FP 4428

Fire Resistance of Pipe and Service Penetrations in a Concrete Floor

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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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   iii. any defects in the Products the subject of the Services; or
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Fire Resistance of Pipe and Service Penetrations in a Concrete Floor

1. CLIENT

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2. TEST SPECIFICATION

The test was conducted in accordance with AS 1530.4-2005 *Fire Resistance tests of elements of building construction*, and AS 4072.1-2005 *Service penetrations and control joints.*

In accordance with the test standard the fire resistance of the specimen is the time, expressed in minutes, before failure under one or more of the following criteria:

2.1 Integrity

Failure shall be deemed to occur when cracks, fissures or other openings develop through which flames or hot gases can pass. Failure occurs;

a) If a gap, crack or fissure develops, which exceeds 6 mm x 150 mm and, allows unobstructed vision into the interior of the furnace from any viewing angle, or a 25 mm gap gauge can be passed through the specimen so that the gauge projects into the furnace; or

b) If flaming on the unexposed surface of the specimen is sustained for longer than 10 seconds; or

c) When flames and/or hot gases cause flaming or glowing of the cotton fibre pad.

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 more than 180K above the initial temperature.

3. DESCRIPTION OF TEST SPECIMEN

3.1 General

The test specimen consisted of a reinforced concrete slab placed above a horizontal 2,200 mm x 1,000 mm pilot furnace to represent a structural concrete floor. Three apertures were cut in the nominal 170 mm thick concrete floor and the pipes, services, seals and collars were installed later. Two apertures were fitted with pipe/service collars grouted within the hole and a single aperture was fitted with a pipe collar on the exposed face.

All pipes and services protruded a minimum of 500 mm into the furnace. Specimen No 1 was a PVC pipe and extended at least 2,000 mm from the unexposed face, specimen No 2 was a floor waste and specimen No 3 contained pre insulated paired copper pipes and cables and projected at least 1,000 mm to the unexposed face of the specimen. All pipes were capped on the exposed ends and were open on the unexposed ends.

The density of the concrete at the time of the fire resistance test was calculated to be: 2,267 kg/m^3. The moisture content of the concrete at the time of the test was calculated to be 3.8%.

A drawing of the layout is included in this report as Figure 8.

3.2 Plans and Specifications

The client supplied a list of the penetration pipe size and sealing system for the fire test. This and other details of the tested specimen are held on confidential file by BRANZ.

3.3 Munson Ring Spacing

Specimen No's 1 and 3 were secured using Munson ring pipe clips supported by a steel framework. The following table details the distance of the Munson ring from the concrete floor for each specimen.

Munson Ring Location measured from face of slab (mm)		
Specimen	1st	2nd
1	650	1520
3	670	-

3.4 Sealing Systems

3.4.1 Type A Prototype Collar 175 mm ID

The collar assembly was fabricated from 0.95 mm thick galvanised steel pressed and formed into a circular collar assembly measuring a nominal 200 mm outside diameter (Ø) x 115 mm height. A folded lip was formed around the top and bottom of the perimeter of the collar turned inwards and measuring 11.8 mm.

The collar comprised four folded "spring" pockets formed and located around the perimeter at 90° from each other. Each pocket contained a 3.95 mm Ø stainless steel wire spring formed with five turns and two straight legs. The overall length of the spring mechanism measured 104 mm. The spring was tensioned by closing the legs such that

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they lay parallel with each other and the spring mechanism was held in the tension mode by a nylon thermal link across the ends of the spring legs. The spring was secured within the folded pocket by an M5 threaded machine screw. The installation of the spring mechanism was such that the spring was fitted with the parallel legs hanging downwards, with the machine screw through the centre of the rolled spring section.

An adjustable 2 mm thick 25 mm wide galvanised steel angle bracket measuring 64 mm x 19 mm with pre formed slots and holes for fastening and adjustment was located on the flat outer face of each spring pocket. The angle bracket facilitated securing the collar assembly to the separating element or, in the case of this test, the timber shuttering at the bottom of the concrete slab.

The formed collar assembly was secured into the circular shape with two self tapping screws at the top and bottom of the collar and into a measured 14.6 mm overlap of one edge of the formed collar body.

A single layer of INTUMESH intumescent measuring 6 mm thick x 110 mm deep with a layer of stainless steel fine mesh measuring 0.25 mm thick stapled to one face was rolled up and inserted into the collar body. The intumescent was overlapped and stapled together to form a tube.

Sandwiched between the intumescent and the inner folded upper lip of the collar body was a ring formed from 0.6 mm thick electro-galvanised steel with an internal diameter of 161 mm. Any gaps located around the galvanised steel body of the collar was filled with acrylic sealant and cloth tape was applied across the open top of each spring pocket.

3.4.2 Type B Prototype Collar 118 mm ID

The smaller prototype collar was manufactured in a similar style as the type A collar except that only three equally spaced spring pockets were located around the perimeter of the collar assembly.

The following lists the major dimensions for the type B collar assembly.

Outside diameter (OD)	140 mm
Height:	56.5 mm
Lip Return:	12 mm
Spring leg length:	53 mm
Angle Bracket:	16 mm wide with leg lengths 19 mm x 32 mm
Intumescent:	INTUMESH, a single layer of 6.5 mm thick x 50 mm with 0.25 mm thick fine stainless steel mesh at both the inner and outer face of the intumescent tube.

The collar was not fitted with the ring as described for the type A collar, nor were the gaps in the collar body sealed up with intumescent sealant or cloth tape.

3.4.3 Intumescent Sealant

Unless otherwise stated all acrylic sealant referred to is Trafalgar FyreFlex$_{TM}$ Fire Resistant Sealant.

3.5 Specimen Descriptions

Specimen 1 and 3 comprised the prototype type A collar with the penetrating service, the collar was installed in the following manner in each instance.

Each hole in the floor slab was core drilled to 330 mm diameter and the type A collar was centrally located within the hole and secured to the timber floor shuttering. A short section of 160 mm diameter (Ø) PVC DWV tube was inserted into the collar such that it projected above the slab and perpendicular to the face of the slab. The penetration was then grouted with the concrete flush with the top face of the slab. After curing a raised grouted section was formed across half of the penetration measuring 25 mm high. Once the grouted collar was fully cured the short section of PVC DWV pipe was removed along with the timber shuttering to facilitate installation of the pipe and or service specimens.

3.5.1 Specimen 1

Pipe:	Iplex Novodrain 4000 DN150
Material:	PVC DWV
Measured Size:	160 mm OD x 4.3 mm average wall thickness
Seal Type:	Type A prototype collar
Penetration Size:	330 mm diameter
Sealant:	The annular space between the pipe and the penetration was filled with FyreFlex$_{TM}$ sealant at the exposed face.

The exposed section of the specimen comprised two DN150 PVC DWV 90° elbows secured end to end with the socket of the top elbow inserted into the collar. See Figure 7 for cross sectional view of the specimen.

3.5.2 Specimen 2

Specimen No 2 consisted of an Allproof floor waste manufactured from ABS plastic with major dimensions of 98 mm ID x 59 mm high. The ABS plastic grate measured an average of 10.5 mm thick. The floor grate was glued to a short length of Iplex Novodrain DN100 PVC DWV measuring 111 mm OD x 3.2 mm average wall thickness. The type B collar was secured at the exposed face of the concrete slab with a single Hilti® DB2 6/4.5 wedge anchor at each angle bracket. The size of the penetration was 116 mm Ø.

3.5.3 Specimen 3

The specimen consisted of eight lengths of pre insulated paired copper refrigeration tube each pair comprising copper tubes measuring 9.52 OD x 0.81 mm wall thickness and 15.88 mm OD x 1.02 mm wall thickness. Each set of copper paired tubes were located within an single section of figure of eight pipe insulation consisting of closed cell polyethylene with an outer shield of embossed P.E film. The nominal insulation wall thickness measured 10 mm. Four lengths of standard extension power cable were included in the specimen assembly. The pipes and power cables were inserted through the type A collar such that 500 mm projected into the furnace and at least 1,000 mm projected on the unexposed face.

4. TEST PROCEDURE

4.1 General

The specimen was tested on the 19 March 2010 at BRANZ laboratories, Judgeford, New Zealand, in the presence of a representative of the client. The ambient temperature at the beginning of the test was 17°C.

The concrete floor slab containing the specimens was placed on top of the horizontal 2,200 mm x 1,000 mm furnace and the temperature and pressure conditions were controlled to the limits defined in AS 1530.4-2005.

4.2 Furnace Temperature Measurement

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

4.3 Specimen Temperature Measurement

To monitor heat conduction through the sealing systems, 35 chromel-alumel thermocouples were attached to the specimens. The arrangement consisted of thermocouples placed as specified in clause 10.5 of the test standard AS 1530.4-2005.

For specimen No's 1 and 3 thermocouples were placed on the unexposed surface of the concrete floor slab at 25 mm from the edge of the penetration on the grout infill level with the floor and on the stepped section 25 mm from the pipe and from the edge of the penetration and on the pipes at 25 mm from the surface of the grout level with the floor and the stepped section. For specimen No 2, two thermocouples were placed on the concrete floor 25 mm from the penetration and central to the floor grate. Two additional thermocouples were placed on the unexposed surface of the wall clear of any of the penetrations.

4.4 Temperature Recording

All the thermocouples described in sections 4.2 and 4.3 were connected to a computer controlled data acquisition system which recorded the temperatures at 15 second intervals.

4.5 Pressure Measurement

The differential pressure was controlled to be not greater than 20 Pa at 100 mm below the concrete slab. The differential pressure was monitored using a micromanometer connected to a computer controlled data acquisition system which recorded the pressure at 15 second intervals.

Figure 3 shows the recorded furnace pressure.

5. RESULTS

5.1 Duration

The test was terminated after the specimen had been exposed to the standard fire resistance conditions for 245 minutes.

5.2 Furnace Temperature

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

Figure 2 shows the percentage deviation of the mean furnace temperature from the standard curve.

In summary the furnace conditions complied with the test standard.

5.3 Integrity

Specimen No 3 failed the integrity criteria after 166 minutes due to flaming in excess of 10 seconds being emitted from the bundle of “P coil” copper pipes. Specimen No’s 1 and 2 did not fail the integrity criteria for the duration of the test.

5.4 Insulation

Specimen No 3 failed the insulated criteria after 2 minutes on the bundle of pipes 25 mm from the surface of the raised grouted section.

None of the remaining specimens failed the insulation criteria for the 245 minute duration of the test.

The maximum temperature rise achieved by either of the two thermocouples located clear of the penetrations on the slab was 98 K.

Graphs displaying the maximum temperature rise for each specimen are included as Figures 4 – 6.

5.5 Observations

Significant observations related to the integrity performance of the specimens were as follows at the times stated in minutes and seconds. All observations are from the unexposed face unless otherwise stated.

Min : Sec

0:21 Black smoke was being emitted from the end of the pipe of specimen No 3.

1:34 The pipes of specimen No 3 moved suddenly indicating that the springs in the collar had deployed.

1:54 Smoke was being emitted through the floor grate of specimen No 2.

2:50 There was a reduction in the volume of smoke being emitted from the end of the pipe of specimen No 2. Glowing was evident within the grate of specimen No 2. A cotton pad was applied with no failure recorded. There was also a reduction in the volume of smoke being emitted from around the pipes of specimen No 3.

3:30 A loud noise was emitted from the location of the collar of specimen No 3 indicating that a further spring had activated.

4:15 Black smoke was being emitted in a steady stream from the end of the pipe of specimen No 1.

4:59 Smoke had virtually ceased to be emitted from specimen No 2. The grating of the PVC floor waste had distorted slightly.

5:20 There was a steady stream of smoke being emitted from the end of the pipe of specimen No 1.

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5:40 The pipe of specimen No 1 had started to distort and soften where it exited the slab. The weight of the unexposed pipe was causing the pliable section to deform with the pipe sinking down onto the slab. The pipe was sliding through the munson rings in the process.

6:39 On specimen No 1 the pipe had slipped through the munson ring and sunk onto the slab where the pipe exited the slab. The pipe was very badly deformed over a length of approximately 150-200 mm. The plastic section had collapsed into and around this area but no gaps in the pipe wall could be observed.

7:12 There was a great reduction in the volume of smoke being emitted from the end of the pipe of specimen No 1.

65:48 Smoke was being emitted from between the insulated copper pipes of specimen No 3 from where they were secured to the framework, 670 mm above the slab.

1137:24 Glowing could be observed from between the copper pipes of specimen No 3 where they exit the slab.

135:20 A cotton pad test was applied to the grating of specimen No 2. Smoke was being emitted from the waste grate and the grating appeared to have distorted further.

166:20 Flaming in excess of 10 seconds occurred from specimen No 3. **This was deemed to be a failure of Integrity according to the test standard.**

175:44 The floor waste of specimen No 2 had distorted further.

177:30 A cotton pad test was applied to specimen No 2 with no failure recorded.

Test was terminated after 245 minutes

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6. SUMMARY

The fire resistance in minutes, in accordance with AS 1530.4-2005 and AS 4072.1-2005, of three penetrations and their sealing systems in a 170 mm thick concrete floor slab, was as follows:

Specimen No 1

A 150 mm PVC DWV pipe with two 90° elbows installed in series at the exposed face with the socket of one of the elbows inserted within the 175 mm ID type A collar that was grouted into the floor with the base flush with the exposed face. The hole in the slab measuring 330 mm diameter and back grouted flush to the surface of the slab. A 25 mm raised grouted area was installed over one half of the penetration.

Integrity: 245 minutes NF

Insulation: 245 minutes NF

Specimen No 2

A plastic ABS floor grate fitted to a 100 mm PVC DWV pipe fitted with a 118 mm ID type B collar installed at the exposed face. The hole in the floor measuring 116 mm diameter.

Integrity: 245 minutes NF

Insulation: 245 minutes NF

Specimen No 3

Eight lengths of pre insulated paired copper refrigeration tube measuring 9.52 mm Ø x 0.8 mm and 15.88 mm Ø x 1.0 mm the insulation comprising closed cell polyethylene with an outer shield of embossed P.E film. Also included were four lengths of standard extension cable. All services were inserted through a 175 mm ID type A collar grouted into the floor with the base flush with the exposed face. The hole in the slab measuring 330 mm diameter and back grouted flush to the surface of the slab. A 25 mm raised grouted area was installed over one half of the penetration.

Integrity: 166 minutes

Insulation: 2 minutes

NF = no failure for the duration of the test

The test standard requires the following statements 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."

"This report details methods of construction, the test conditions and results obtained when the specific element of construction described herein was tested following the procedure outlined in this standard. Any significant variations 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 covered by this report.

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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7. PERMISSIBLE VARIATIONS

As specified in section 10.11 of AS 1530.4 -2005 as applicable to this test specimen.

Separating Element

The results for the sealing systems may be applied to concrete with a density within ±15% of 2,267 kg/m³ (Test slab density).

Slab Thickness

The test results may be directly applied to concrete elements thicker than the tested prototype when installed in accordance with Figure 10.11.5 of AS 1530.4-2005.

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 as discussed in this report.

8. ATTACHMENTS

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Figure 1 Furnace Temperature

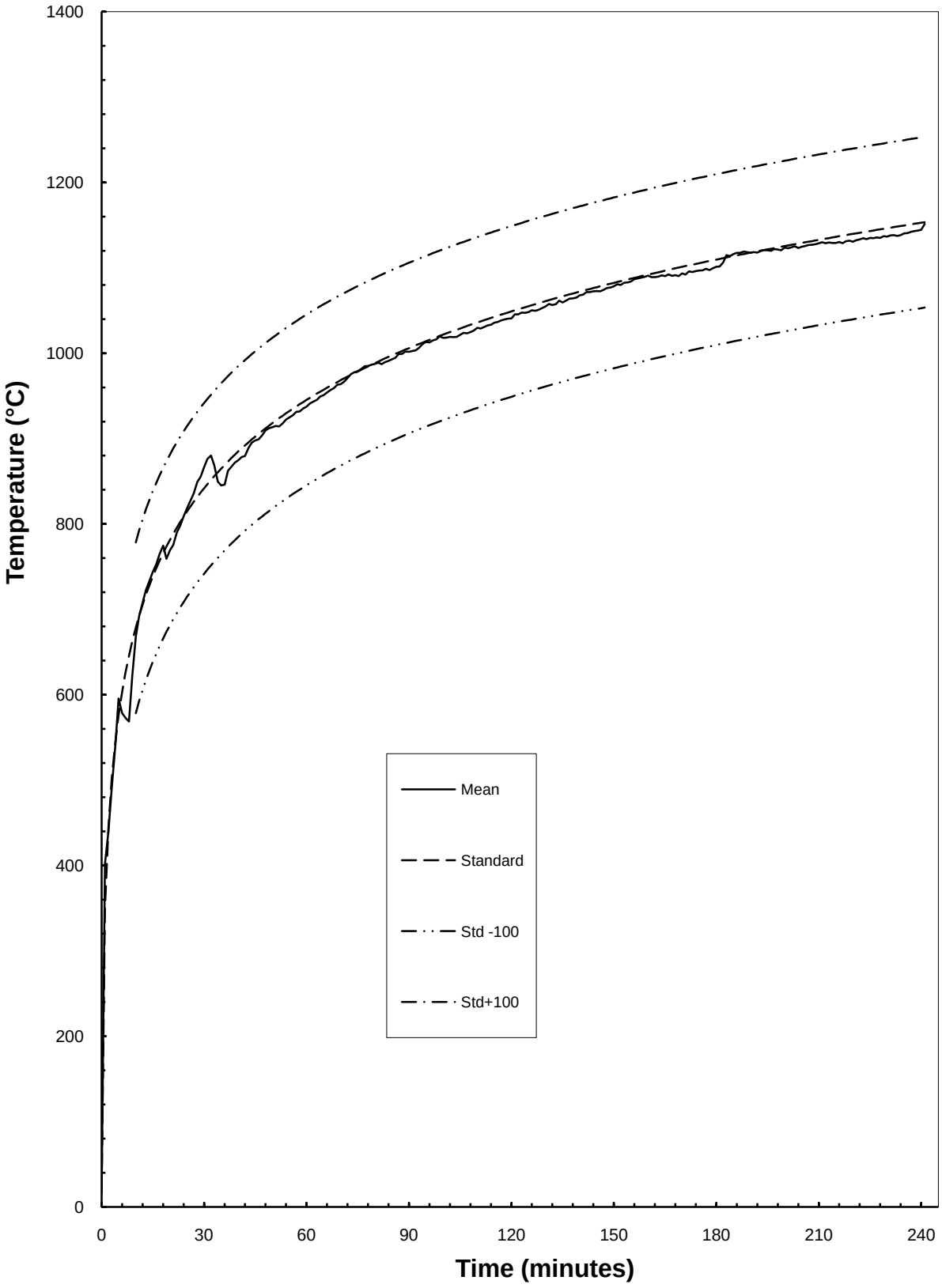

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Figure 2 Furnace Accuracy of Control

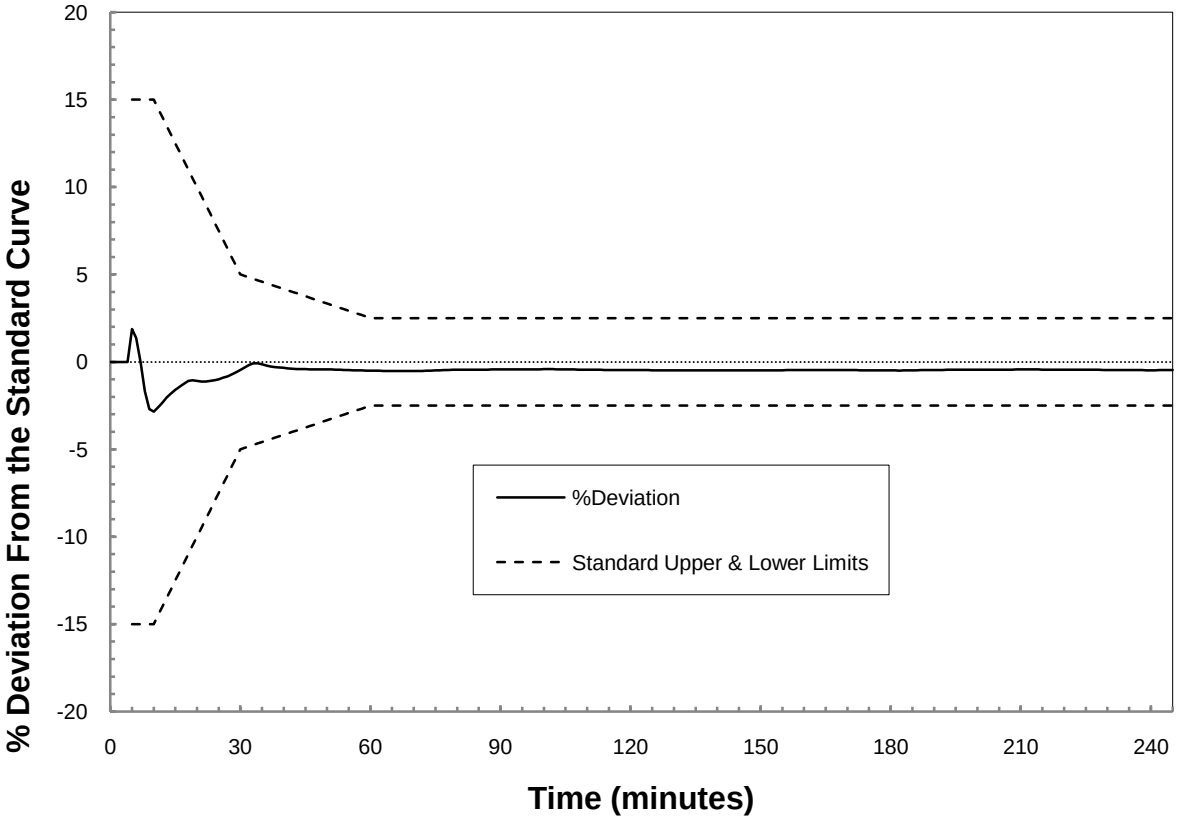

Figure 3 Furnace Pressure

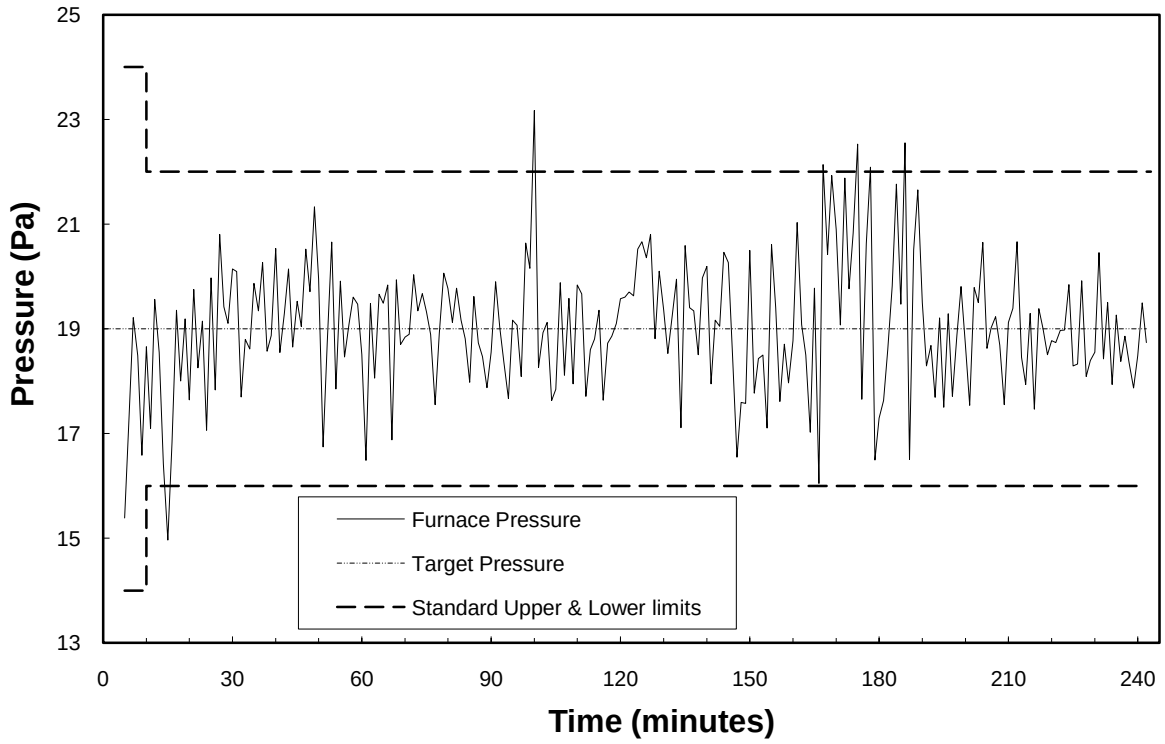

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Figure 4 Specimen 1 Maximum Temperature Rise

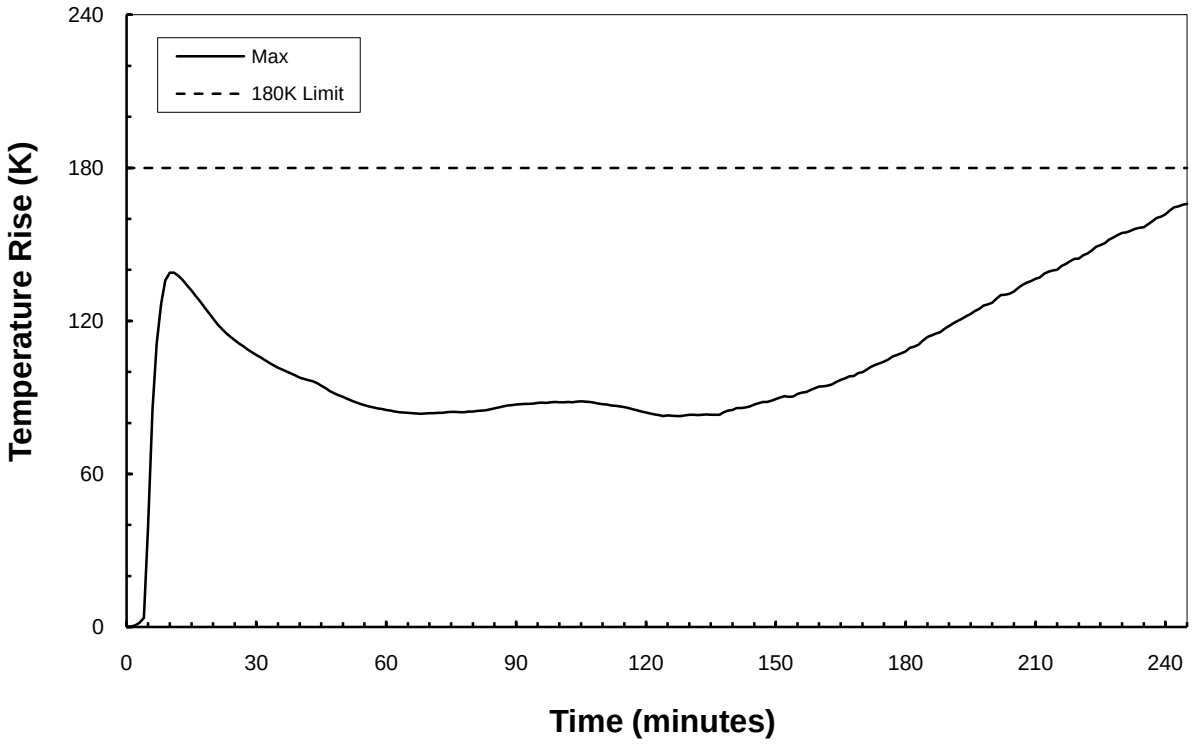

Figure 5 Specimen 2 Maximum Temperature Rise

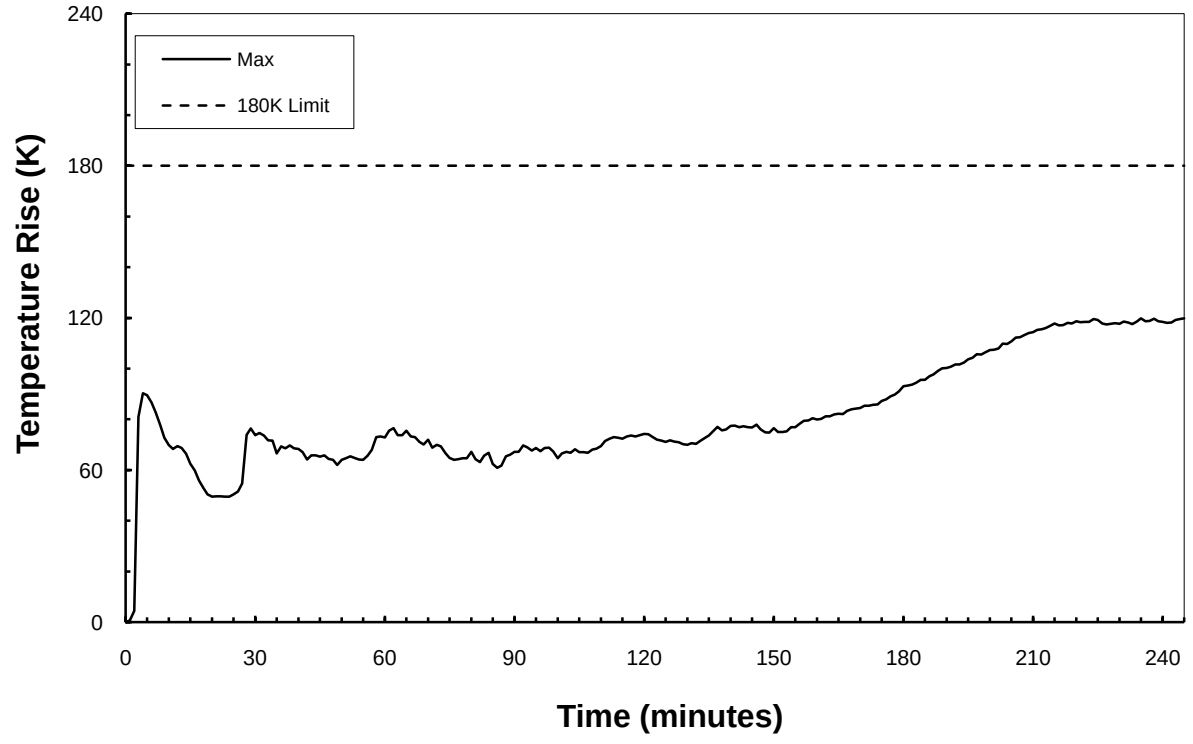

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Figure 6 Specimen 3 Maximum Temperature Rise

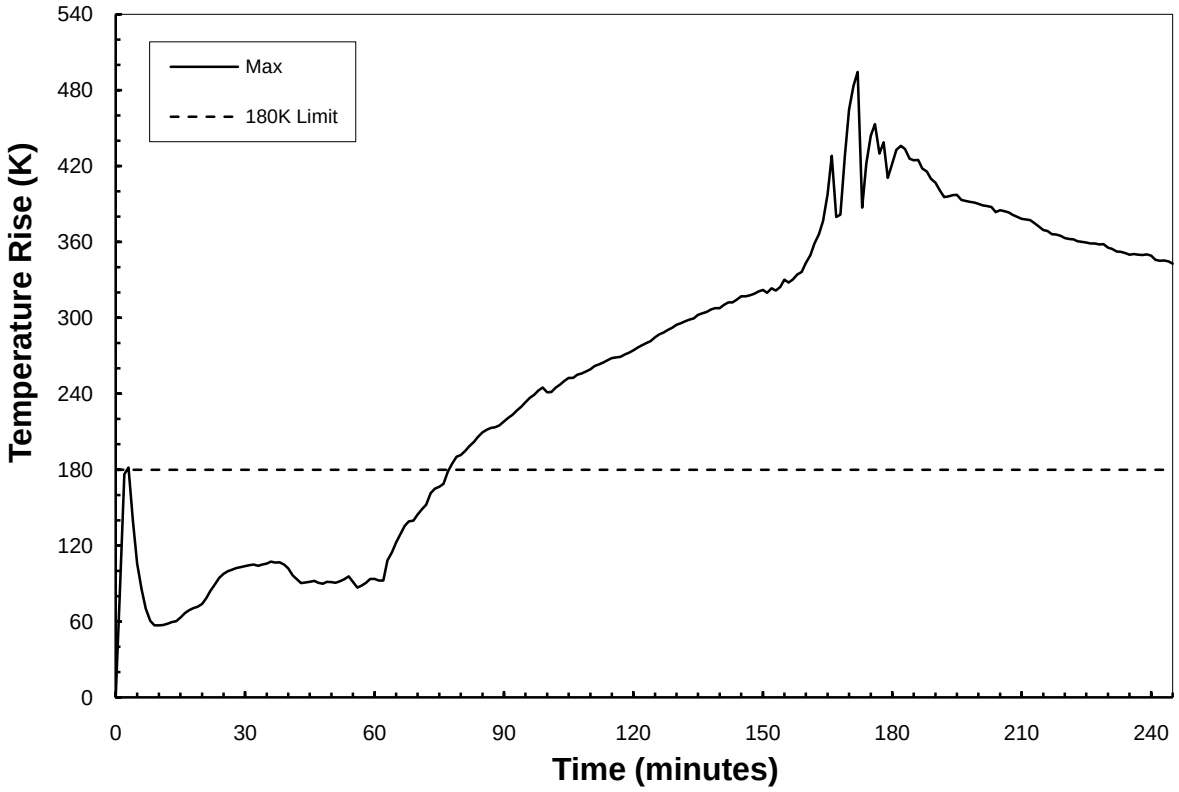

Figure 7 Cross Sectional View of Specimen No 1

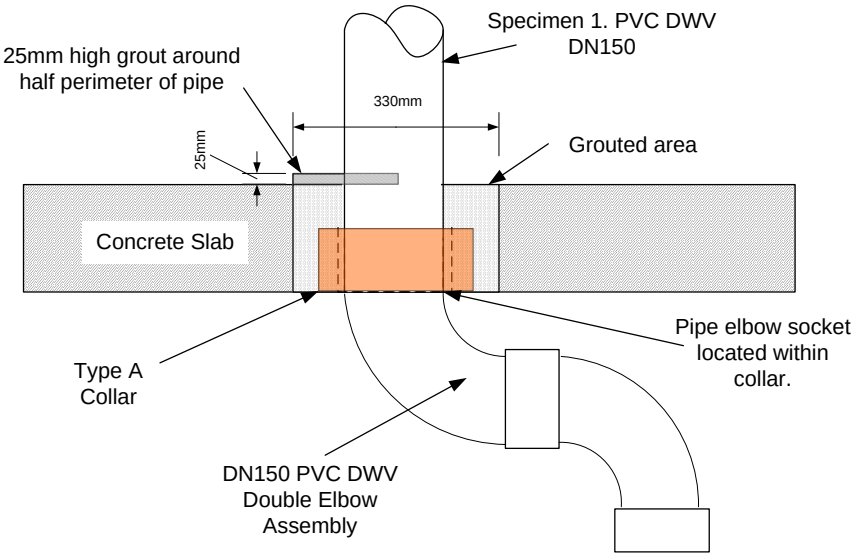

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Figure 8 Specimen Layout

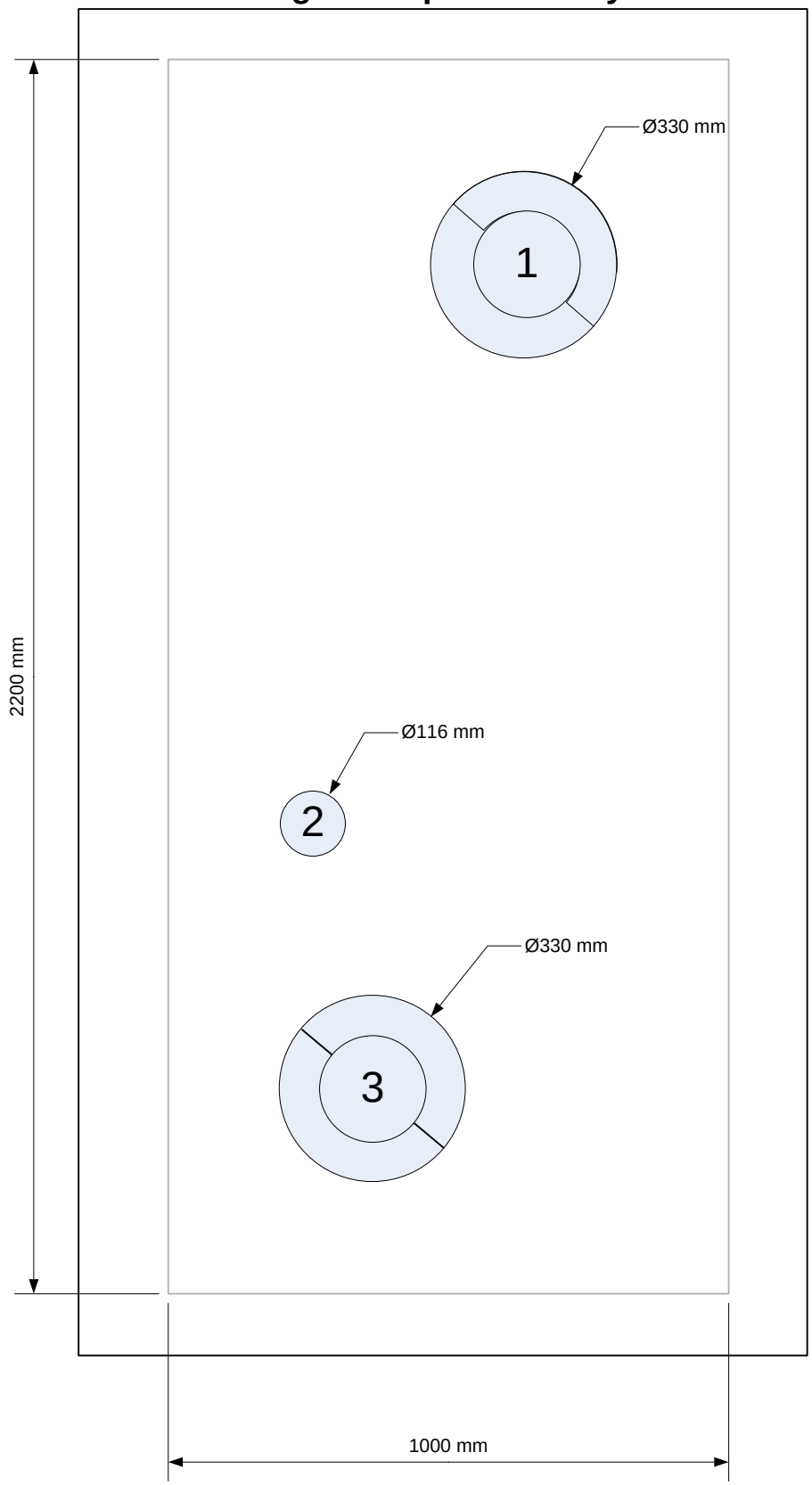

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Figure 9 Specimen Photographs

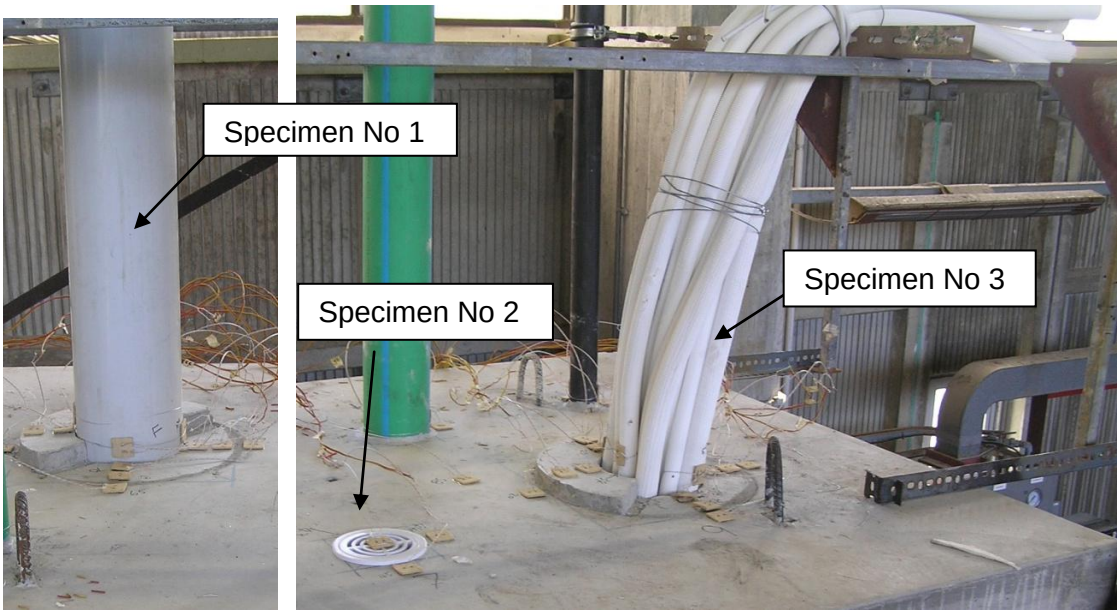

Figure 10 Specimen No 1 Exposed Face

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