The right pipe for the job

Purpose-manufactured plastic pipes negate the consequences of damage caused to pipes when using trenchless technology and other alternative installation techniques. This ensures a working life of at least 100 years. **By Mike Smart***

HDPE pipes can sustain damage if not installed carefully using alternative installation and trenchless technologies

High-density polyethylene (HDPE) pipes have earned widespread acceptance as the material of choice for numerous applications in many markets, including civil engineering infrastructure, mining service columns and slurry pipelines, irrigation, AIT (alternative installation techniques), and many more. Greater market proliferation has resulted in a growing appreciation of HDPE pipes' superior qualities.

AIT – particularly the sub-discipline of trenchless technology (TT) – imposes extremely demanding conditions on pipes being installed, usually causing short- and long-term damage. Installation conditions for AIT require a pipe with a service life that is not affected by surface damage or imposed point loads. To this end, a substantial improvement has occurred in the MRS (minimum required strength) of HDPE pipes' polymer over the last 60 years.

This has enabled the allowable design stress (σ) to be increased by 60% – from 5 MPa (megapascals) to 8 MPa, including the applicable International Standards Organisation (ISO) safety factor or design coefficient (C). Table 1 illustrates these improvements in polyethylene (PE) polymers.

Polyethylene strides

There have also been improvements made in third-generation PE (PE100) itself since its introduction in 1990, as shown in diagrams 1 and 2. Diagram 1 shows the creep rupture regression curves for an earlier PE100 polymer with an 80°C curve "knee" at about 150 hours. Diagram 2 shows the creep rupture regression curves for the latest PE100 polymer with the 80°C curve having no "knee" at over 10 000 hours. For a polymer to be designated PE100, the technical requirement is that there is no "knee" on the 80°C curve before 5 000 hours. These improvements in the MRS of PE100 notwithstanding, the unique, extremely onerous conditions imposed on pipes used for AIT require a product with better SCG (slow crack growth) characteristics.

TABLE 1 Improvements in PE polymers

Polymer nomenclature	MRS (MPa)	σ (MPa)	Safety factor (C)
First generation (PE63)	6.3	5.0	1.25
Second generation (PE80)	8.0	6.3	1.25
Third generation (PE100)	10.0	8.0	1.25

TABLE 2 PE100 and PE100-RC SCG resistance comparison

Test type	PE100 hours	PE100-RC hours
Notch Pipe Test (NPT)	2 200	11 580
Full Notch Creep Test (FNCT)	1 600	8 552*
Point Load Test (PLT)	2 200	>9 000

Note: **Ductile failure not a brittle failure. NPT (ISO 13479); FNCT (ISO 16770); PLT (Hessel Ingenieurtechnik)*

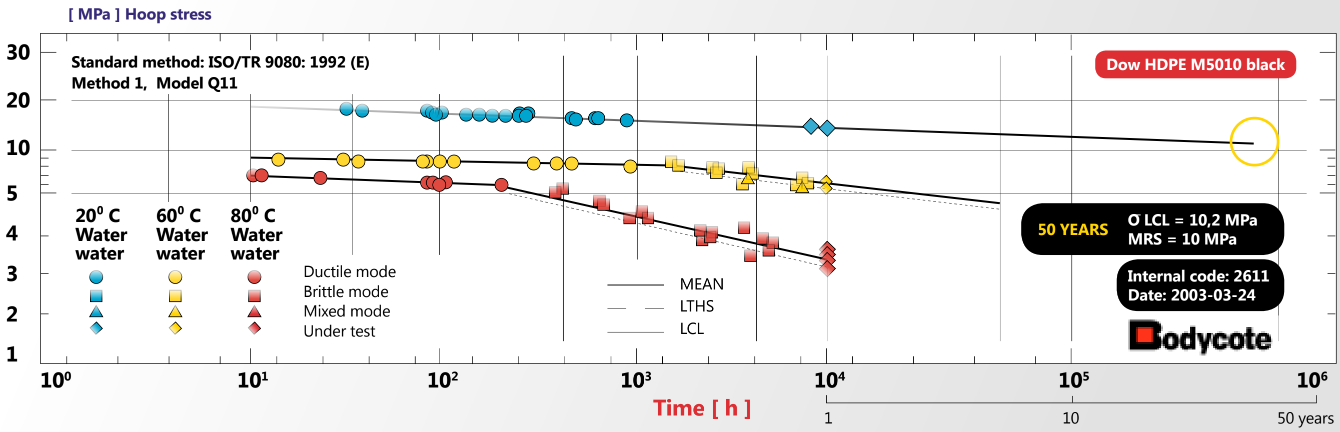
Crack resistance comparison

Standard PE100 pipes, conforming to SANS 4427/4437-2, have historically been used for AIT applications with great success. However, AIT imposes extremely demanding conditions on the pipes installed and there have been some premature failures of these "standard" pipes because of short- and long-term damage sustained. A PE100-RC polymer is a PE100 polymer with extremely high resistance to cracking (RC). The comparison of SCG resistance characteristics is set out in Table 2.

In response to these unique, extremely onerous conditions and probable damage, pipes have been specifically engineered that take cognisance of this environment and ensure the preservation of the lifetime of the pipes. Preventing premature failure caused by damage occurring during or after installation is how this is achieved.

The outer PE100-RC layer prevents premature failure of the pipe that may be caused by external damage, such as scratches, scores, notches, grooves

DIAGRAM 1 Earlier PE100 creep rupture regression curves



and point loads. Additionally, the inner PE100-RC layer prevents premature failure of the pipe that may be caused by external point loads creating stress magnification and initiating crack growth on the inside of the pipe wall.

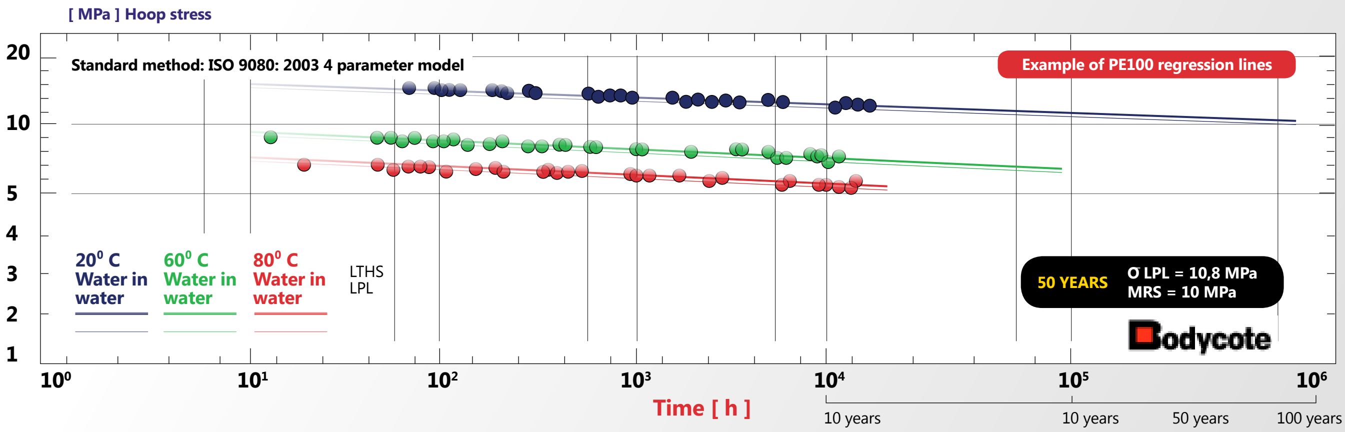
Specifications upgrade

Until 2009, the requirements of pipes used in AIT were insufficiently described in various technical directives. Authoritative requirements on materials and piping were specified for the first time in Publically Available Specification (PAS) 1075: 2009 'Pipes made from polyethylene for alternative installation techniques', which comprises the following:

- Type 1: Solid wall PE100-RC pipe
- Type 2: Pipe with integrated protective layers of PE100-RC, double and triple layered

AIT – particularly the sub-discipline of trenchless technology – imposes extremely demanding conditions on pipes being installed, usually causing short- and long-term damage

DIAGRAM 2 Latest PE100 creep rupture regression curves



- Type 3: Pipe with dimensions according to ISO 4069 with an additional external protective layer. In South Africa, coextruded pipe that conforms to PAS 1075 Type 2 pipe is manufactured by Rare Plastics, in association with the company's international technology partner, Borealis, and branded as RPC (Rare Plastics Coextruded).

The wall of RPC comprises three inseparably bonded coextrusion fused layers as follows:

- an outer layer of PE100-RC conforming to PAS 1075
- a core of PE100 conforming to 4427-2/4437-2: Pipes
- an inner layer of PE100-RC conforming to PAS 1075.

The total wall thickness of the above three layers conforms to the requirements of SANS 4427-2: 'Pipes for water' and SANS 4437-2: 'Pipes for gas', and the layers are fused together by coextrusion and are inseparably bonded.

Coextruded pipe compliance

RPC is either Type 1 for small diameters or Type 2 triple-layered pipe, inner and outer layer PE100-RC and PE100 core for larger diameters. RPC pipes are far superior to SANS 4427-2/4437-2 pipes because of the outer and inner layer of PE100-RC. The SCG, notch and point load resistance properties of PE100-RC are substantially superior to those of SANS 4427-2/4437-2 PE100 pipes. In PAS 1075, differentiation is made between approval testing and quality control testing and, in addition, between material testing and pipe testing to ensure the customer receives a conforming product. Material approval testing provided by the raw material supplier is required to conform to the

AIT AND TRENCHLESS TECHNOLOGY

AIT comprises two categories of construction:

- TT (trenchless technology), which includes (among others):
  - Directional drilling
  - Pipe bursting
  - Close-fit, site deformed swagelining
  - Close-fit deformed pipe
  - Slip lining
- Conventional trench and backfill (cut and cover):
  - Without selected or imported embedment (bedding and surround)

TABLE 3 PAS 1075 PE100-RC conformance requirements

Test	Requirement	RPC result
FNCT	>8 760 hours (80°C; 4 N/mm²)	8 552 hrs
ACT	>320 hours (90°C; 4 N/mm²)	926 hrs
PLT	>8 760 hours (80°C; 4 N/mm²)	>9 000 hrs
TAT	>100 years 20°C	>100 years
NPT	>8 760 hours	>11 580 hrs
ρ	> 945 kg/m3	947 kg/m3
MFR	0.2 g to 0.4 g/10 minutes	0.26 g/10 min

following four tests:
- FNCT (Full Notch Creep Test) conforming to ISO 16770
- PLT (Point Load Test) conforming to Hessel Ingen.
- TAT (Thermal Aging Test) conforming to DVS 2205
- NT (Notch Test) conforming to ISO 13479.

There are two additional requirements for PE100-RC provided by the raw material supplier, in addition to PAS 1075, which are:
- density (ρ) conforming to ISO 1183
- MFR (melt flow rate) conforming to ISO 1133.

The quality control of the PE100-RC material is provided by the raw material supplier and has three tests, which are:
- FNCT conforming to ISO 16770
- PLT conforming to Hessel Ingen.
- NT conforming to ISO 13479.

Pipe approval testing is provided by the raw material supplier and has three tests, which are:
- 2NCT(Two Notch Creep Test) conforming to EN 12814
- PLT conforming to Hessel Ingen.
- PT (Penetration Test) conforming to IKT.

The quality control of piping is provided by the manufacturer and has two tests, which are:
- 2NCT conforming to EN 12814
- PLT conforming to Hessel Ingen.

RPC conforms to the Centre for Expertise's trenchless technology tender specification. It also has Joint Acceptance Scheme for Water Services Installation Components accreditation and has supplied a number of projects in South Africa with pipes for AIT projects.

RPC pipes are available in diameters from 90 mm outside diameter (OD) to 250 mm OD – SDR (standard dimension ratio) 11 (PN 16), 13.6 (PN 12.5) and 17 (PN 10) – 100 m coils up to 180 mm OD, and 6 m or 12 m straight lengths throughout the range.

Conclusion

RPC pipes are specifically engineered for AIT construction methods and are not intended to replace "standard" SANS 4427 or 4437 PE pipes. They are fit for purpose for the appropriate application and will provide a service life of not less than 100 years where AIT construction methods are used – other products may not. The cost of failure compared to the cost of the product may pale into insignificance when the engineer compares and considers the two. 3S

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