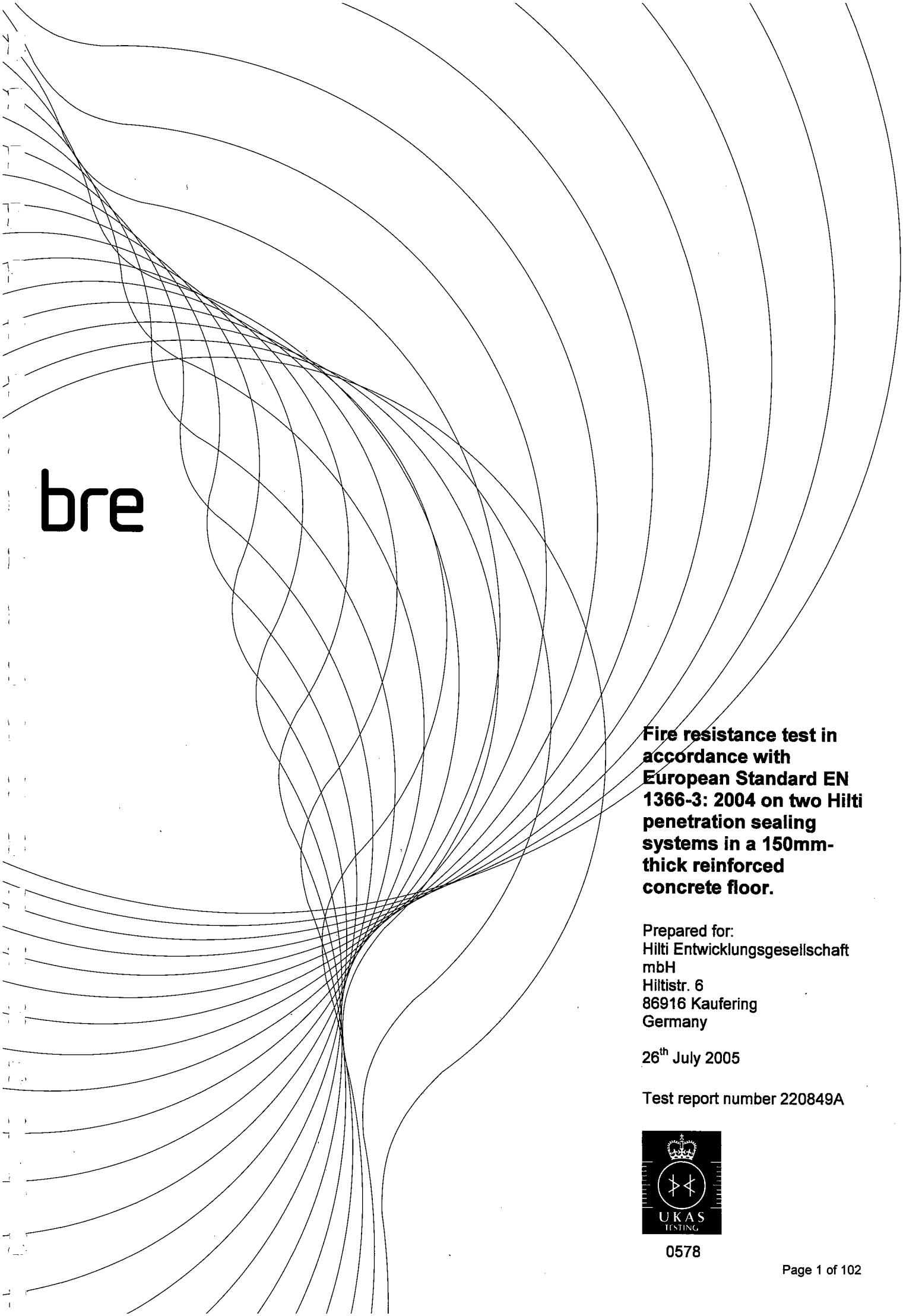

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Fire resistance test in accordance with European Standard EN 1366-3: 2004 on two Hilti penetration sealing systems in a 150mm-thick reinforced concrete floor.

Prepared for:
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26th July 2005

Test report number 220849A

UKAS TESTING

0578

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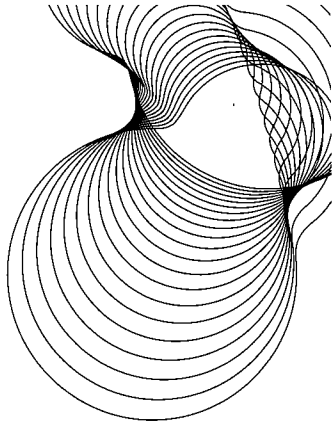

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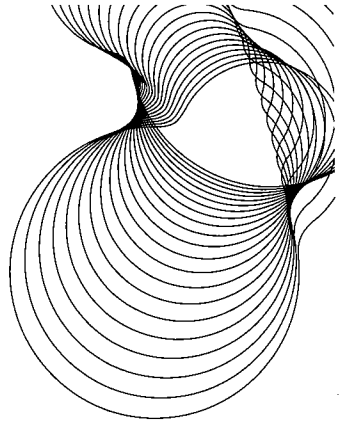

Summary

A fire resistance test in accordance with European Standard EN 1366-3: 2004[1] was carried out on Wednesday 13th April 2005 on two penetration sealing systems, referenced A and B when installed in a 150mm-thick reinforced concrete floor. The test was continued for a duration of 97 minutes.

Sealing system A, comprised a variety of PVC and PE plastic pipes, copper and steel pipes and a number of cables strapped to galvanised steel cables trays, passing through an aperture in a concrete floor, 2200mm long x 600mm wide and sealed with a single horizontal layer of Hilti CP 670 Fire Safety Board system, 50mm thick, coated on both faces with CP 670 Fire Safety Coating, 0.7mm thick.

Sealing system B, comprised a variety of PVC and PE plastic pipes, copper and steel pipes and a number of cables strapped to galvanised steel cables trays, passing through an aperture in a concrete floor, 2100mm long x 1200mm wide, and sealed with a double horizontal layer of Hilti CP 670 Fire Safety Board system, 50mm thick, coated on both faces with CP 670 Fire Safety Coating, 0.7mm thick.

The individual penetration sealing systems achieved the following fire resistance periods, expressed in complete minutes:

Sealing system A (single board layer)

"Integrity:	- Sustained flaming:	65 minutes;
	- Cotton pad:	65 minutes;
	- Gap gauge:	97 minutes;
Insulation:		60 minutes."

Sealing system B (double board layer)

"Integrity:	- Sustained flaming:	75 minutes;
	- Cotton pad:	75 minutes;
	- Gap gauge:	97 minutes;
Insulation:		75 minutes."

A further twelve individual penetrations were included in the test, but are not the subject of this report.

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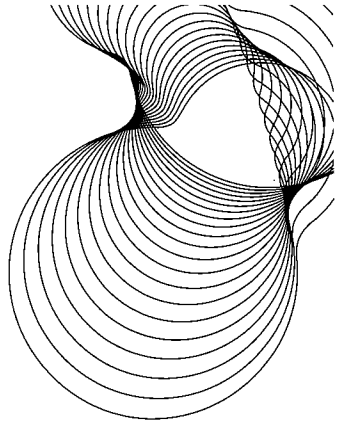

1 Objective

To determine, at the request of Hilti Entwicklungsgesellschaft mbH, the fire resistance of two penetration sealing systems, referenced A and B, installed in apertures within a 150mm-thick reinforced concrete floor, when subjected to a fire resistance test in accordance with European Standard EN 1366-3: 2004[1].

2 Test construction

2.1 General

Installation of the sealing system took place between Monday 7th and Friday 18th March 2005. **The concrete floor was supplied by the sponsor and stated to have been conditioned for a period in excess of one month prior to test.**

A floor, nominally 4500mm long x 3500mm wide x 150mm thick, comprising three concrete slabs of reinforced concrete, A (3440mm long x 1350mm wide), B (3440mm long x 1800mm wide) and C (3440mm x 1320mm), was built into a horizontal concrete lined reinforced test frame. Slabs A and B had nominally central penetrations (apertures) measuring 600mm wide x 2200mm long and 1200mm wide x 2100mm long respectively (see Figure 1). The installed system in slab A is referenced Sealing system A and system in slab B is referenced sealing system B. Slab C is not covered by this report. The overall aperture of the test frame, to be exposed to the furnace conditions, measured 4170mm long x 3500mm wide.

Slabs A and C were partially supported at the ends of the test frame (150mm overlap) and additionally supported with mild steel angle, which was fixed to both the long edges of the test frame. Slab section B was simply supported across the width of the test frame by the mild steel angle. During installation, ceramic blanket was fitted between the slabs to form a seal, and over the mild steel angle to provide insulation during the test.

Various penetrating services were installed vertically through the floor and the penetration openings through slabs A and B sealed with a single (seal A) and a double (seal B) horizontal layer of mineral wool board, 50mm thick, fixed flush with the unexposed side of the floor.

2.2 Penetrating services

Systems A and B included a variety of services, as chosen by the sponsor, to represent a range of plastic pipes, steel pipes, copper pipes, and electrical cables attached to cables trays.

The following, listed in Table 1 below, shows a list of services installed through penetration seal A, ***single board layer:***

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Table 1 Sealing system A services

Service	Description	Additional
Cable tray	500mm wide x 60mm deep (number 1).	* including a cable configuration 3 x b(1, 2 and 3) .
Cable tray	300mm wide x 60mm deep (number 1).	* including a cable configuration of 1 x a, 1 x c and 1 x g.
Cable tray	300mm wide x 60mm deep (number 2).	* including a cable configuration of 1 x b(4) and 5 x e.
Flammable Pipe	PVC-U pipe 32mmØ x 1.8mm thick.	** Hilti collar CP 643 N-50/1.5".
Flammable Pipe	PVC-U pipe 110mmØ x 3.2mm thick.	** Hilti collar CP 643 N-110/4".
Flammable Pipe	PVC-U pipe 110mmØ x 8.2mm thick.	** Hilti collar CP 643 N-110/4".
Flammable Pipe	PE pipe 32mmØ x 1.8mm thick.	** Hilti collar CP 643 N-50/1.5".
Flammable Pipe	PE pipe 110mmØ x 2.2mm thick.	** Hilti collar CP 643 N-110/4".
Flammable Pipe	PE pipe 110mmØ x 10mm thick.	** Hilti collar CP 643 N-110/4".
Non flammable Pipe	Steel pipe 42.4mmØ x 2.6mm thick.	*** insulated with 40mm-thick non-combustible classified mineral wool of 40-50kg/m³ nominal density.
Non flammable Pipe	Steel pipe 168.3mmØ x 4.5mm thick.	**** insulated with 40mm-thick non-combustible classified mineral wool of 40-50kg/m³ nominal density.
Non flammable Pipe	Steel pipe 168.3mmØ x 14.2mm thick.	**** insulated with 40mm-thick non-combustible classified mineral wool of 40-50kg/m³ nominal density.
Non flammable Pipe	Copper pipe 28.1mmØ x 1mm thick.	*** insulated with 40mm-thick non-combustible classified mineral wool of 40-50kg/m³ nominal density.
Non flammable Pipe	Copper pipe 88.9mmØ x 2mm thick.	*** insulated with 40mm-thick non-combustible classified mineral wool of 40-50kg/m³ nominal density.
Non flammable Pipe	Copper pipe 88.9mmØ x 2.5mm thick.	*** insulated with 40mm-thick non-combustible classified mineral wool of 40-50kg/m³ nominal density.

* = See Table 3 for cable descriptions.

** = fixed to the exposed face (underside) of the penetration seal with M8 threaded passing through the seal and secured on the unexposed face with washers and nuts.

*** = Heizungsrohrschale 800 pre-fabricated mineral wool laggings, 500mm length on the exposed face and 1000mm length on the unexposed face.

**** = Klimarock mineral wool coil ware, 500mm length on the exposed face and 1000mm length on the unexposed face.

Details of the location of the services installed in seal A are shown Figure 2.

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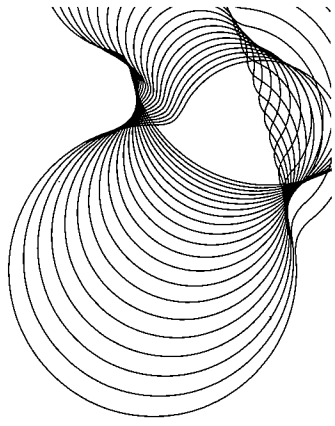

The following, listed in Table 2 below, shows a list of services installed through penetration seal B, ***double board layer:***

Table 2 Sealing system B services

Service	Description	Additional
Cable tray	500mm wide x 60mm deep (number 1).	* including a cable configuration 3 x b(1, 2 and 3).
Cable tray	500mm wide x 60mm deep (number 2).	* including a cable configuration of 1 x a, 1 x c and 1 x g.
Cable tray	500mm wide x 60mm deep (number 3).	* including a cable configuration of 1 x b(6) and 5 x e.
Cable tray	100mm x 60mm deep (number 1).	* including a cable configuration of 1 x b(4).
Cable tray	100mm x 60mm deep (number 2).	* including a cable configuration of 1 x b(5).
Flammable Pipe	PVC-U pipe 32mmØ x 1.8mm thick.	** Hilti collar CP 643 N-50/1.5".
Flammable Pipe	PVC-U pipe 160mmØ x 3.2mm thick.	** Hilti collar CP 643 N-160/6".
Flammable Pipe	PVC-U pipe 160mmØ x 11.9mm thick.	** Hilti collar CP 643 N-160/6".
Flammable Pipe	PE pipe 32mmØ x 1.8mm thick.	** Hilti collar CP 643 N-50/1.5".
Flammable Pipe	PE pipe 160mmØ x 4mm thick.	** Hilti collar CP 643 N-160/6".
Flammable Pipe	PE pipe 160mmØ x 14.6mm thick.	** Hilti collar CP 643 N-160/6".
Non flammable Pipe	Steel pipe 42.4mmØ x 2.6mm thick.	*** insulated with 40mm-thick non-combustible classified mineral wool of 40-50kg/m³ nominal density.
Non flammable Pipe	Steel pipe 168.3mmØ x 4.5mm thick.	**** insulated with 40mm-thick non-combustible classified mineral wool of 40-50kg/m³ nominal density.
Non flammable Pipe	Steel pipe 168.3mmØ x 14.2mm thick.	**** insulated with 40mm-thick non-combustible classified mineral wool of 40-50kg/m³ nominal density.
Non flammable Pipe	Copper pipe 28.1mmØ x 1mm thick.	*** insulated with 40mm-thick non-combustible classified mineral wool of 40-50kg/m³ nominal density.
Non flammable Pipe	Copper pipe 88.9mmØ x 2mm thick.	*** insulated with 40mm-thick non-combustible classified mineral wool of 40-50kg/m³ nominal density.
Non flammable Pipe	Copper pipe 88.9mmØ x 2.5mm thick.	*** insulated with 40mm-thick non-combustible classified mineral wool of 40-50kg/m³ nominal density.

* = See Table 3 for cable descriptions.

** = fixed to the exposed face (underside) of the penetration seal with M8 threaded passing through the seal and secured on the unexposed face with washers and nuts.

*** = Heizungsrohrschale 800 pre-fabricated mineral wool laggings, 500mm length on the exposed face and 1000mm length on the unexposed face.

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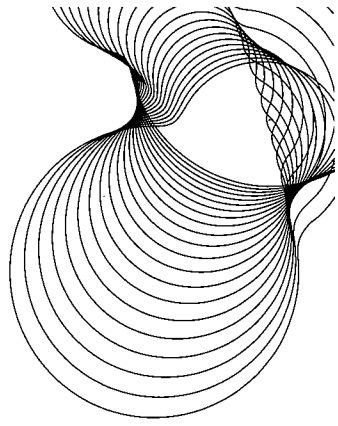

**** = Klimarock mineral wool coil ware, 500mm length on the exposed face and 1000mm length on the unexposed face.

Details of the location of the services installed in seal B are shown in Figure 5.

The following, listed in Table 3 below, indicates those cables referenced in Tables 1 and 2 and used for seals A and B.

Table 3 Cable references

Cable reference	Description
a	3 x 185mm² copper core.
b	3 x 185mm²/95mm² copper core.
c	1 x 150mm² copper core.
e	5 x 1.5mm² copper core.
g	4 x 185mm² aluminium core.

2.3 CP 670 Fire Safety Board System

The CP 670 Fire Safety Board System were pre-coated mineral wool boards stated by the sponsor to be 50mm thick having a density of 160kg/m³ with a layer of CP 670 Fire Safety Coating, applied to both faces to a thickness of 0.7mm. The boards were supplied 1200mm long x 600mm wide and were cut to fit around the installed services in the aperture, as in practise. Once in place the boards were additionally sealed at the their edges with CP 606 mastic.

2.4 CP 606 Mastic

CP 606 intumescent gap filler was described by the sponsor as an acrylic-dispersed firestop mastic. It was white in colour, supplied in 310ml cartridges.

2.5 CP 670 Fire Safety Coating

The CP 670 Fire Safety Coating was described by the sponsor as a water based ablative mastic. It was white in colour, supplied in 4.5 litre tubs.

2.6 Mineral wool insulation for the metal pipes

Foil faced circular mineral wool were used to insulate the copper and metal pipes. Both types of insulation were described by the sponsor as having a thickness of 40mm, a nominal density of 40-50kg/m³ and stated to be incombustible (DIN4102-A2). "Klimarock" coil ware was used for the 168.3mmØ steel pipes only where no standardized pre-fabricated mineral wool lagging of 168.3mmØ could be supplied and "Heizungsrohrschale 800" for all other pipe diameters. The mineral wool lagging was covered on the visible face with a reinforced foil which incorporated an adhesive strip to seal the collar at the joint. Further details of both types of the Rockwool insulation are kept on confidential file.

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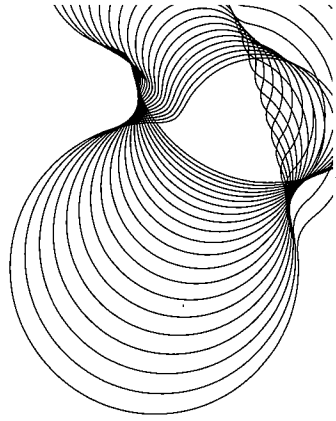

2.7 CP 643 N Pipe closures

The CP 643 N pipe closures, 50mmØ (CP 643 N-50/1.5), 110mmØ (CP 643 N-110/4) and 160mmØ (CP 643 N-160/6) comprised a galvanised steel shell and fixing mounts, and layers of intumescent strip which expand upon heating and seal the aperture when the plastic pipe has melted. Further details are shown in Table 4 below:

Table 4 Pipe closure details

Pipe Closure	Number of fixing tabs	Height of Closure (mm)	Outside Diameter (mm)
CP 643 N-50/1.5	2	22.4	66.7
CP 643 N-110/4	3	47.4	145.7
CP 643 N-160/6	4	48.4	235.35

2.8 Hilti MQ channel services support system

The MQ channel system comprised sections of 41mm-square U-channel galvanised steel, fixed to the upper side of the floor with anchor bolts and to each other with connection pieces to form a rigid frame to which the services were retained.

Parallel horizontal U-channel sections, nominally 3000mm long, one at each side of the long edge of seals A and B, were bolted to the floor with anchor bolts to provide a firm base for fixing the frame work of the support system. Vertical U-channel sections, 500mm long, were bolted to the parallel horizontal floor sections of each seal at locations adjacent to the penetrating services, in pairs. Horizontal U-channel sections, spanning the width of each seal, were then bolted to each pair of vertical sections at 150mm and 420mm from the unexposed face of the floor. The cable trays were then bolted directly to the U-channel. The metal and plastic pipes were secured to the frame via a length of M8 threaded rod which was attached to a "standard duty pipe ring", bolted and tightened round the services. The standard duty pipe rings were supplied in diameters ranging from 28mm to 170mm.

2.9 Assembly

2.9.1 General assembly details

All penetrating services were supported with the Hilti MQ channel-system, incorporating 41mm-square U-channel section, M8 threaded rod and standard duty pipe clamps to secure all penetrating services. Standard duty pipe clamps, attached to the support frame via the M8 threaded rod, were secured round each service at nominally 150mm and 420mm from the upper face of the floor, with each clamp tightened to rigidly secure the service.

All metal pipes were 1500mm long on the unexposed face, the first 1000mm length was covered with insulation with 500mm of bare pipe protruding from the end of the insulation.

All metal pipes were 800mm long on the exposed face, the first 500mm was covered with insulation with 300mm of bare pipe protruding from the end of the insulation.

All metal pipes were sealed at their ends, on the exposed face, with mineral wool insulation, nominally 75mm thick.

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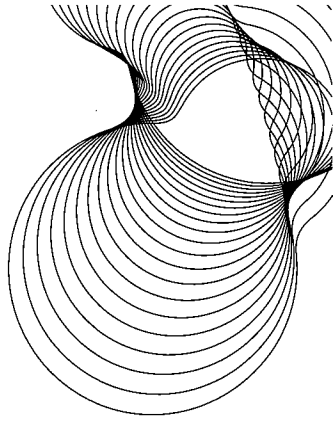

The metal pipe insulation was secured in place on the exposed side of the penetration seal using a single wrap of steel wire applied nominally 150mm and 250mm from the face of the seal. An additional wrap of steel wire was applied around the steel pipe at the bottom of the insulation to prevent movement during the test.

The metal pipe insulation was sealed after installation using aluminium foil tape, wrapped over each butt joint and onto the steel pipe at the end of the insulation on the exposed and unexposed sides of the seal.

All plastic pipes protruded from the unexposed face by nominally 600mm and by 500mm from the lowest point of each pipe closure on the exposed face.

All plastic pipes were sealed at their ends, on the unexposed face, with mineral wool insulation, nominally 75mm thick.

All cable trays protruded from both sides of the penetration seals by no nominally 570mm.

All cables, which were attached to the cable trays, protruded from both sides of the penetration seal by 500mm.

All cables and cable trays were coated with CP 670 Fire Safety Coating for a length of 150mm from the face of the penetration seal, on the exposed and unexposed sides.

All cables were retained to the cable trays using a single wrap of steel wire at nominally 150mm and 450mm from the face of the penetration seal, on the exposed and unexposed faces.

All cables are sealed with CP 606 acrylic firestop mastic at their ends, on the unexposed side of the penetration seal only.

Detailed diagrams showing the location of the penetrating services for seal A and B are show in Figures 2 to 7.

2.9.2 General Assembly

Heavy duty mild steel angle, 4050mm long, was bolted to the two long edges of the test frame aperture, at a height adjacent to a step in the test frame, 300mm from the base of the frame. The three concrete slabs, A, B and C were lowered into place to ensure service penetrations would be a minimum of 200mm from the internal walls of the furnace.

The MQ channel support frame system was bolted in place then the services were secured in their pre-designated locations to the support frame. One 50mm thick layer of CP 670 Fire Safety Board System was fixed into place around the services, flush with unexposed face of the floor, to seal the penetration through slab A, **(seal A)**. Two 50mm thick layers of CP 670 Fire Safety Board System were fixed into place around the service penetrations, flush with the unexposed face of the floor, to seal the penetration through slab B, **(seal B)**.

The CP 643 N pipe closures were placed around the pipes and fixed in place by passing M8 threaded rod through the fixing tabs and CP 670 Fire Safety Boards, securing the closures on the unexposed face with a nut and steel washer and on the exposed face with a nut to the fixing tab. The CP 643 N pipe closures were flush with the exposed face of the CP 670 Fire Safety Board System.

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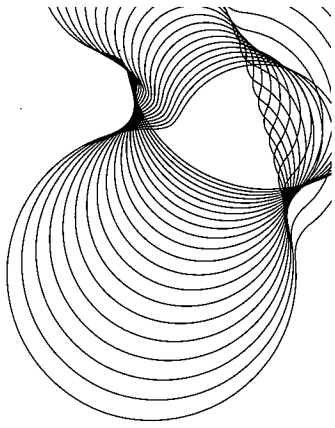

The mineral wool laggings were then wrapped around the metal pipes, 1000mm long on the unexposed face and 500mm long on the exposed face. The unexposed face collars incorporated horizontal joints 150mm and 420mm from the face of the floor which were sealed with aluminium foil tape. In addition, the ends of the collars were sealed with the aluminium foil tape. Steel wire was then twisted around the insulation 150mm and 250mm from the exposed face of the floor to prevent movement of the insulation down the metal pipes during the test. In addition, steel wire was wrapped around the metal pipes at the end of the exposed insulation to provide additional support.

CP 606 mastic was then applied to all butt joints between the CP 670 Fire Safety Board System boards. CP 670 Fire Safety Coating was applied to all cables / cable-trays for a length of 150mm, from the exposed and unexposed sides of the seal.

Seal A is shown prior to the test in Photographs 1, 2, 5 and 6. Seal B is shown prior to the test in Photographs 3, 4, 7 and 8. The "EMPTY BOARD" span is shown in Photograph 9.

3 Test procedure

3.1 General

The test was carried out on Wednesday 13th April 2005 in accordance with European Standard EN 1366-3: 2004[1]. The test was witnessed by Mr Harald Bock representing the of the sponsor, Mr George Scholten representing TNO and Mr Poppe representing ISIB. The ambient temperature within the Laboratory at the start of the test was **13**°C.

3.2 Furnace control

The furnace temperature was measured using ten plate thermometers arranged symmetrically within the furnace chamber, nominally 100mm from the exposed face of the floor. The furnace was controlled so that the mean temperature of the furnace followed the time/temperature relationship specified in European Standard BS EN 1363-1: 1999[2].

The mean furnace temperature is plotted against time in Graph 1 together with the specified time/temperature curve for comparison.

The pressure in the furnace was monitored throughout the test at a position approximately 750mm below the underside of the floor. The pressure was controlled, as close as practically possible, to be 20Pa ± 2Pa above the laboratory, 100mm below the underside of the floor, as required by the standard[1]. The pressure recorded during the test at approximately 750mm below the seals is plotted against time in Graph 2. The pressure attained during the test at approximately 100mm below the seals is plotted against time in Graph 3.

3.3 Specimen temperature

The temperature of each penetrating service through seal A and seal B was monitored in accordance with the standard[1] (section 9.1.2.2, thermocouple Type A to E) to determine the point of insulation failure, i.e.

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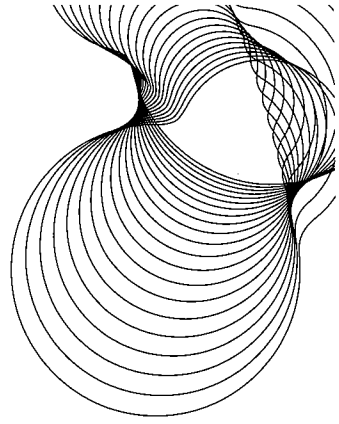

180°C rise above the initial average seal temperature. The initial average seal temperature of seal A and seal B is taken as the average of all the thermocouples on seal A and seal B respectively. The penetrating services and adjacent penetration seals, were monitored for temperature rise in the following positions:

i) on the penetration seal 25mm from the service penetration, one thermocouple per 500mm circumference (Type B).

ii) on the penetrating service 25mm from the point of exit from the penetration seal, one per 500mm circumference (Type A).

iii) on the penetrating service 25mm from the point were the applied CP 670 Fire Safety Coating ceases, one per 500mm circumference (Type A2).

iv) on the surface of the supporting construction (Type E).

v) on the cable tray 25mm from the point of exit from the penetration seal, one per cable tray (Type D).

vi) on the cable tray 25mm from the point were the applied CP 670 Fire Safety Coating ceases, one per cable tray (Type D2).

vii) on each penetration seal, near a joint between CP 670 Fire Safety Board System.

At the request of the sponsor additional thermocouples were positioned 25mm above the upper fixation point of all steel and copper pipes were there was a joint in the insulation (ISIB requested thermocouple).

The location of thermocouples positioned on ***Sealing system A*** are detailed below in Table 5 and shown in Figure 2:

Table 5 Thermocouple locations for Sealing system A

Thermocouple Number	Location
1	on seal 25mm from cable B1
2	on cable B1/mastic 25mm up from seal
3	on cable B1 25mm from end of mastic
4	on seal 25mm from cable B2
5	on cable B2/mastic 25mm up from seal
6	on cable B2 25 from end of mastic
7	on seal 25mm from cable B/ number 1 500mm x 60mm cable tray
8	on 500mm x 60mm cable tray/mastic 25mm from seal
9	on 500mm x 60mm cable tray 25mm from end of mastic
10	on cable B3/mastic 25mm from seal
11	on cable B3 25mm from end of mastic
12	on seal 25mm from 110Øx3.2mm PVC/110Øx2.2mm PE pipes
13	on 110Øx3.2mm PVC pipe 25mm from seal
14	on 110Øx2.2mm PE pipe 25mm from seal
15	on seal 25mm from 32Øx1.8mm PVC pipe
16	on 32Øx1.8mm PVC pipe 25mm from seal

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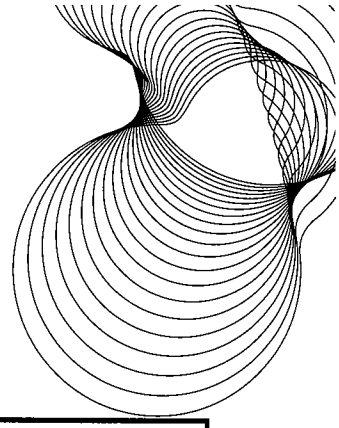

Thermocouple Number	Location
17	on seal 25mm from 110Øx8.2mm PVC pipe
18	on 110Øx8.2mm PVC pipe 25mm from seal
19	on seal 25mm from 42Øx2.6mm/28Øx1mm copper pipes
20	on insulation around 42Øx2.6 copper pipe 25mm from seal
21	on insulation around 28Øx1mm copper pipe 25mm from seal
22	25mm above upper insulation joint on 28Øx1mm copper pipe (TNO TC)
23	25mm above upper insulation joint on 42Øx2.6mm copper pipe (TNO TC)
24	on 42Øx2.6mm copper pipe 25mm from end of insulation
25	on 28Øx1mm copper pipe 25mm from end of insulation
26	on seal 25mm from 110Øx10mm PE pipe
27	on 110Øx10mm PE pipe 25mm from seal
28	on floor slab 25mm from edge of penetration seal
29	in the centre of the penetration slabs/seal uninterrupted area
30	25mm from joint between penetration seal slabs at mid width
31	on seal 25mm from 168.3mmØ steel pipes
32	on seal 25mm from 168.3mmØ steel pipes
33	on insulation around 168.3Øx4.5mm steel pipe, 25mm from seal
34	on insulation around 168.3Øx4.5mm steel pipe, 25mm from seal
35	on insulation around 168.3Øx14.2mm steel pipe, 25mm from seal
36	on insulation around 168.3Øx14.2mm steel pipe, 25mm from seal
37	25mm above upper insulation joint on 168.3Øx14.2mm steel pipe(TNO TC)
38	25mm above upper insulation joint on 168.3Øx4.5mm steel pipe(TNO TC)
39	on 168.3Øx4.5mm steel pipe 25mm from end of insulation
40	on 168.3Øx4.5mm steel pipe 25mm from end of insulation
41	on 168.3Øx14.2mm steel pipe 25mm from end of insulation
42	on 168.3Øx14.2mm steel pipe 25mm from end of insulation
43	on seal 25mm from 88.9Øx2mm/2.5mm copper pipes
44	on insulation around 88.9Øx2mm copper pipe 25mm from seal
45	on insulation around 88.9Øx2.5mm steel pipe 25mm from seal
46	25mm above upper insulation joint on 88.9Øx2.5mm steel pipe(TNO TC)
47	25mm above upper insulation joint on 88.9Øx2.0mm steel pipe(TNO TC)
48	on 88.9Øx2mm steel pipe 25mm from end of insulation
49	on 88.9Øx2.5mm steel pipe 25mm from end of insulation
50	on seal 25mm from cable G/ number 1 300mm x 60mm cable tray
51	on cable G/mastic 25mm from seal
52	on cable G 25mm from end of mastic
53	on number 1 300mm x 60mm cable tray /mastic 25mm from seal
54	on number 1 300mm x 60mm cable tray, 25mm from end of mastic
55	on seal 25mm from cable C
56	on cable C/mastic 25mm from seal
57	on cable C 25mm from end of mastic

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Thermocouple Number	Location
58	on seal 25mm from cable A
59	on cable A/mastic 25mm from seal
60	on cable A 25mm from end of mastic
61	on seal 25mm from cable E
62	on cable E/mastic 25mm from seal
63	on cable E 25mm from end of mastic
64	on number 2 300mm x 60mm cable tray/mastic 25mm from seal
65	on number 2 300mm x 60mm cable tray, 25mm from end of mastic
66	on seal 25mm from cable B4
67	on cable B4/mastic 25mm from seal
68	on cable B4 25mm from end of mastic
69	On seal 25mm from 32Øx1.8mm PE pipe
70	on 32Øx1.8mm+B31 PE pipe 25mm from seal

The location of thermocouples positioned on ***Sealing system B*** are detailed below in Table 6 and shown in Figure 5:

Table 6 Thermocouple locations for Sealing system B

Thermocouple Number	Location
71	on seal 25mm from cable B1/number 1 500mm x 60mm cable tray
72	on cable B1/mastic 25mm from seal
73	on cable B1 25mm from end of mastic
74	on cable B2/mastic 25mm from seal
75	on cable B2 25mm from end of mastic
76	on number 1 500mm x 60mm cable tray/mastic 25mm from seal
77	on number 1 500mm x 60mm cable tray 25mm from end of mastic
78	on seal 25mm from cable B3 and 160Ø PE pipe
79	on cable B3/mastic 25mm from seal
80	on cable B3 25mm from end of mastic
81	on seal 25mm from 160Ø PE and PVC pipes
82	on seal 25mm from 160Ø PVC pipe
83	on 160Øx3.2mm PVC pipe 25mm from seal
84	on 160Øx3.2mm PVC pipe 25mm from seal
85	on 160Øx4mm PE pipe 25mm from seal
86	on 160Øx4mm PE pipe 25mm from seal
87	on seal 25mm from 160Øx11.9mm PVC pipe
88	on seal 25mm from 160Øx11.9mm PVC pipe
89	on 160Øx11.9mm PVC pipe 25mm from seal

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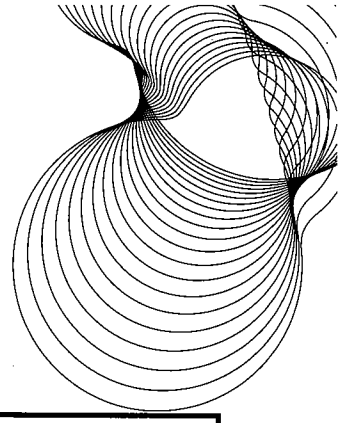

Thermocouple Number	Location
90	on 160Øx11.9mm PVC pipe 25mm from seal
91	on seal 25mm from 160Øx14.6mm PE pipe
92	on seal 25mm from 160Øx14.6mm PE pipe and 42.4Øx2.6mm steel pipe
93	on 160Øx14.6mm PE pipe 25mm from seal
94	on 160Øx14.6mm PE pipe 25mm from seal
95	on insulation around 42.4Øx2.6mm steel pipe 25mm from seal
96	25mm above upper insulation joint on 42.4Øx2.6mm steel pipe(TNO TC)
97	on 42.4Øx2.6mm steel pipe 25mm from end of insulation
98	on floor slab 25mm from edge of penetration seal
99	in the centre of the uninterrupted area
100	25mm from joint between penetration seal slabs at mid width
101	on seal 25mm from 168.3Øx4.5mm/168.3Øx14.2mm steel pipes
102	on seal 25mm from 168.3Øx4.5mm/168.3Øx14.2mm steel pipes
103	on insulation around 168.3Øx14.2mm steel pipe, 25mm from seal
104	on insulation around 168.3Øx14.2mm steel pipe, 25mm from seal
105	on insulation around 168.3Øx4.5mm steel pipe, 25mm from seal
106	on insulation around 168.3Øx4.5mm steel pipe, 25mm from seal
107	25mm above upper insulation joint on 168.3Øx4.5mm steel pipe(TNO TC)
108	25mm above upper insulation joint on 168.3Øx14.2mm steel pipe(TNO TC)
109	on 168.3Øx14.2mm steel pipe 25mm from the end of the insulation
110	on 168.3Øx14.2mm steel pipe 25mm from the end of the insulation
111	on 168.3Øx4.5mm steel pipe 25mm from the end of the insulation
112	on 168.3Øx4.5mm steel pipe 25mm from the end of the insulation
113	on seal 25mm from 28Øx1mm copper pipe
114	on 28Øx1mm copper pipe 25mm from seal
115	25mm above upper insulation joint on 28Øx1mm copper pipe(TNO TC)
116	on 28Øx1mm copper pipe 25mm from end of insulation
117	on number 1 100mm x 60mm cable tray/mastic 25mm from seal
118	on number 1 100mm x 60mm cable tray 25mm from end of mastic
119	on cable B4 /mastic 25mm from seal
120	on cable B4 25mm from end of mastic
121	on seal 25mm from 100x60mm cable tray/32Øx1.8mm PE pipe
122	on 32Øx1.8mm PE pipe 25mm from seal
123	on seal 25mm from 88.9Øx2.5mm/88.9Øx2mm copper pipes
124	on insulation around 88.9Øx2.5mm copper pipe, 25mm from seal
125	on insulation around 88.9Øx2mm copper pipe, 25mm from seal
126	25mm above upper insulation joint on 88.9Øx2mm copper pipe(TNO TC)
127	25mm above upper insulation joint on 88.9Øx2.5mm copper pipe(TNO TC)
128	on 88.9Øx2mm copper pipe 25mm from end of the insulation
129	on 88.9Øx2.5mm copper pipe 25mm from end of the insulation
130	on cable B5/mastic 25mm from seal

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Thermocouple Number	Location
131	on cable B5 25mm from end of mastic
132	on number 2 100mm x 60mm cable tray/mastic 25mm from seal
133	on number 2 100mm x 60mm cable tray 25mm from end of mastic
134	on seal 25mm from 32Øx1.8mm PVC pipe
135	on 32Øx1.8mm PVC pipe 25mm from seal
136	on seal 25mm from cable G
137	on cable G/mastic 25mm from seal
138	on cable G 25mm from end of mastic
139	on seal 25mm from cable C
140	on cable C/mastic 25mm from seal
141	on cable C 25mm from end of mastic
142	on seal 25mm from cable A
143	on cable A/mastic 25mm from seal
144	on cable A 25mm from end of mastic
145	on seal 25mm from number 2 500mm x 60mm cable tray
146	on number 2 500mm x 60mm cable tray/mastic 25mm from seal
147	on number 2 500mm x 60mm cable tray 25mm from end of mastic
148	on seal 25mm from cable E
149	on cable E/mastic 25mm from seal
150	on cable E 25mm from end of mastic
151	on seal 25mm from cable B6
152	on cable B6/mastic 25mm from seal
153	on cable B6 25mm from end of mastic
154	on seal 25mm from number 3 500mm x 60mm cable tray-mastic/100mm x 60mm cable tray-mastic
155	on number 3 500mm x 60mm cable tray/mastic 25mm from seal
156	on number 3 500mm x 60mm cable tray 25mm from end of mastic

Each thermocouple was soldered to a 12mm-diameter copper disk and covered with an insulating pad, nominally 30mm x 30mm x 2mm thick, as specified in the standard[2].

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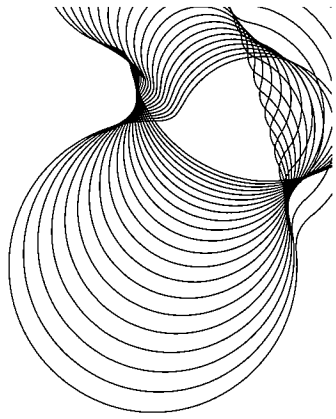

4 Results

4.1 Observations

Observations made during the test are given in Table 7 below. Unless otherwise stated they are of the unexposed face.

Table 7 Observations

Time Min/sec	Observations
0	Test starts.
8/20	All plastic pipes and cable sheathing are melting and flaming on the exposed face of the floor.
12/49	No significant change.
17/03	Visible char expansion from the CP 643 N pipe closures on exposed side of pipes. Also one of the threaded rods and washer securing the 160mmØ x 14.6mm PE pipe is beginning to cut into the CP 670 Fire Safety Boards on seal B.
21	160mmØ x 14.6mm PE fixings continue to cut into the CP 670 Fire Safety Board and the same 160mmØ x 11.9mm PVC pipe fixings are starting to do the same.
26/55	No significant change to seals however the concrete floor slabs are bowing towards the centre of the furnace 20-30mm.
31/59	The actual metal collar for the CP 643 N pipe closures around the PE and PVC 160mmØ pipes have fallen off, the intumescent char is left in place.
56	One of the CP 670 Fire Safety Board butt joints is opening up on the exposed face, the mastic covering is visibly separated.
60	Seal B is visibly splitting open, mastic is detaching, at the edges of the "EMPTY BOARD" CP670 mineral wool boards, adjacent to the concrete floor slab.
65/51	**INTEGRITY FAILURE ON SEAL A.** Sustained flaming from the base of the 110mmØ x 3.2mm PVC pipe, cotton pad failure also. (see Photograph 10)
75/05	**INTEGRITY FAILURE ON SEAL B.** Sustained flaming from the base of the 100mm x 60mm cable tray and cable B5.
80	The sustained flaming on seal A is extending towards the uninterrupted area of the seal and igniting the pipes and cables in its path. The sustained flaming on seal B has been partially contained in the region of the point of first ignition.
83	The flaming on seal B is now spreading and igniting other cables close to the initial failure point. The sustained flaming on seal A has now engulfed the 110mmØ x 10mm PE pipe and the 42mmØ/28mmØ copper pipes.
89	Sustained flames now issue from the centre of seal B as the mastic joints separate.
91	160mmØ x 11.9mm PVC pipe now flaming along with cables C and G on seal B. The mineral wool insulation has fallen away from the centre

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Time Min/sec	Observations
	CP 670 Fire Safety Boards, leaving just the mastic coating to maintain integrity (gap gauge).
96	All "B" cables on seal B are now flaming.
97	The centre of the uninterrupted area on seal B has fallen into the furnace leaving a large aperture in the centre of the floor. It is not possible to maintain pressure and as conditions have deteriorated the test is stopped.

Seals A and B are shown post test on Photographs 11 to 16.

4.2 Temperatures recorded

The maximum temperature rise recorded on the unexposed face of seal A is plotted against time in Graph 4. The limit for maximum temperature (180°C rise) on **Sealing system A** was first exceeded by thermocouple 10 after **60** complete minutes.

The maximum temperature rise recorded on the unexposed face of seal B is plotted against time in Graph 29. The limit for maximum temperature (180°C rise) on **Sealing system B** was first exceeded by thermocouple 133 after **78** complete minutes.

Temperatures associated with seal A are shown in Graphs 4 to 28 and those which are associated with seal B are shown in Graphs 29 to 56.

The time to first insulation failure, **196**°C, and the thermocouple which recorded the earliest time to failure (**180**°C rise plus **16**°C average initial start temperature of seal A and seal B), of each of the individual penetrating services on seal A and seal B are shown in below in Table 8 and Table 9:

Table 8 Failure times on individual penetrating services on seal A

Service description	Thermocouple	Time Insulation failure 196°C
Cable b1.	3	67
Cable b2.	4	66
Cable b3.	10	60
Cable tray 500mm wide x 60mm deep (number 1).	9	66
PVC-U pipe 110mmØ x 3.2mm thick.	12	65
PE pipe 110mmØ x 2.2mm thick.	12	65
PVC-U pipe 32mmØ x 1.8mm thick.	15	67
Steel pipe 42.4mmØ x 2.6mm thick.	19	67
Copper pipe 28.1mmØ x 1mm thick.	19	67
PVC-U pipe 110mmØ x 8.2mm thick.	18	86
PE pipe 110mmØ x 10mm thick.	26	80
Uninterrupted board.	29	74
Steel pipe 168.3mmØ x 14.2mm thick.	31	94
Steel pipe 168.3mmØ x 4.5mm thick.	33	83
Steel pipe 168.3mmØ x 4.5mm thick.	43	61
Copper pipe 88.9mmØ x 2mm thick.	43	61

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Service description	Thermocouple	Time Insulation failure 196°C
PE pipe 32mmØ x 1.8mm thick.	69	70
Cable tray 300mm wide x 60mm deep (number 1).	No failure	No failure
Cable tray 300mm wide x 60mm deep (number 2).	65	94
Cable g.	No failure	No failure
Cable c.	56	87
Cable a.	No failure	No failure
Cable e.	No failure	No failure
Cable b4.	68	95

Table 9 Failure times on individual penetrating services on seal B

Service Description	Thermocouple	Time of Insulation failure 196°C
Cable tray 500mm wide x 60mm deep (number 1).	76	91
Cable b1.	72	96
Cable b2.	75	89
Cable b3.	79	95
PVC-U pipe 160mmØ x 3.2mm thick.	83	96
PE pipe 160mmØ x 4mm thick.	85	96
PVC-U pipe 160mmØ x 11.9mm thick.	87	92
PE pipe 160mmØ x 14.6mm thick.	93	92
Steel pipe 42.4mmØ x 2.6mm thick.	95	96
Uninterrupted board.	99	93
Steel pipe 168.3mmØ x 14.2mm thick.	103	96
Steel pipe 168.3mmØ x 4.5mm thick.	105	84
Copper pipe 28.1mmØ x 1mm thick.	113	95
Cable tray 100mm x 60mm deep (number 1).	117	95
Cable b4.	119	96
PVC-U pipe 32mmØ x 1.8mm thick.	No failure.	No failure.
Copper pipe 88.9mmØ x 2.5mm thick.	No failure.	No failure.
Copper pipe 88.9mmØ x 2mm thick.	125	83
Cable tray 100mm x 60mm deep (number 2).	133	78
Cable b5.	130	79
PE pipe 32mmØ x 1.8mm thick.	No failure.	No failure.
Cable tray 500mm wide x 60mm deep (number 2).	146	83
Cable tray 500mm wide x 60mm deep (number 3).	156	80
Cable g.	138	92
Cable c.	140	81
Cable a.	144	89
Cable e.	150	81
Cable b6.	151	85

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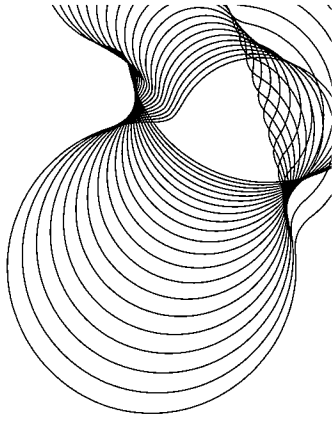

5 Performance criteria

The criteria for failure specified in the draft standard[1] were as follows:

Integrity:	- Sustained flaming:	when sustained flaming occurs on the unexposed face;
	- Cotton pad:	when ignition of a cotton pad occurs on application to an opening in the test specimen;
	- Gap gauge	when a 25mmØ gap gauge can pass into the furnace or 6mmØ gap gauge can pass into the furnace and move be moved a distance of 150mm.
Insulation:	When the temperature of the unexposed face increases above the initial average temperature at any location by more than 180°C.	

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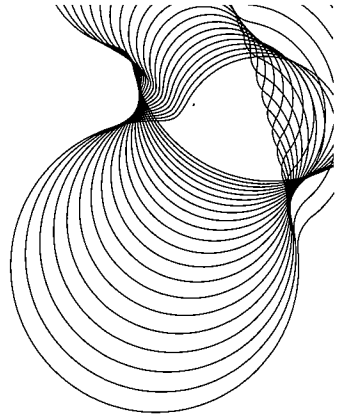

6 Conclusion

Two Hilti Entwicklungsgesellschaft mbH penetration sealing systems referenced A and B, installed in a 150mm-thick reinforced concrete floor, as detailed within this report, were submitted to a fire resistance test in accordance with European Standard EN 1366-3: 2004[1] on Wednesday 13th April 2005 for a duration of 97 minutes.

The individual penetration seals achieved the following fire resistance periods:

Sealing system A (single board layer)

"Integrity:	- Sustained flaming:	65 minutes;
	- Cotton pad:	65 minutes;
	- Gap gauge:	97 minutes;
Insulation:		60 minutes."

Sealing system B (double board layer)

"Integrity:	- Sustained flaming:	75 minutes;
	- Cotton pad:	75 minutes;
	- Gap gauge:	97 minutes;
Insulation:		75 minutes."

A further twelve individual penetrations were included in the test, but are not the subject of this report.

This report details the method of construction, the test conditions and the results obtained when the specified element of construction described herein were tested adopting appropriate procedures outlined in EN1363:Part 1:1999. Any significant deviation 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.

The specification and interpretation of fire test methods are the subject of ongoing development and refinement. Changes in associated legislation may also occur. For these reasons it is recommended that the relevance of test reports over 5 years old should be considered by the user. The laboratory that issued the report will be able to offer, on behalf of the legal owner, a review of the procedures adopted in a particular test to ensure that they are consistent with current practices, and if required may endorse the test report.

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7 Field of Direct Application of test results

7.1 Orientation

The test results are only valid for the orientation in which the penetration sealing systems were tested.

7.2 Cables

Test results for cables remains valid if the diameter of the cable is reduced and/or the number of cables in a bunch is reduced provided that the overall diameter of the bunch or of any individual cable is not greater than that tested.

Test results obtained with the standard configuration cover all types of insulated cables with copper or aluminium conductors, fibre optics cables and bundled communication cables, except hollow cables.

Results obtained form tests where the supports pass through the seal are applicable to those situations where the support is not continued but not *vice versa*.

The test results obtained using standard configurations for cables penetration systems are valid for:

- all types of steel cables trays and ladders;
- any penetration size equal to or smaller than that tested, provided the total amount of cross sections of the cables (core and insulation) does not exceed 60% of the penetration.

In practise the minimum working clearance (a_1 to a_5, see EN 1366-3:2004) used in the test shall be applied.

For floor constructions, results from tests with a penetration sealing system length of 1000mm, as shown in Figure B.5 (EN1366-3:2004) apply to any length as long as the width is not longer than that of the test specimen tested.

8 References

1 Fire resistance tests for service installations. Part 3. Penetration seals. European Standard EN 1366-3: 2004.

2 Fire resistance tests. Part 1. General requirements. European Standard BS EN 1363-1: 1999. Dated August 1999.

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Figures

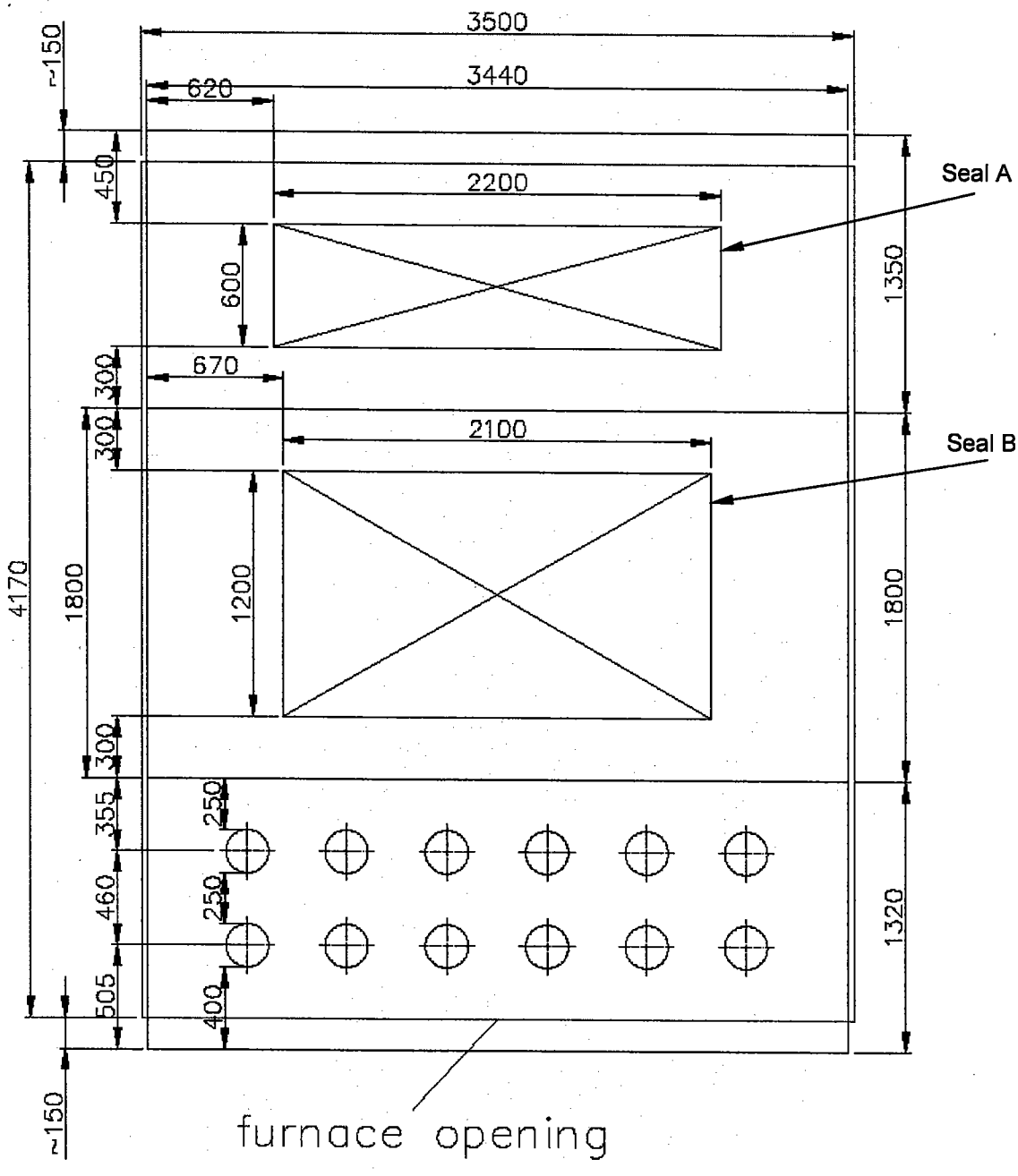

Figure 1 Diagram showing the position of the floor slabs as installed within the test frame.

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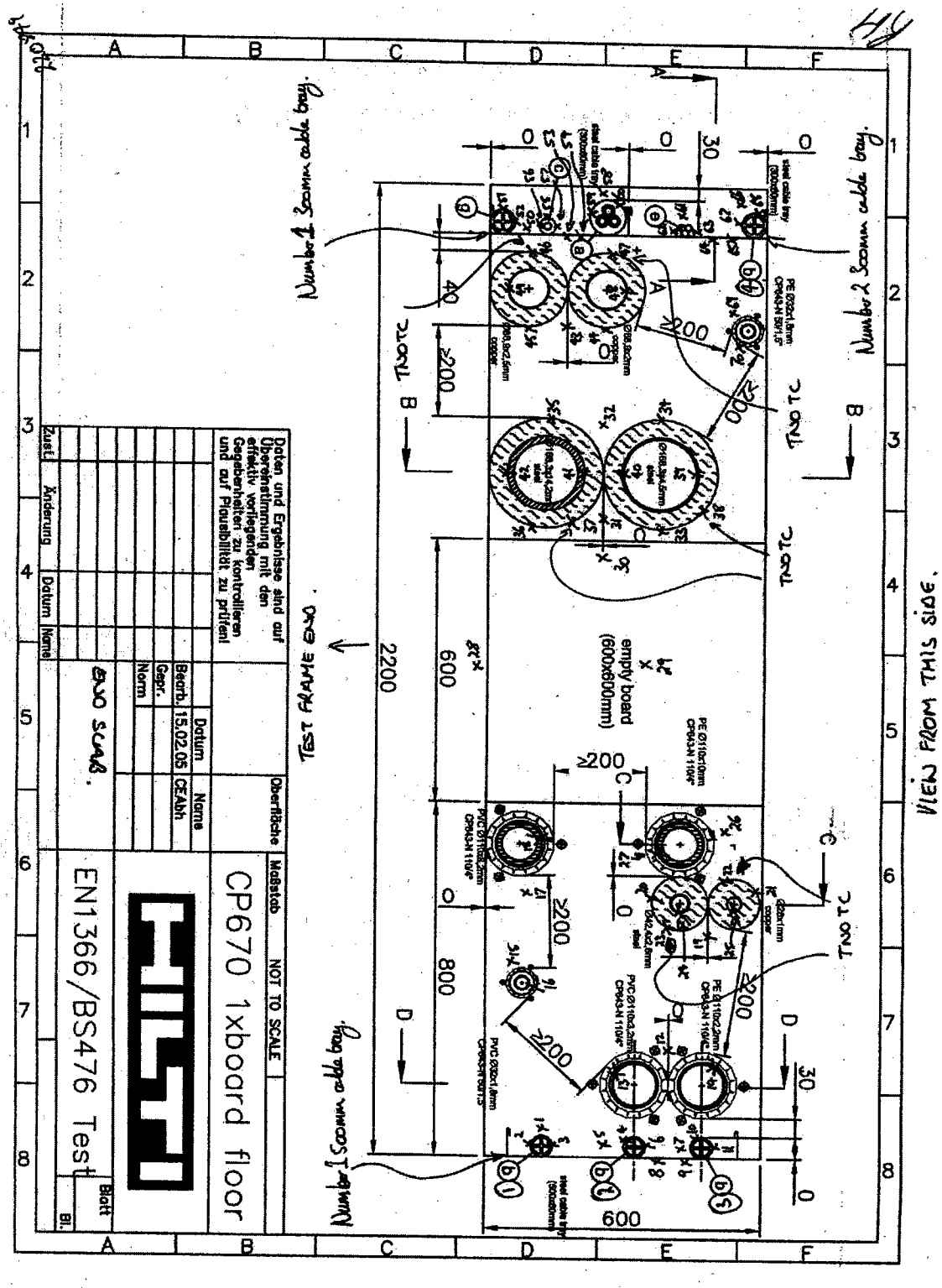

Figure 2 Diagram showing the location of the thermocouples attached to seal A.

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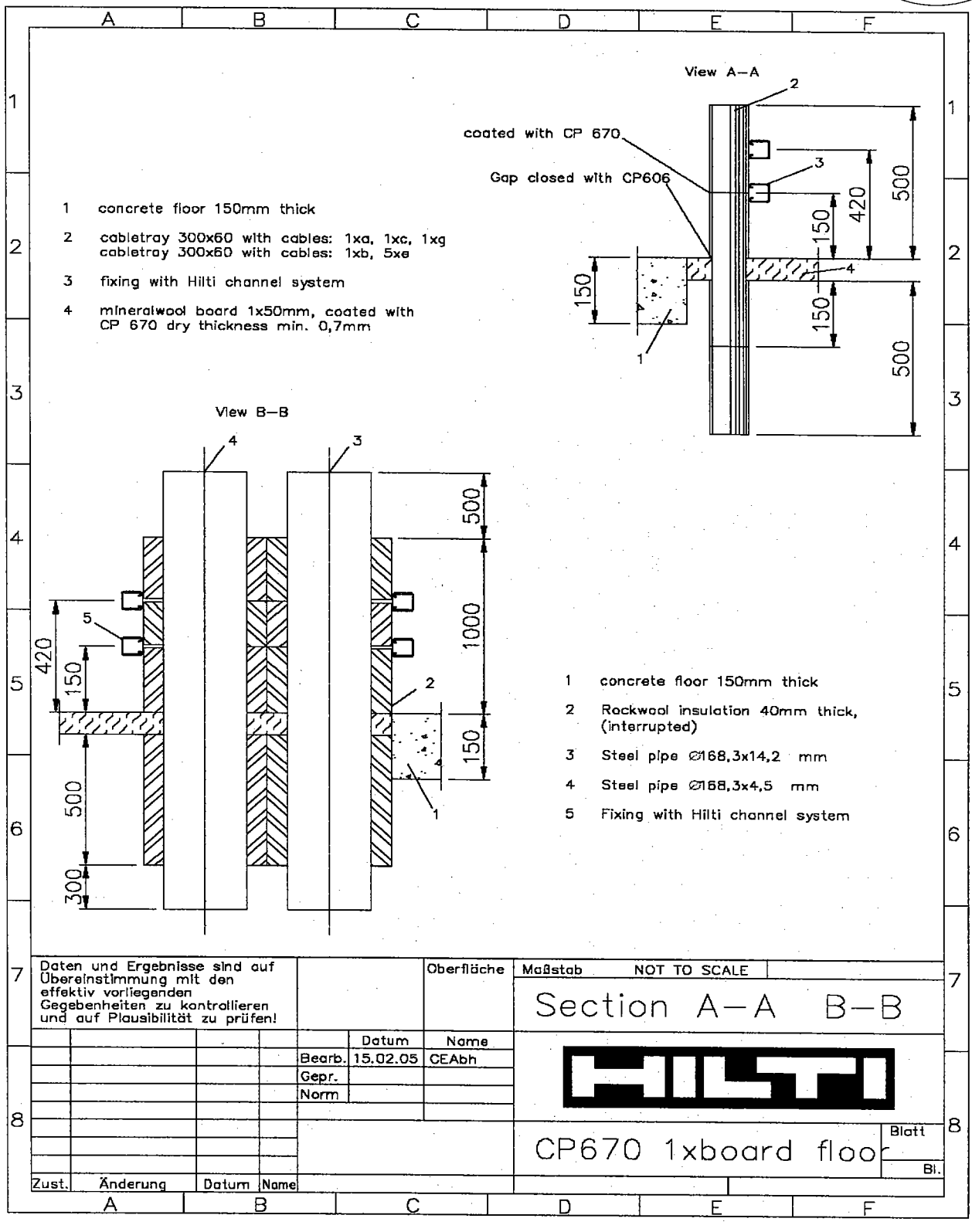

Figure 3 Diagram showing details of penetrating services passing through seal A.

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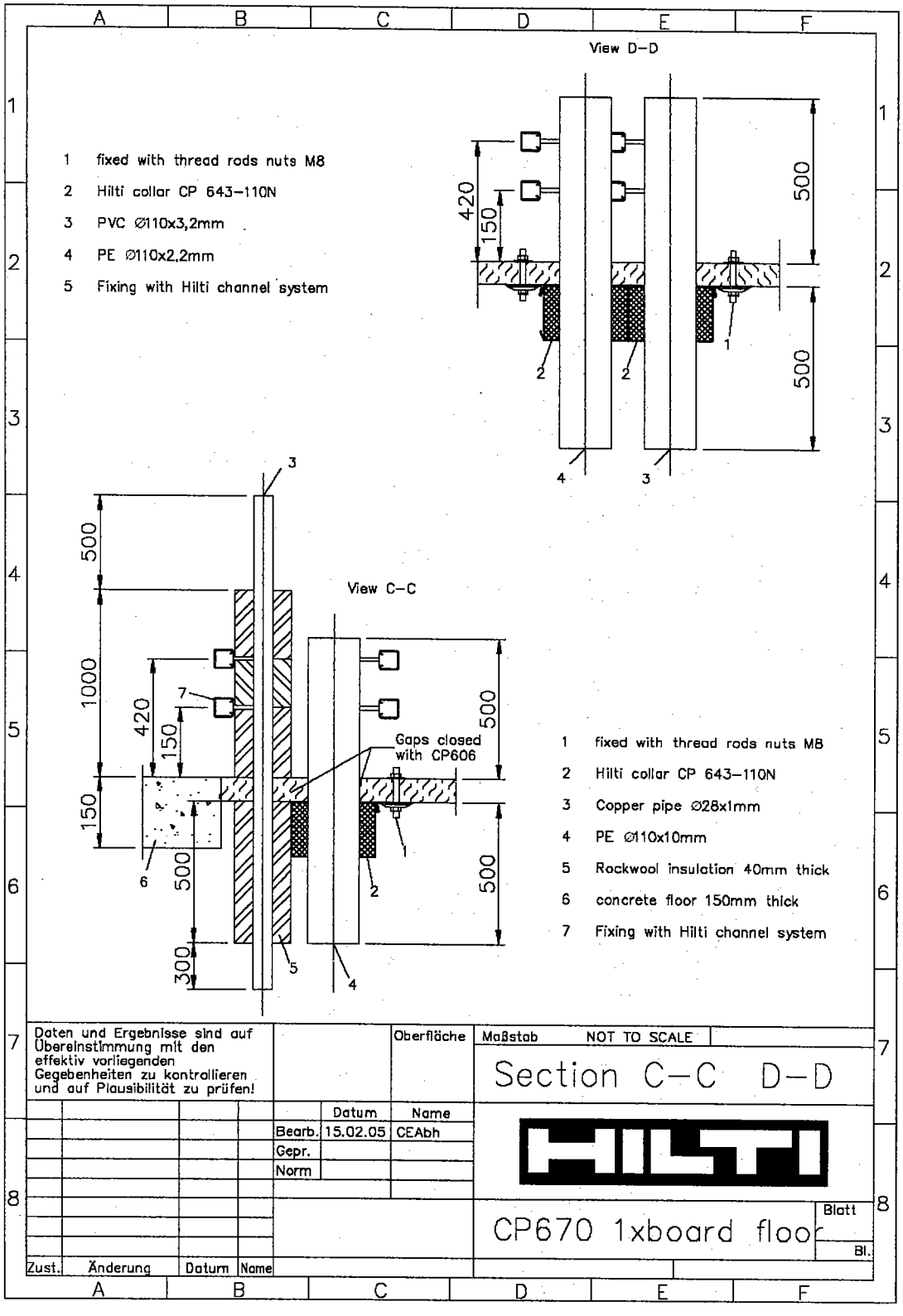

Figure 4 Diagram showing detail of penetrating services passing through seal A.

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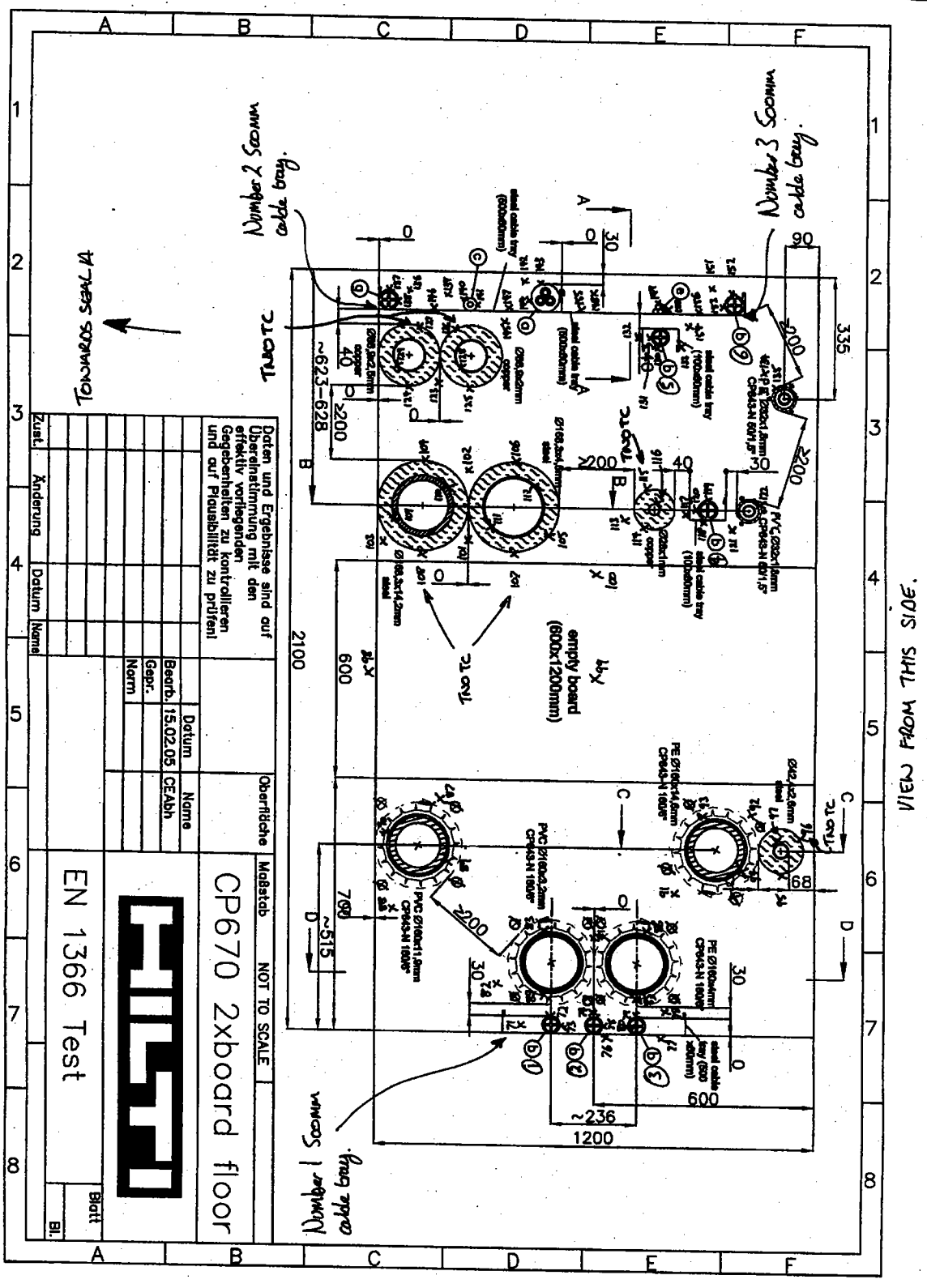

Figure 5 Diagram showing the location of the thermocouples attached to seal B.

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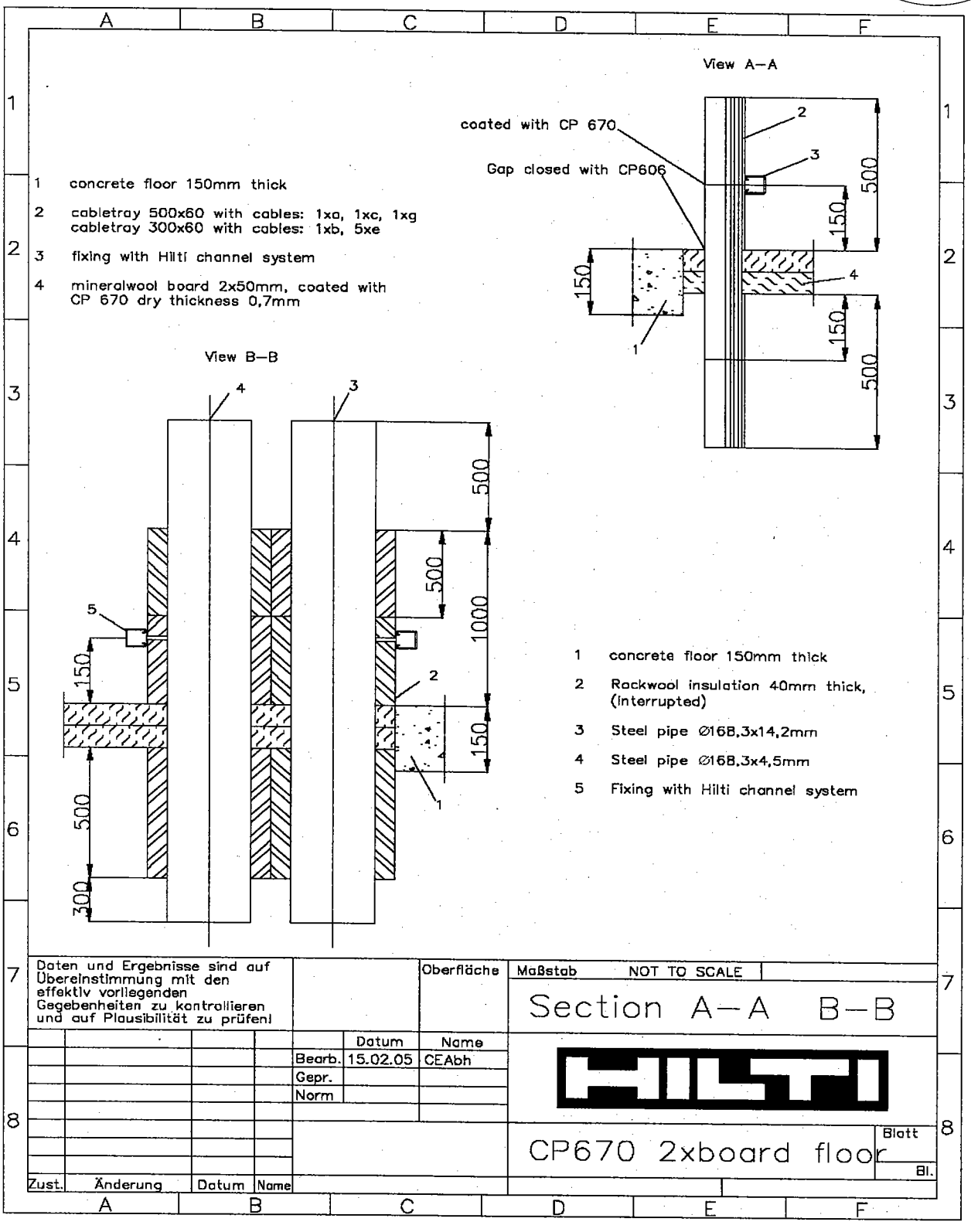

Figure 6 Diagram showing details of penetrating services passing through seal B

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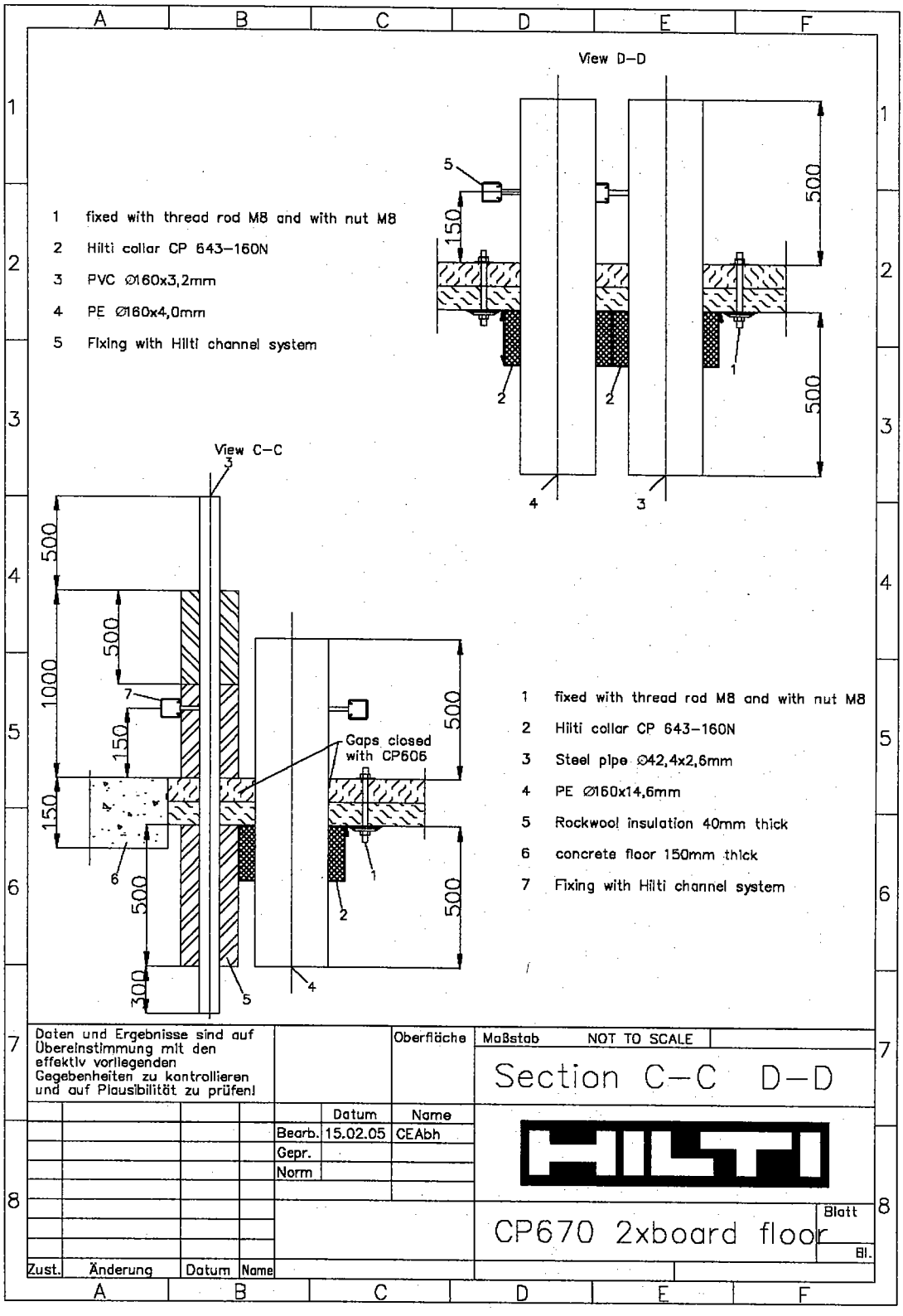

Figure 7 Diagram showing details of penetrating services passing through seal B

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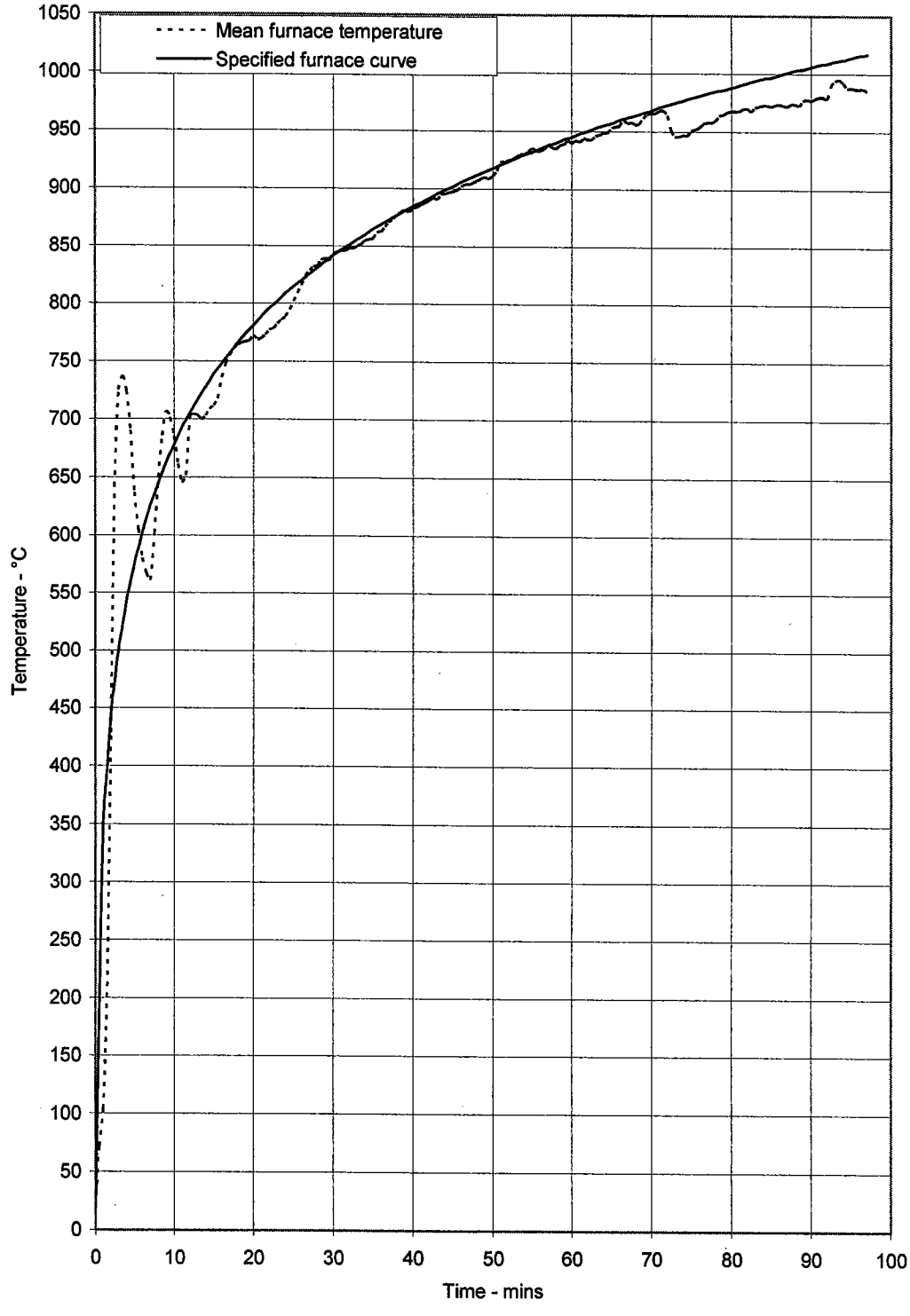
Graphs



Graph 1 Mean furnace temperature with the specified furnace curve for comparison.

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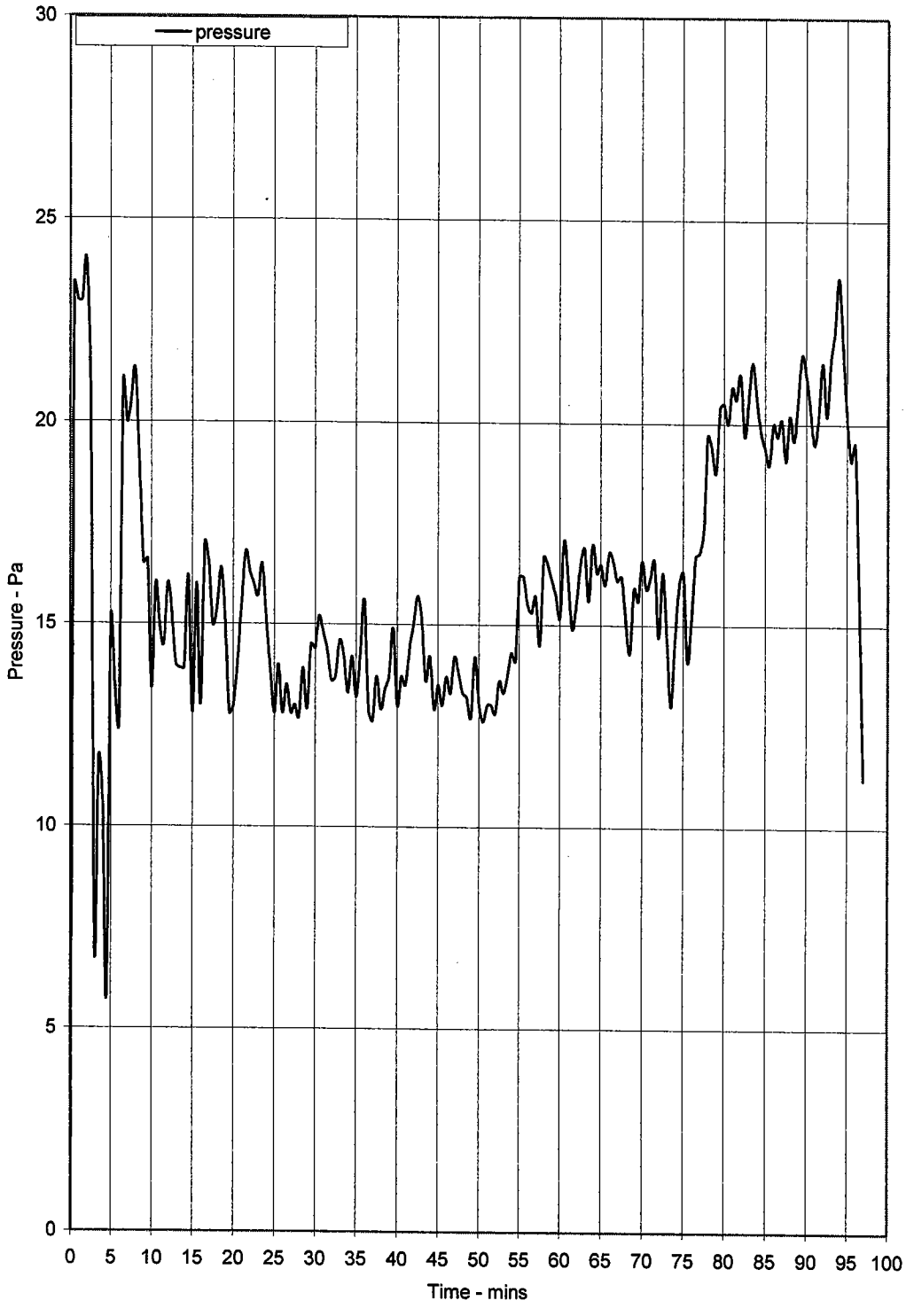

Graph 2 Furnace pressure recorded throughout the test at approximately 750mm below the seals. The increase in furnace pressure after 75 minutes is due to failure of both seal A and seal B affecting furnace control.

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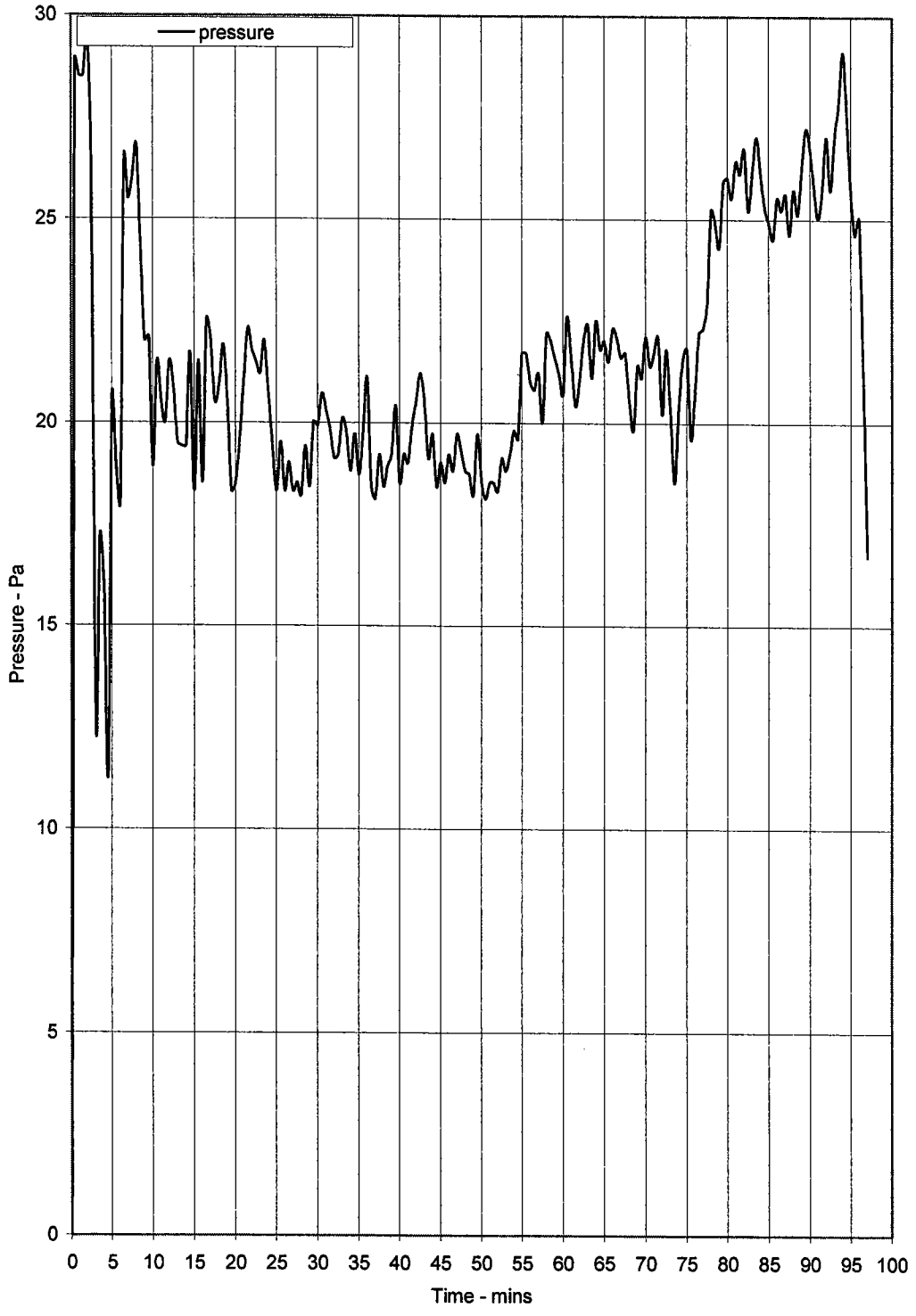

Graph 3 Effective pressure at a position 100mm below the seals.

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