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FP 3699

FIRE RESISTANCE OF A 2 HOUR STEEL FRAMED PLASTERBOARD LINED WALL WITH EDGE SEALS AND PENETRATIONS

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All tests reported herein have been undertaken at the BRANZ Ltd laboratories located in Judgeford, Porirua, New Zealand, unless stated otherwise.

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FIRE RESISTANCE OF A 2 HOUR STEEL FRAMED PLASTERBOARD LINED WALL WITH EDGE SEALS AND PENETRATIONS

1. CLIENT

Ramset Fasteners (Aust) Pty Ltd
Marcondah Highway
Croydon North
Victoria
Australia

2. TEST STANDARD

2.1 Test Specification

The test was conducted to AS 1530.4-1990, 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, to failure under one or more of the following criteria:

2.2 Integrity

Failure shall be deemed to occur when cracks, fissures or other openings develop through which flames or hot furnace gases can pass to the unexposed side of the penetrated element.

2.3 Insulation

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

3. DESCRIPTION OF TEST SPECIMEN

3.1 General

The test specimen consisted of a non-loadbearing nominal 2200 mm high x 1000 mm wide steel framed wall, lined on both faces with two layers of 13 mm Boral Firestop gypsum plaster board. The construction was in accordance with the Boral specification for a 2 hour fire rated wall system SS3 except for variation of edge detail to test the method of finishing the edges at the sides and top of the wall. The wall also included a vertical expansion joint 600 mm from the left hand edge, a pipe penetration and a cable penetration in the left hand vertical half and an electrical socket outlet in each of the exposed and unexposed faces of the lining.

All dimensions are nominal unless otherwise stated.

3.2 Framing

The steel frame was constructed using 64 mm x 35 mm x 0.6 mm thick galvanised steel lipped channel studs fitted into galvanised steel channel runners at the top and bottom. The bottom channels were 65 mm x 32 mm x 0.6 mm thick and the top channels were 66 mm x 50 mm x 0.8 mm thick.

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There were four studs in total with one stud each side and two studs back to back with a separation of 20 mm to form the expansion joint. The top and bottom channels were fixed to the specimen holder using two bolts at the top and two at the bottom at 600 mm and 800 mm centres respectively. The side studs were not fixed to the specimen holder.

3.3 Lining

The specimen was lined on both sides with two layers of nominal 13 mm thick Boral Firestop gypsum plasterboard. The measured thickness of the lining was 12.8 mm.

The sheets were fixed to the studs at 200 mm centres using nominal 3 mm diameter and 32 long Streaker countersunk head screws for the first layer and 3 mm diameter x 45 mm long screws through the second layer. Adjacent screws on the centre studs were staggered. The lining was not fixed to the channel runners at top and bottom.

All screw heads were stopped.

3.4 Edge Detail

All lining sheets were cut and fitted to leave a gap between the edge of the sheet and the specimen holder at both sides and head of the specimen and between the edges of the sheets at the expansion joint. The gap widths were as follows:

Specimen A - Deflection head	20 mm
Specimen B - Left hand edge	15 mm
Specimen C - Right hand edge	10 mm
Specimen D - Expansion joint	20 mm

At the top and side edges Ramset Blazebrake 201 sealant was gunned into the gap to a depth of 13 mm.

Polyurethane foam backing strip, 25 mm wide x 25 mm thick, was compressed into the gap at the expansion joint. Ramset Blazebrake 201 sealant was gunned into the gap to a thickness of 13 mm.

The lower half of the joint was covered with a section of Rondo P35 Control Joint. This consisted of two perforated galvanised steel angle strips over the edge of the plasterboard joined together within the joint by an extruded PVC flexible plastic strip. As fitted, the plastic was recessed approximately 3 mm below the surface of the plasterboard lining.

In each case the same method of sealing the gap was used in the corresponding gap on the other side of the wall.

3.5 Penetrations

3.5.1 Specimen E – Copper Pipe

Opening: A 98 mm diameter hole through both faces of the wall.

Penetration: A 80 mm copper pipe. Outside diameter 79 mm, wall thickness 1.4 mm.

Seal: A sleeve 80 mm long x 98 mm diameter formed from 0.6 mm thick galvanised steel sheet was installed around the pipe spanning the linings of the wall. The annular gap between the pipe and the sleeve was sealed to a depth of 26 mm from each face using gun applied Ramset Blazebrake 201.

A half circumference, steel mesh radiation guard 450 mm long x approximately 240 mm diameter was fitted concentrically around the right vertical half of the pipe and secured to the pipe with metal strips clamped to the pipe.

3.5.2 Specimen F – Cable Bundle

Opening: An 80 mm diameter hole through both faces of the wall.

Penetration: A bundle of electrical and telecommunication cables of overall diameter approximately 65 mm and including the following cables:

Number of cables	Outside diameter mm	Conductors No. x diam. mm
1	21	37 x 1.8
1	17	4 @ (7 x 1) + 1 @ (7 x 0.65)
2	16	4 @ (7 x 1)
2	12.5	4 @ (7 x 0.6)
2	11	24 @ (5 x 0.16)
1	11 x 7.5	2 x 1.8
2	10.5	19 x 1.6
1	9	19 x 1.3
1	8	7 x 1
1	4.2	7 x 0.8

Seal: The annular gaps between the bundle of cables and the plasterboard on each face were sealed using gun applied Ramset Blazebrake 201 to a depth of 26 mm from each face. All visible gaps between cables in the bundle were also sealed with the sealant.

3.5.3 Specimen G - Socket Outlets

A double, 10 amp electrical socket outlet was installed in each face of the wall at a height of 300 mm above the floor level. Each outlet was fixed to a standard 93 mm high x 52 mm wide x 42 mm deep metal flush box within the wall cavity. The flush boxes were screw fixed to short lengths of vertical metal stud which were in turn fixed in place with screws through the wall lining. The exposed socket outlet was positioned 300 mm from the right hand edge of the wall and the unexposed outlet was positioned 300 mm from the left hand edge viewed from the unexposed face.

Four layers of 2.5 mm thick Intumex L were placed inside the back of each of the flush boxes.

3.6 Plans and Specifications

Copies of client-supplied drawings of Specimens A, B, D, E and F are shown in Figure 9.

4. TEST PROCEDURE

4.1 General

The specimen was tested on 10 November 1994 at Branz Ltd laboratories, Judgeford, New Zealand. The ambient temperature at the beginning of the test was 14 °C.

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The specimen was placed against the 2.2 m x 1 m furnace and the temperature and pressure conditions were controlled to the limits defined in AS 1530.4-1990. The test was terminated after 154 minutes from the commencement of the test.

4.2 Furnace Temperature Measurement

Temperature measurement within the furnace was made using four chromel-alumel thermocouples uniformly distributed in a vertical plane approximately 100 mm back from the exposed face of the specimen

4.3 Specimen Temperature Measurement

In order to monitor heat conduction through the systems, 48 chromel-alumel thermocouples mounted on copper discs, in accordance with clause 2.2.3.2 of the AS 1530.4 test standard, were attached to the specimen. The arrangement consisted of thermocouples placed as specified in clause 10.3.2(f) of the test standard specification. Thermocouples were placed on the unexposed surface of the wall at the approximate quarters, on the wall 25 mm from the two penetrations (designated in the figures as "wall"), on the penetration seals and edge seals and each half of the centre expansion joint (designated as "seal"), on the pipe and bundle of cables at 25 mm and 400 mm from the wall (designated "inner pipe", "outer pipe", "inner cables", "outer cables" respectively) on the radiation screen at 25 mm and 400 mm from the wall (designated "inner screen" and "outer screen") and one on the unexposed face plate of the socket outlet. The positions of these thermocouples are shown in Figure 8.

Additional thermocouples were also placed on and within the specimen for information purposes.

4.4 Temperature Recording

All the thermocouples described in section 4.2 and 4.3 were connected to a computer controlled data acquisition unit which sampled the temperatures at one minute intervals.

4.5 Pressure Measurement

As required by the test standard, the differential pressure within the furnace was controlled to be not less than 8 Pa above the laboratory atmosphere at the position of the lowest penetration, which was the socket outlets. The differential pressure was monitored using a micromanometer connected to a continuously reading recorder.

5. RESULTS

5.1 Severity of the Test

The severity of the fire resistance test can be established by comparison of the area under the curve of mean furnace temperature with the area under the standard curve for the same period. Figure 1 shows the time-temperature curve from the standard in relation to the actual mean furnace temperature. The severity of this test for 154 minutes was 100%.

5.2 Integrity

The time to integrity failure of each specimen is shown in Table 1.

The upper section of the expansion joint, specimen D, failed integrity at 153 minutes due to formation of through gaps.

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5.3 Insulation

The time to insulation failure of each specimen is shown in Table 1.

Figure 2 shows the average and maximum temperature rise of the thermocouples placed at the quarter points of the wall. Figures 3 to 7 show the time/temperature rise graphs for the maximum temperature rise measured by the thermocouples placed on each specimen.

5.3.1 Specimen A

At 114 minutes the temperature rise on the seal of the deflection head exceeded 180 K.

5.3.2 Specimen B

At 141 minutes the temperature rise on the seal of the left hand edge exceeded 180 K.

5.3.3 Specimen C

At 146 minutes the temperature rise on the seal of the right hand edge exceeded 180 K.

5.3.4 Specimen D

At 91 minutes the temperature rise on the seal of the upper expansion joint exceeded 180 K. It was observed that the sealant had expanded over the majority of the length of the seal except at the position of the thermocouples. It appeared that the insulating pads were jammed between the edges of the plasterboard and restricting the expansion of the sealant at these positions. An additional thermocouple was placed on an expanded section of the sealant and the temperature rise recorded at this point exceeded the 180 K criterion at 113 minutes. This is considered to be indicative of the Insulation of the seal clear of the restriction imposed by the thermocouple pads.

At 154 minutes the temperature rise on the plastic strip within the groove of the lower expansion joint exceeded 180 K. Temperatures measured by thermocouples placed on the surface of this joint did not exceed 180 K rise for the duration of the test.

5.3.5 Specimen E

At 18 minutes the temperature rise on the pipe 25 mm from the wall exceeded 180 K.

At 24 minutes the temperature rise on the seal of the pipe exceeded 180 K.

At 107 minutes the temperature rise on the wall 25 mm from the pipe exceeded 180 K.

At 137 minutes the temperature rise on the wall 100 mm from the pipe exceeded 180 K. This was outside the radiation screen.

5.3.6 Specimen F

At 66 minutes the temperature rise on the cables 25 mm from the wall exceeded 180 K.

At 78 minutes the temperature rise on the seal of the cables exceeded 180 K.

At 154 minutes the temperature rise on the wall 25 mm from the cables exceeded 180 K.

5.3.7 Specimen G

At 130 minutes the temperature measured with a roving thermocouple on the intumescent within the flush box on the unexposed face of the wall was 212 °C which was a temperature rise in excess of 180 K rise above the ambient temperature of 14 °C. This constituted a failure to the insulation criterion of the test standard.

There were no other failures of insulation for the duration of the test.

5.4 Observations

At 2 minutes the plastic face plate of the exposed socket outlet began to melt and flow down the wall. By 7 minutes the plate had completely fallen away.

Similarly at 2 minutes the metal joint cover over the lower exposed expansion joint had begun to move away from the wall and by 12 minutes was clear of the exposed face of the wall.

At 12 minutes the sealant in the exposed side of the expansion joint was beginning to expand into the furnace.

At 13 minutes the intumescent material in the flush box on the exposed side had expanded to more than the depth of the box but did not completely fill the upper approximate quarter.

By 23 minutes the upper expansion seal on the exposed face had almost expanded to be flush with the exposed face of the wall. Also the sealant around the pipe on the unexposed had expanded approximately 10-12 mm from the face of the wall.

Similarly at 45 minutes the seal in the unexposed face of the cable penetration had started to expand. The seal around the pipe had expanded 20 mm beyond the surface of the wall and had shrunk back from the pipe surface.

At 65 minutes the exposed lining was bulging into the furnace and lateral cracks about 50 mm long had started to develop from the centre joint.

At 72 minutes the top edge of the outer exposed lining above the pipe penetration had detached and started to move away from the inner lining. This continued until by 95 minutes this section had fallen away exposing the inner layer which had a heavily crazed appearance.

At 92 minutes the face plate of the unexposed electrical socket had begun to soften and move away from the surface of the wall. This continued due to the expansion of the intumescent within the flush box until 109 minutes when the plate had fallen off exposing the expanded intumescent filling the flush box.

At 100 minutes the upper section of the outer layer of the exposed lining above the exposed flush box had started to detach. This progressed until at 117 minutes the top centre corner of this sheet had detached for about 500 mm exposing the inner lining which also appeared heavily crazed. The top approximately 600 mm of this sheet fell away at 128 minutes.

At 153 minutes, gaps with direct vision into the furnace developed past the centre seal to the left of the expansion joint studs starting about 300 mm from the top of the wall and continuing down about the top third height. This constituted an integrity failure.

At the end of the test at 154 minutes there had been no other gaps or fissures develop in the wall, seals or penetrations and no flaming and hence no failure of integrity of any specimen other than the upper half of specimen D.

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6. SUMMARY

6.1 Fire Resistance

Table 1 summarises the performance, under integrity and insulation, of each specimen.

Table 1 - Time to Failure

SPECIMEN	TIME TO FAILURE (minutes)	
	INTEGRITY	INSULATION
A	154 NF	114
B	154 NF	141
C	154 NF	146
D Upper	153	113
D Lower	154 NF	154
E	154 NF	18 137 *
F	154 NF	66
G	154 NF	130

NF = No failure up to the termination of the test at 154 minutes
* Time to insulation failure if the radiation screen was completely surrounding the specimen

6.2 Fire-resistance level (FRL)

For the purposes of the building regulations in Australia the seals and penetrations achieved fire resistance levels (FRL) as shown in Table 2:

Table 2 - Fire Resistance Levels

Specimen	FRL
A	-/120/90
B	-/120/120
C	-/120/120
D upper	-/120/90
D lower	-/120/120
E without screen	-/120/0
E with screen	-/120/120
F	-/120/60
G	-/120/120

The test standard requires the following statement to be included in the report: "The results of these fire tests may be used to directly assess fire hazard but it should be recognised that a single test method will not provide a full assessment of fire hazard under all fire conditions."

7. ATTACHMENTS

Fig 1 Furnace Temperatures

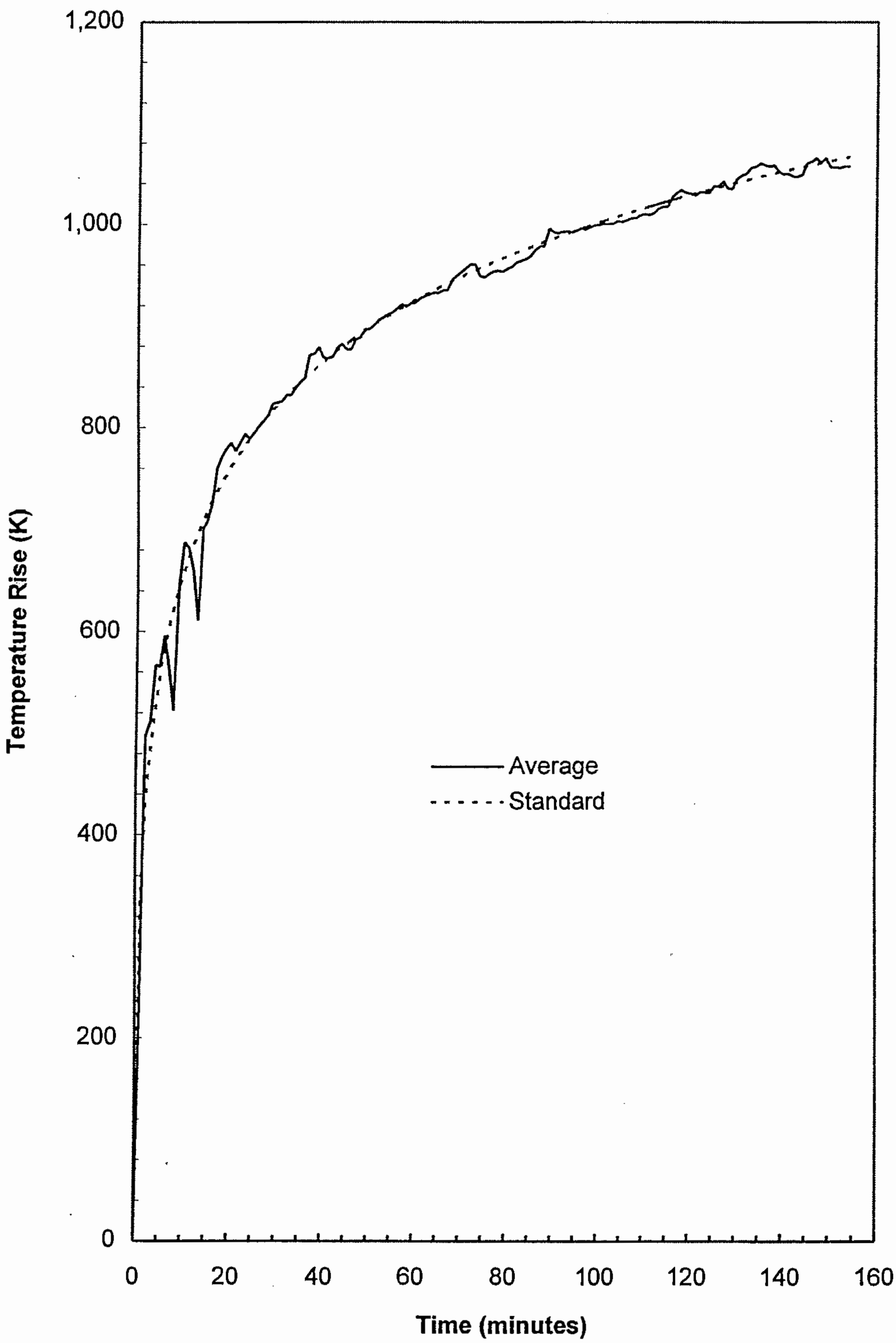

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Fig 2 Temperature Rise- Wall

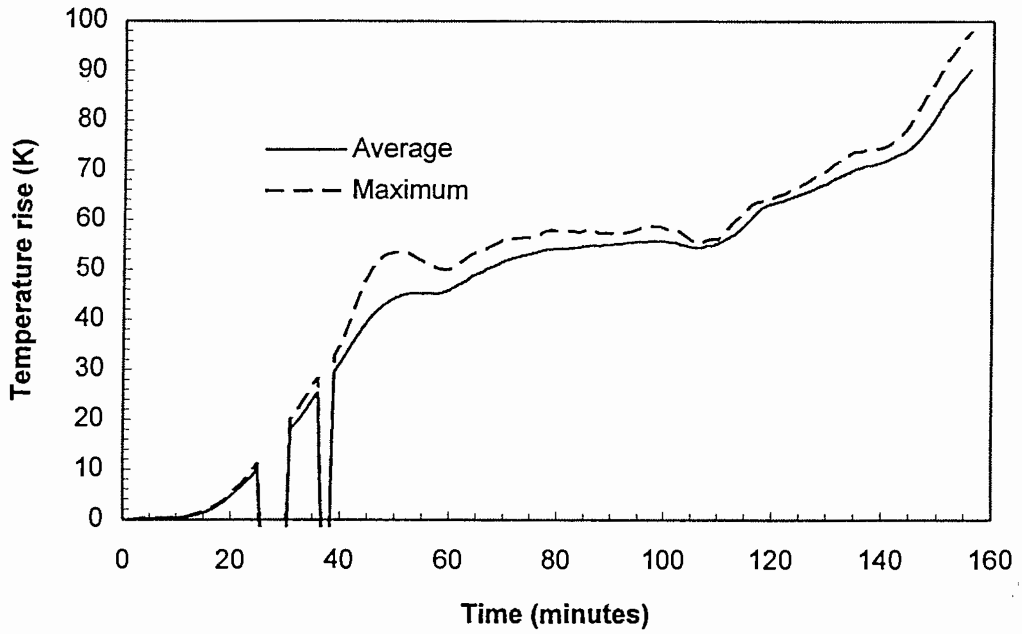

Fig 3 Temperature Rise - Specimens A, B, C

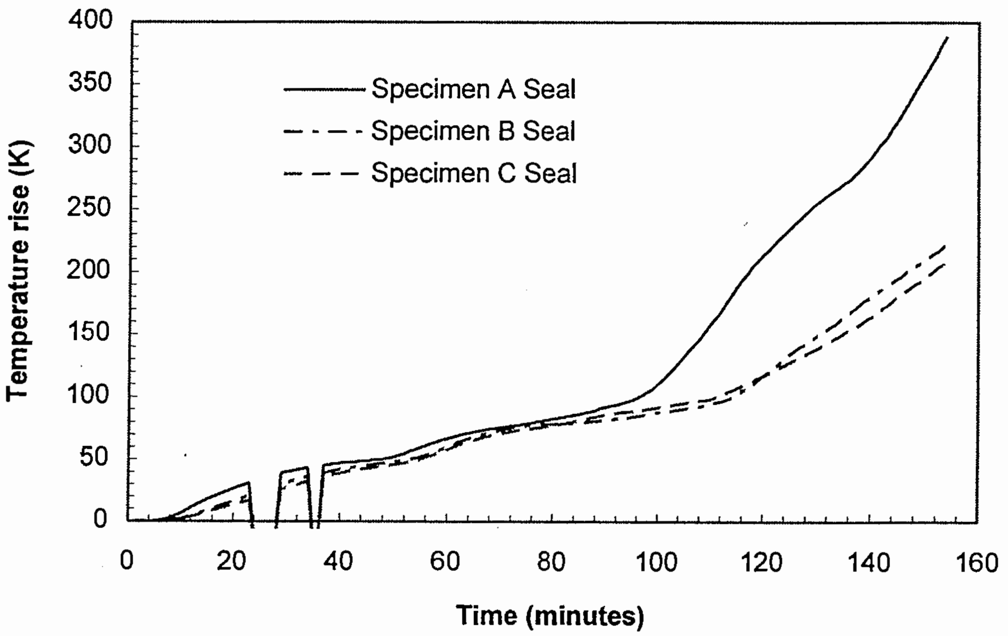

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Fig 4 Temperature Rise - Specimen D

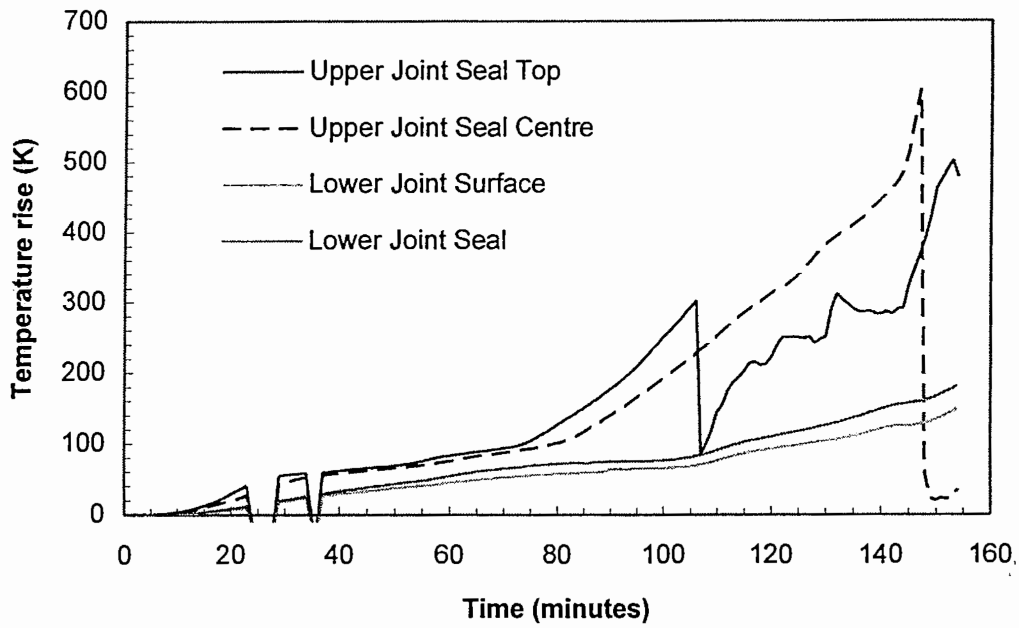

Fig 5 Temperature Rise - Specimen E

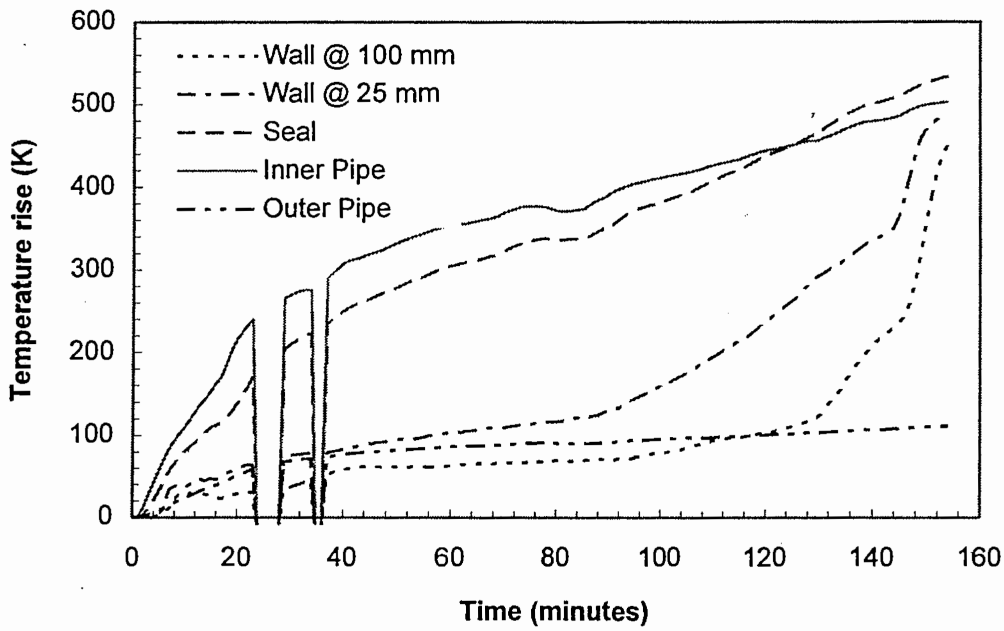

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Fig 6 Temperature Rise - Specimen F

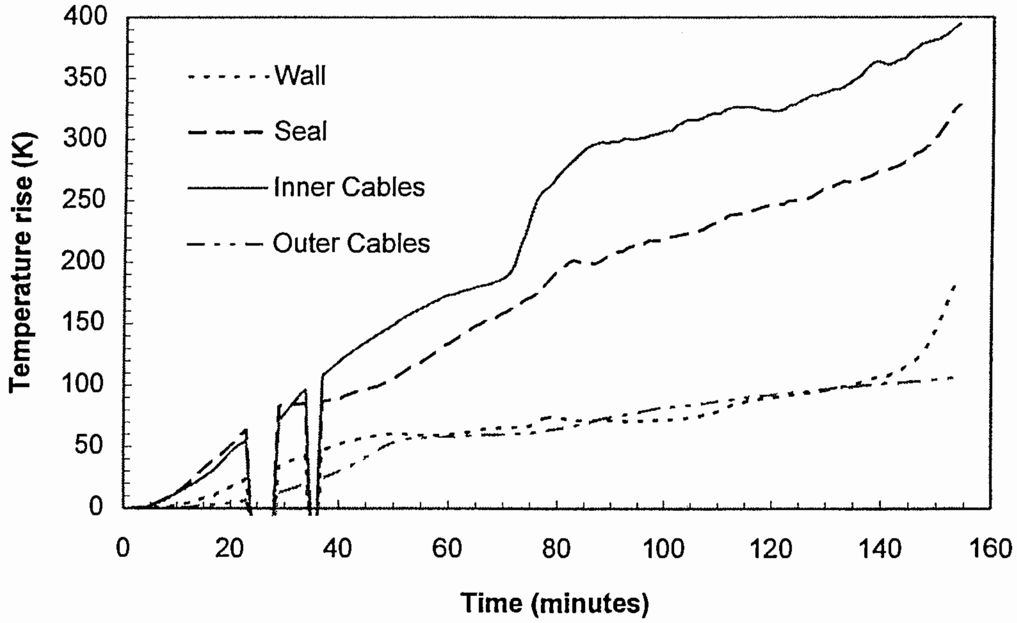

Fig 7 Temperature Rise - Specimen G

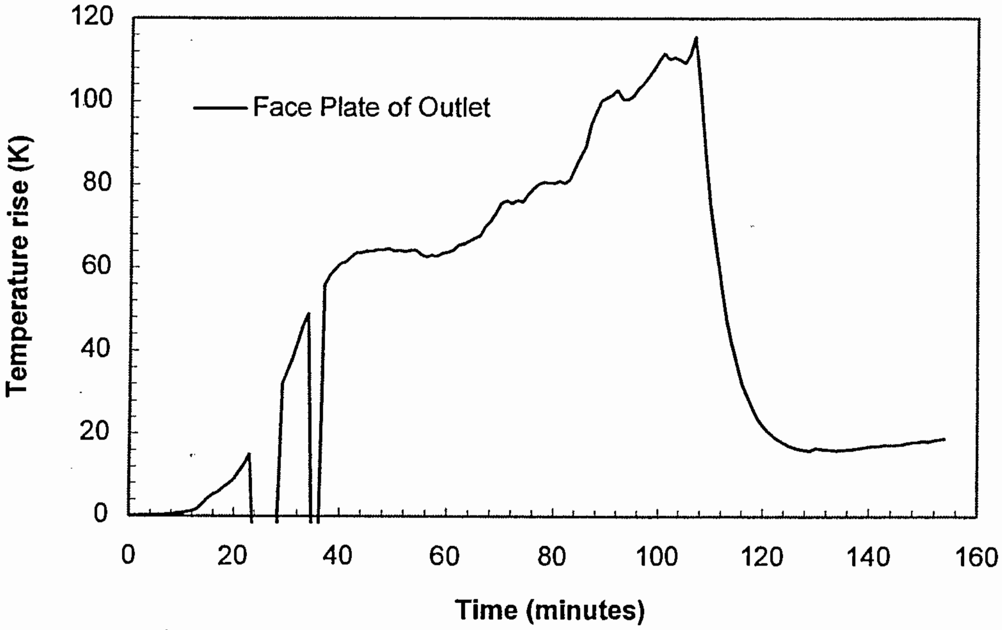

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Fig 8 Thermocouple Positions

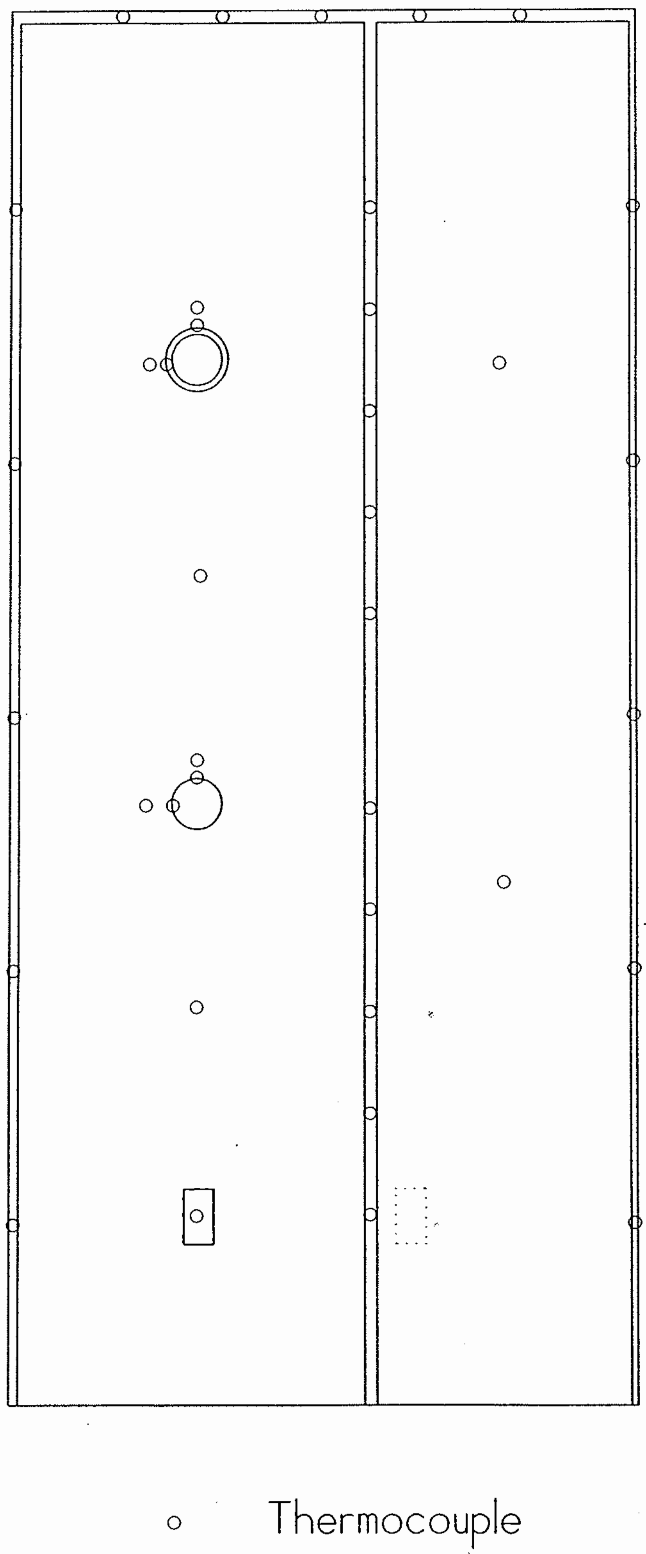

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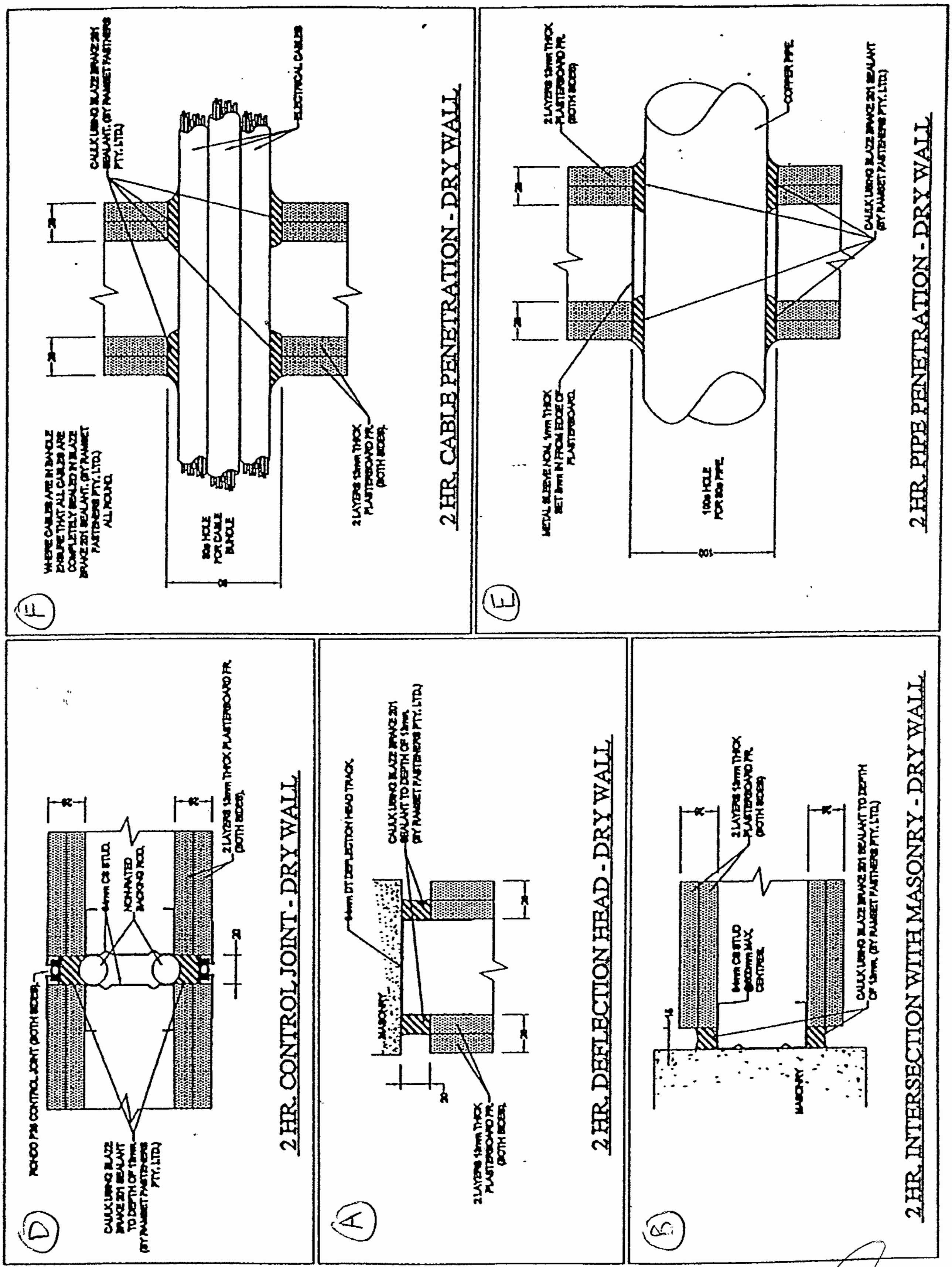
Fig 9 Ramset Drawings of Specimens A, B, D, E, F



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