TNO-report
98-CVB-R1018 (E)

Determination of the fire resistance of two cable penetration seals in a wall

TNO Building and
Construction Research

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Date
October 1999

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Project name : Fire resistance
Project number : 07.20.6.7097/147
006.90433.01.86.86

Number of pages : 10
Number of tables : 29
Number of figures : 4
Number of appendices : 1 (1 page)

1999

1 SUBJECT

Aerated concrete wall with two cable penetration seals, one with a Beeseal seal and the other with a RISE seal.

2 TEST

Fire resistance in accordance with NEN 6069:1997 and prEN 1366-3[1]

3 SPONSOR

Beele Engineering
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4 PLACE AND DATES OF TEST

The test has been carried out in the laboratory of the Centre for Fire Research Centre of TNO Construction and Building Research in Rijswijk, Netherlands.

Installation of cable penetrations ans seals	:	10 November 1997
Fire test	:	25 November 1997.

5 DATE AND NUMBER OF THE REPORT

Original version in Dutch language.
June 1998; 98-CVB-R1018.

Translation in English
October 1999; 98-CVB-R1018 (E).

[1]) Fire resistance tests for service installations; Part 3, Penetration seals. Document CEN/TC 127 N 1094

TEST SPECIMEN

6.1 General

The test specimen consisted of an aerated concrete wall, 200 mm thick, with two cable penetration seals, one with a so-called Beeseal seal consisting of MPM (multi-passage module) plugs and MSM (multi-seal module) plugs and the other with a so-called Rise penetration.
To accommodate the penetrations two openings apertures with the following dimensions had been made in the wall (Figure 1):

- for the Beeseal penetration 744 x 620 mm (w x h);
- for the Rise penetration 600 by 600 mm (w x h).

6.2 Cables

Identification of the cables used is summarised in Table 1.

The number and type of the cables used correspond to the standard configuration as prescribed in Table B.1. of prEN 1366-3 [1].
In front of the penetration the type C cables were fitted with a plastic conduit sleeve with an outer diameter of 65 mm; at each side of the wall these sleeves extended 250 mm outside the seal.
The total length of the cables was 2200 mm, of which a length of 1000 mm was located at the exposed side.

Table 1 cable configuration

Cable	cable type	Nominal voltage KV	outer di-ameter mm	Markings on cable	insulation		conductor		No. of cables
					sheath	conductor	material	nominal core surface area/total surface area, mm^2	
A	1 x 150 mm^2 RM [1)2)]	6-10	31.4	Poland N2 XSY 1x 150 RM/25 6/10kV <VDE>0273 1992 102140	PVC	XLPE	copper	150 / 150	2
B	3 x 185 mm^2 RM [1)2)]	6-10	72	FACAB 15101 <VDE>0273 1996 N2XSEY 3x 185/25MN2 6/10kV	PVC	XLPE	copper	185 / 555	3
C	3 x 185/95 mm^2 SM [2)3)]	0.6/1.0	51.7	0.6/1kV FACAB 05/03/1995 <VDE>027INYCWY 3 x 185 SM 95	PVC	PVC	copper	185 / 555	3
d	4 x 10 mm^2 RE [1)4)]	0.6/1.0	18.8	FACAB 60102 NYY-3 0.6/1kV <VDE>0276 1997	PVC	PVC	copper	10/40	20
e	5 x 1.5 mm^2 RE [1)4)]	0.6/1.0	13.2	FACAB 106120276 NYY J 5x1.5 0.6/1kV 1997 02831	PVC	PVC	copper	1.5/7.5	20
f	24 x 2 x 0.6 mm^2		11.5	Communication cables	PVC	PVC	copper		[5)]
g	4 x 185 mm^2 SE [3)4)]	0.6-1kV	49.8	MKM BALAS-SAGY-ARMAT 1994 <VDE>0271 NAVY J4 x 185 mm^2 SE	PVC	PVC	alumin-ium	185/740	2

[1)] R = round conductor
[2)] M = multi-conductor
[3)] S = segmented conductor
[4)] E = single conductor
[5)] bunched

6.3 Cable ladders and trays (see Figures 3 and 7)

The cable ladders and trays differed in the following respects from the requirements of EN 1366-3:
- in ladder 1 the material thickness was 1 mm instead of 1.25 mm,
- in trays 1 and 2 the material thickness was 1.1 mm instead of 1.5 mm.

6.4 Supports (Figures 3 and 7)

The ladders were supported by a steel structure consisting of:
- H-profiles measuring 80 x 40 x 5 mm
- carriers, length 530 mm, material thickness 3 mm, welded to the H-profiles;
- U-profiles 22 x 60 x 22 x 5;
- steel rods, diameter 14 mm, welded to the carriers at 140 mm and 500 mm from the seal.

The supports were constructed as shown in Figures 3 and 7, and corresponds broadly to the proposed structure as given in Figure B.3 of prEN 1366-3 [1].
By means of attachment plates (40 mm high) welded to the H-profiles, these profiles were secured to the support structure with M12 bolts. These bolts were countersunk into the wall and coated with Durofix at the opposite side of the wall in order to prevent these bolts from forming a potential cold bridge.
At the penetration with plugs, the plugs were installed at the exposed and non-exposed side in a steel frame, type MCP 6 x 120 x 5 FB, with the following dimensions:
- external dimensions 865 x 735 mm (width by height), material thickness of flange 6 mm;
- internal dimensions of apertures for plugs 120 x 120 mm;
- height of chambers for plugs 60 mm.

6.5 Sealing materials

6.5.1. Rise penetration (Figure 10)

The seal of the 'Rise' penetration consisted of the following components:
- sleeves of 'Rise' material, length 160 mm, internal diameter 19 mm, wall thickness 4 mm, provided with a groove along the entire length;
- sealant type FIWA putty, coating thickness 20 mm, applied over the 'Rise' sleeves at both sides of the opening.

6.5.2. *Beeseal penetration (Figures 2, 3 and 4)*

The plug seals consisted of the following components:
- for the A type cables: module 120/2x54 FRR with 2 sealing plugs 54,5/31 FRR
- for the B type cables: module 120/60-70 FRR
- for the C type cables: module 120/1x82 FRR with sealing plugs 82,5/50 FRR
- for the D type cables: module 120/30-19 FRR
- for the E type cables: module 120/30-13 FRR
- for the F type cables: module 120/30-11 FRR
- for the G type cables: module 120/1x82 FRR with sealing plugs 82,5/50 FRR
- for the uncabled penetrations: blind module 120/60-0 FRR.

A gasket type FRR/HF was fitted between the steel frame and the wall.

6.6 Assembling and sealing

First the supports were mounted on the aerated concrete wall described in 6.1. The cable ladders and trays were then mounted against the supports.
Figures 2, 3, 7 and 8 illustrate:
- the position of the ladders and trays in the wall opening;

Table 3 illustrates:
- the working distances a_1 to a_5 inclusive, indicated in Figure B.3 of prEN 1366-3.

The bunched cables were held together by means of Ty-raps.

At the non-exposed side the cable ends were given a coating of fire resistant putty, type Satef Hötenus Albertus.

Table 1: measured working distances

Size	Beeseal penetration	Rise penetration
a1	34 mm	51 mm
a2	68 mm	25 mm
a3	18 mm	45 mm
a4	35 mm	35 mm
a5	238 mm	130 mm

7 CONSTRUCTION OF THE TEST SPECIMEN

Centre for Fire research
TNO Building and Construction Research,
Rijswijk : the test frame with aerated concrete wall

Beele Engineering, Aalten : installation of the penetrations

8 TEST METHOD

8.1 Verification of the test specimen

General
During the installation procedure checks on the materials and components used were performed by referring to the drawings and data supplied.

8.2 Conditioning

From the start of installation until the test the construction was present in the testing hall of the Centre for Fire Research under ambient conditions, temperature (20 ± 5)°C and relative humidity (50 ± 10)%.

8.3 Fire test

8.3.1 *Conditions*
The test was carried out in accordance with the requirements of prEN 1366-3[1)].

8.3.2 *Measurements*
During the test the following measurements were made and recorded:
- the temperatures in the furnace with eight thermocouples (TOV1 - TOV8), regularly spaced over the exposed side of the test specimen;
- the surface temperatures at the non-exposed side of the test specimen, on the following components of both penetrations:
  - the cables;
  - the ladders;
  - the seal of the penetration;
    the top of the xxxx.
- the air temperature and air speed outside the furnace.

For the positions and code references of the thermocouples attached to the penetrations see figures 12 and 13.
In addition, measurements were performed at appropriate locations by means of a mobile thermocouple.

9 OBSERVATIONS DURING THE HEATING PERIOD

After a heating period of 168 minutes, a temperature increase of 180 °C was measured at thermocouple I6 on the Rise penetration. After 209 minutes a temperature increase of 180° C was measured at thermocouple I9 on the Beeseal penetration.
After a period of 240 minutes heating both penetrations still fulfilled the integrity criterion.

For a more detailed description of the observations refer to Annex A.

10 MEASUREMENTS RESULTS

The measurement results are given in Figures 14 – 29.

During the heating period, the pressure in the furnace and the air velocity outside the furnace complied with the requirements of NEN 6069:1997.

11 SUMMARY OF TEST RESULTS

Table 4 summarises the most important results of the test.

Table 4 Summary of test results

Criterion	Faillure time	
	Beeseal seal	Rise seal
a) Integrity	> 240 minutes[2]	> 240 minutes
b) Thermal insulation	209 minutes	168 minutes

[2] The heating was terminated in consultation with the sponsor

12 CONCLUSION

The penetration fitted with the Beeseal seal has a fire resistance of 168 minutes.

The penetration fitted with the Rise seal has a fire resistance of 209 minutes.

13 AREA OF APPLICATION AND CONDITIONS

The conclusion applies only to a floor with cable penetration seals as specified in (i) and (ii) respectively:

(i) *wall:*

- of stone material with a minimum thickness of 200 mm and a density mass of at least 600 kg/m^3, having a fire resistance of at least 168 minutes;

(ii) *cable penetrations and seals*

- installed in apertures having maximum dimensions as indicated in Figure 1 on condition that the total surface area of the cable cross sections (core and insulation) does not exceed 60% of the surface area of the aperture;
- all types of insulated cables with copper conductors, fibre-optic cables and bunched communication cables (cables f). The diameter of this bunch must not exceed approx. 150 mm.
- cable ladders with an element height of 60 mm and steel thickness of 1.0 mm;
- a sealing system and cable surface treatment as described in this report;
- working distances $a_1 - a_5$ inclusive and distances between the cables and the sides of the ladder elements as tested.

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List of figures

Photographs

Appendix A: Observations during the test

Time (min.)		Observation[3]
0		: start of heating.
5	N	: smoke escaping by the cables visible at both penetrations.
9	V	: lot of fire and smoke visible.
144	N	: thermocouples I2', I6' and I7' detached from cable; at these points further measurements made with mobile thermocouple.
152	N	: mobile thermocouple used to measure temperatures at: - thermocouple I2' (Rise penetration): 130°C; - thermocouples I6' and I7' (Rise penetration): 180 °C.
158	N	: at the Rise penetration the sheaths of cables A have rolled up.
160	N	: smoke escaping from Rise penetration.
168	N	: mobile thermocouple used to measure temperatures at couple I6' (Rise penetration): 203 °C.$\Delta T = > 180$ °C at end of thermal insulation with reference to the temperature in front of the Rise penetration.
183	N	: mobile thermocouple used to measure temperatures at: couple I6 (Beeseal penetration): 110°C; - on cable b on the tray: 100 °C; - at the side of cable bunch D: 160 °C.
184	N	: at the Rise penetration a discoloration of the sealing putty is visible below ladder 1.
200	N	: mobile thermocouple used to measure temperatures at: - couple I7 (Beeseal penetration): 180°C; - couple I11 (Beeseal penetration): 160 °C; - on cables D: 165 °C.
209	N	: couple I9 (Beeseal penetration) temperature = 203 °C, $\Delta T = > 180$ °C ,end of thermal insulation with reference to the temperature in front of the Beeseal penetration.
211	N	: massive smoke formation at the Beeseal penetration.
215	N	: between ladder 1 and tray 1 at the Beeseal penetration, test with pad of cotton: no ignition.
229	N	: see 215 minutes.
240	N	: heating terminated in consultation with sponsor, both penetrations integrity still intact

[3] N = non-exposed side
V = exposed side