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Assessment of the suitability of the
NOFIRNO sealing system for pipe transits
in bund walls around aboveground storage
tanks for flammable liquids



Requirements according to Directive PGS 29



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Assessment of the suitability of the NOFIRNO sealing system for pipe transits in bund walls around aboveground storage tanks for flammable liquids

Requirements according to Directive PGS 29

Colophon

Title	Assessment of the suitability of the NOFIRNO sealing system according to Directive PGS 29
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Preface

The Advisory Board Dangerous Substances, appointed by the Dutch government, has developed safety guidelines for the aboveground storage of flammable liquids in vertical cylindrical tanks. These guidelines are published in the Directive PGS 29, dated October 7, 2008.

This report contains an assessment of the suitability of the NOFIRNO sealing system for transits in bund walls according to the Directive PGS 29.



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1 NOFIRNO sealing system

The NOFIRNO sealing system from Beele Engineering B.V. consists of hollow rubber tubes of NOFIRNO and NOFIRNO sealant. Both materials are fire resistant. The NOFIRNO sealing system meets the requirements of the EOTA standard ETAG 026-2 "Fire stopping and fire sealing products – penetration seals". Beele has an European Technical Assessment (ETA) with number 13/0153. In this ETA the sealing system is described in detail.

The NOFIRNO products are CE-certified on AVCP level 1. This means that the manufacturer's quality control system for maintaining the product quality on a constant level is audited by Kiwa on the production location twice a year. In figure 1 an example is displayed of a pipe transit through a wall with a thickness of 200mm.

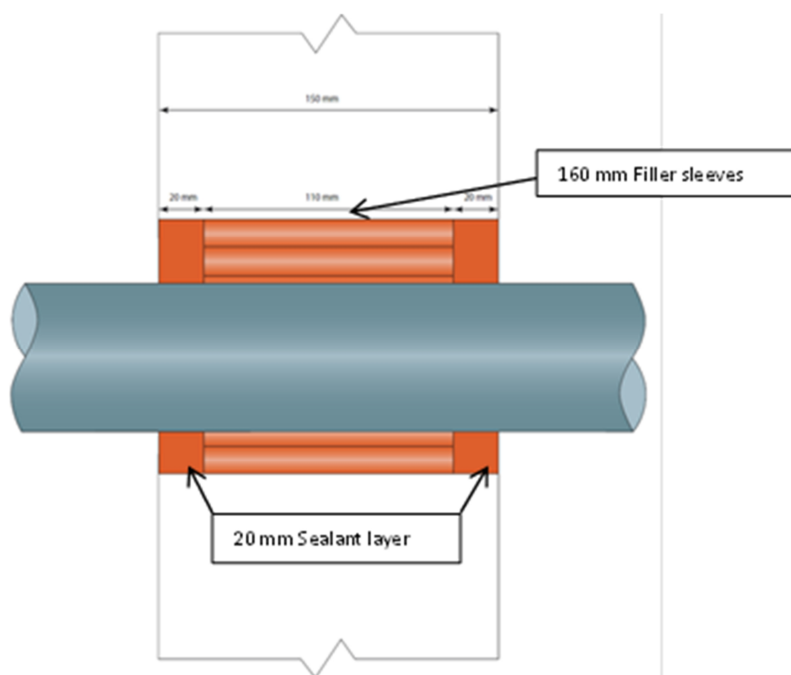


Figure 1. NOFIRNO pipe transit sealing system in a wall with a thickness of 200mm.



2 Directive PGS 29: Requirements to transits in bund walls

In the PGS 29 the following is described with respect to transits:

'5.4.3 Transits

47. Transits through a bund wall shall be liquid tight, fire resistant, capable to withstand the expected hydrostatic pressure and resistant to stored liquids. The transits shall be strong and flexible enough to counteract the displacements of pipes and bund walls.

In the directive PGS29 the conditions that can occur in case of hazardous situations are not described in further detail. No mention is made of height and duration of the maximum possible hydrostatic pressure, of which fire conditions need to be resist and of the magnitude of displacements.

Kiwa formulated risk scenarios and based on these set up functional requirements for the transits, taking the non-specific PGS 29 guidelines as a starting point. These scenarios are intended to be worst case scenarios.

In chapter 3 the properties mentioned in the PGS 29 Directive are translated to risk scenarios with consequent functional requirements to the transits.

In chapter 4 the performance of the NOFIRNO sealing system for pipe transits in bund walls is assessed, using available results of conducted tests.



3 Risk scenarios and functional requirements set to transit sealing systems

3.1.1 Risk scenarios with respect to the requirement for liquid tightness

Hazardous situation: Extremely high water level at the outside of the bund wall. The transit sealing system shall remain water tight.

Translated functional requirement to the transit sealing system (worst case):
No water leakages at a hydrostatic pressure of magnitude of maximum 5 meter water column.

Hazardous situation: The spill containment within the bund wall is completely filled with flammable liquid from the storage tank for a maximum of 72 hours; the height of the liquid is the distance between the top of the bund wall and the transit.

Translated functional requirement to the transit sealing system (worst case):
No liquid leakage at a hydrostatic pressure with a magnitude of maximum several meters liquid column for maximum 72 hours.

3.1.2 Risk scenarios with respect to the requirement for fire resistance

Hazardous situation: The spill containment is completely filled with flammable liquid until the height of the transit; the liquid is on fire for maximum 2 hours.

Translated functional requirement to the transit sealing system (worst case):
The integrity of the transit sealing system shall remain intact during a 2 hour pool fire.

3.1.3 Risk scenarios with respect to the requirement for unexpected displacements of pipes and bund walls

Hazardous situation: There is an unexpected displacement of pipes and bund walls.

Translated functional requirement to the transit sealing system (worst case):
The integrity and the tightness of the transit sealing system shall remain intact in case of the following displacements;

- The pipe is displaced in longitudinal direction; the displacement of the pipe in relation to the outer transit wall is maximum half of the difference in diameter between the pipe and the transit wall. See figure 2 in the Annex.
- The pipe is displaced in the lateral direction (perpendicular to the longitudinal direction); the displacement is maximum one sixth of the difference in diameter between the pipe and the transit wall. See figure 3 in the Annex.



4 Assessment of the performance of the NORFIRNO sealing system

4.1 Functional requirement for water tightness

No leakages at a hydrostatic pressure of magnitude of maximum 5 meter water column.

Performance of the transit sealing system

In the R&D centre of Beele Engineering several tests have been conducted in respect of the water tightness of pipe transits with a NORFIRNO sealing system. The tests were witnessed by independent certification bodies (Kiwa, ABS or DNV-GL). Tests showed that NORFIRNO sealing systems for pipes in a rectangular transit frame with a length of minimum 90 mm show no signs of leakages at a hydrostatic pressure of maximum 20 meter water column. In longer transit frames the sealing system can even resist higher pressures. NORFIRNO sealing systems in a circular transit with single pipes showed to be water tight up to 50 meter of water column. A long term high level of water resistance can be maintained.

Assessment of the NORFIRNO sealing system for water tightness according to PGS 29

The NORFIRNO system complies with the functional requirement for water tightness.

References

Kiwa report 20150909HN1 Evaluation of air and water tightness of NORFIRNO multi cable penetrations.

Beele test reports 1312-127, 1040-131, 1408-140, 1409-142, 1412-146, 1502-147.



4.2 Functional requirement for the tightness for flammable liquids

No leakages at a hydrostatic pressure of magnitude of several meters water column for a time period of maximum 72 hours.

Performance of the transit sealing system.

The outer surface of the NOFIRNO penetration seal is a cured flexible silicon sealant. When the sealant comes in contact with liquid mineral hydrocarbons it will swell slowly in time due to take up of liquid. The amount and the rate of the volume increase is depending on the type of liquid. The volume increase of silicon sealants in liquid mineral hydrocarbons can range typically between 25% and 100% after 3 days. In an investigation of the behaviour of a silicon sealant from Beele for transit sealing (tradename FIWA) conducted by TNO, the volume increase after 1 month was 92 % in petrol and 27 % in diesel. After 4 days of drying the remaining volume increase for petrol was less than 5% and for diesel less than 20%.

The volume increase of silicon sealant in contact with these type of liquids does not continue: the swelling rate is decreasing fast after several days and will stop at a certain maximum, depending on the type of liquid. The volume increase is only a physical phenomenon; there is no chemical degradation in contact with many different mineral hydrocarbons.

Considering a few days period a volume increase is not unfavourable for the liquid tightness of the sealant. The material will remain tight in the transit but also will bulge outside. After a few days some types of liquids can cause a high volume increase to an extent that the sealant material will weaken; at large bulging there is an increasing chance of tearing of the sealant. This doesn't has to immediately cause a leaking of the liquid to the inner of the penetration seal.

After emptying the spill containment the swelling of the sealant will decrease for a large part due to the evaporation of the liquid.

The NOFIRNO sealing system has a sealant layer on both outer sides of the transit. In case that the one in contact with the flammable liquid would start to leak, the second sealant layer will function as a second barrier.

Assessment of NOFIRNO penetration sealing system for the tightness for flammable liquids according to PGS 29

The NOFIRNO system complies with the functional requirement for liquid tightness.

References

TNO report TQS-RAP-07-3192/gge of 20 December 2007.



4.3 Functional requirement for fire resistance

The integrity of the transit sealing system shall remain intact during a 2 hour pool fire while the flammable liquid in the spill containment has reached the level of the transit seal.

Performance of the transit sealing system

The NORFIRNO penetration seals are fire resistant. This has been proven in several different fire tests of transit sealing systems through walls and floors of aerated concrete (construction) and metal bulkheads and decks (shipping), where the integrity of the transit sealing system remained intact for at least 4 hours. The conditions of the fire tests are more severe than the conditions during a pool fire.

Reports of fire tests conducted in independent laboratories and in the R&D centre of Beele Engineering (witnessed by ABS or Kiwa) are in possession of Beele Engineering B.V.

Assessment of NOFIRNO penetration sealing system for fire resistance according to PGS 29

The NOFIRNO system complies with the functional requirement for fire resistance.

References

ETA 13/0153

Kiwa Evaluation report for ETA 13/0153

Several fire tests reports

Classification reports



4.4 Functional requirement for unexpected displacements of pipes and bund walls

The integrity and the tightness of the transit sealing system shall remain intact in case of the following displacements;

- The pipe is displaced in longitudinal direction; the displacement of the pipe in relation to the outer transit wall is maximum half of the difference in diameter between the pipe and the transit wall. See figure 2 in the Annex.
- The pipe is displaced in the lateral direction (perpendicular to the longitudinal direction); the displacement is maximum one sixth of the difference in diameter between the pipe and the transit wall. See figure 3 in the Annex.

Performance of the transit sealing system

Recently Beele Engineering B.V. has conducted dynamical tests with the NORFIRNO transit sealing system in respect of earthquake resistance. The conducted tests were witnessed by Kiwa.

NOFIRNO pipe transits were dynamically loaded using different maximum displacements of the ducted pipe in longitudinal as well as in lateral direction during a large number of cycles. At longitudinal displacements no cracks were detected at displacements up till half of the difference in diameter between the pipe and the transit wall. At lateral displacements no cracks were detected at displacements up till one sixth of the difference in diameter between the pipe and transit wall. At larger displacements the sealant slightly peeled off from the transit pipe's inner surface over a small area around the circumference. It is noticed that the displacement was carried out in two directions in respect of the starting position; the sealant was repeatedly submitted to stress and compression loads. Consequently after the dynamical tests the transit sealings were tested on water tightness. The seals showed to be water tight at 25 meter water column for a long time period.

Assessment of NOFIRNO transit sealing system to unexpected displacements of pipes and bund walls according to PGS 29

The NOFIRNO system complies with the functional requirement for resistance to the mentioned maximum displacements of the penetrated pipe.

References

Test results of Beele by videos, photos and test data.



5 Conclusions

Based on this assessment it can be stated that there is sufficient confidence that the NOFIRNO sealing system meets the functional requirements for pipe transits in bund walls around aboveground storage of flammable liquids in vertical cylindrical tanks. Therefore NOFIRNO penetration sealing system complies with the Directive PGS 29.

The following conditions apply.

1. The NOFIRNO transit sealing system shall be applied by qualified employees according to the installation manual of Beele Engineering B.V.;
2. The transits with the NOFIRNO sealing system shall not be damaged by future activities on the concerning penetrated wall or other activities;
3. After the event of hazardous situations as described in this report the quality of the transit sealing systems shall be controlled.

Rijswijk, October 2015

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Annex



Figure 2. Displacement of the pipe in the longitudinal direction in relation to the outer transit wall with half of the diameter difference between the pipe and the transit wall.



Figure 3. Displacement of the pipeline in lateral direction (perpendicular to the longitudinal direction); the displacement in relation to the transit wall is one sixth of the difference in diameter between the pipe and the transit wall.