BUILDING ON KNOWLEDGE

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FIRE RESISTANCE OF SYSTEMS INTENDED FOR SEALING PENETRATIONS AND CONSTRUCTION JOINTS IN FLOORS

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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 SYSTEMS INTENDED FOR SEALING PENETRATIONS AND CONSTRUCTION JOINTS IN FLOORS

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 specimen consisted of three 170 mm thick reinforced concrete slabs placed on the horizontal 4 m x 3 m horizontal furnace to represent a structural concrete floor. The measured thickness of the concrete varied between 170 mm and 175 mm and in the vicinity of the penetrations and joint concerned averaged 172 mm. The concrete slabs had openings left during construction and 21 penetrations and sealing systems and one seal between two of the slabs were inserted later. The joint between the other two slabs was sealed with mineral fibre.

Only two penetrations and the construction joint will be reported as specimens 20 to 22 inclusive. The other penetrations were included for development purposes.

Two 170 mm thick samples of the concrete were cast at the same time as the specimen and allowed to cure under the same conditions as the test specimen. Based on the weighing of these samples before and after drying in an oven at 105 °C the average density of the concrete at the time of the fire resistance test was calculated to be 2,188 kg/m³ and the moisture content (by weight) was 5.4 %.

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All pipes were closed on the end within the furnace, left open on the unexposed end and secured by clamps to a steel framework at 530 mm and 1410 mm from the top face of the concrete floor slab. The penetrations protruded at least 100 mm into the furnace and extended at least 2,000 mm from the unexposed face of the concrete.

All dimensions are nominal unless otherwise stated.

3.2 Sealing Systems

Descriptions of the sealing materials used are as follows:

3.2.1 Blazebrake 201

An acrylic based fire stopping sealant manufactured by Ramset Fasteners (Aust) Pty Ltd.

3.3 Specific Descriptions

Specific descriptions of the sealing systems as constructed are as follows. The pipe size shown is nominal internal diameter (ID). All dimensions are nominal unless otherwise stated.

3.3.1 Specimen 20

Opening: A 100 mm diameter hole through the concrete.

Penetration: An 80 mm diameter copper pipe with 79 mm outside diameter and 1.5 mm wall thickness.

Seal: Blazebrake 201 sealant was gun applied from the unexposed side to a depth of 20 mm in the annular gap between the pipe and concrete slab to finish flush with the unexposed surface.

A half-circumference, steel mesh radiation guard 450 mm long x 240 mm diameter was fitted concentrically around the pipe where it protruded from the concrete slab.

3.3.2 Specimen 21

Opening: An 80 mm diameter hole through the concrete.

Penetration: A bundle of electrical power cables with an overall diameter of 60 to 65 mm. The bundle included the following cables:

Number of cables	Outside diameter mm	Number of cores	Conductors No. x diam. mm
1	16.3	3	Screen 35 x 0.7, cores 7 x 1
4	9.3 x 6.7	3	7 x 0.7
2	10.8	23	7 x 0.2 (Telecom)
1	10.5	1	19 x 1.6
1	10.4	1	19 x 1.6
3	10.0	1	19 x 1.5
2	9.0	1	19 x 1.3
4	7.2	1	7 x 0.85

Seal: Blazebrake 201 sealant was gun applied from the unexposed side to a depth of 20 mm in the annular gap between the bundle and concrete slab to finish flush with the unexposed surface.

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3.3.3 Specimen 22

Opening: A gap between two of the concrete slabs 3,680 mm long x 25 mm wide. An upstand was included at the edge of one slab so that the specimen represented a joint between a floor slab and a wall. The width of the joint varied from 25 to 27 mm wide and averaged 25.6 mm and the length of the joint exposed to the furnace was 3,000 mm.

Seal: A foamed polyurethane backing rod was inserted from the unexposed side to provide a depth of 12.5 mm for the Blazebrake 201 sealant which was finished flush with the unexposed surface of the concrete.

3.4 Plans and Specifications

Copies of client-supplied drawings of Specimens 20, 21 and 22 are shown in Figure 6.

4. TEST PROCEDURE

4.1 General

The specimen was tested on 1 February 1995 at Branz Ltd laboratories, Judgeford, New Zealand. The ambient temperature at the beginning of the test was 23 °C.

The specimen-containing frame was placed on the 4 m x 3 m horizontal furnace and the temperature and pressure conditions were controlled to the limits defined in AS 1530.4-1990.

4.2 Furnace Temperature Measurement

Temperature measurement within the furnace was made using twelve chromel-alumel thermocouples uniformly distributed in a horizontal plane approximately 100 mm below the exposed face of the specimen.

4.3 Specimen Temperature Measurement

In order to monitor heat conduction through the sealing systems, chromel-alumel thermocouples were attached to the specimens. The arrangement consisted of thermocouples placed as specified in clause 10.3.2 of the test standard specification, except that only one thermocouple was placed on the pipes and cables at the 400 mm position.

Thermocouples were placed on the unexposed surface of the concrete slab 25 mm from the penetrations or joint seal (designated in the figures as "concrete"), on the seal of specimens 20, 21 and 22 (designated as "seal"), on the pipes at 25 mm and 400 mm from the floor slab (designated “inner pipe” and “outer pipe” respectively), on the cables at 25 mm and 400 mm from the floor slab (designated “inner cables” and “outer cables” respectively) and on the radiation guard (designated as “inner guard” and “outer guard” respectively). Additional thermocouples were placed on the unexposed surface of the concrete clear of any of the penetrations.

4.4 Temperature Recording

All the thermocouples described in section 4.2 and 4.3 were connected to a computer controlled data acquisition system which sampled the temperatures at 1 minute intervals.

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4.5 Pressure Measurement

The differential pressure was controlled to be not less than 8 Pa above the laboratory atmosphere at 100 mm below the exposed face of the specimen. The differential pressure was monitored using a micromanometer connected to a continuously reading recorder.

5. RESULTS

5.1 Duration

The test was terminated after the specimen had been exposed to the standard fire resistance conditions for 248 minutes.

5.2 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 248 minutes was 100%.

5.3 Integrity

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

Significant observations related to the integrity performance of the specimens were as follows at the times stated in minutes and seconds:

5.3.1 Specimen 20

40.40 The sealant had expanded upward.

The seal remained intact for the duration of the test.

5.3.2 Specimen 21

69.00 The sealant had expanded above the surface of the concrete slab.

149.00 The insulation on the cables had softened and had begun to char around the larger conductors.

210.00 Some of the cable insulation had charred.

The seal remained intact for the duration of the test.

5.3.3 Specimen 22

42.25 There was a vertical differential movement between the concrete each side of the seal estimated to be 25 to 30 mm.

63.00 The vertical differential movement across the seal had increased to approximately 40 to 50 mm.

112.00 The seal had expanded out of the joint and the vertical differential movement between the two concrete slabs was measured at 50 mm.

223.00 The relative differential movement across the seal had increased to 55 mm.

5.4 Insulation

The time to insulation failure of each of the seal systems is shown in Table 1.

Figures 2 to 4 show the time/temperature rise graphs for the maximum temperature rise measured by the thermocouples placed on each specimen.

5.4.1 Specimen 20

The temperature rise exceeded 180 K on the pipe at 25 mm from the floor slab at 30 minutes, on the seal at 214 minutes. The temperature rise did not exceed 180 K on the pipe at 400 mm from the floor slab, on the adjacent concrete or the radiation guard.

5.4.2 Specimen 21

The temperature rise exceeded 180 K on the cables at 25 mm from the floor slab at 171 minutes and on the seal at 235 minutes. The temperature rise did not exceed 180 K on the adjacent concrete.

5.4.3 Specimen 22

The temperature rise did not exceed 180 K on the seal or adjacent concrete for the duration of the test. The peaks shown in Figure 4 are due to flaming from adjacent specimens before they were covered. The thermocouples on the concrete adjacent to the joint were lost during the test but the temperature was monitored by a roving thermocouple and the maximum temperature measured at 241 minutes was 138 °C.

The concrete floor slab clear of the penetrations did not reach the insulation failure criterion for the duration of the test. Figure 5 shows the temperature rise measured on the floor slab.

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
20	248 NF	30 248 NF*
21	248 NF	171
22	248 NF	248 NF

NF = No failure up to the termination of the test at 248 minutes
* Time to insulation failure if the radiation screen was completely surrounding the specimen

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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
20 without screen	-/240/30
20 with screen	-/240/240
21	-/240/120
22	-/240/240

The test standard requires the following statement to be included: "The results only relate to the behaviour of the specimen of the element of construction under the particular conditions of test; they are not intended to be the sole criteria for assessing the potential fire performance of the element in use nor do they reflect the actual behaviour in fires."

7. ATTACHMENTS

Figure	1	Furnace Temperatures
	2	Temperature Rise - Specimen 20
	3	Temperature Rise - Specimen 21
	4	Temperature Rise - Specimen 22
	5	Temperature Rise - Concrete
	6	Ramset Drawings of Specimens 20, 21, 22

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Fig 1 Furnace Temperatures

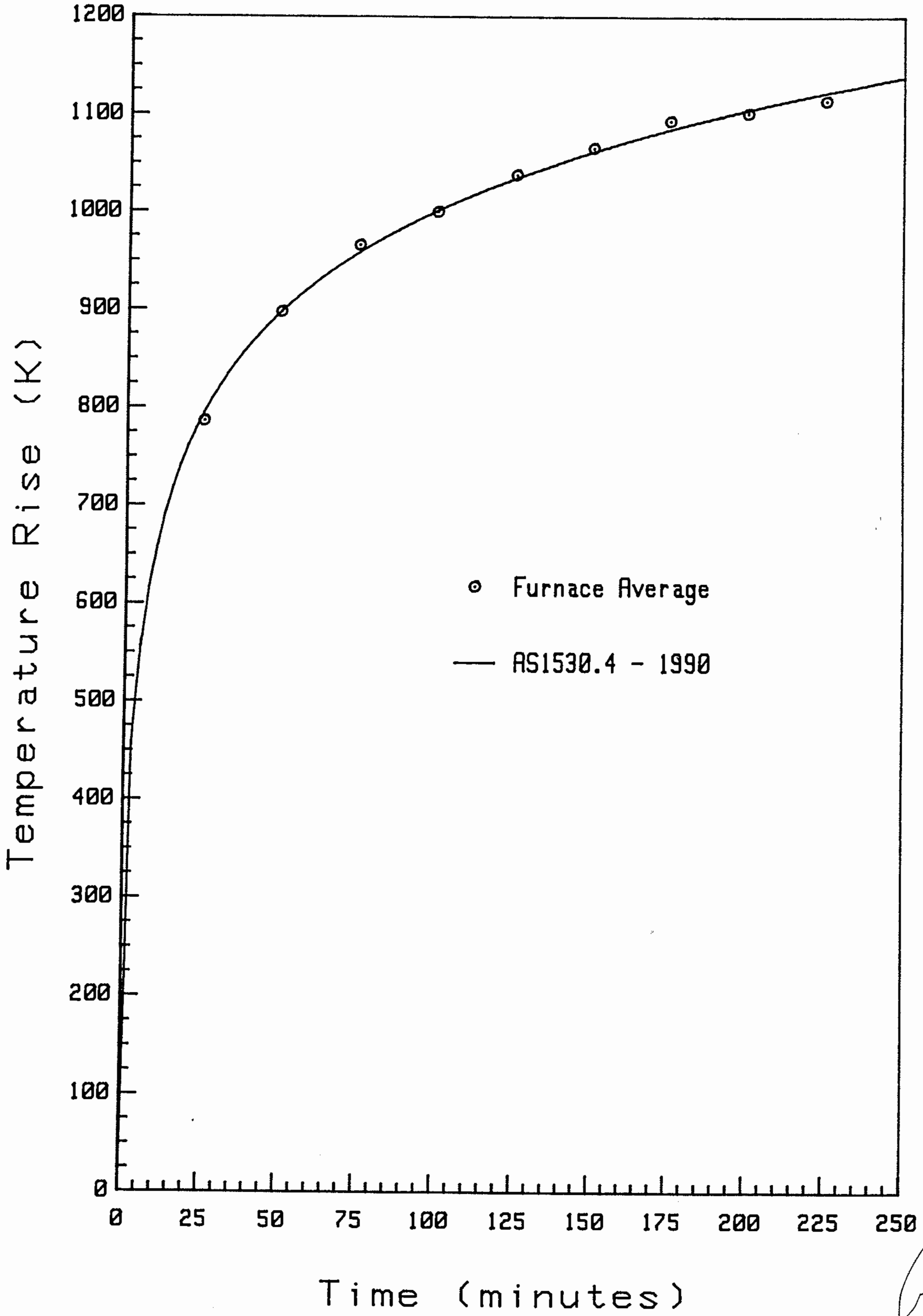

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Fig 2 Temperature Rise - Specimen 20

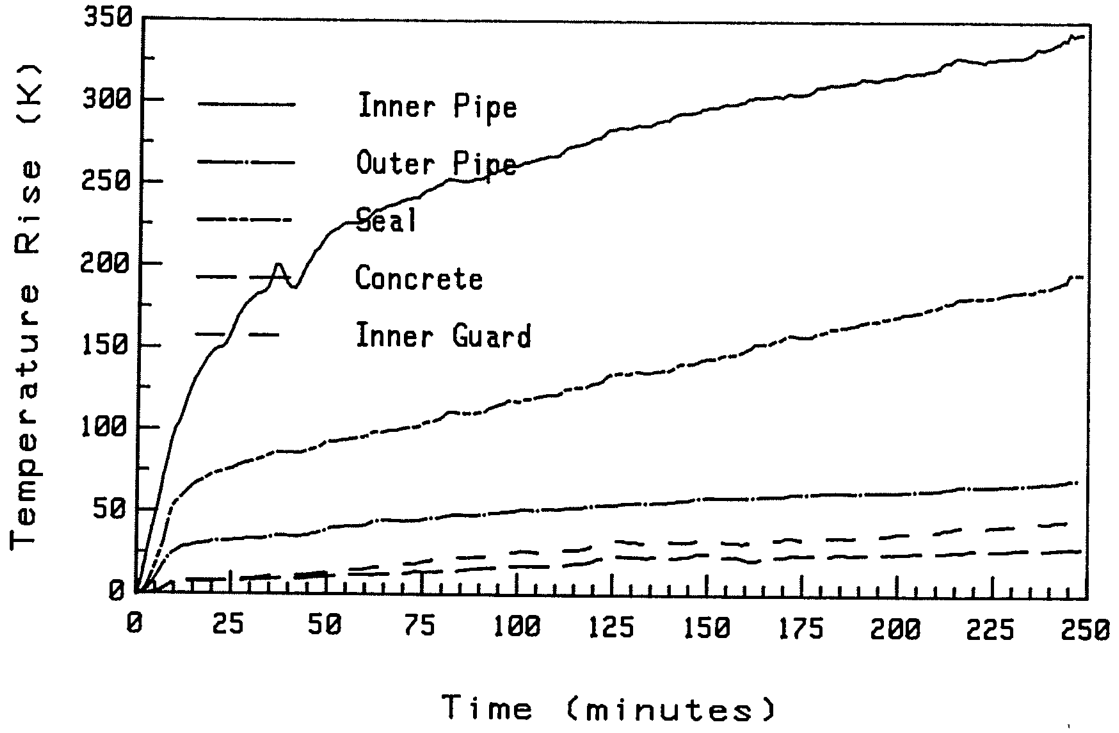

Fig 3 Temperature Rise - Specimen 21

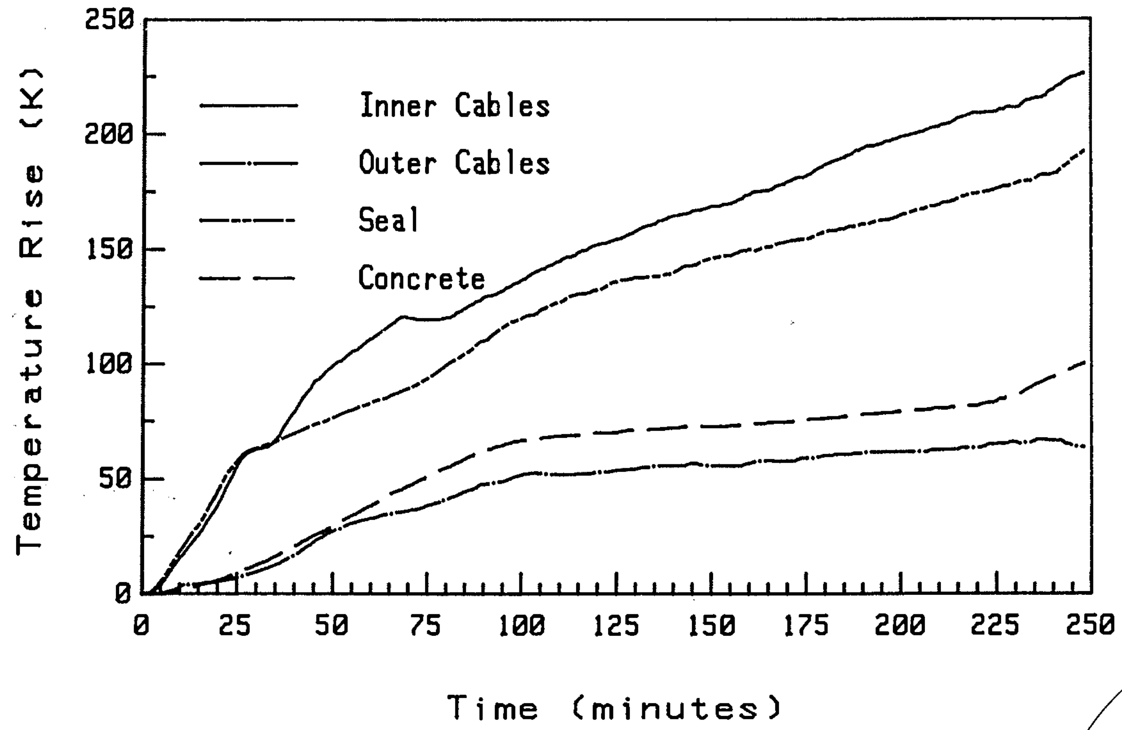

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Fig 4 Temperature Rise - Specimen 22

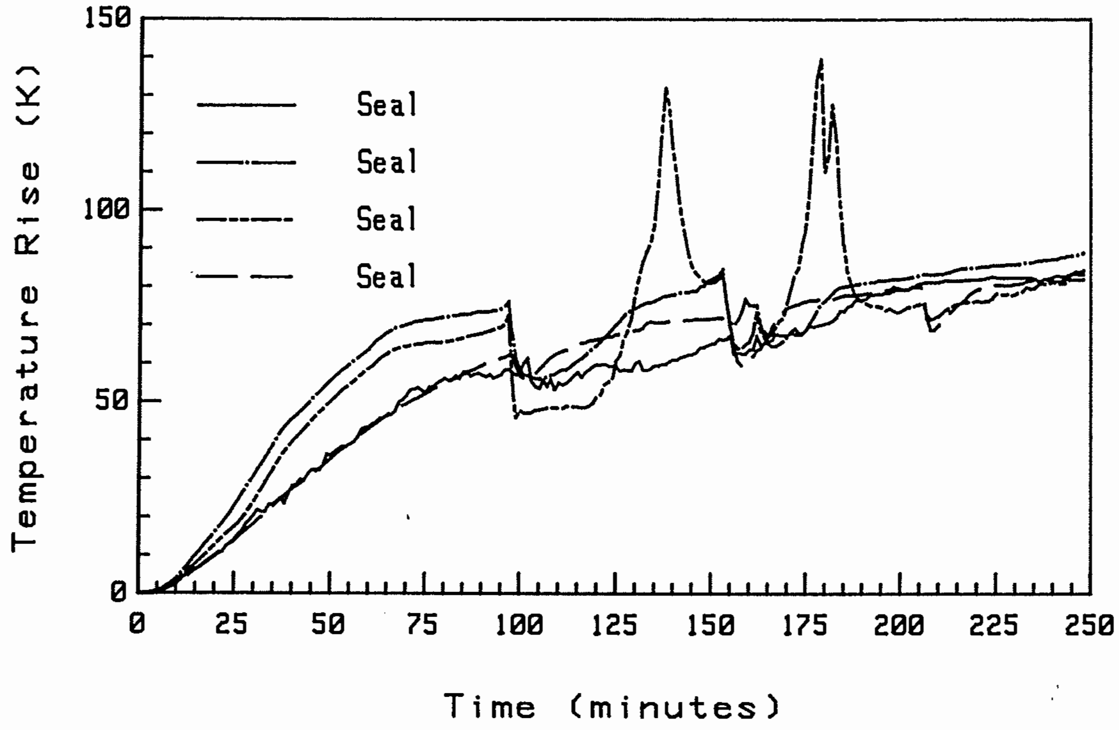


Fig 5 Temperature Rise - Concrete

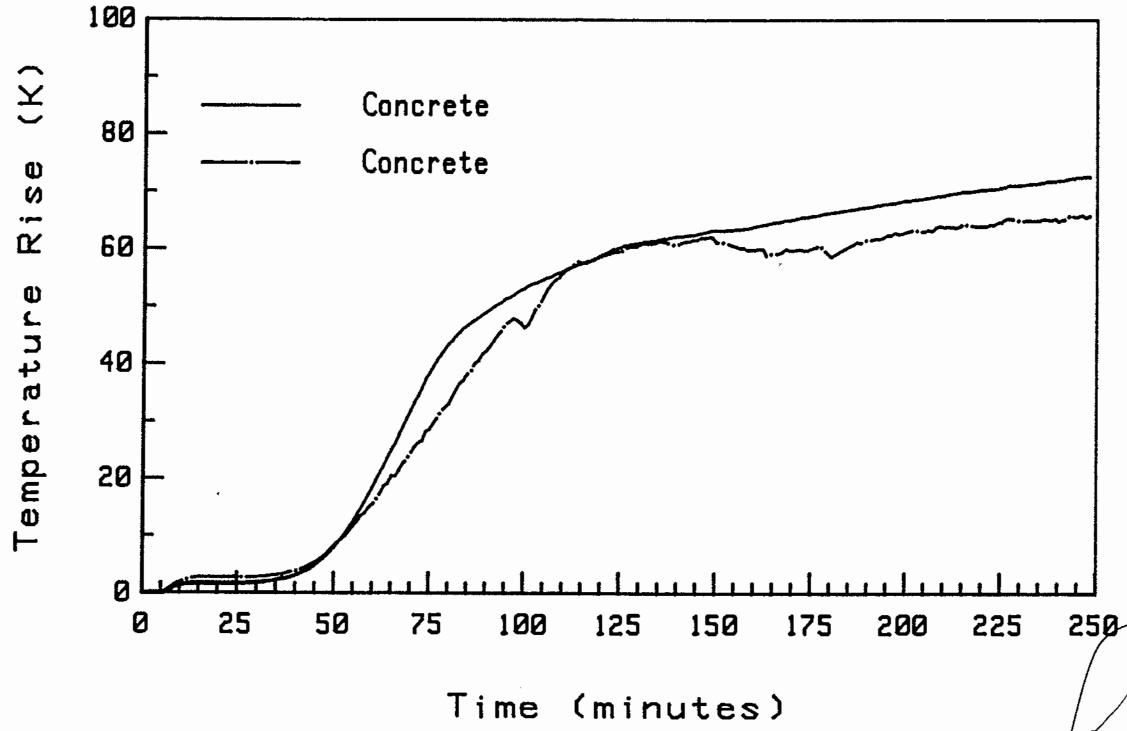
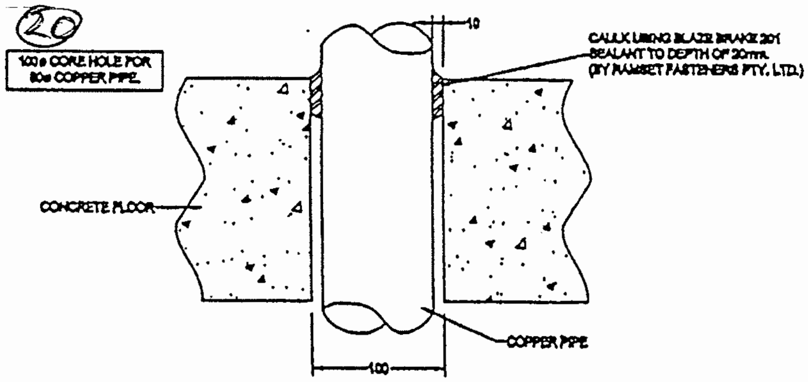
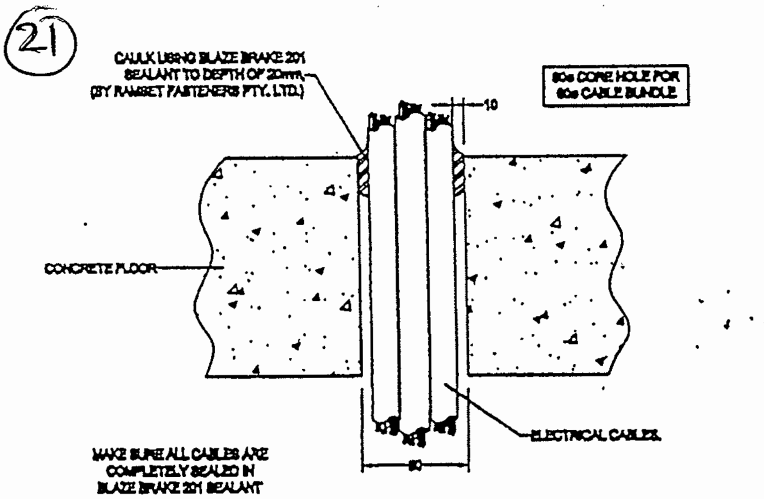


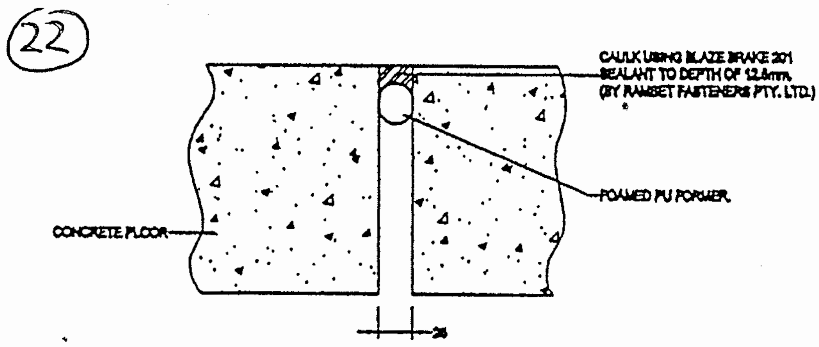
Fig 6 Ramset Drawings of Specimens 20, 21, 22



4 HR. PIPE PENETRATION - CONCRETE FLOOR



4 HR. CABLE PENETRATION - CONCRETE FLOOR



4 HR. CONTROL JOINT - CONCRETE FLOOR

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