Article

# “Regular enhanced test schedule for maximum safety”

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***Founded on February 24th, 1999, the PE100+ Association is an industry organisation of several polyethylene (PE) manufacturers whose objective is to guarantee consistent quality at the highest level in the production and use of PE 100 pipe material.***

***By monitoring the most critical properties of enhanced requirements, the Association is able to issue a "PE100+ Association Positive List of Materials" on a regular basis. The Association also aims to create a marketing platform to promote the use of PE piping in general.***

## Topics

- The PE100+ Association testing schedule
- Testing coordination of test rounds and the test institutes
- The enhanced requirements for PE 100 pipe materials
- The used testing methods
- The ”PE100+ Association Positive List of Materials”

## The PE100+ Association testing schedule

All procedures and administration before and after testing are handled by Gastec, who is heading the technical committee. The tests are performed at 3 different testing institutes on behalf of Gastec.

*Fig.1: Gastec Certification B.V.*

The PE 100 product manufacturers send 30 (15 for testing, 15 back-up) extruded 110 mm, SDR 11 pipes to Gastec. Each testing institute performs a different type of testing. Gastec forwards PIN-coded samples to those institutes and collects the results.


This testing schedule, which is repeated every seventh month, builds the base for the ”PE100+ Association Positive List of Materials”, which is issued by the Association. This list shows those products, which successfully met the PE100+ Associations requirements and has passed 2 test rounds.

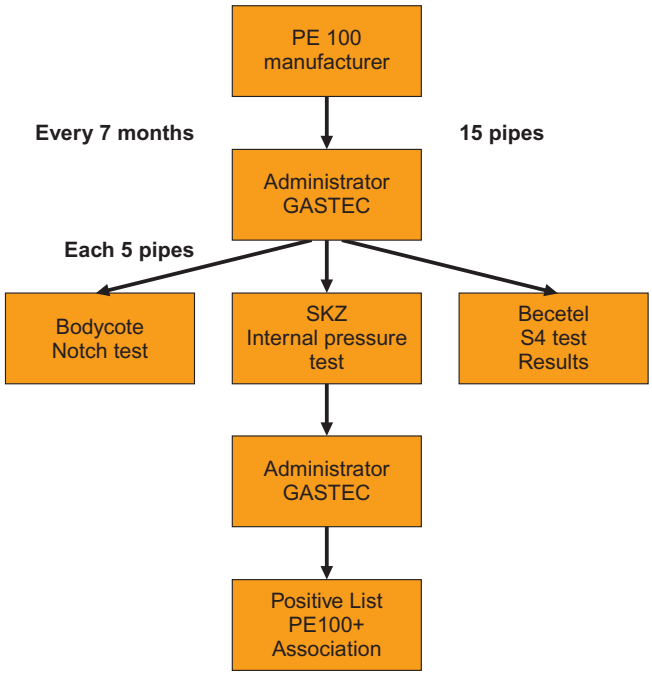


*Fig.2: PE100+ testing schedule*

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## The enhanced requirements for PE 100 pipe materials

PE 100 pipe materials are designed for long-term and secure use in both natural gas and water distribution systems. Therefore, the industry has developed a set of challenging and stringent requirements.

The PE100+ Association bases its material acceptance on the ISO and CEN standards: the relevant to be tested materials must conform to EN 1555-1 and ISO 4437, or EN 12201-1 and ISO 4427. To comply with this, fully documented data sets have to be provided demonstrating a long-term strength of at least 10.0 MPa at 20ºC over a period of 50 years according to ISO 12162 and as a consequence classified as MRS 10 (MRS … minimum required strength). This classification is based on an extrapolation method given in ISO/TR 9080. The designation on the pipe is according to ISO 1043-1. The manufacturer has to produce according to a certain ISO standard i.e. ISO 9000 or 9001.

A polyethylene with MRS of 10.0 MPa at 50 years, 20ºC is classified as PE 100 pipe material.

The PE100+ Association aims to set higher performance standards than those founded in CEN/ISO. Therefore, the Association organises regular controls on three critical properties, which ensures the secure operation of PE 100 pipes. These three properties are:

- A high degree of Long-term Strength
  **Creep Rupture Strength**
- Excellent resistance to Slow Crack Growth
  **Stress Crack Resistance**
- Good behaviour in Rapid Crack Propagation
  **Resistance to Rapid Crack Propagation**

The PE100+ requirements listed in the table (Fig. 3), show the testing methods and the enhanced requirements by the PE100+ Association compared with EN/ISO standards.

| Property | Test Method | EN/ISO Standard requirement | PE100+ requirement |
|---|---|---|---|
| **Creep Rupture Strength** | Internal pressure test at 20°C and 12.4 MPa ISO 1167/EN 921 | ≥ 100 h | ≥ **200 h** |
| **Stress Crack Resistance** | Pipe notch test at 80°C and 9.2 bar ISO 13479 | ≥ 165 h | ≥ **500 h** |
| **Resistance to Rapid Crack Propagation** | S4 test at 0°C ISO 13477 | $Pc \geq \frac{MOP}{2.4} - \frac{13}{18}$ Pc: critical pressure, MOP: max. operat. pressure | ≥ **10 bar** |

*Fig.3: PE100+ requirements compared with EN/ISO standards*

All tests are performed on 110 mm SDR 11 pipes.

## The used testing methods

In the following section all three testing methods used for the PE100+ Association testing schedule are described. In addition, the full-scale test (FST) is also mentioned in order to complete this section.

### Creep rupture strength – Internal pressure test

The internal pressure test is standardised in ISO 1167 and EN 921 ”Thermoplastic pipes for the conveyance of fluids – Resistance to internal pressure – Test method”. The test specifies a method for determination of the resistance to constant internal pressure at constant temperature. The test samples are kept in an environment at a specific constant temperature, which can be either water (”water-in-water” test), another liquid (”water-in-liquid”) or air (”water-in-air” test). The tests for the PE100+ Association are performed on 110 mm SDR 11 pipes as ”water-in-water” test.
In terms of lengths of the pipe, the standard requires at least three times the outside diameter. For pipes bigger that 315 mm outer diameter, a minimum length 1.000 mm shall be used.

*Fig.4: Internal pressure testing equipment*

***The CEN/ISO standard refers to a testing time of > 100h at 20°C at 12.4 MPa for PE 100 materials.***
***The PE100+ Association requirement is enlarged by two times up to > 200h using the same testing conditions.***

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## Stress crack resistance – Pipe notch test

The Pipe notch test is standardised in ISO 13479 ”Polyolefin pipes for the conveyance of fluids – Determination of resistance to crack propagation – Test method for slow crack growth on notched pipes (notch test)”. The test simulates slow crack growth and record time to failure on notched pipes. The testing environment accords to ISO 1167 and EN 921 in terms of temperature and specified constant internal pressure. PE pipes are tested at 80ºC under certain pressure levels, depending on the SDR (Standard Dimension Ratio). All tests for the PE100+ Association are carried out on 110 mm SDR 11 pipes, which leads to an internal test pressure of 9.20 bar.

**Pipe notch test**

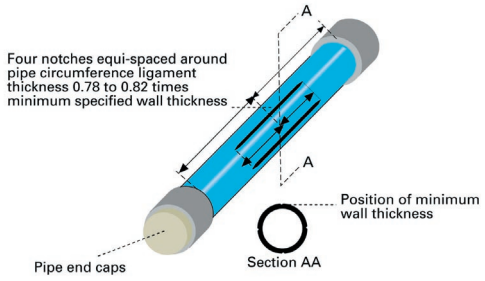


*Fig.5: Testing sample schedule for notch test*

***The CEN/ISO standard refers to a testing time of ≥ 165h at 80°C at 9.20 bar for PE 100 materials. The PE100+ Associations requirement is enlarged by three times up to ≥ 500h using the same testing conditions.***

## Resistance to Rapid Crack Propagation – S4 Test

The small-scale steady-state test (S4 test) is standardised in ISO 13477 ”Thermoplastics pipes for the conveyance of fluids – Determination of resistance to rapid crack propagation (RCP).” The test simulates the phenomenon of RCP in plastic pipes and measure the determination of arrest or propagation of an initiated crack.
In pipelines RCP, caused by a brittle crack, could undergo the length of several hundred meters almost at the sound of speed. This requires even more awareness about RCP. The current EN/ISO standards provide a maximum of 10 bar for natural gas and 25 bar for potable water pipelines as operating pressure. The determination of the required testing pressure is based on the MOP (maximum operation pressure) and would result in a testing pressure of only 4.2 bar for a MOP of 10 bar. The PE100+ Association takes that into consideration and raises it’s requirement in terms of the testing pressure in the S4 test up to minimum 10 bars.

Straight test pipe samples are used with square ends with a specified length of seven times external diameter of the pipe. All tests within the PE100+ Association are specified with 110 mm SDR 11 pipes with 800 mm length. The test is carried out by a conditioning temperature of 0°C using nitrogen or air to pressurise up the pipe. The pipes are prepared with leaktight endcaps, which are fitted over each end.

The test apparatus, showed and described in figure 6 is designed to simulate a fast-running longitudinal crack following a small notch inside the pipe. The energy obtained during an impact on a pipe sample, caused by a falling weight including a striker blade, might assure a fast running crack if the resistance to RCP is below a certain level.

**Rapid Crack Propagation, S4-test apparatus**
**(Small Scale Steady State)**

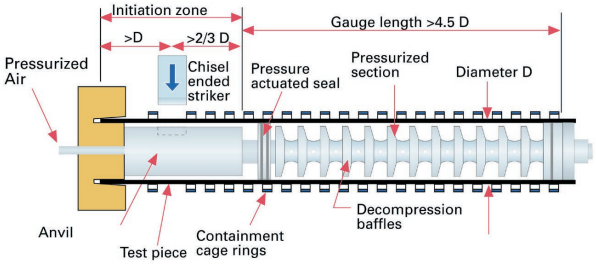


*Fig.6: Apparatus schema for S4 test*

The required crack arrest is defined, when the crack does not exceeds or equal 4.7 times the outer diameter of the pipe.

*Fig.7: Crack-initiation equipment*

Research work to determine the correlation factor between of the S4 and the full-scale test is ongoing. The full-scale test is described below, in order to complete this section about relevant testing methods for PE 100 pipe materials.

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***The CEN/ISO standard requires a critical pressure Pc,S4 with the displayed formula above at a testing temperature of 0ºC. The PE100+ Association takes that into consideration and raises it's requirement in terms of the testing pressure in the S4 test up to minimum 10 bars.***

## Full-scale test (FST)

In 1975, discussions started about the possibility of rapid crack propagation in polyethylene gas pipes. British Gas developed a "full-scale test" based on their experience on steel pipes. This test is today described in ISO-13478 "Thermoplastics pipes for the conveyance of fluids – Determination of resistance to rapid crack propagation (RCP) – Full-scale test (FST)". The test is done under a certain temperature and an internal pressure and specifies the determination of arrest or propagation of a crack initiated in a thermoplastic pipe.

*Fig.8: RCP Full scale test site (BECETEL/Belgium)*

## Apparatus for FST

### Preparation and performing a FST

- Length of the straight testing pipe is min. 14 m, joints are butt-fusion welded and every location of joints are measured
- Placing an end cap which will withstand testing end load
- Installation of straight test pipe and connection to steel pipe reservoir
- Cool the gravel along the pipe and the cooling system to +/- 1,5°C
- Bring down to - 60°C before testing the crack initiation zone
- Pressurise the system up to the required test pressure
- Initiate a crack by a metal blade

The crack arrest is defined, if the longest crack does not exeed 90% of the test pipes length, otherwise RCP has taken place. It is also important to state, that the crack shall not terminate at a butt – fusion joint applied within the pipe sample to be tested.

*Fig.9: RCP Full scale test site (BECETEL/Belgium)*

## The "PE100+ Association Positive List of Materials"

The PE100+ Association publishes the "PE100+ Association Positive List of Materials" showing the materials that successfully meet the PE100+ requirements. In order to keep the "safety plus" objective of the PE100+ Association, only materials which are regularly controlled can be part of that list.

In addition, all PE 100 pipe materials have to pass two successive test rounds in order to be listed, thus not only ensuring quality control, but quality consistency as well. The current positive list is published on the Associations web site **www.PE100plus.net.**

## Testing coordinating of test rounds and the test institutes

### Gastec N.V. in The Netherlands

One of the companies in the holding of Gastec N.V., GASTEC Certification B.V.is Europe's market leader in the field of certification. Gastec N.V. works for industries in the entire gas chain and its products and services offer successful solutions for companies operating in gas exploration, production, treatment, transmission and distribution, storage, and trade as well as for installation firms and manufacturers of gas applications such as appliances and components. One of the other companies in the holding GASTEC Training B.V., is operating succesfully in the market for training employees of companies in the area's of gas distribution, installation,

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maintenance etc., and organizing of seminairs. Gastec's corporate headquarter is located in Apeldoorn with subsidiaries in the Netherlands such as Petrogas Gas-systems B.V. and Dejatech B.V., and foreign branches in the UK, Italy, Bulgaria, Germany and the USA, as well as an agency in Japan and Brasil. GASTEC Certification offers pipe grade evaluations and SEM-analyses in accordance with ISO-9080, Notch testing, RCP-S4 testing, Fracture mechanics, mechanical testing like Tensile tests, Cone-tests, FNC-tests, Condensate tests, as well as physical analyses such as: DSC, DSC/SIS, FTIR, O.I.T., Density, M.F.R, Carbon Black Content and Pigment dispersion measurements etc., and offers as well Welding Technologies on various plastics applied in the gas and water industries. Gastec Certification is accredited by the Dutch Council of Accreditation in the Netherlands, following EN-45001, EN-45011, EN-45012 and ISO-17025, and is member of EA, European Cooperation for Accreditation.
**(Gastec web site: www.gasteccertification.com)**

**Bodycote**
Bodycote Polymer is an independent laboratory for the testing and evaluation of the lifetime of plastic materials. The laboratory has more than 4,300 testing positions for the hydrostatic pressure testing of plastic pipes. As the laboratory is accredited by SWEDAC according to EN 45001 and ISO/IEC Guide 25, the testing results from the Bodycote Polymer laboratory are accepted in many countries. SWEDAC is a member of EA (European Cooperation for Accredidation). Bodycote is located in Nyköping, Sweden.
**(Bodycote web site: www.studsvik.se/polymer)**

**Becetel vzw**
Becetel vzw, the Belgian Research Centre for Pipes and Fittings, is specialised in testing plastics pipes and accessories for utilisation in gas-, water- and drain pipe systems. In order to fulful its tasks and to guarantee a high quality of it services, Becetel disposes of a plastics research centre in Melle (B) and a RCP research centre in Evergem (B). Becetel is offering a complete range of testing services in the field of plastics pipes and fittings, e.g. determination of regres-sion curves following the SEM analysis of ISO 9080, experi-mental fracture mechanics tests (like S4, Full scale and Slow crack growth testing), mechanical testing, physical testing. Becetel partici-pates in international conferences and promotes standardisation and regulation through active participation in international standardisation commissions. Becetel is accredited by Beltest in according with NBN EN ISO/IEC 17025.
**(Becetel web site: www.becetel.be)**

**SKZ (Süddeutsches Kunststoff-Zentrum)**
Founded in 1961 in Würzburg, Germany, the independent SKZ (Süd-deutsches Kunststoff-Zentrum) is working in testing, research and professional education in the field of plastics. It is an accredited testing institute according to DIN EN 45001, DIN EN 45004, ISO Guide 25 and ISO/IEC 17025. Tests are per-formed in accordance with guidelines and specifications of re-nowned organizations and certification bodies. The SKZ is a competent partner for testing, approval and certi-fication of pipe systems and fitting and jointing technologies. Apart from initial type tests (ITT) and approval tests regular product inspection in the production plant is part of the activities of the SKZ.
According to ISO/DIS 9080 hydrostatic long-term pressure tests are carried out with modern testing equipment corresponding to the latest state of art. For calculating the regression curves SEM is used. Pipes up to an outside diameter of 400 mm can be pressure tested. The test temperatures vary from 20°C to about 130°C.
Concerning fracture mechanics the SKZ performs examinations like S4 test (RCP), SCG-tests and dynamical tests with pipes. Besides mechanical testing the SKZ also offers a lot of physical and chemical measuring methods in the polymer field.
**(SKZ web site: www.skz.de)**

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