TNO-report
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Ageing tests on the RISE-system

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TNO Institute of Industrial Technology is a merger of TNO Plastics and Rubber Research Institute/Branche-specific Research Centres, TNO Metals Research Institute and TNO Product Centre.

Netherlands Organization for Applied Scientific Research (TNO).

1 Introduction

At the request of Beele Engineering at Aalten in the Netherlands the TNO Institute of Industrial Technology has investigated a RISE Multi-Cable Transit System. The aim of this investigation was to get an impression of the long term behaviour of RISE insert sleeves and the FIWA putty. Furthermore a temperature cycle test was carried out on the whole multi-cable transit system to control the adhesion of the silicone sealant to the substrate and tightness of the system.

2 Samples

Responsible for the samples was Beele Engineering BV at Aalten, the Netherlands. The samples are described in table 1.

Table 1 Samples

Sample (code)	Describtion	Dimensions
990869/1	RISE EMC Multi-cable transit with 1 cable	Diameter 80 mm Length 200 mm
990869/2	RISE Multi-Cable transit with 1 stainless steel pipe	Diameter 110 mm Length 200 mm
990869/3	RISE Multi-Cable transit with 6 cables	Diameter 110 mm Length 200 mm
990869/4	RISE sheet material	Thickness 8 mm
990869/5	FIWA putty	Cartridge

3 Investigations

The investigations were carried out on complete multi-cable transits for the temperature cycle test. The other experiments were done using sheet material.

The multi-cable transits were prepared by Beele Engineering. To show the behaviour of the RISE-system (inside), the three RISE (model)systems were transparant. The steel pipe therefore had been replaced by a pipe based on polycarbonate.

3.1 Temperature cycle test

The temperature cycle test was carried out on all three model samples. The temperature cycle test was carried out using the following scheme.
Starting at a temperature of 23 °C :

24 hours at 70 °C
24 hours at 23 °C
24 hours at -40 °C
24 hours at 23 °C
24 hours at 70 °C

After the last temperature step, the transits were cooled down to 23 °C. At each temperature change, the transits were visually inspected. No visual defects were shown.

The test concerning long term behaviour (expansion of the RISE material) was to be carried out at a temperature of 120 °C. Therefore, a second temperature cycle test was carried out with a maximum temperature of 120 °C. The test was carried out on sample 990869/3, multi-cable transit with 6 cables (worst case). Because of the softening of the plastic, the exposure period at 120 °C was limited to 2 hours.
Starting at a temperature of 23 °C:

2 hours at 120 °C
24 hours at 23 °C
24 hours at -40 °C
24 hours at 23 °C
4 hours at 120 °C

After the last temperature step, the transit was cooled down to 23 °C. At each temperature change, the transit was visually inspected. Some remarks can be made:

- after the first 2 hours at 120 °C the pipe diameter had increased from 110 mm to 132 mm. This increase seemed to be caused by the softening of the plastic in combination with the overpressure in the pipe as a result of heating and the production of water vapour caused by the fillers in the RISE sleeves;
- after the second temperature step during 4 hours at 120 °C the pipe diameter had increased from 132 mm to 170 mm;
- after cooling down the cable sheaths had shrunk due to orientation of the molecules of the plastic (PVC) material;
- the adhesion of the silicone sealant to the plastic pipe and the cables is good, therefore, due to shrinking of the plastic cable sheath, the silicone seals (on both sides) were pulled inwards for about 10 mm, some delamination was shown on the edge;
- the RISE sleeves were still around the cables.

From the samples some photo's were taken.

Photo 1	Sample 990869/1, as such;
Photo 2	Sample 990869/1, after temperature cycle test at 70 °C;
Photo 3	Sample 990869/2, after temperature cycle test at 70 °C;
Photo 4	Samples 990869/1 and /2, after temperature cycle test at - 40 °C;
Photo 5 and 6	Sample 990869/3, after temperature cycle test at 120 °C, as can be seen on these photo's the shrinking of the cable sheaths.

The photo's are shown in the enclosures.

3.2 Long term behaviour

The most important property for functioning of the RISE material upon heat exposure, is the expansion. Ageing of polymers can be accelerated by increasing the temperature. To get an impression of what can be expected of the transit system after several years of functioning, the expansion capability has been determinated before and after ageing. To carry out these experiments samples of the RISE sheet and FIWA putty as such, without a pipe and cables, have been used. Therefore the extra protection which they will have in practice is not taken in account.
Roughly it can be said that the ageing for polymers accelerates by a factor 2 to 3 for each 10 °C the temperature is increased. Taking the average of a factor of 2.5 the long term behaviour of 50 years at 40 °C can be simulated by an oven test during 2 weeks at 120 °C. Because a somewhat lower factor can be more realistic for this material, also 4 weeks exposure was used.
After the accelerated ageing in an air oven at 120 °C for 2 weeks and 4 weeks the expansion capability was tested by storing the samples for 30 minutes at 350 °C.

The RISE material (sheet) was cut into pieces of 40 x 40 mm. The samples were exposed during 1 week, 2 weeks and 4 weeks at 120°C. After the exposure time the samples were heated during 30 minutes at 350 °C. After the heating period the height was measured in mm. The results in table 2 are the median values of three samples.

Table 2 Volume increase during exposure (RISE sheet material)

	Original height (mm)	Height (mm) after 30 min 350 °C	Increase (%)
As such	8	32	400
After ageing 1 week at 120 °C	8	32	400
After ageing 2 weeks at 120 °C	8	29	360
After ageing 4 weeks at 120 °C	8	29	360

A second test was carried out on FIWA sheet material. The sheet was prepared from the FIWA putty. After 1 week drying the sheet was cut into pieces of about 40 x 40 mm. The samples were exposed during 2 weeks at 120 °C. After the exposure time the samples were heated during 30 minutes at 350°C. After the heating period the height was measured in mm. The results in table 3 are the median values of three samples.

Table 3 Volume increase during exposure (FIWA silicone sealant)

	Original height (mm)	Height (mm) after 30 min 350 °C	Increase (%)
As such	9	29	320
After ageing 2 weeks at 120 °C *	9.5	30	315

* polymer degradation

As can be seen from table 2 the RISE sheet material shows after accelerated ageing for 2 and for 4 weeks at 120 °C, a decrease of 10%. As can be seen from table 3 the FIWA sealant shows even a smaller decrease. However, it must be noticed that after 2 weeks the silicone sealant shows some polymer degradation at the sides of the samples.

4 Conclusions

The temperature cycle test for the three model samples at a temperature of + 70 °C to - 40 °C showed no visible damages. For sample 990869/3 (worst case), a temperature cycle test of + 120 °C to - 40 °C showed an increase of the pipe diameter and some debonding of the silicone sealant from the edges of the pipe. The adhesion was still good as can be seen by the high increase of the pipe diameter as a result of the internal overpressure. Such overpressure was never possible if the silicone sealant had been leaking.

The longterm expansion behaviour of the RISE material and the FIWA sealant showed just minor changes after accelerated ageing at high temperature.

From all tests it is concluded that the system will still function well after a long period of use. Probably for over 50 years.

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Project Manager

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Enclosures

Photo 1	Sample 990869/1, as such
Photo 2	Sample 990869/1, after a temperature cycle test at 70 °C
Photo 3	Sample 990869/2, after a temperature cycle test at 70 °C
Photo 4	Samples 990869/1 and /2, after a temperature cycle test at -40 °C
Photo 5	Sample 990869/3, after a temperature cycle test at 120 °C, overview
Photo 6	Sample 990869/3, after a temperature cycle test at 120 °C, detail

Photo 1
Sample 990869/1, as such

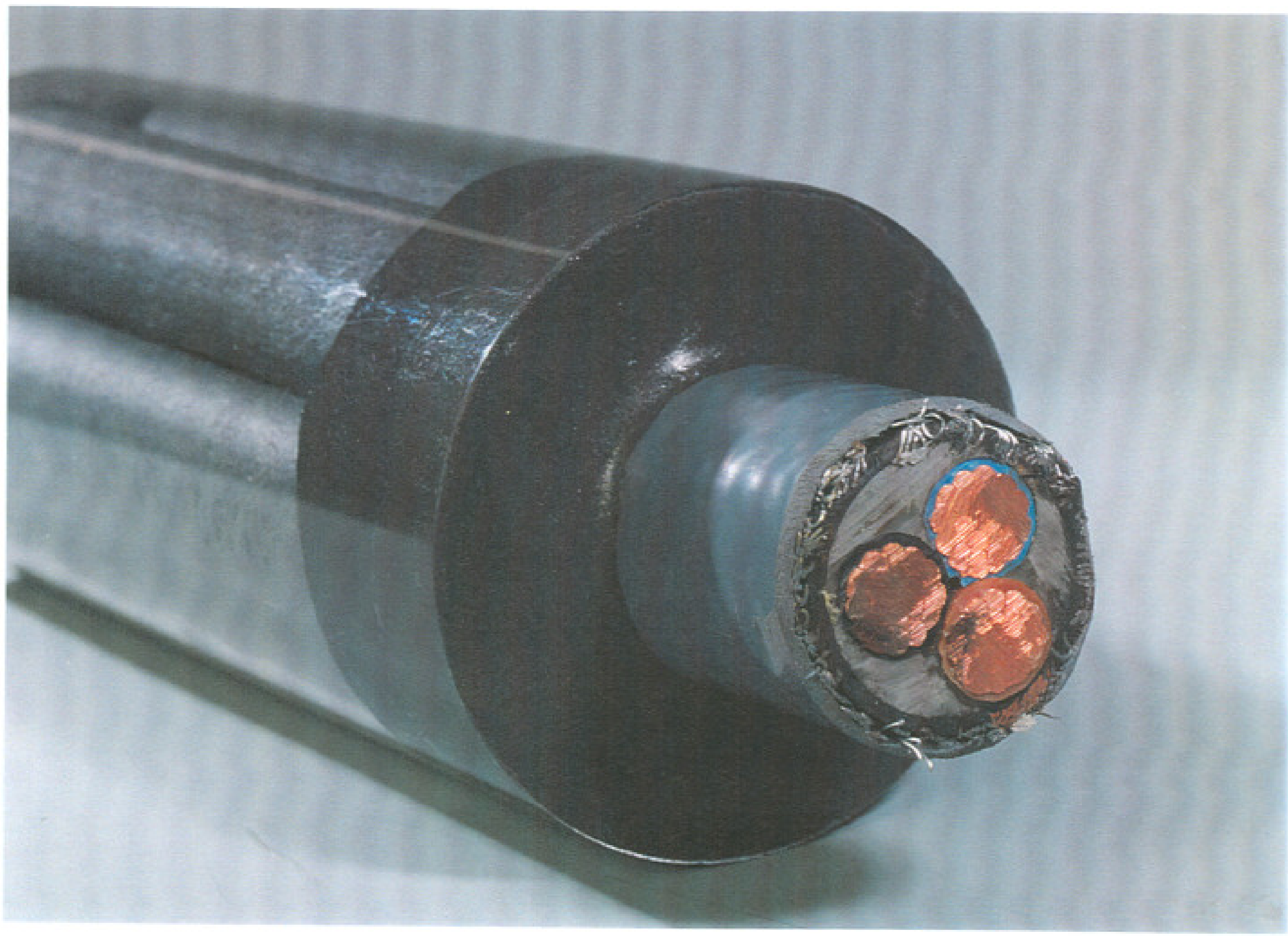

Photo 2
Sample 990869/1, after a temperature test at 70 ℃

Photo 3
Sample 990869/2, after a temperature cycle test at 70 °C

Photo 4
Sample 990869/1 and /2, after a temperaure cycle test at -40 °C

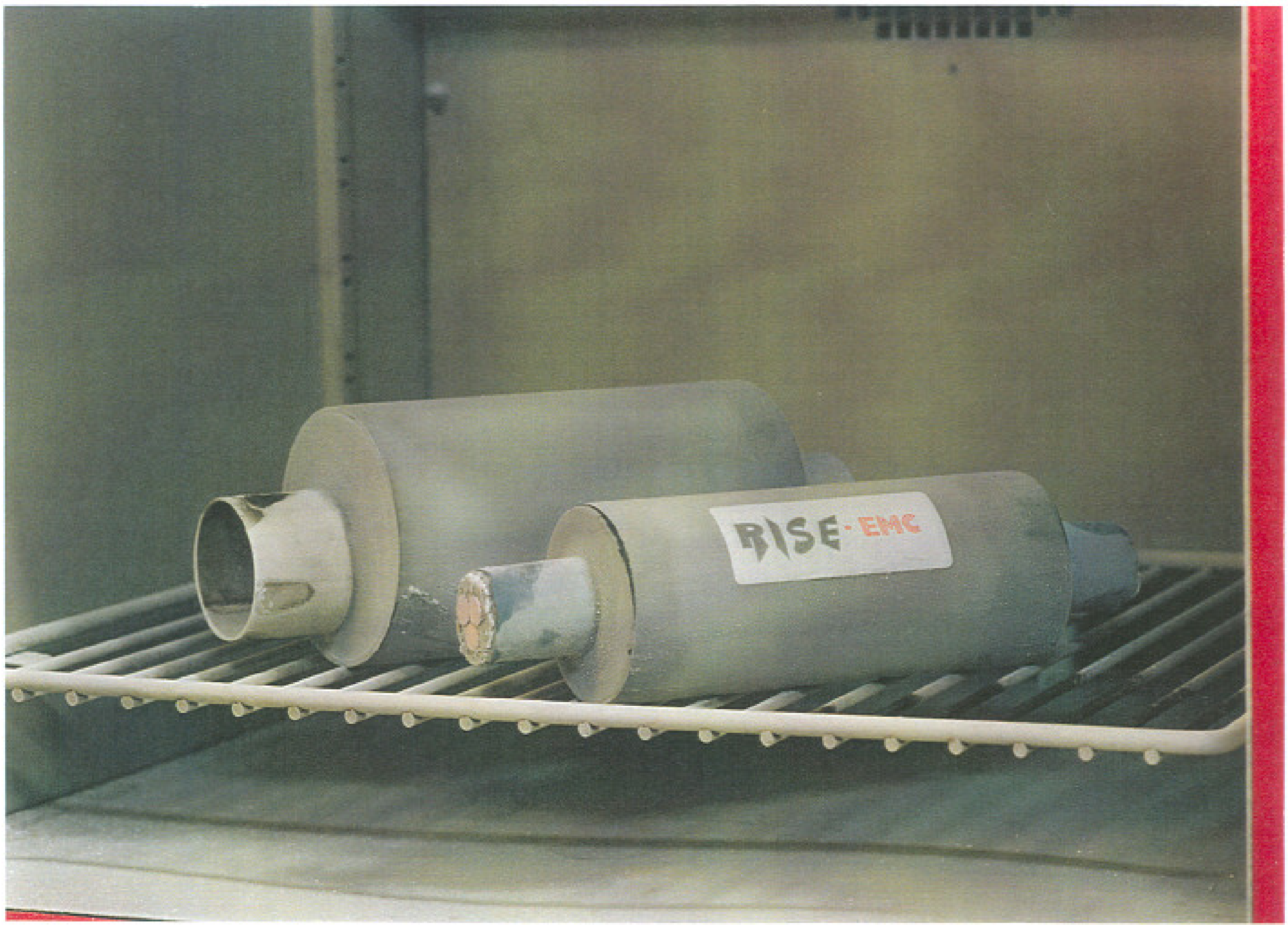

Photo 5

Sample 990869/3, after a temperature cycle test at 120 °C, overview

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Photo 6
Sample 990869/3, after a temperature cycle test at 120 °C, detail