FP3271

FIRE RESISTANCE TEST ON A PIPE AND CABLE PENETRATION THROUGH A DRY WALL

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FIRE RESISTANCE TEST ON A PIPE AND CABLE PENETRATION THROUGH A DRY WALL

1. GENERAL

1.1 Test Client

Holdfast NZ Ltd
14 Avalon Drive
State Highway 1
Hamilton 2032
New Zealand

1.2 Test Specification

The test was conducted in accordance with AS 1530.4-1997 "Fire Resistance Tests of Elements of Building Construction", and AS 4072.1-1992, "Service penetrations and control joints". In accordance with the standards the fire resistance of the specimen is the time, expressed in minutes, before failure under one or more of the following criteria:

1.2.1 Integrity

Failure shall be deemed to occur when;

(a) cracks or fissures or other openings develop through which flames or hot gases can pass to the unexposed side of the element, which is further defined as any gap which permits a line of sight from the unexposed face of the specimen through to the interior; or

(b) Flaming takes place at the unexposed surface of the specimen for a period exceeding 10 seconds duration.

1.2.2 Insulation

Failure shall be deemed to occur when any of the relevant thermocouples attached to the unexposed face of the test specimen rises by more than 180 K above the initial temperature.

2. DESCRIPTION OF TEST SPECIMEN

2.1 General

The test specimen consisted of a non-loadbearing nominal 2,200 mm high x 1,000 mm wide, timber framed wall, lined on each face with one layer of 13 mm thick Gib® Fyreline gypsum plaster board. The wall contained a single steel pipe penetration and a cable penetration consisting of four bundles of cables on a cable tray. A drawing of the layout is included in this report as Figure 6.

The pipe passed through the wall and extended 100 mm from the wall on the exposed face and protruded 760 mm from the wall on the unexposed face. The pipe was supported at 670 mm from the unexposed face of the wall. The exposed end of the pipe was closed with a welded steel plate and the unexposed end was left open.

The cables were supported on a 300 mm wide galvanised slotted steel cable tray. There were four groups of cables with the composite complying with Figure D1 of Appendix D of AS 4072.1-1992. The cable tray and cables passed through the wall and extended at least 100 mm from the wall on the exposed face. The cable tray protruded approximately 2 m from the wall on the unexposed face and was supported at 670 mm and 1,570 mm from the unexposed face of the wall. All cables extended at least 600 mm from the unexposed face.

2.2 Plans and Specifications

The client did not supply any drawings but did provide construction specifications. These and other details of the tested specimen are held on confidential file by BRANZ.

2.3 Wall

The wall construction was in accordance with the Winstone Wallboards Gib® Fire Rated Systems, August 2001, specification GBT 60a for a one hour fire rated wall system. The three timber studs and top and bottom plates were nominal 90 mm x 35 mm Pinus Radiata. The middle stud was offset from the vertical centre line as indicated in Figure 6. Each face of the wall was lined with one layer of 13 mm thick Gib® Fyreline gypsum plasterboard.

2.4 Sleeves

Steel sleeves were placed around both penetrations and were sized to provide a tight fit around the edges of the apertures cut into the wall. They were used to prevent the viscous sealing system from migrating into the wall cavity during installation of the seal.

2.4.1 Pipe Sleeve

A hole of 186 mm diameter was cut through the test wall at the location shown in Figure 8. A 1 mm thick sheet steel was coiled and then placed so that it expanded to form a tight fit within this aperture and form a sleeve of length 103 mm. This length corresponded to the wall width less one thickness of the wall lining. The ends of the sleeve terminated approximately half the lining thickness from the wall outside on both faces.

2.4.2 Cable tray sleeve

Two ‘C’ shaped steels channels of length 103 mm were folded from 2 mm thick sheet steel to give overall cross section dimensions 82 mm high by 320 mm wide. A rectangular hole of length 328 mm and height 105 mm was cut through the test wall to closely fit the sleeves around the penetrations shown in Figure 6 and 8. This length corresponded to the wall thickness less one thickness of the wall lining. One steel channel was placed at the bottom of the hole in the wall and one at the top as shown in Figure 8. This resulted in a tight fit around the edges of the aperture. The cable tray and cables were located within the opening to give at least 15 mm clearance between the top of the cables and top of the aperture and also between the bottom of the cable tray and bottom of the aperture as shown in Figure 8.

2.5 Sealing Systems

The gap between the pipe penetration and the steel sleeve and also between the cable penetrations and the steel sleeve were filled with sealant as follows:

1. The surfaces to receive the foam coating were sprayed with a thin mist of water.

2. One bead of Soundafoam FR was applied to the penetration within the cavity and resprayed with a mist of water.
3. Another bead of Soudafoam FR was applied to the first bead and the process repeated until the cavity was filled throughout.
4. After a curing period of 72 hours the exterior surface of the seal was trimmed flush on both sides of the wall with a cutter knife.
5. Two weeks later the Soudafoam FR was gouged out to a depth of 15 mm and replaced with Firecryl on both sides of the wall.
6. The fire test commenced 13 days later.

2.6 Specific Descriptions

Specific descriptions of the sealing systems as constructed are as follows. All dimensions are nominal unless otherwise stated.

2.6.1 Pipe penetration.

Penetration: A steel pipe with measured 152 mm outside diameter and 4.9 mm mean measured wall thickness passing through a 186 mm diameter hole and steel sleeve in the wall.

Seal: A 15 mm depth of Soudal Firecryl FR acrylic sealant filling the gap between pipe and sleeve on both sides of the wall. The gap between pipe and sleeve in the remaining depth of the wall was filled with Soudal Soundafoam FR Fire Retardant PU gun foam.

2.6.2 Cable penetration

Penetration: A 300 mm wide galvanised slotted cable tray and four groups of cables complying with Figure D1 of Appendix D of AS 4072.1-1992. The cables groups are referred to as 'A', 'B', 'C' or 'D' and correspond with the cable labelling system of Figure D1 (i.e., cables in Group 'A' are labelled 'a' in Figure D1 etc). Cable diameters are given in Table 1.

Seal: A 15 mm depth of Soudal Firecryl FR acrylic sealant filling the gap between cables and sleeve on both sides of the wall. The gap in the remaining depth of the wall was filled with Soudal Soundafoam FR Fire Retardant PU gun foam.

Table 1. Cable diameters and numbers.

Cable group label	Number of cables	Cable diameter (mm)
'A'	1	34
'B'	1	65
'C'	3	14
'D'	8	18

3. TEST PROCEDURE

3.1 General.

The specimen was tested on 11 May 2004 at BRANZ laboratories, Judgeford, New Zealand, in the presence of representatives of the client. The ambient temperature at the beginning of the test was 14°C. The frame containing the specimens were placed against the 2.2 m x 1.0 m furnace and the temperature and pressure conditions were controlled to the limits defined in AS 1530.4-1997.

The test was terminated after the specimen had been exposed to the standard fire resistance conditions for 62 minutes.

3.2 Furnace Temperature Measurement

Temperature measurement within the furnace was made using four chromel-alumel mineral insulated metal sheathed (MIMS) thermocouples 3 mm in diameter uniformly distributed in a vertical plane approximately 100 mm from the exposed face of the specimen.

3.3 Specimen Temperature Measurement

In order to monitor heat conduction through the sealing systems, 26 chromel-alumel thermocouples on copper disks were attached to the specimens. The arrangement consisted of thermocouples placed as specified in clause 10.3.2 of the test standard AS 1530.4. The short hand notation in referring to these thermocouples in the figures in this report is given in Table 2.

Table 2. Short hand notation used for thermocouple location

Notation	Location
Wall	Unexposed surface of the wall 25 mm from the penetrations
Pipe seal	Unexposed surface of pipe seal
Pipe @ 25 mm	On the pipe at 25 mm from the wall
Pipe @ 400 mm	On the pipe at 400 mm from the wall
Cable seal	Unexposed surface of cable seal
Cable @ 25 mm	On the cable at 25 mm from the wall
Cable @ 400 mm	On the cable at 400 mm from the wall

Three additional thermocouples were placed on the unexposed surface of the wall clear of any of the penetrations and two at 25 mm from the wall on the cable tray.

3.4 Temperature Recording

All the thermocouples described in section 3.2 and 3.3 were connected to a computer controlled data acquisition system which recorded the temperatures at 15 second intervals.

3.5 Pressure Measurement

The differential pressure was controlled to be not less than 20 Pa above the laboratory atmosphere at the centre of the lowest specimen. The differential pressure was monitored using a micromanometer connected to a computer controlled data acquisition system which recorded the pressure at 15 seconds intervals.

4. OBSERVATIONS

4.1 Severity of the Test

Figure 1 shows the time-temperature curve from the standard in relation to the actual mean furnace temperature.

In accordance with the test standard the accuracy of control of the furnace was as follows:

	Variation of area under time-temperature curve (%)	
	Standard	**Actual**
End of first 10 minutes	± 15.0	-4.6
End of first 30 minutes	± 10.0	-1.5
After 30 minutes (max)	± 5.0	-1.5 to -0.7
End of test	± 5.0	0.1

	Variation of mean furnace temperature (°C)	
	Standard	**Maximum Actual**
After 10 minutes	± 100	-38 to 18

	Temperature difference of any thermocouple from Standard Curve (°C)	
	Standard	**Maximum Actual**
After first 10 minutes	±200	-71 to 57

The furnace conditions complied with the test standard.

Time to integrity failure of each specimen is shown in Table 3. Significant observations related to the integrity performance of the specimens were as follows at the times stated in minutes and seconds. All observations are on the unexposed face unless noted otherwise:

Elapsed Time	Observations
2:30	Smoke was being emitted between the cables of Group ‘C’.
4:00	The plastic coating of cables on the exposed face was melting and dripping.
10:00	The plastic coating of cables on the exposed face was burning and the Firecryl had blackened and activated.
11:00	The smoke emitted between pipes noted at 2:30 had stopped.
20:00	The cable tray section against the wall surface on the exposed face had sagged in the middle. A hole had formed in the Firecryl above the cables and the Soudafoam FR at this location was now directly exposed to the flames. The Firecryl had expanded approximately 10 mm into the furnace and sagged vertically.
23:00	The pipe had displaced down the wall by compressing the bottom seal.
28:00	The Firecryl had expanded away from the wall by approximately 10 mm from the wall around the pipe and 5 mm around the cables.
36:00	Smoke was being emitted from an opening on the unexposed face where the Firecryl had pulled away from Cable Group ‘B’. This corresponded with the hole in the Firecryl on the exposed face noted at 20:00.
40:00	The gap noted at 36:00 was now 20 x 5 mm but there was no vision into the furnace. The smoke from this hole had increased.

45:00 The smoke noted at 36:00 and 40:00 had reduced considerably. Wisps of smoke were coming from the seal at the top of the pipe.
48:00 The smoke noted at 45:00 had stopped.
50:00 The lining of the exposed face was pulling away from the steel sleeve of the cable penetration hole perimeter.
52:00 The Firecryl had expanded approximately 20 mm away from the wall around the pipe and 10 mm around the cables. Smoke density from below the pipe had increased.
55:00 The smoke density from below the pipe had further increased and dark staining was appearing on the adjacent unexposed face of the wall.
57:00 The Firecryl seal protruding from the face of the wall had fallen for half the pipe circumference. The adjacent wall was charring black.
59:50 The steel sleeve around the pipe was now visible around the entire pipe circumference.
62:00 No charring was evident on the wall around the cable tray but was visible around the entire pipe circumference.

The test was stopped after 62 minutes. Integrity failure had not occurred at this stage.

4.2 Insulation

The time to insulation failure of each of the seal systems is shown in Table 3.

Figure 2 shows the time/temperature rise graphs for the most critical thermocouples at each pipe thermocouple placement location shown in Table 1.

Figure 3 shows the time/temperature rise graphs for the most critical thermocouples for each cable group.

Figure 4 shows the time/temperature rise graphs for the two thermocouples on the cable tray.

Figure 5 shows the temperature rise on the unexposed face of the wall clear of the penetrations.

Pipe penetration The most critical thermocouple showed a temperature rise which exceeded 180 K on the pipe after 23 minutes. This thermocouple was located on the pipe at 25 mm from the wall.

Cable penetration The most critical thermocouple on each cable group was located at 25 mm from the wall. The time for the corresponding temperature rise to exceed 180 K is given below.

- Group ‘A’. 38 minutes
- Group ‘B’. 61 minutes
- Group ‘C’. 51 minutes
- Group ‘D’. 55 minutes
- Cable tray. 54 minutes

5. SUMMARY

Table 3 summarises the performance, under Integrity and Insulation, of each specimen.

Table 3. Summary of measured fire resistance

Specimen	Time to failure (minutes)	
	Integrity	Insulation
Steel pipe penetration	62 NF	23
Cable Group ‘A’ penetration	62 NF	38
Cable Group ‘B’ penetration	62 NF	61
Cable Group ‘C’ penetration	62 NF	51
Cable Group ‘D’ penetration	62 NF	55
Cable tray.	62 NF	54

NF = no failure for the 62 minutes duration of the test.

The test standard requires the following statement to be included: “The results of these fire tests 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.”

6. ATTACHMENTS:

Figure 1 Furnace Temperature

Figure 2 Pipe Temperatures

Figure 3 Cable Temperatures

Figure 4 Cable Tray Temperatures

Figure 5 Wall Temperatures

Figure 6 Specimen Layout

Figure 7 Section through wall

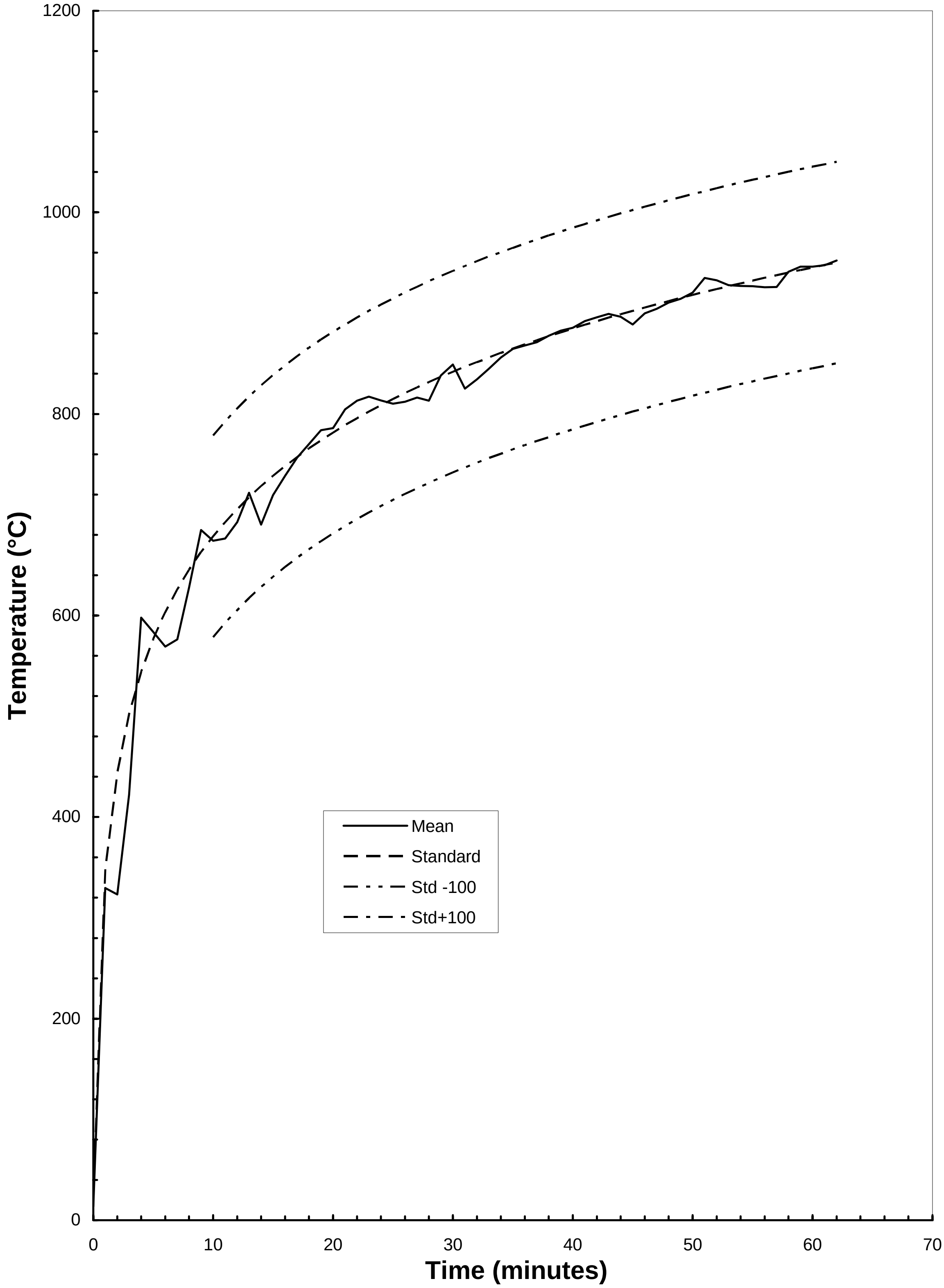
Figure 8 Sections through penetrations

Figure 8 Test photographs

Original signed by: SJT

Original signed by: MG

Figure 1 Furnace Temperature



Original signed by: SJT

Original signed by: MG

Figure 2 Pipe Temperatures

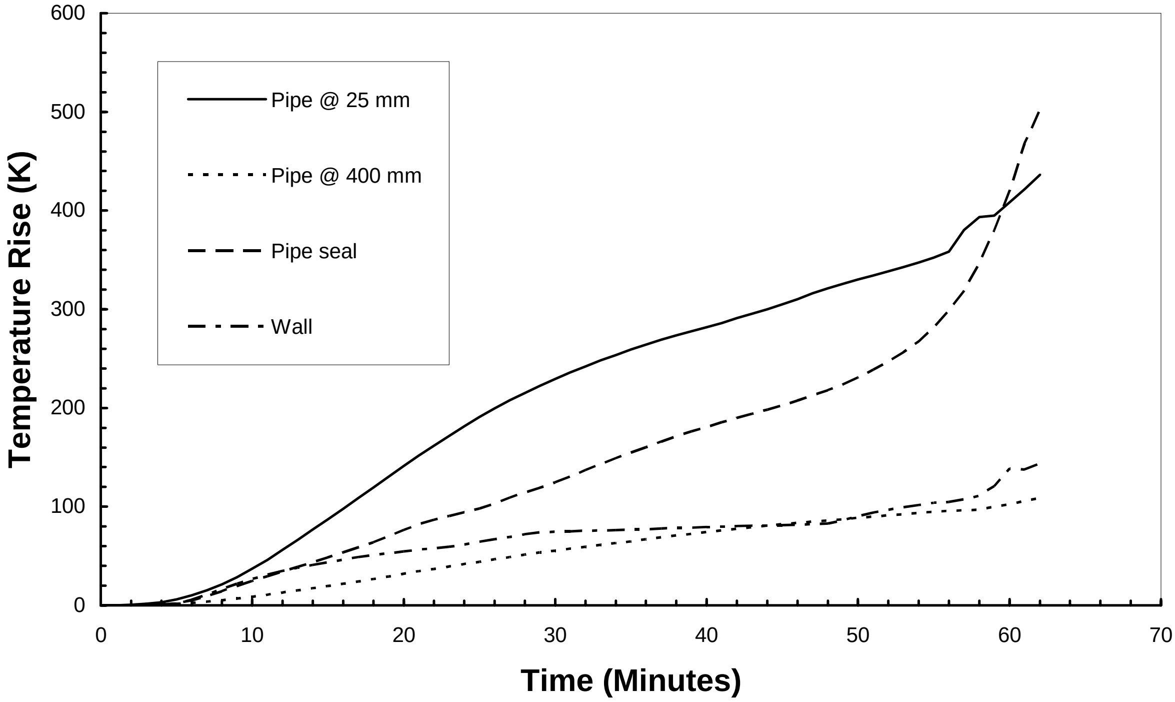
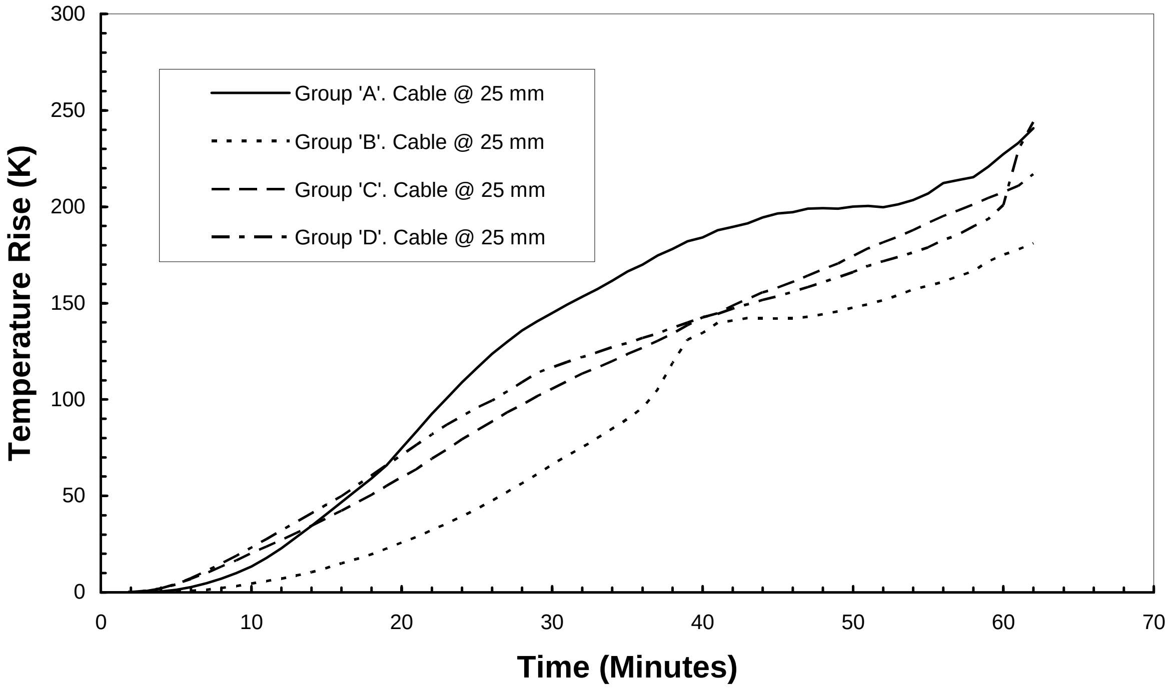


Figure 3 Cable Temperatures



Original signed by: SJT

Original signed by: MG

Figure 4 Cable Tray Temperatures

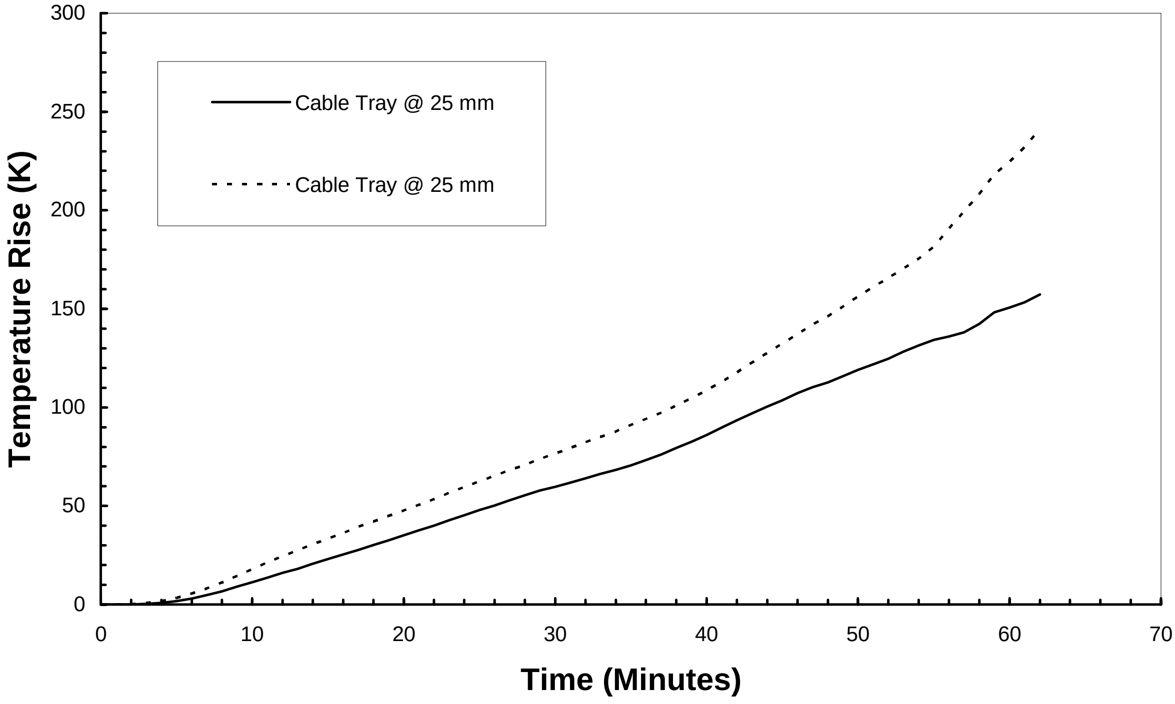
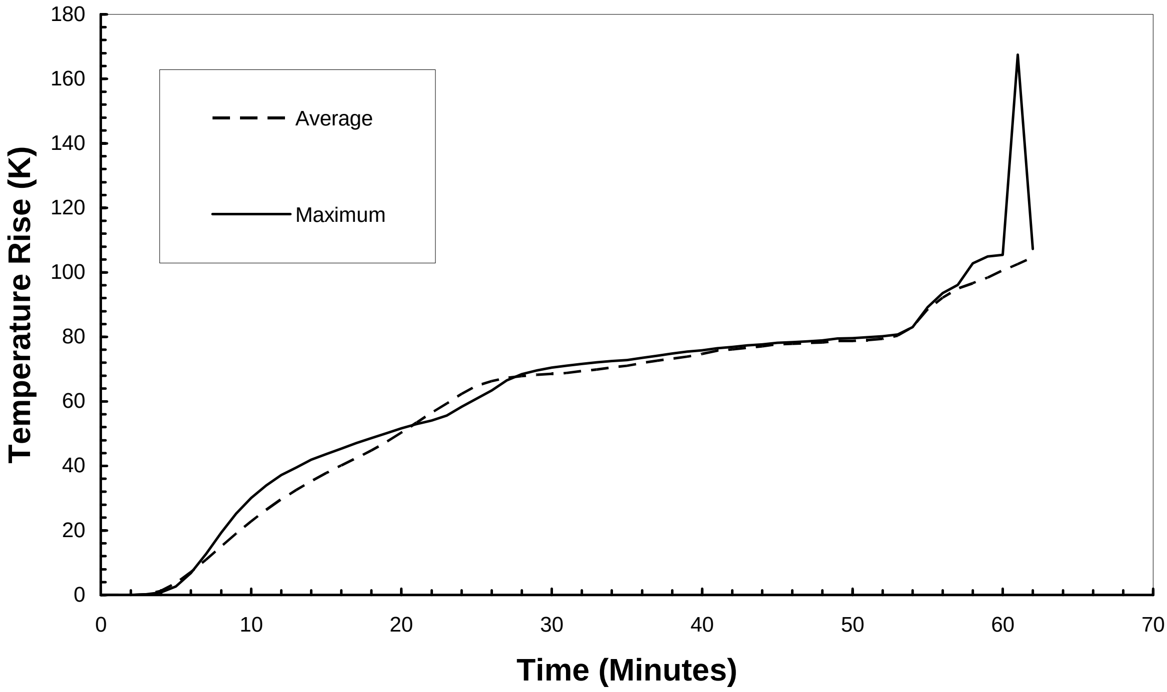


Figure 5 Wall Temperatures



Original signed by: SJT

Original signed by: MG

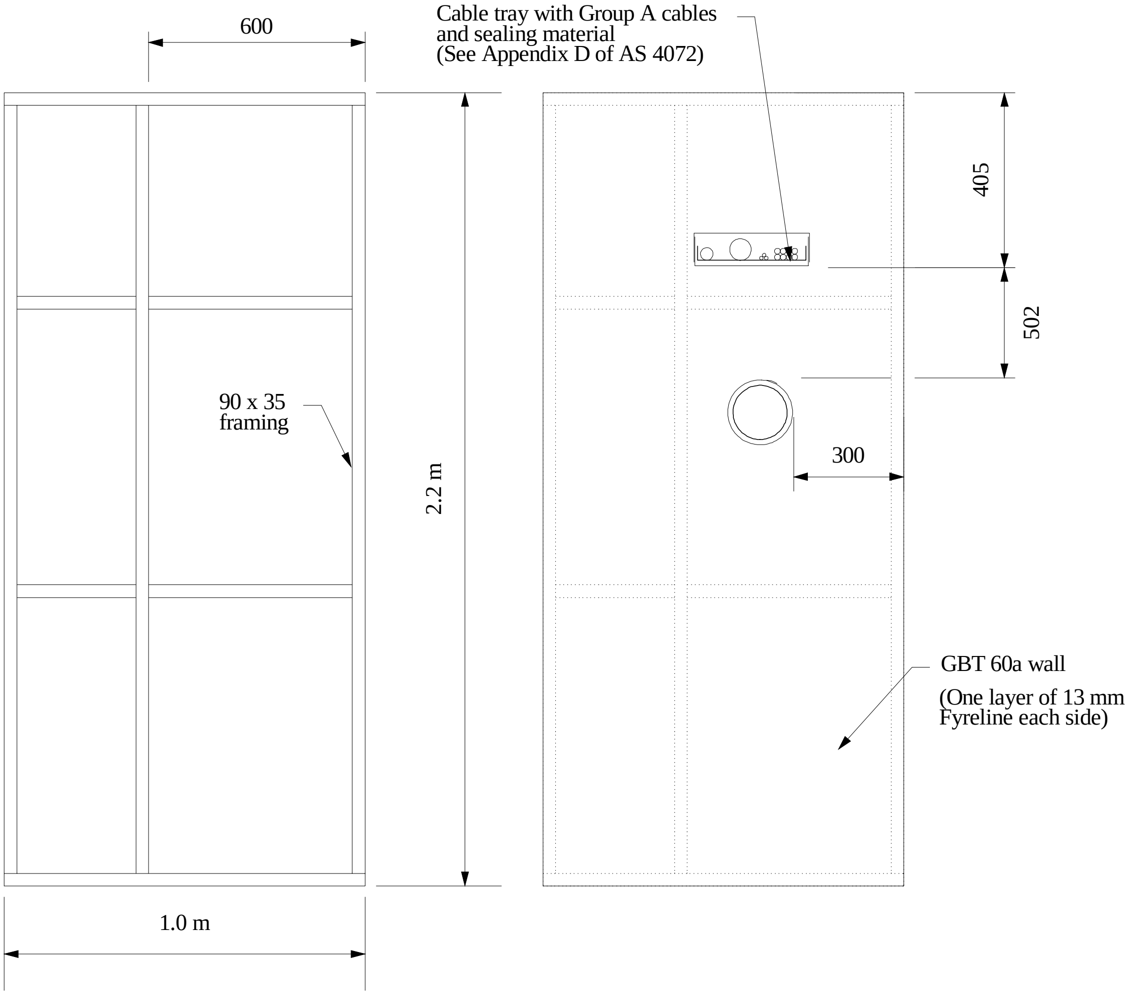


Figure 6 Specimen Layout

Original signed by:
SJT

Original signed by:
MG

Figure 7 Section through wall

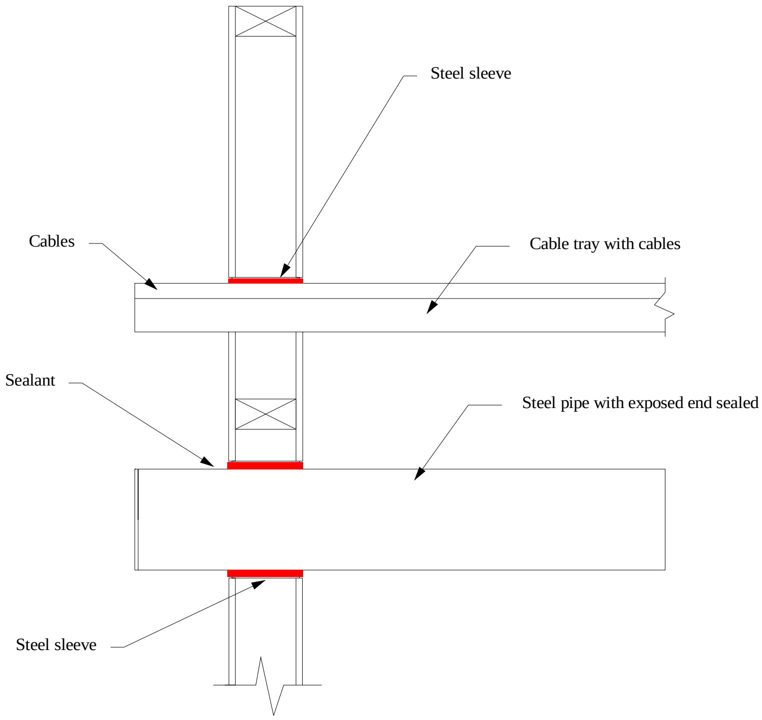
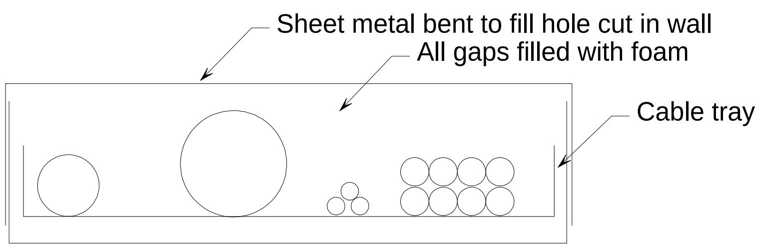


Figure 8 Sections through penetrations



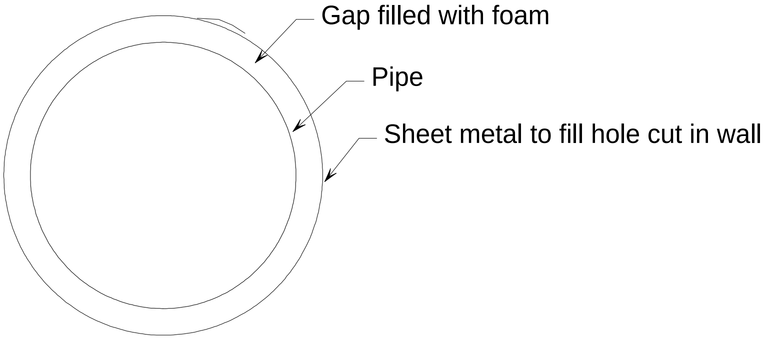


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Figure 9 Test photographs

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