130-135	**17**
40-45	**14**	135-140	**18**
45-50	**14**	140-145	**17**
50-55	**13**	145-150	**18**
55-60	**14**	150-155	**16**
60-65	**16**	155-160	**16**
65-70	**15**	160-165	**24**
70-75	**14**	165-170	**38**
75-80	**11**	170-175	**16**
80-85	**13**	175-180	**15**
85-90	**13**	180-185	**15**
90-95	**12**	185-190	**13**
95-100	**14**	190-195	**17**

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A 5.3 SPECIMEN TEMPERATURES

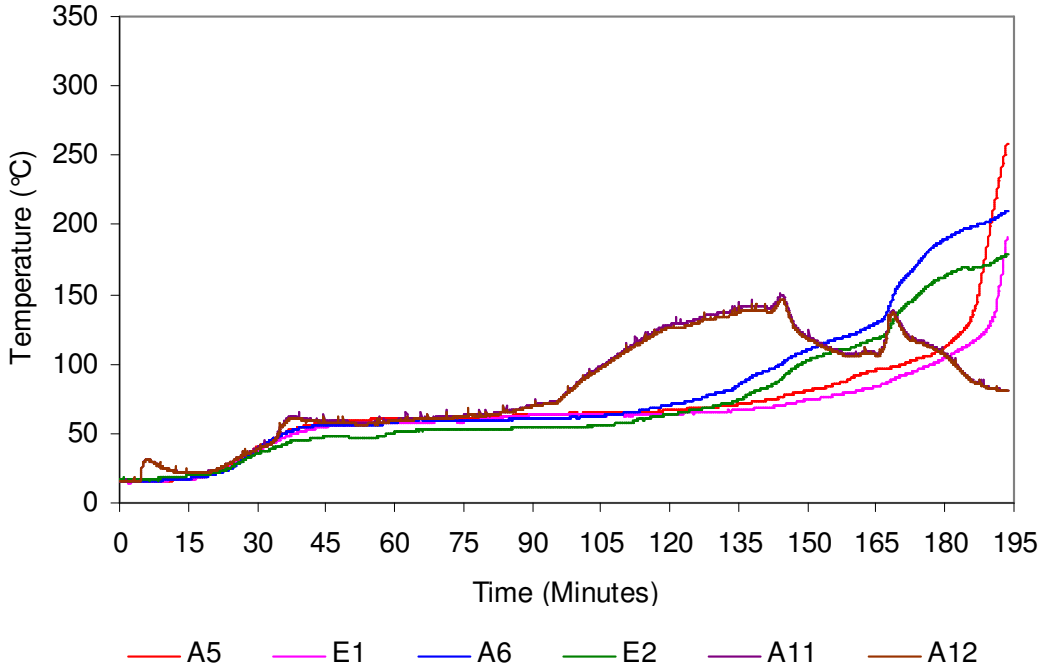

Figure A5.2: Service A Temperatures vs. Time

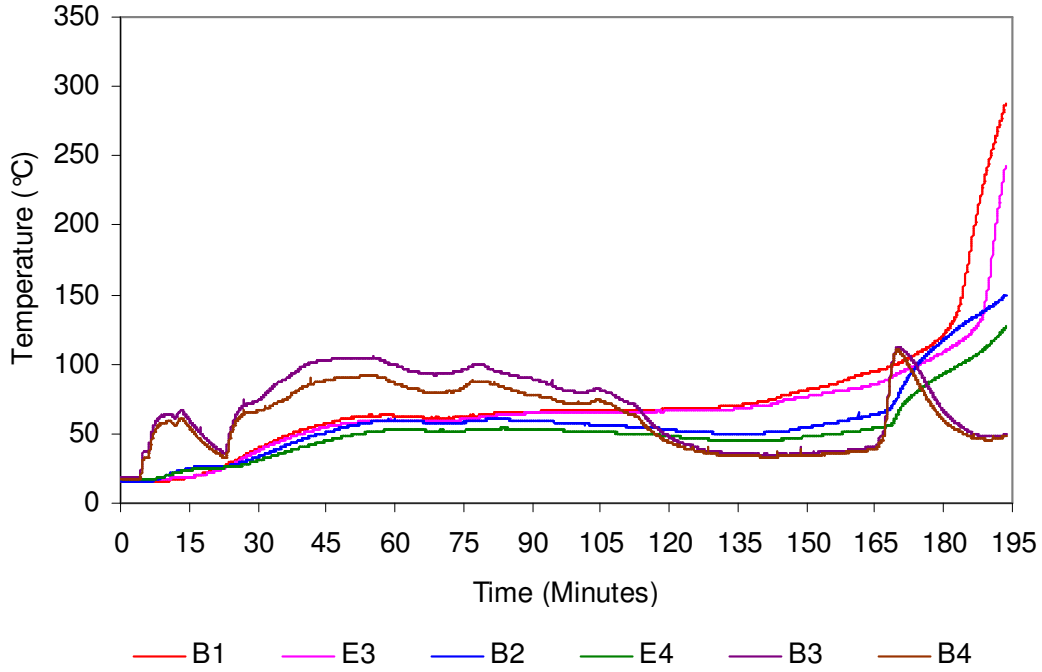

Figure A5.3: Service B Temperatures vs. Time

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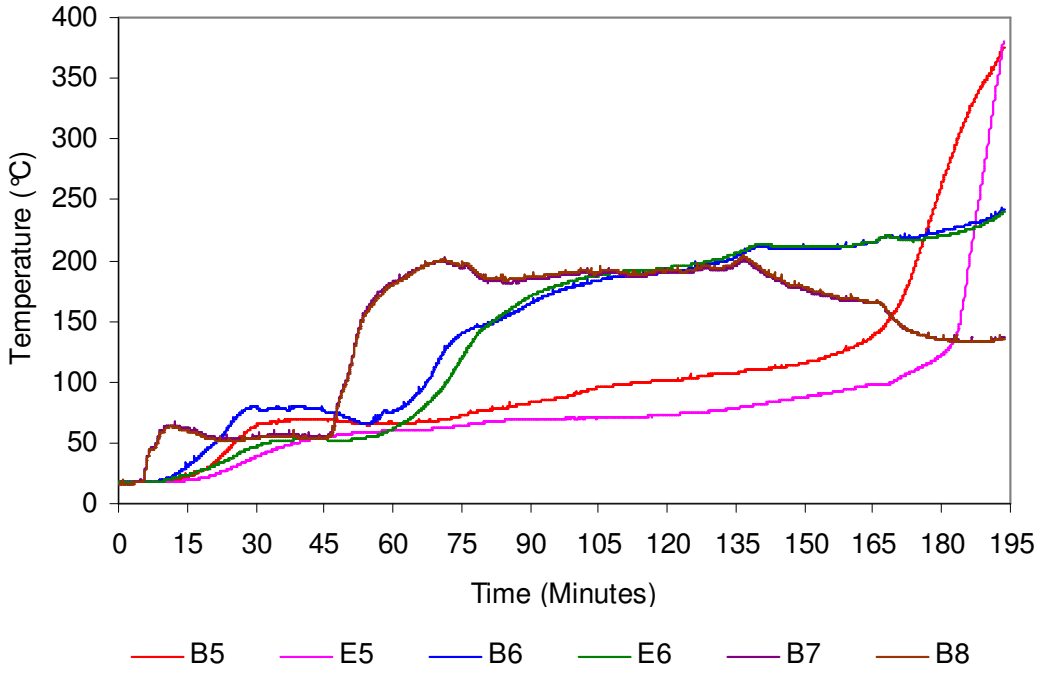

Figure A5.4: Service C Temperatures vs. Time

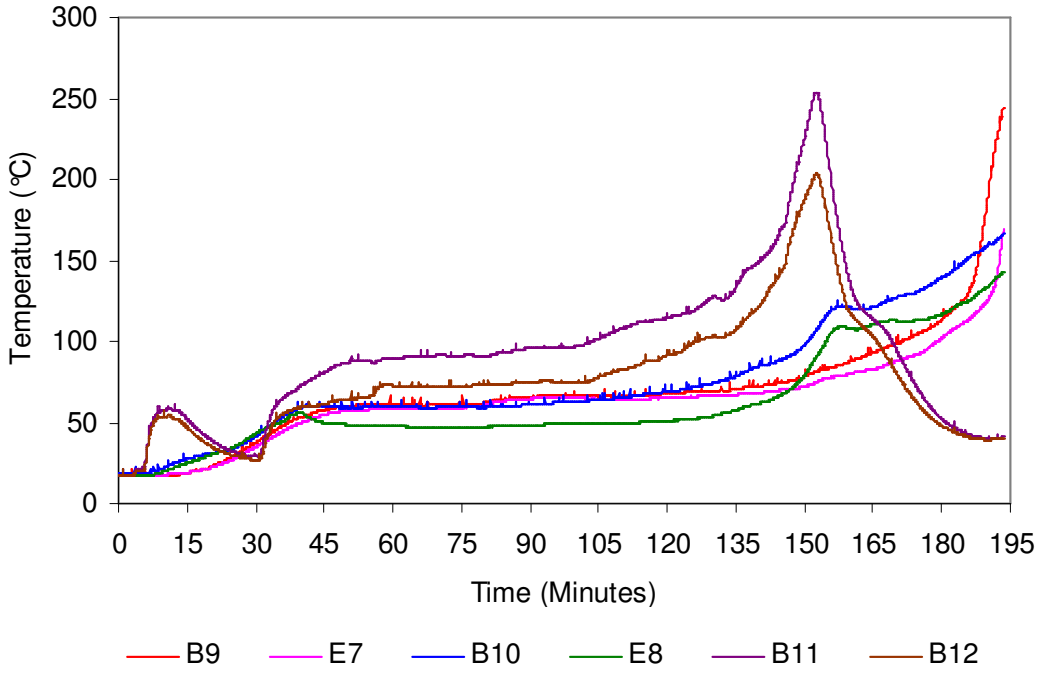

Figure A5.5: Service D Temperatures vs. Time

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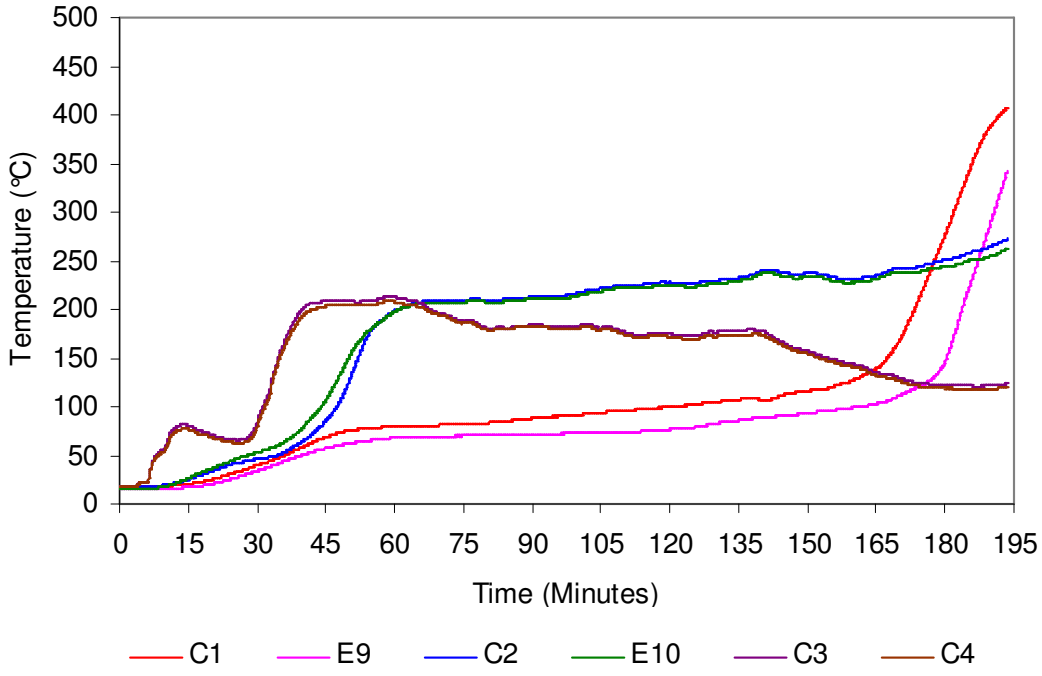

Figure A5.6: Service E Temperatures vs. Time

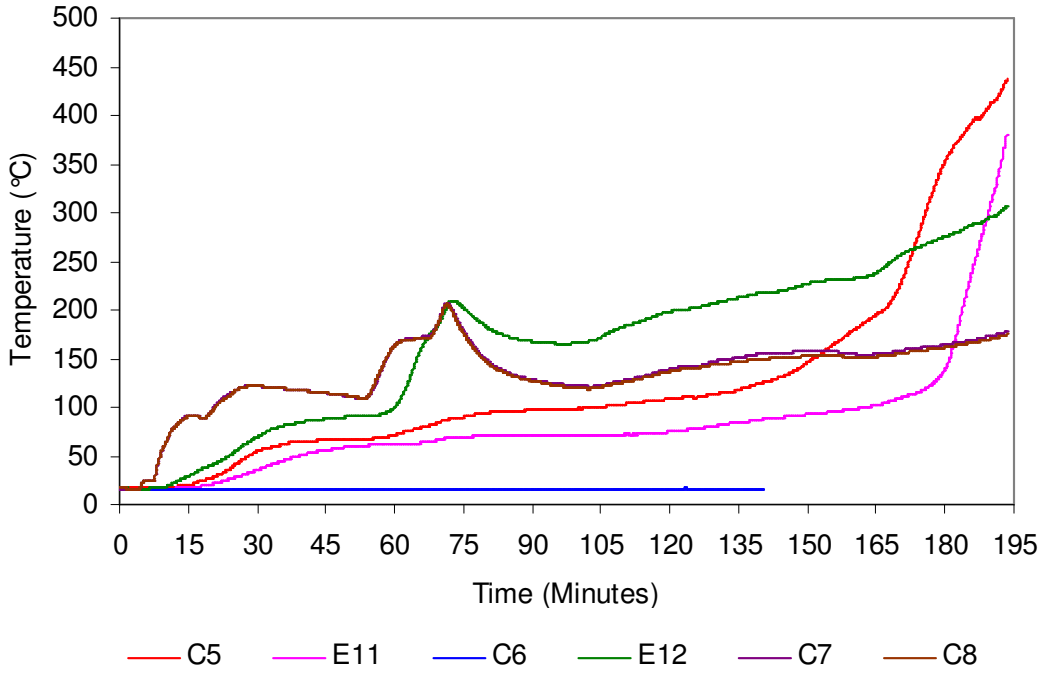

Figure A5.7: Service F Temperatures vs. Time
Note: Thermocouple C6 had become faulty.

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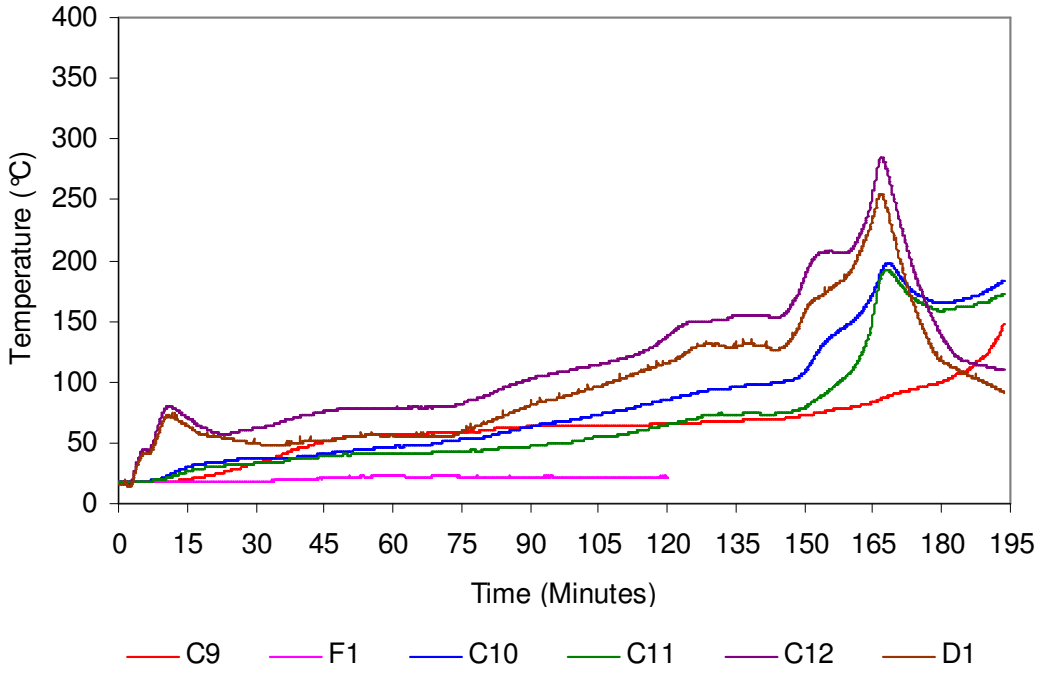

Figure A5.8: Service G Temperatures vs. Time
Note: Thermocouple F1 had become faulty.

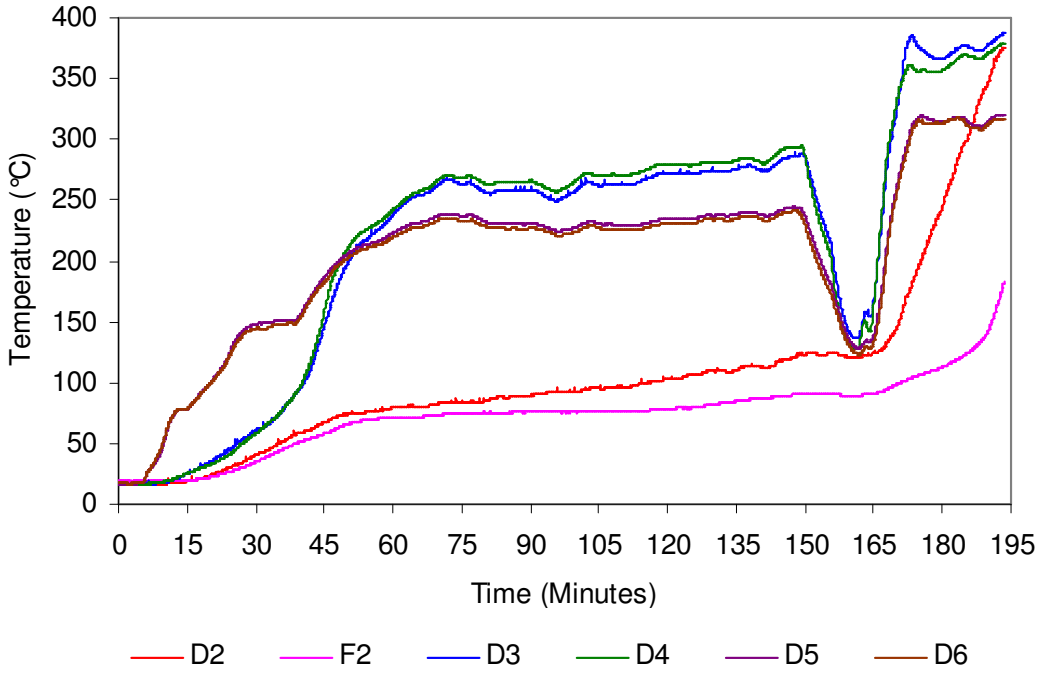

Figure A5.9: Service H Temperatures vs. Time

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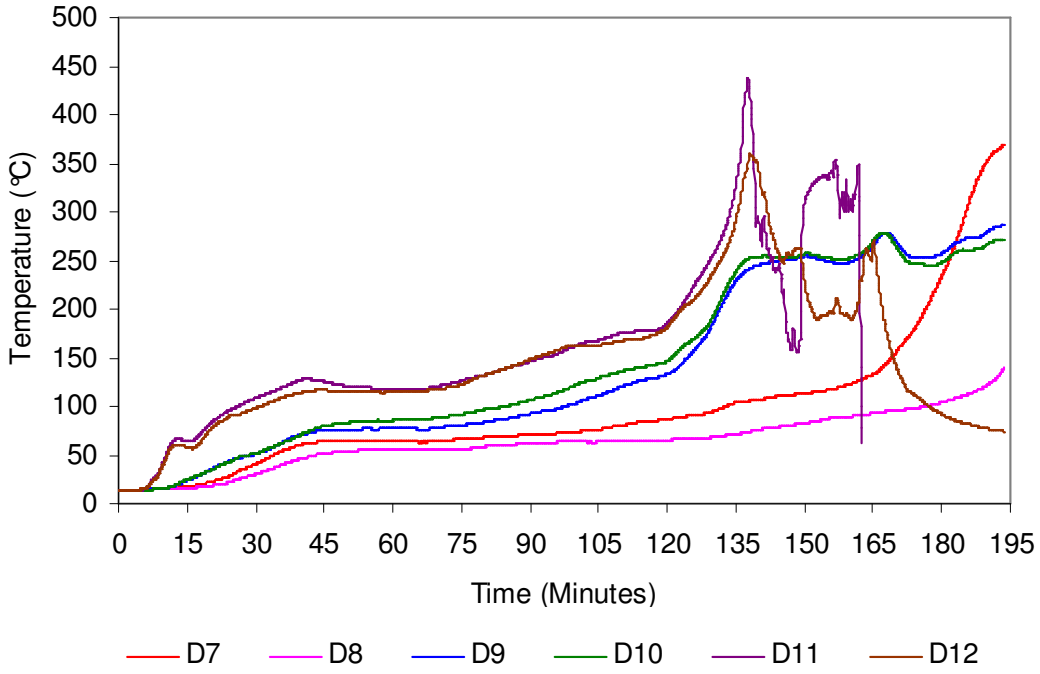

Figure A5.10: Service I Temperatures vs. Time
Note: Thermocouple D11 had become faulty.

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TABLE A5.1: TEST SPECIMEN TEMPERATURES

Service	T/C No.	Description[2]	Temp (°C) at t (minutes)					Limit[1] (Mins)
			t=0	t=60	t=120	t=180	t=193	
A	A5	25 mm from collar on the wall	16	60	67	112	251	189
	E1	25 mm from collar on the wall	15	58	64	105	181	-
	A6	25 mm from wall on the collar	15	58	71	190	210	183
	E2	25 mm from wall on the collar	17	51	64	163	178	-
	A11	25 mm from collar on the pipe	16	60	128	107	81	-
	A12	25 mm from collar on the pipe	15	59	126	106	81	-
B	B1	25 mm from collar on the wall	16	63	68	122	282	186
	E3	25 mm from collar on the wall	17	60	66	109	233	191
	B2	25 mm from wall on the collar	15	60	53	118	149	-
	E4	25 mm from wall on the collar	17	53	48	93	125	-
	B3	25 mm from collar on the pipe	18	99	48	66	49	-
	B4	25 mm from collar on the pipe	18	86	44	59	48	-
C	B5	25 mm from collar on the wall	18	66	101	263	373	174
	E5	25 mm from collar on the wall	17	60	73	123	368	185
	B6	25 mm from wall on the collar	17	76	191	224	243	128
	E6	25 mm from wall on the collar	17	62	194	220	239	126
	B7	25 mm from collar on the pipe	17	182	190	135	136	67
	B8	25 mm from collar on the pipe	16	181	191	135	136	67
D	B9	25 mm from collar on the wall	17	62	68	114	238	190
	E7	25 mm from collar on the wall	18	59	65	102	159	-
	B10	25 mm from wall on the collar	18	60	69	140	165	193
	E8	25 mm from wall on the collar	17	48	51	117	142	-
	B11	25 mm from collar on the pipe	17	90	115	52	41	147
	B12	25 mm from collar on the pipe	17	73	91	48	40	151
E	C1	25 mm from collar on the wall	18	80	100	277	405	173
	E9	25 mm from collar on the wall	17	68	77	146	335	183
	C2	25 mm from wall on the collar	18	199	228	122	272	59
	E10	25 mm from wall on the collar	16	198	224	244	261	59
	C3	25 mm from collar on the pipe	17	213	175	119	123	-
	C4	25 mm from collar on the pipe	17	208	172	26	120	-
F	C5	25 mm from collar on the wall	17	72	108	353	433	165
	E11	25 mm from collar on the wall	17	62	75	139	369	183
	C6	25 mm from wall on the collar	15	#	#	#	#	#
	E12	25 mm from wall on the collar	17	100	198	276	305	70
	C7	25 mm from collar on the pipe	16	164	139	164	177	70
	C8	25 mm from collar on the pipe	17	164	137	161	174	70
G	C9	25 mm from collar on the wall	17	57	65	100	143	-
	F1	25 mm from collar on the wall	17	#	#	#	#	#
	C10	25 mm from wall on the collar	17	47	86	165	182	167
	C11	25 mm from wall on the collar	18	42	65	159	171	-
	C12	25 mm from collar on the pipe	17	79	138	137	110	151
	D1	25 mm from collar on the pipe	16	56	116	117	93	160

Notes

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

[2] Refer to Appendix 4 for locations of thermocouples as only a generic description is included in the table.

* Integrity failure of specimen

\# Thermocouple failure

'-' Under limit column indicates the temperature limit was not exceeded during the test period or up until the time of integrity failure if a failure occurred.

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TABLE A5.1: TEST SPECIMEN TEMPERATURES

Service	T/C No.	Description[2]	Temp (°C) at t (minutes)					Limit[1] (Mins)
			t=0	t=60	t=120	t=180	t=193	
H	D2	25 mm from collar on the wall	16	79	103	245	374	174
	F1	25 mm from collar on the wall	17	23	22	24	29	-
	D3	25 mm from wall on the collar	16	238	272	366	386	49
	D4	25 mm from wall on the collar	16	242	279	357	378	47
	D5	25 mm from collar on the pipe	17	223	235	314	321	47
	D6	25 mm from collar on the pipe	17	220	231	314	317	48
I	D7	25 mm from collar on the wall	14	65	87	234	367	175
	D8	25 mm from collar on the wall	14	55	65	104	135	-
	D9	25 mm from wall on the collar	13	77	133	257	286	130
	D10	25 mm from wall on the collar	13	86	147	248	271	129
	D11	25 mm from collar on the pipe	14	118	187	#	#	121
	D12	25 mm from collar on the pipe	14	115	182	92	75	121

Notes
[1] Limit time is the time to the nearest whole minute, rounded down to the nearest minute, at which the temperature recorded by the thermocouple does not rise by more than 180 K above the initial temperature.
[2] Refer to Appendix 4 for locations of thermocouples as only a generic description is included in the table.
* Integrity failure of specimen
# Thermocouple failure
'-' Under limit column indicates the temperature limit was not exceeded during the test period or up until the time of integrity failure if a failure occurred.

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APPENDIX 6 PHOTOGRAPHS

Figure A6.1: Exposed face of specimen prior to commencement of the test.

Figure A6.2: Unexposed face of specimen prior to commencement of the test.

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Figure A6.3: Unexposed face of specimen after approximately 120 minutes test duration.

Figure A6.4: Unexposed face of specimen after the completion of the test.

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Figure A6.5: Exposed face of specimen after the completion of the test.

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