PE100 RC and relevance to future AS/NZ PE pipe pressure product standards

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- Introduction to PE100 RC

Market Applications and Standards

Designing with PE100 RC

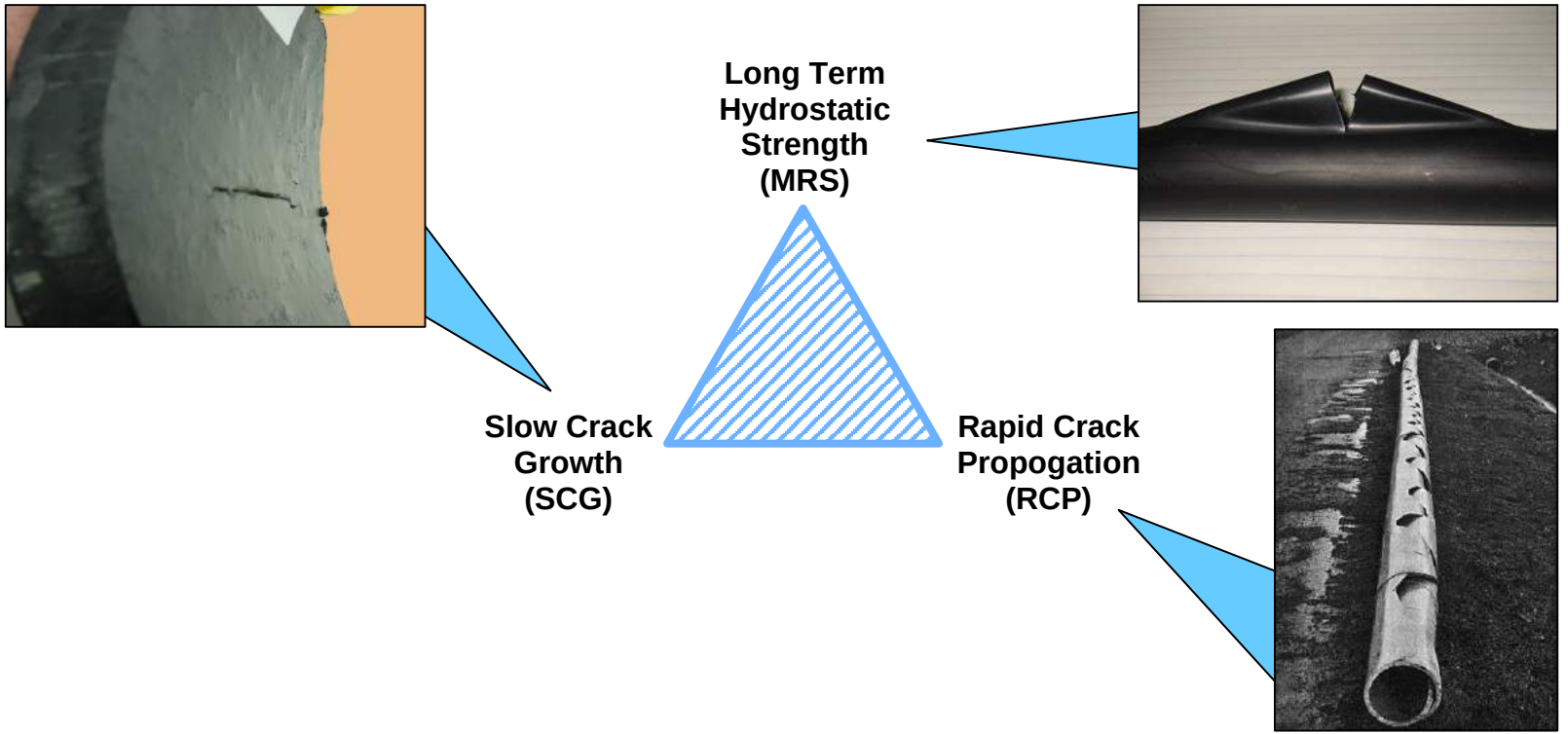
Conclusions

Qenos polyethylene is supplied to all market segments: rigid and flexible packaging and pipe applications

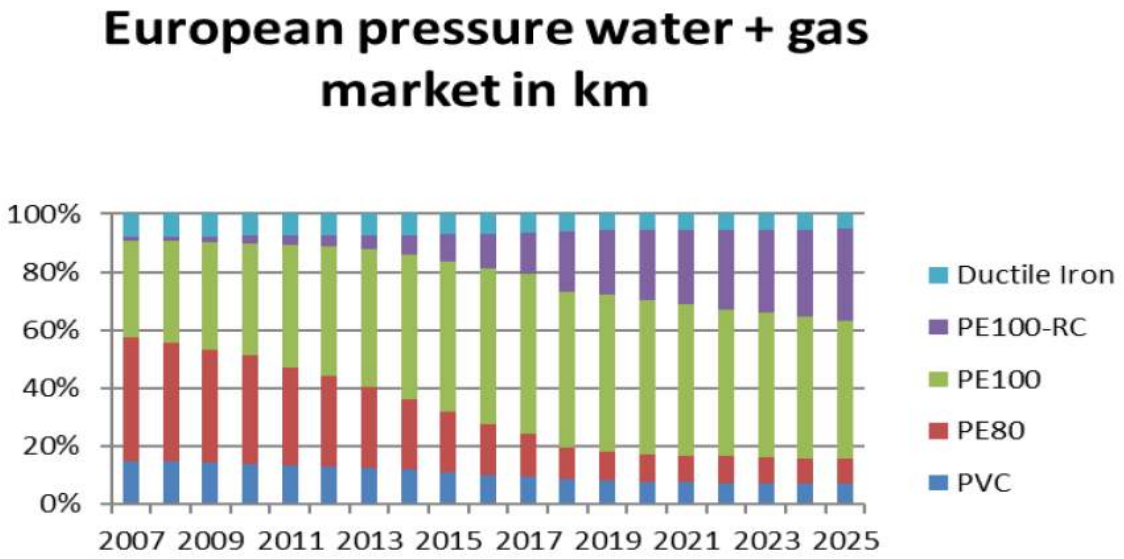
Natural PE granules

Black PE granules

PE100 RC: PE100 with raised resistance to slow crack growth as an application most relevant pipe compound/pipe property



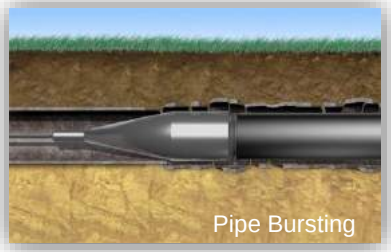
PE100 RC usage is growing in the European market

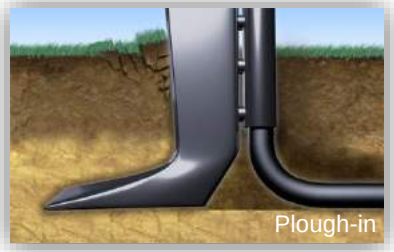


Norbert Jansen and Günter Dreiling:Webinar November 2020

We need materials with greater Slow Crack Growth (SCG) resistance for demanding installations

- Trenchless techniques are transforming HDPE Pipe installation





Trenchless installation techniques carry a high risk of damage to the pipe surface

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EN and ISO product standards for polyethylene pressure pipes

EN 1555	• Plastics piping systems for the supply of gaseous fuels — Polyethylene (PE) — Part 1-5
EN 12201	• Plastics piping systems for water supply, and for drainage and sewerage under pressure — polyethylene (PE) — Part 1-5
ISO 4437	• Plastics piping systems for the supply of gaseous fuels — polyethylene (PE) — Part 1-5
ISO 4427	• Plastics piping systems for water • supply and for drainage and sewerage • under pressure — polyethylene (PE) — Part 1-5

In Australia HDPE pressure pipes are governed by AS/NZS 4130 (pipe) and AS/NZS 4131 (compound) to ensure fitness for purpose

Pipes AS/NZS 4130:2018
(Type Test Requirements*)

Classification	PN 3.2 – PN25
Composition	AS 4131 compound (PE100)
Rework	Internal only
Striping	AS 4131 base resin + pigment + UV stabiliser
Dimensional Tolerance	Depending on size ca. 5% wall thickness variation
Effect on water	AS 4020 pass
Internal pressure	>165 h (@80°C, @5.4MPa) & >1000 h (@80°C, @5.0MPa)
Thermal stability	>20 min (@ 200°C)
Slow crack growth	>500 h (@ 80°C, @ 920kPa)

PE100 Compound
AS/NZS 4131:2010
(Type Test Requirements*)

Classification	PE100: MRS >10MPa (@ 20°C)
Composition	HDPE + antioxidant + UV stabiliser + pigment
Dispersion	Agglomerates <60 µm
Volatile content	≤350 mg/kg
Rapid crack propagation	Critical pressure > 1.0MPa
Effect on water	AS 4020 pass
Internal pressure	>165 h (@80°C, @5.4MPa) & >1000 h (@80°C, @5.0MPa)
Thermal stability	>40 min (@ 200°C)
Slow crack growth	>500 h (@80°C, @920kPa)

* Non-exhaustive

PE100RC Standard Development History

2009: PAS 1075 Publicaly Available Specification for PE100 RC

2015-2018: DVGW project G-3-01-14 developed accelerated tests for predicting SCGR

2018: ISO and EN pipe committees – TC 138 and TC 155 - defined specifications for PE100 RC based on conclusions of the DVGW project G-3-01-14

2021: EN 1555 published with PE100RC criteria included. ISO DIS 4437 and prEN 12201 ballot stage finished

Changes in product standards with introduction of PE100 RC

- Introduced in EN 1555 → ISO DIS 4437 ballot finished → EN 12201 DIS ballot finished

- AS/NZS 4131/4130 revisions expected to follow ISO/EN and include PE100 RC; At that time POP016 (PE100 HSCR specifications) would be phased out

Classification	MRS ISO12162
PE80	8
PE100	10
PE100 RC	10

- New tests introduced for PE100 RC for Resistance to Slow Crack Growth specification (not for PE80 and PE100):

Accelerated Slow Crack Growth Tests for PE100 RC

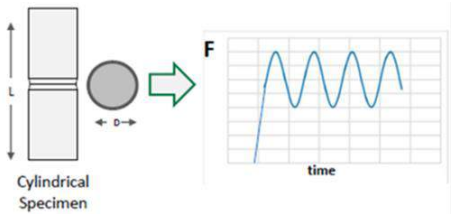
- AFNCT: ISO 16770: Determination of ESC - Full Notch Creep test
  - Accelerated using Lauramine Oxide (Dehyton PL) as surfactant

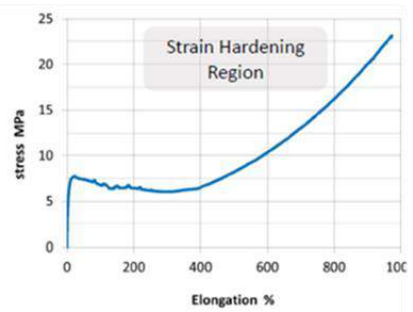
- ANPT: ISO 13479: Test Method for Slow Crack Growth on Notched Pipes
  - Accelerated by placing pipes in Nonylphenol (Akropal) solution instead of water

- CRB: ISO 18489: Determination of resistance to SCG under cycle loading

  Cracked Round bar test method
  - Fatigue Crack Growth (FCG) under cyclic loading

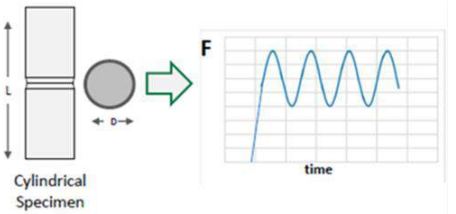
- SHM: ISO 18488: Strain Hardening Modulus-Test method
  - The modulus <Gp> is obtained from slope of the σ_{true} in the linear region
  - Can be used for batch release



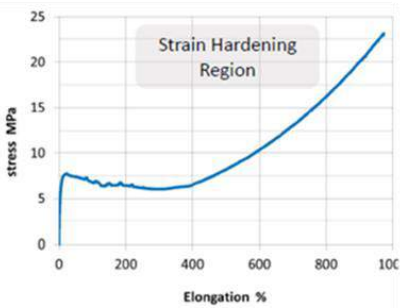


Accelerated Slow Crack Growth Tests for PE100 RC

Test	Test title	Standard	Notes
aFNCT (accelerated Full Notch Creep Test)	Determination of ESC (Environmental Stress Crack) - Full Notch Creep test	ISO 16770	Accelerated using Lauramine Oxide (Dehyton PL) as surfactant
aNPT (accelerated Notch Pipe Test)	Test Method for Slow Crack Growth on Notched Pipes	ISO 13479	Accelerated by placing pipes in Nonylphenol (Akropal) solution instead of water
CRB (Cracked Round Bar)	Determination of resistance to SCG under cycle loading	ISO 18489	Fatigue Crack Growth (FCG) under cyclic loading
SHM (Strain Hardening Modulus)	Strain Hardening Modulus-Test method	ISO 18488	The modulus <Gp> is obtained from slope of the σ_{true} in the linear region. Can be used for batch release



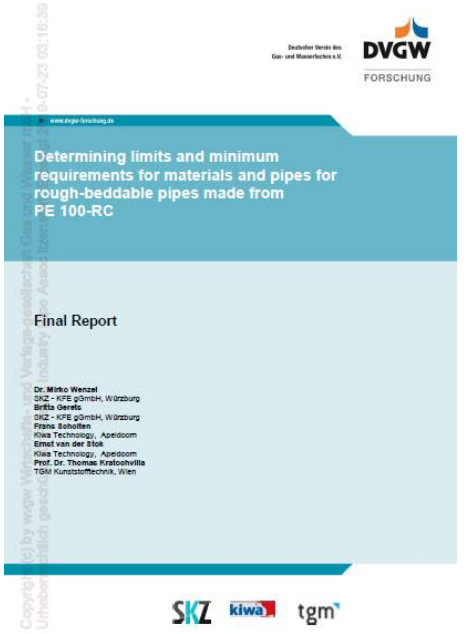
CRB



SHM

PE100 RC Testing Criteria was developed by DVGW coordinated program

Test	Test Conditions	PE100RC Minimum Criteria
AFNCT	ISO 16770, 90ºC, 4.0 MPa, 2% Lauramine Oxide	550 hours
SHM	ISO 18488	53 MPa
CRB	ISO 18489	1 500 000 cycles
ANPT	ISO 13479, 80ºC, 9.2 MPa, 2% Akropal N100	300 hours



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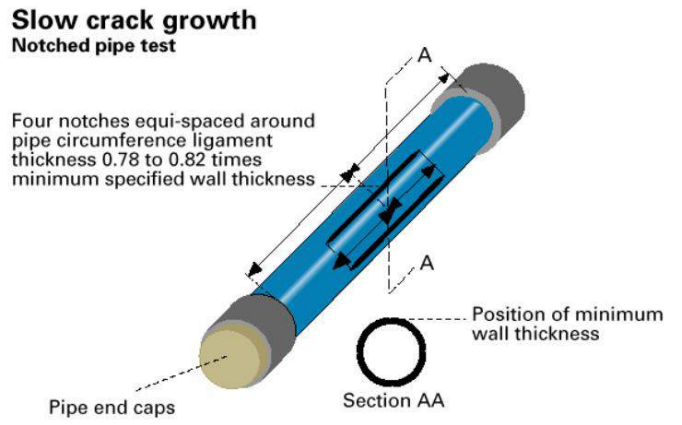
In trenchless installations, damage may exceed the conventional allowance of 10% of the pipe wall thickness

- If the possibility of significant external damage exists the potential for slow crack growth must be considered

Installation Method	Installation Factor
Open Trench	1.0
Plough-in	1.1
Directional Drilling	1.2

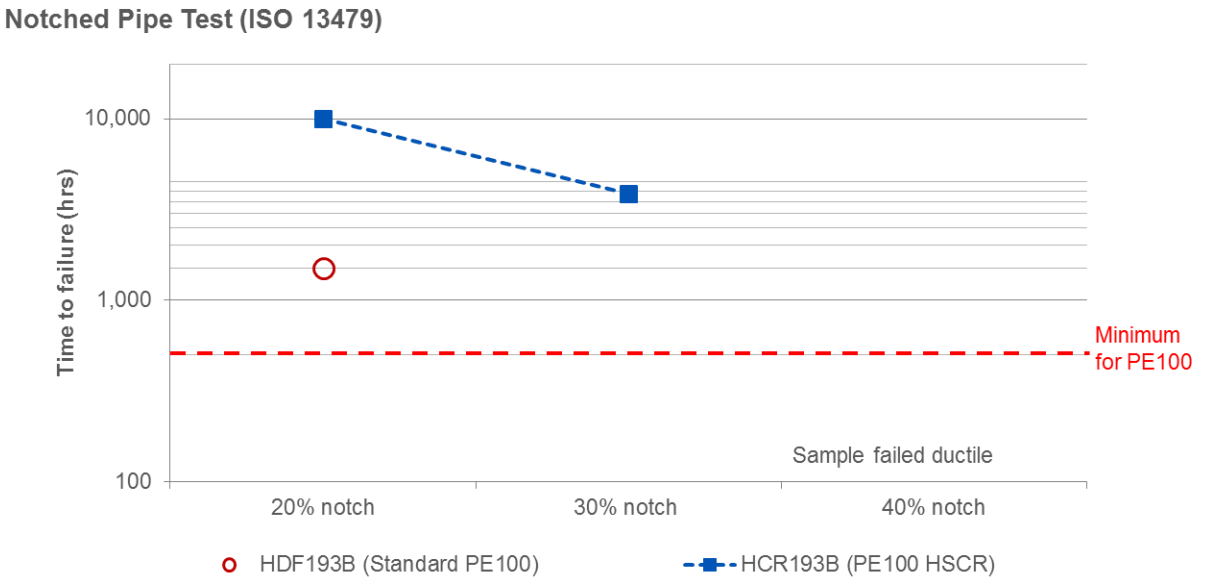
- Prescribed design factors nominated in Standard/Codes for different installation methods: risk management with emphasis on design factors

Notched Pipe Testing is representative of pipe installed and damage during aggressive installation methods such as HDD



Pipes notched and assembled to be tested for Slow Crack Growth property as per ISO 13479. Pipes made from Qenos PE100 RC (PE100 HSCR) pipe grade HCR193B

PE100 RC provides a large safety margin to SCG failure, even at 30% notch depth



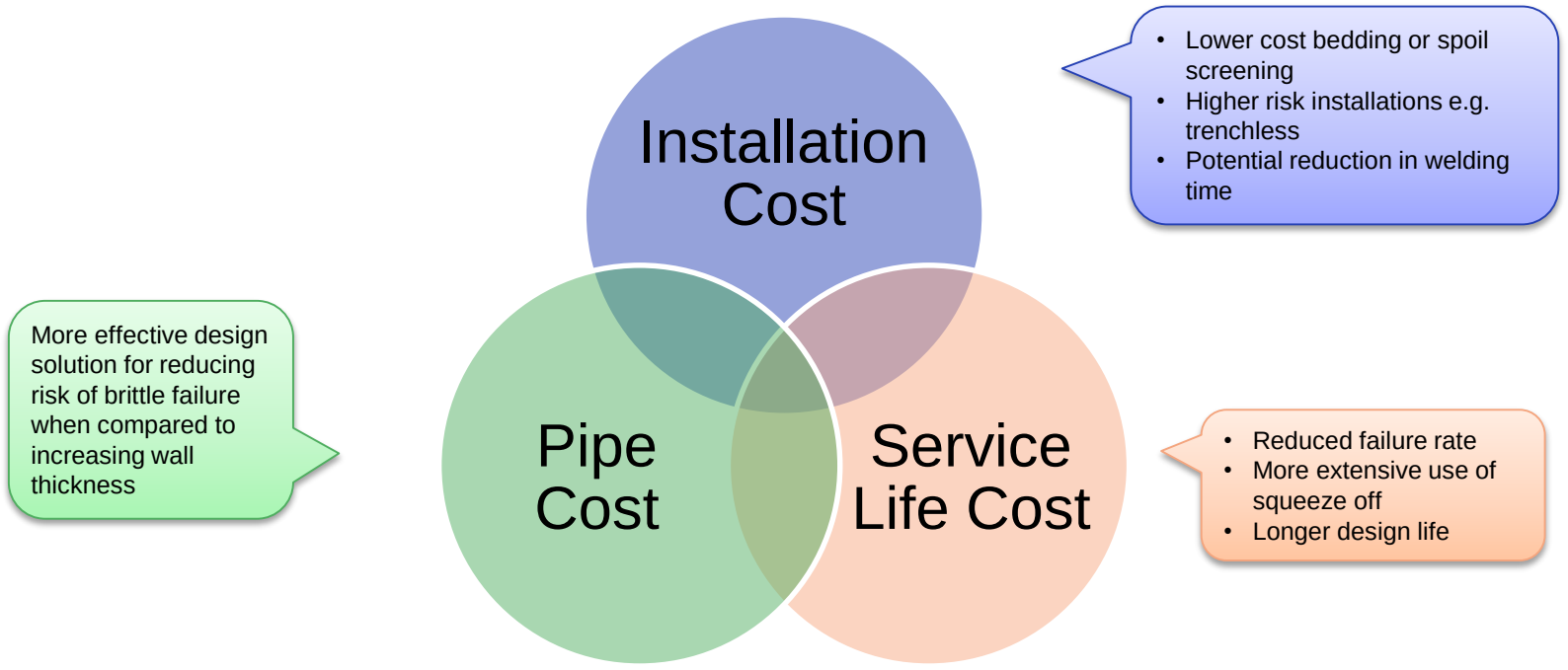
- Test covered 110 mm SDR11 pipes with varied notch depth tested in hydrostatic pressure test at 920 kPa/80°C

If PE100 RC is specified to guard against brittle failure, a lower installation design factor can be considered

Installation Method	Installation Factor (Prescribed design)	Installation Factor (Risk based design with PE100 RC)
Open Trench	1.0	1.0
Plough-in	1.1	1.0
Directional Drilling	1.2	1.0

- Proposed design factors for different installation techniques with risk based “fit for purpose” design when PE100 RC pipe is specified

An increase in service life and savings in pipe and construction costs can be achieved with PE100 RC



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- Failure by slow crack growth is the main threat to PE pipeline long term integrity and of particular concern in trenchless installations

- PE100 RC is specifically designed for trenchless pipe installations to provide:
  - Increased service life
  - Confidence to tackle difficult ground conditions

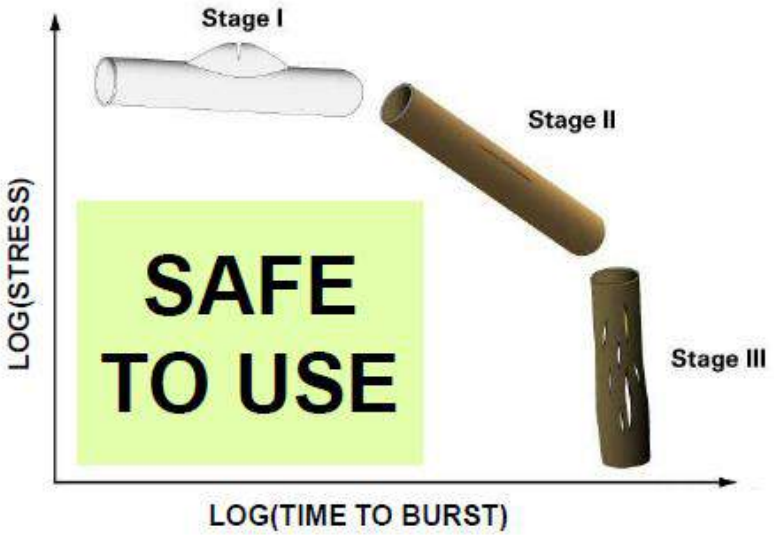
- PE100 RC provides a built-in safety factor against slow crack growth failure and may be used for “fit for purpose” design of pipes with lower installation design factors

Conclusions

- ISO/TC 138: Plastics pipes, fittings and valves for the transport of fluids and CEN/TC 155: Plastics piping and ducting systems, agreed on testing methods and specifications for PE100RC
- EN 1555-1: PE for gas supply was published in 2021 with PE100 RC classification
- ISO 4437-1: PE for gas supply finished DIS balloting stage complete with PE100 RC included
- EN 12201-1: PE for water supply. Revision agreed to follow EN 1555 to add PE 100 RC materials; prEN 12201 ballot stage complete in 2022
- PL006 committee looks after AS/NZS 4131 for PE pressure pipe compounds and pipes respectively and it is expected to follow ISO / EN taken approach and introduce PE100 RC classification to complement PE80 and PE100 classifications
- Future revision of AS/NZS 4131/4130 are expected to follow ISO/EN taken approach and include PE100 RC
- POP 016 and PE100HSCR specifications are expected to be made redundant once AS/NZS incorporated PE100 RC

Appendix

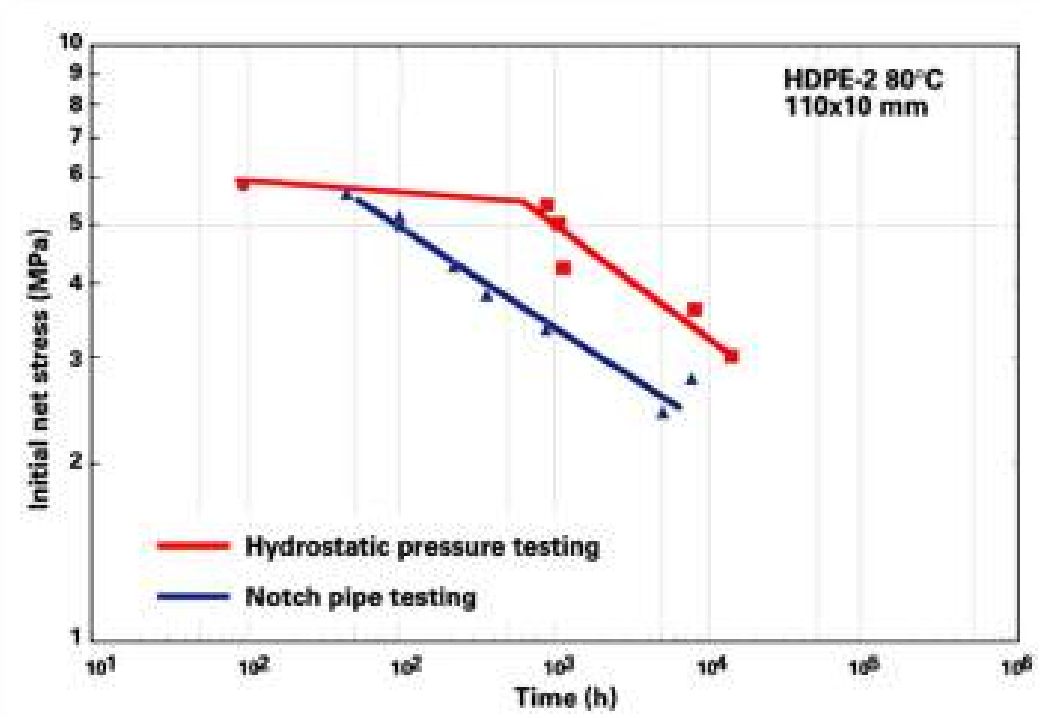
EXPECTED LIFETIME OF A PIPE



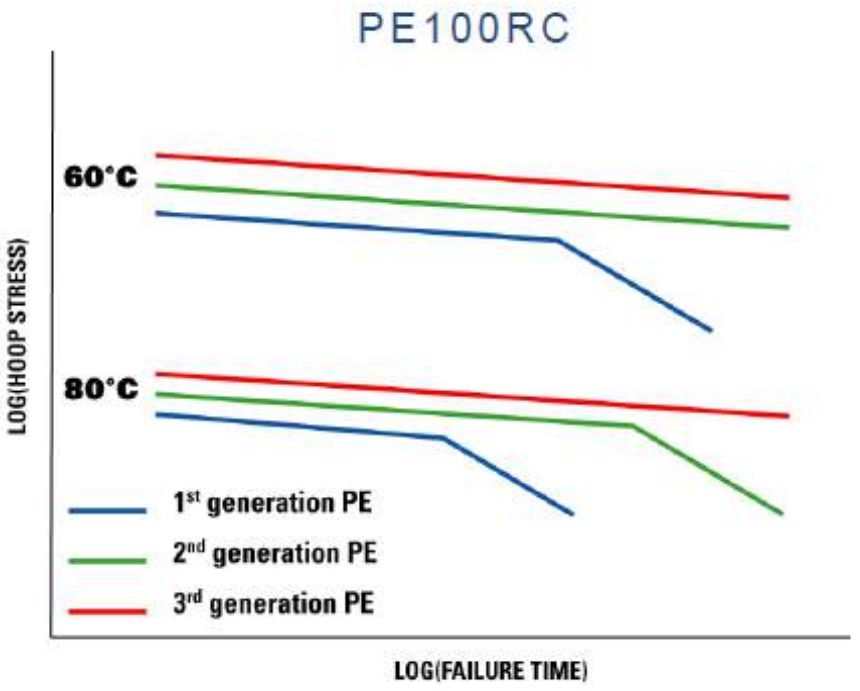
METHODS

STAGE I	STAGE II	STAGE III
• ISO 9080 • ASTM D2837	• NOTCH • PENT	• ASTM F2263 OXIDATIVE RESISTANCE

Appendix – Element information on how NPT was set at 165hr/ 500hrs / 8760hrs



Appendix


PE100RC
60°C
80°C
LOG(HOOP STRESS)
LOG(FAILURE TIME)
1st generation PE
2nd generation PE
3rd generation PE