

To: PLC's
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Tests performed on the Manholes PRO800 and PRO1000

1 Summary

This report is designed to provide Pipelife Companies with general overview of the tests performed on Pipelife Manhole PRO800 and PRO1000. The test results allow Pipelife Corporate R&D to conclude that PRO manholes are safe as they pass all the requirements of prEN 13598-2 "Plastics piping systems for non-pressure underground drainage and sewerage - Unplasticized poly (vinyl chloride) (PVC-U), polypropylene (PP) and polyethylene (PE) Part 2: Specifications for manholes and inspection chambers in traffic areas and deep underground installations".





2 Contents

1	Summary	1
2	Contents	2
3	Introduction.....	3
4	Experimental	3
4.1	Description of the manholes PRO800 and PRO1000	3
4.2	Raw materials.....	4
4.3	Processing	5
4.3.1	Low pressure injection moulding.....	5
4.3.2	Extrusion moulding.....	6
4.3.3	Rotational Moulding	6
4.4	Testing.....	7
4.4.1	Impact testing.....	7
4.4.2	Resistance to internal under and over pressure.....	8
4.4.3	Mechanical strength of the fittings	8
4.4.4	Mechanical strength of the cones.....	9
4.4.5	Underground installation	9
4.4.6	Quality of the welds	10
4.4.7	Tensile tests.....	10
4.4.8	Step bending test	11
5	Results	12
5.1	Impact and tensile testing.....	12
5.2	Resistance to over pressure.....	13
5.3	Resistance to under pressure.....	13
5.4	Mechanical strength of the fittings	13
5.5	Mechanical strength of the cones.....	13
5.6	Underground installation	14
5.7	Ring stiffness	14
5.8	Welding quality.....	14
5.9	Step bending test	15
6	Conclusions.....	15
7	Appendix A: Drawings	16
8	Literature.....	19



3 Introduction

The experiments and tests are performed on the manholes PRO800 and PRO1000 for marketing and certification purposes. This report summarizes these tests and discusses the results.

4 Experimental

4.1 Description of the manholes PRO800 and PRO1000

The manholes consist of 3 major parts:

- BASE with inlet/outlet adapters for pipeline connections,
- one or more RISER rings with or without integrated steps
- CONE with telescopic or fixed entrance shaft

All major parts of the manholes are made out of Polypropylene using low pressure injection moulding (LPIM), high pressure injection moulding (HPIM), extrusion or roto-moulding technologies.

The parts could be joined by extrusion welding or with the sealing rings made out of EPDM rubber, according EN681-1.

Principal drawings of the manhole in Appendix A.

BASE

The BASE body is a cylindrical LPIM ring with internal diameters of 800 or 1000 mm, effective height of 500 mm and socket height of 90 mm.

BASE bottom plug consists of two butt-welded LPIM plates with internal rib reinforcement. Bottom plug is extrusion welded in BASE body/ring

For pipeline connections to PRO Manhole various inlet/outlet adapters can be welded in BASE or RISER. The adapters are injection moulded or made out of extruded pipes.

The flow channels / shells that direct sewer flow could be made of:

- LPIM PP shells from PRO630 combined with side extensions (pipe connections OD 160, 200)
- Roto-moulded PP shells full size or with side extensions (pipe connections OD 250, 315, 400)
- GFRP shells full size (pipe connections OD 250, 315, 400)

Pipelife PRO800/1000 manholes offer 78 standard and more than 3000 custom made inlet/outlet adapter and flow channel configurations. In combination with 7.5° adjustable double sockets (ADS), PRO800/1000 manholes offer unlimited variety of different angle and height pipeline connections to fit the most complicate pipeline junction design.



RISER

RISER consists of the same cylindrical ring(s) as BASE body. RISER rings could be equipped with integrated step profiles. The height of the RISER can be increased by adding one or more rings. The height of each RISER rings can be shortened for 100 or 200 mm on site.

CONE

On top of the RISER, a CONE is used to decrease the manhole ID 800 mm or 1000 mm to entrance shaft ID 600 mm.

- CONE for manhole PRO800 consists of LPIM reducing cone 800x630 and telescopic or fixed entrance shaft ID 600mm
- CONE for manhole PRO1000 consists of LPIM reducing cone 1000x800 in combination with cone 800x630 and telescopic or fixed entrance shaft ID 600mm
- Telescopic entrance shaft is made of PVC, PP or PE pipe OD 630mm and sealed in reducing cone 800x630 with LPIM telescope adapter and standard 630mm L ring.
- Fixed entrance shaft is made of HPIM 630 socket butt-welded on the top of the reducing cone 800x630.

For entrance shaft top solutions local certified EN124 type Cast Iron Covers are used.

4.2 Raw materials

Sabic’s Stamylyan P 71EK71PS² is used for the LPIM and extruded parts. This is a polypropylene block copolymer particularly suitable for sewage pipe applications. In table IA provides some relevant material properties from the technical data sheet of Sabic.

Table IA

Property	Values	Test method
Density	905 kg/m ³	ISO 1183
MFI at 230°C and 2.16 kg	0.3 g/10min	ISO 1133
Izod impact strength at 23°C	>50 kJ/m ²	ISO 180
Tensile stress at yield	35 MPa	ISO 527
Elongation at break	>500 %	ISO 527
Flexural modulus	1500 MPa	ASTM D790



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ICO Polymers's Icorene® PPCO14RM³ is used for the rotational moulded flow channels and the telescope part. This is a polypropylene block copolymer. Table IB provides some relevant properties from the technical data sheet of ICO Polymers.

Table IB

Property	Values	Test method
Density	900 kg/m ³	ISO 1183
MFI at 190°C and 2.16 kg	13.0 g/10min	ISO 1133
Tensile stress at yield	27 MPa	ISO 527
Strain at yield	7 %	ISO 527
Flexural modulus	1350 MPa	ISO 527

BP's Innovene 433NA00⁴ is used for the injection moulded and extruded inlet/outlet adapters. Table IC provides some relevant properties from the technical data sheet of BP.

Table IC: *Some data of Innovene 433NA00 taken from the datasheet.*

Property	Values	Test method
MFI at 230°C and 2.16 kg	0.3 g/10min	ISO 1133
Tensile stress at yield	28 MPa	ISO 527
Flexural modulus	1350 MPa	ISO 527

4.3 Processing

4.3.1 Low pressure injection moulding

The major manhole parts are made by LPIM technology.

With this technology, nitrogen - as a physical blowing agent - is injected under pressure in the polymer melt in order to expand in the mould where the temperatures will be high and the pressures low. The blowing agent quantity in the melt will determine the product density. After injection, the melt at the wall of the mould will cool down very quickly resulting in a foam free wall. Irregularities at the surface are avoided by two methods: (1) a two component system, one component with blowing agent and one without and (2) applying a gas pressure in the mould higher than the expansion pressure of the blowing gas, resulting in foam suppressing. The latter results in a thick compact skin, free of internal stresses and sink-marks.

The products are made by IPS.⁵

Due to this processing method, a foamy structure exists in the core of the layers of the product. This will slightly reduce product density, impact strength and some tensile properties. The above mentioned reductions of the properties are considered as non critical.

The material used is Stamylan P71EK71PS.



4.3.2 Extrusion and injection moulding

The PP inlet/outlet adapters could be high pressure injection moulded or made from extruded pipe. In case of extruded pipe solution, inlet/outlet adapters should be sawed to the appropriate length and conically chamfered for poly-fusion welding in the BASE or RISER. Inlet/outlet adapters are made from BP's Innovene 433NA00. The properties of these parts will be close to the raw material properties provided by producer.

4.3.3 Rotational Moulding

The telescope and some of the flow channels are made by rotational moulding. Rotational moulding technology allows pressure free moulding of closed design parts. The concept is as follows: A predetermined charge of cold plastic powder is placed in one 'half' of the cold mould. The mould is then closed and rotated biaxial in a heated oven. When the metal mould heats up, the plastic powder tumbling inside the mould starts to melt and stick to the inner surface of the mould. When all the powder is melted, the mould is transferred into cooling environment. The biaxial rotation continues until all the plastic is solidified. At this point the mould can be opened and product removed.⁶

The material used is Icorene® PPCO 14RM

4.4 Testing

4.4.1 Impact testing

Falling weight tests from a height of 2.5 m with a 1 kg weight and a cone radius of 50 mm were performed close to the injection points of the flow channels (see figures 1A and B) at 23°C.

The area close to the injection point is supposed to be the weakest part of the flow channel.

The same test is described in prEN 13598-2. According to this standard the weight should fall in the middle of the chamber. However, this is in the middle of the flow channel on the two edges of the halves. Because of the fact that this will give undefined results a better defined place is chosen, which is also expected to be more critical.

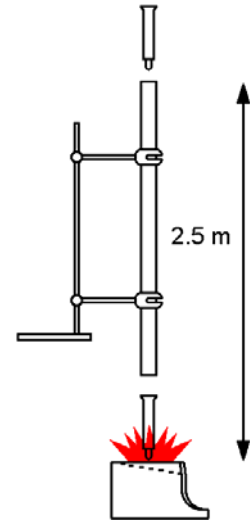


Figure 1A: Impact test set up.



Figure 1B: Impact test set up for the rotational moulded shells. The left picture shows the full set up, the middle picture shows the alignment at the place of impact and the right picture shows the used impact weight.

4.4.2 Resistance to internal and external pressure

The tightness of the manholes is tested with the positive internal pressure tests. In these tests the inlet/outlet adapters are closed with tensile fixed couplers so that tests could additionally examine strength of inlet/outlet welds. Internal pressure is created with water and allows simulating a water filled manhole.

The deformation of the base under external pressure can be determined with the negative internal pressure tests. The tests have the objective to test the resistance against deformation and to control the short and long term behaviour for leakage. The negative pressure is created with vacuum and it allows simulating conditions of high ground water level.



Figure 2: Test set up for internal pressure test

4.4.3 Mechanical strength of the fittings

The mechanical test for fabricated fittings is described in EN12256.

In these tests a forced deformation is applied on inlet/outlet adapters by connecting a double socket and short pipe (see figures 3A and 3B) and bending it to the effective angle of 8°.

In order to get a deformation of 8° according to EN12256 the allowed cornering of the flexible double socket (= 2 x 7.5°) has to be added. To have a margin of the extra 2° the angle of 25° was chosen (see figures 3 and 4).



Figure 3A: Test set up for mechanical testing of the fittings and inlet/outlet adapters under the angle of 25° (left) and 10° (right) on PRO800 manhole.



Figure 3B: Test set up for mechanical testing of the fittings and inlet/outlet adapter under the angle of 25° (left and right) on PRO1000 manhole.

In case of standard double socket the adapter allows the angle of 2°. The angle in total was 10° in order to force a deformation of 8° (see figure 3A on the right side).



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During the testing the BASE was filled with water and elevated above the floor to avoid temperature variation effects. Steel end caps were used to close the two short pipes connected with the double sockets to the inlet/outlet adapters.

4.4.4 Mechanical strength of the cones

The strength of the cones against buckling is tested under a constant pressure speed conditions. A fixed flat rigid metal plate was mounted as top clamp in a ZWICK UPM 1486 Z 250. The bottom rested on a series of flat plates allowing deformations in horizontal directions only. In figures 4A and 4B the tests are performed on Pipelife manhole PRO800 and PRO1000.



Figure 4A: *Testing of the 800 cone on a 800 riser*

Figure 4B: *Testing of the 800 and 1000 cone on a 1000 riser*

The test performed on PRO800/1000 manholes is slightly different than described in prEN14802 where the load is not applied to the bottom, but to the surrounding soil via the (concrete) cover solution. Furthermore, the standard describes a manhole surrounded by soil allowing limited deformation of the rings themselves. It is acceptable that the maximum load values in PRO800/1000 manhole tests are lower than the values which will be measured in standard.

4.4.5 Underground installation

To test the resistance against rising due to floating and the tightness of the sealing rings under working conditions two manholes PRO800/1000 were installed underground.

Standard fine sand was used and compacted each half meter with relevant equipment.

For the PRO800 two riser rings and cone with telescopic entrance shaft were used. The EN124 type cast iron cover was installed on the top of the concrete plate. Due to telescopic entrance shaft solution the major part of surface load was directed into the surrounding soil.



Figure 5: *Impression of burying the 800 and 1000 manholes*



The same set up was chosen for the PRO1000, except that only one riser ring was used. Despite the high ground water level (~1 m) no any leakages or deformations in Pipelife manholes PRO800/1000 were observed.

4.4.6 Quality of the welds

The quality of the welds has the following control options:

- tightness tests
- deformation tests
- visual control

Tightness tests are described in 4.4.2

Deformation tests include bending test (see 4.4.3) and inlet/outlet adapter flattening test. In the flattening test the welds are deformed and stressed by compressing the adapter between two plates. The flattening is defined as the percentage of change in diameter between the compressed adapter and the initial diameter of the adapter. A picture is shown in figure 6.



Figure 6: *Clamping of the adapter to stress inlet/outlet adapter and base body weld..*

Visual control

A good quality can be observed when:

- a thick bead is observed around the welded edges.
- the bead is regular, equally distributed
- no bubbles forming in the bead.

4.4.7 Tensile tests

Tensile tests according to ISO527 were performed on specimens taken out of the flow channels. The specimens were taken out of it according to figure 7.

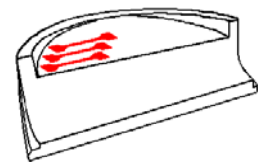


Figure 7: *acquiring test specimens*

4.4.8 Step bending test



The step profile is extruded from PP block copolymer BP's Innovene 433NA00 and installed between RISER ring ribs. Step profile has abrasive surface and could be supplied in red brown and bright yellow colours. The step width and distance to the wall fulfils prEN 13598-2 requirements. The step profile mechanical strength fulfils requirements of prEN 13598-2. In this test a vertical load in the middle of the step is applied downwards and the deflection is measured. The load is applied over a length of 90 mm exactly in the middle of the step. The deflection of the vertical load is measured according EN13101 at a force of 2.0 kN (This is comparable with a man weight of 204 kg) directly and after 1 minute. After 1 minute the load is quickly removed and the remaining deformation is measured.



5 Results

5.1 Impact and tensile testing

The falling weight tests were performed on the flow channels as described here above. The weight was dropped just above or very close to the injection point, which is situated in the middle on the flat declivity part of the flow channel.

For the low pressure injection moulded samples, two straight 180° flow channels were tested and one with a bend of 45°.

After the first impact no failure could be observed at all 3 flow channels. No cracks were observed, however the surface shows minor lasting deformations.

The tests were repeated on the same spots 5 times for all flow channels. Even, after 5 times of impact testing, no cracks could be observed.

For the rotational moulded samples, the following five shells have been tested 1 time on impact:

(1) 630 - 10"-90°; (2) 630 - 315-90°; (3) 630 - 315-135°; (4) 630 - 315-180°; (5) 630 - 315-180°.

After impact no failure could be observed at all 5 flow channels. No cracks were observed, however the surface shows minor lasting deformations.

Also tensile tests were performed. Tensile specimens were milled out of the flat plates according to figure 6. The results are summarised in tables IIA and B.

Table IIA: *Tensile tests on low pressure injection moulded Stamylan P71EK71PS.*

Property	Values	Test method
Tensile stress at yield	16.7 MPa	ISO 527
Elongation at break	42 %	ISO 527
Young's modulus	781 MPa	ISO 527

The foamy inner structure lowered the measuring tensile values. Although these values are lower than given in the material data sheets, they are supposed to be much larger than the operating circumstances. For example under normal working conditions the maximum elongation will not exceed the 4-5%, while the elongation at break is about 10-20 times higher.

Table IIB: *Tensile tests on rotational moulded Icorene® PPCO14 RM.*

Property	Values	Test method
Tensile stress at yield	24,22 MPa	ISO 527
Tensile strain at yield	6,7 %	ISO 527

Although these values due to LPIM technology process are slightly lower than given in the material data sheets, they are enough to prevent any failure under the operating circumstances.



5.2 Resistance to internal pressure

The test was performed on the Manhole 1000. At a testing pressure of +0.5 bars for 15 minutes no water leakage or cracks appeared. No damages were found at the welds of the adapter to the base.

Therefore, it can be concluded that the manhole is 100% watertight. It is not expected that any water will leak from into or out of PRO manhole.

5.3 Resistance to external pressure

PRO800 base, 2 raiser rings and cone was tested at -0.5 bar.
PRO1000 base, 1 raiser rings and cone was tested at -0.5 bar.

After 10 days of negative pressure at -0.5 bar no leakage or collapse was observed. The decrease of diameter measured in the first ring was 3 mm.

Those results insure safe PRO manhole installation in high groundwater conditions.

5.4 Mechanical strength of the fittings

The mechanical strength of the fittings was tested under an angle of 8° and 10° as can be seen in figure 3.

The test on the Manhole PRO800 with 2x200mm inlet/outlet adapters lasted for 96 hours and gave no leakage, cracking or collapsing.

The test on the Manhole PRO1000 with 2x315mm inlet/outlet adapters lasted more than 10 weeks and gave no leakage, cracking or collapsing.

Based on these results, the conclusion can be drawn that under normal circumstances no breakage, cracking or collapsing will occur.

5.5 Mechanical strength of the cones

The 800 cone in the 800 manhole carried a maximum load of 90 kN. The cone buckled downwards into the manhole.

The 800 cone on top of the 1000 manhole carried increasing load of more than 50 kN. The cone 800 socket area started to buckle in when loading increased above 50 kN. The cone 1000 did not buckle.

The loads acting on the cones are lower than the values measured here, because it is absorbed by the surrounding soil. Furthermore, due to the telescope construction, the cones are free from any stress.

Therefore, it is not expected that any buckling could occur when PRO manholes installed underground.



5.6 Underground installation

As discussed in chapter 4.4.5, the Manholes PRO800 and PRO1000 were buried underground on special test site.

PRO800 was 1.75 m submerged and PRO1000 was 1.25 m submerged into the ground water. In practice this means that on the lowest part of the base a pressure of respectively 0,175 and 0,125 bars act.

Both manholes did not show any tendency to rise or float up.
 No groundwater was observed leaking into the manholes.
 No deformation or cracks from inside were observed after one month.

From these tests it can be concluded that under normal installation conditions there is no risk of PRO manhole failure, collapse or leakage during its lifetime.

5.7 Ring stiffness

The ring stiffness was measured according ISO 9969

Table III: Results of the ring stiffness measurements

Set up	Ring Stiffness (kN/m ²)
Manhole 800 riser	2,5
Manhole 1000 riser, complete with spigot , socket and rubber seals	2,1
Manhole 1000 ring, taken out of the riser (l = 303 mm) body + 1/1 spigot	2,3

According to prEN 14982 the ring stiffness should be higher then 2 kN/m². This means that PRO manholes fulfil the standard.

5.8 Welding quality

A regular smooth bead can be observed in all welds. The welds appear to be of high quality.

The weld between the adapter and the base was mechanically tested (see figure 6 in chapter 4.4.6). The adapter was pressed between two plates starting at about 5 cm from the weld

The percentage of flattening was 20% and resulted in large deformations and stress concentrations in the welds.

After 24 hours no cracks were found between adapter and base.



5.9 Step bending test

The deflection was measured at 2.0 kN. Immediately after applying the load and one minute later deflection was not more than 10 mm. The remaining deformation after unloading was less than 1 mm.

The deflection at this weight is low and non critical. The remaining deformation after unloading is considered irrelevant.

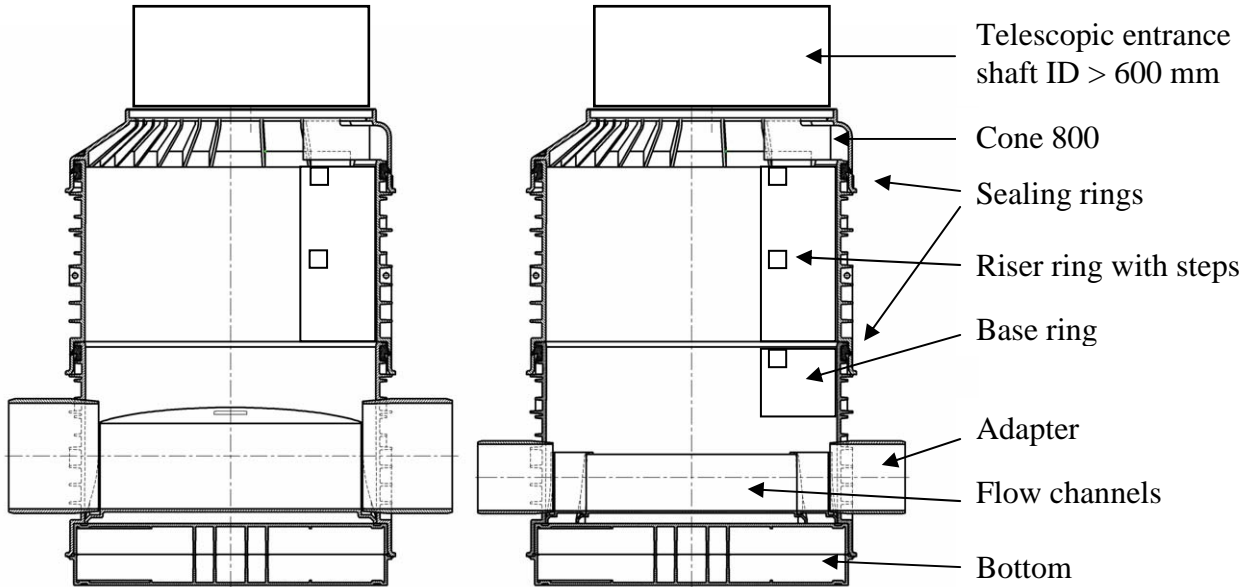
The steps of the stair can be considered safe and there is no risk of failure during normal use.

6 Conclusions

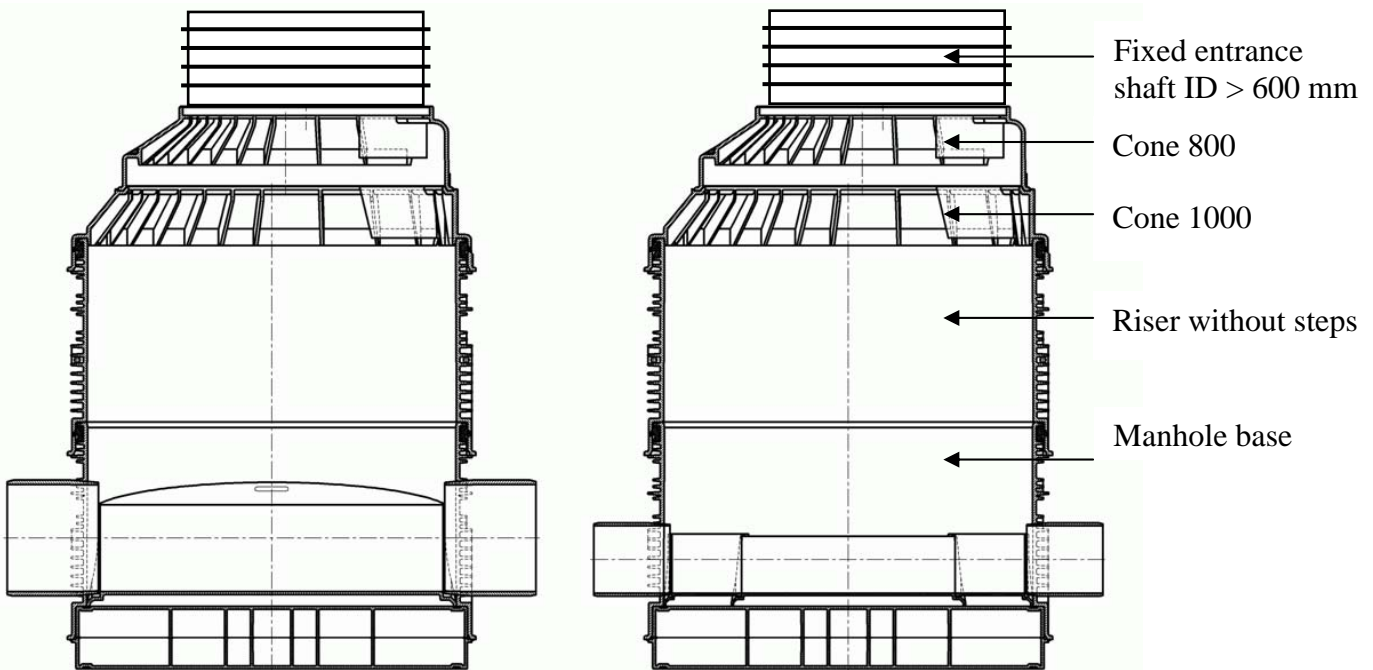
- The Manholes PRO800 and PRO1000 successfully pass the impact tests on Base bottoms and the internal and external pressure tests presented in this report.
- No leakage from inside or outside is expected to occur.
- Collapse or critical deformation of PRO manholes will not occur under normal operational circumstances including heavy traffic load.
- The ring stiffness of the structure is according to the relevant standards.
- The welds are watertight and mechanically strong.
- The integrated steps are considered safe.
- Pipelife manhole PRO800/1000 maximum installation depth is 5 meters (based on prEN 13598-2). In case of deeper installations, additional calculations are required. In order to install PRO Manholes in more than 3 meter high ground water, additional weld reinforcement will be added.

7 Appendix A: Drawings

PRO800 and PRO1000 general composition examples

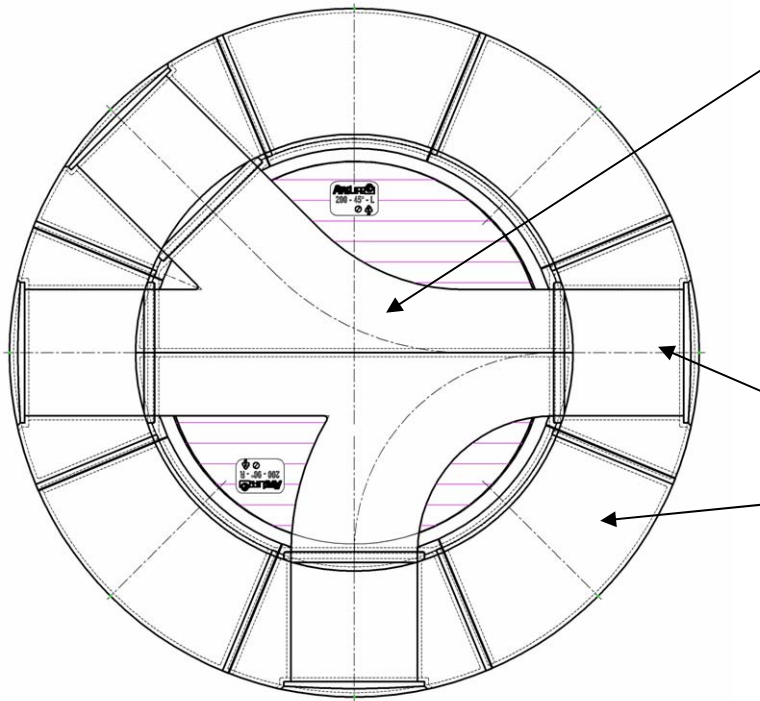


Manhole 800 with 315mm pipe adaptors Manhole 800 with 200mm pipe adaptors



Manhole 1000 with 315mm pipe adaptors

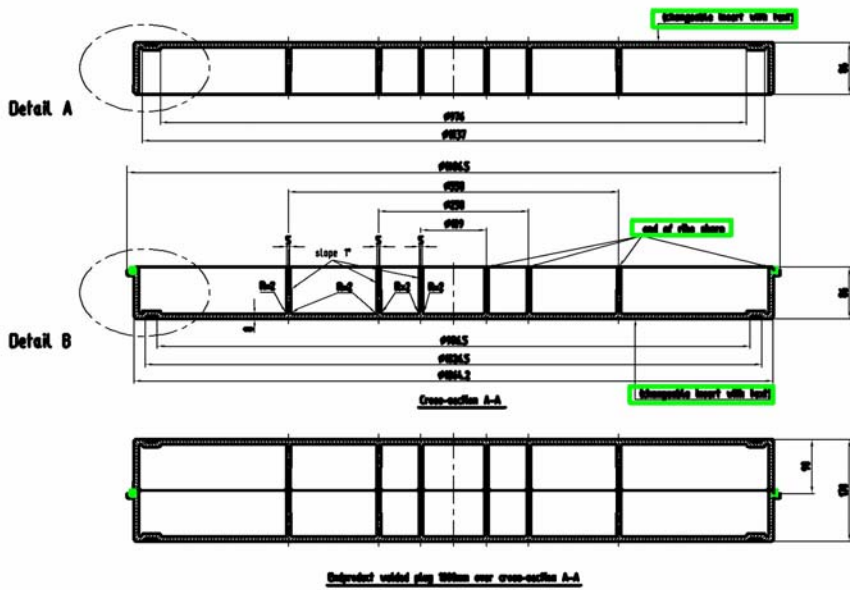
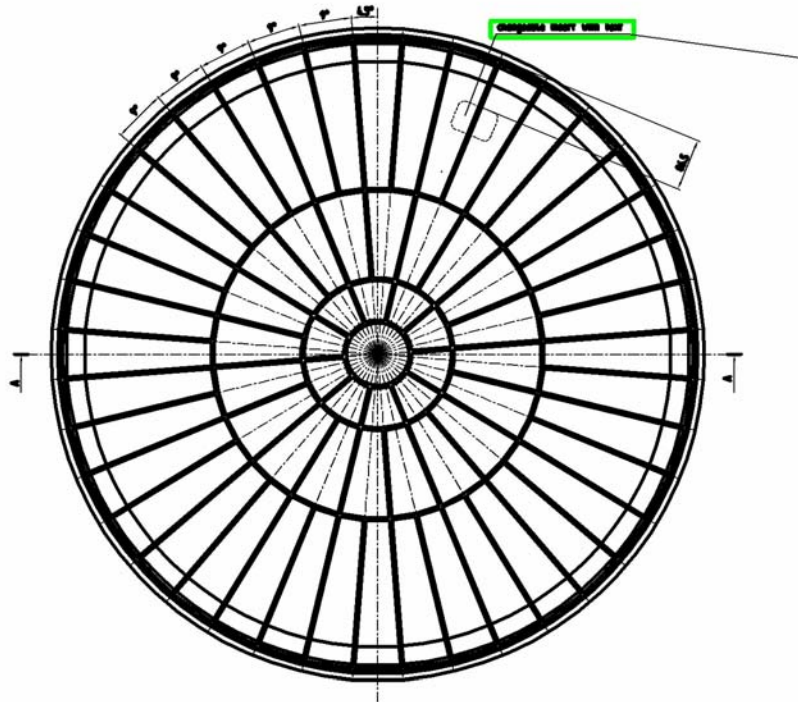
Manhole 1000 with 200mm pipe adaptors



Flow channel PRO630 mother shell, made of various configuration elements.

Side extension shells (with and without profile) fill the gap between PRO630 mother shell and PRO800 or PRO1000 mm inside wall

Samenstelling Stroomprofiel M1000



PRO800/1000 bottom plug sandwich construction.
 BASE bottom plug consists of two butt-welded LPIM plates with internal rib reinforcement.



8 Literature

- ² [SABIC Polypropylene B.V.](#), Technical data sheet Stamyran P 71EK71PS Revision 2/04-07-2003.
- ³ [ICO Polymers](#), Product data sheet ICORENE®PPCO14RM
- ⁴ [BP](#), Product data sheet overview PP Grade Range, INNOVENE 433NA00
- ⁵ [IPS](#): Innova Packaging systems NV, Rozendaalstraat 101 B-8900 Ieper - Belgium
- ⁶ Source: R.J.Crawford 'Rotational Moulding of Plastics. Second edition' ,1996, Rapra Technology Limited, 2003