Ground Heat Exchangers for High Temperature BTES Applications

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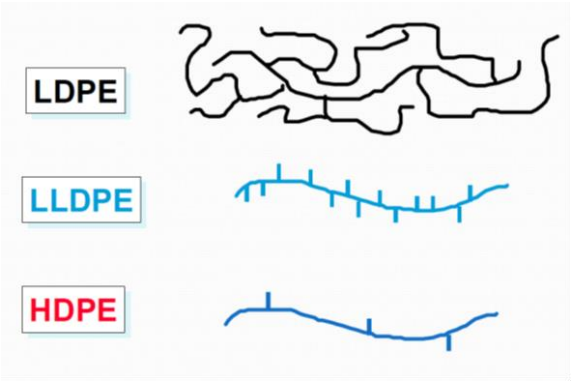
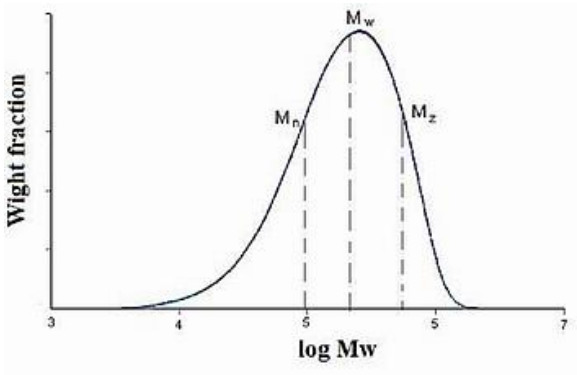
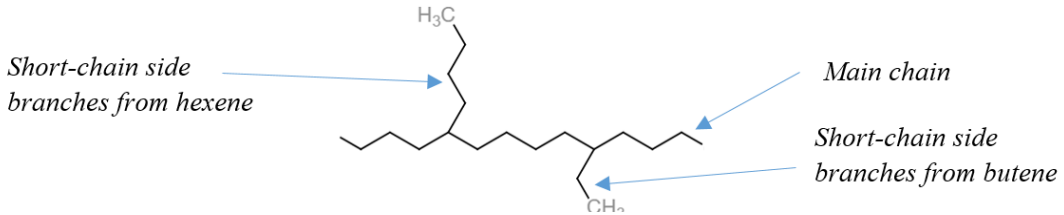
Changing Properties of PE

- **Low density polyethylene (LDPE)**
  high temp and high pressure, long side chains, low density, (eg. Plastic bags)
  Properties: soft, flexible and translucent with a waxy surface and hydrophobic
- **High Density Polyethylene (HDPE)** lower temp and pressure, very few short branches, dispersion forces more effective, high density (eg. plastic bottles)
  Properties: rigid, stronger and less blurry than LDPE, slightly flexible, waxy surface and hydrophobic







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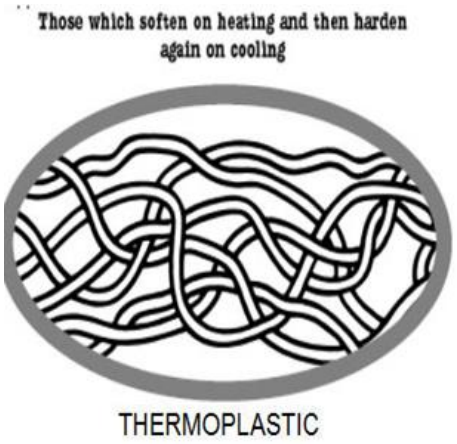
Bonding Properties of PE

- When thermoplastic polymers are heated they flow. Molecules can slide over each other.



- Thermosetting polymers do not really melt when heated because molecules are crosslinked together and remain rigid. PEX a, PEX b & PEX c

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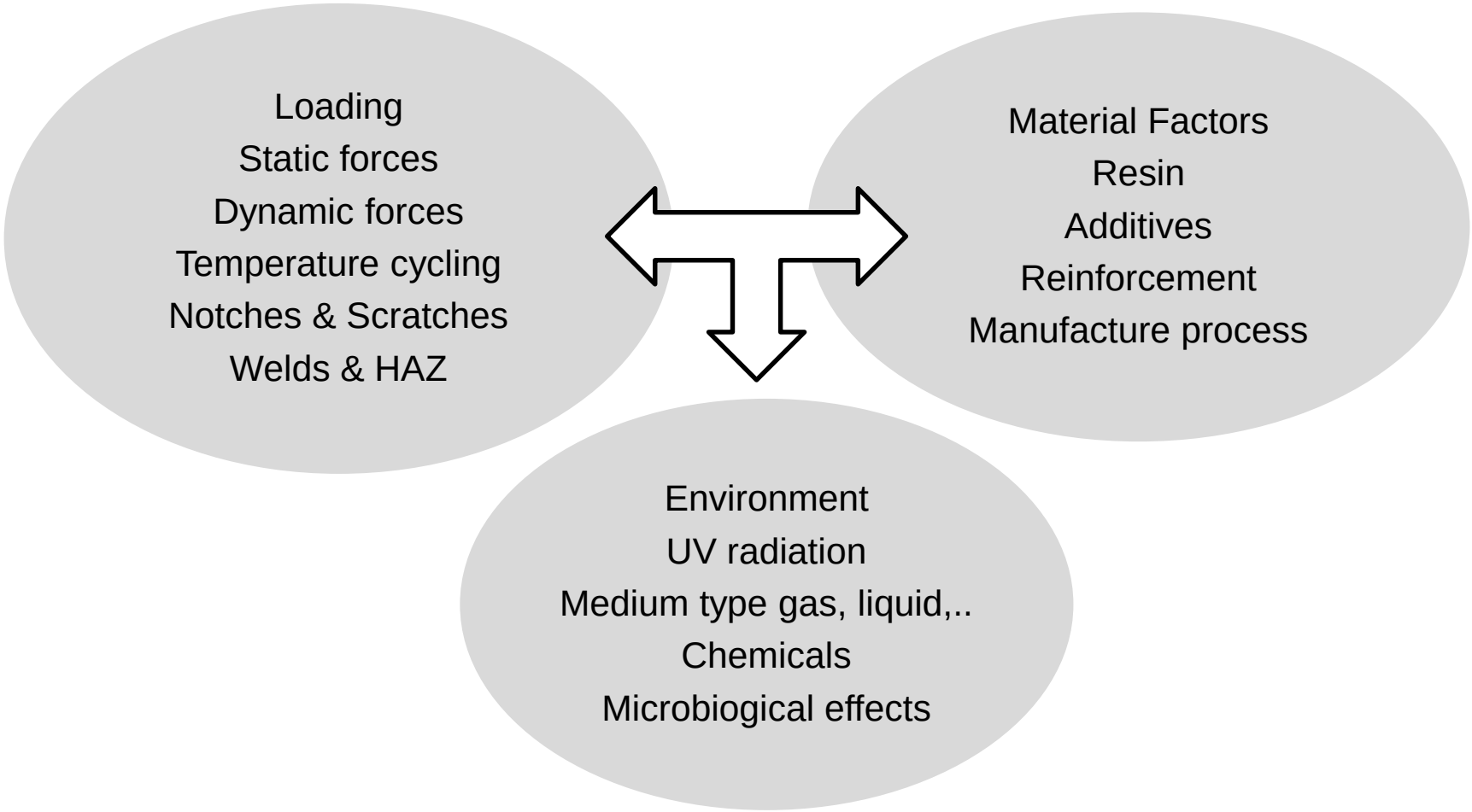
Life Expectancy



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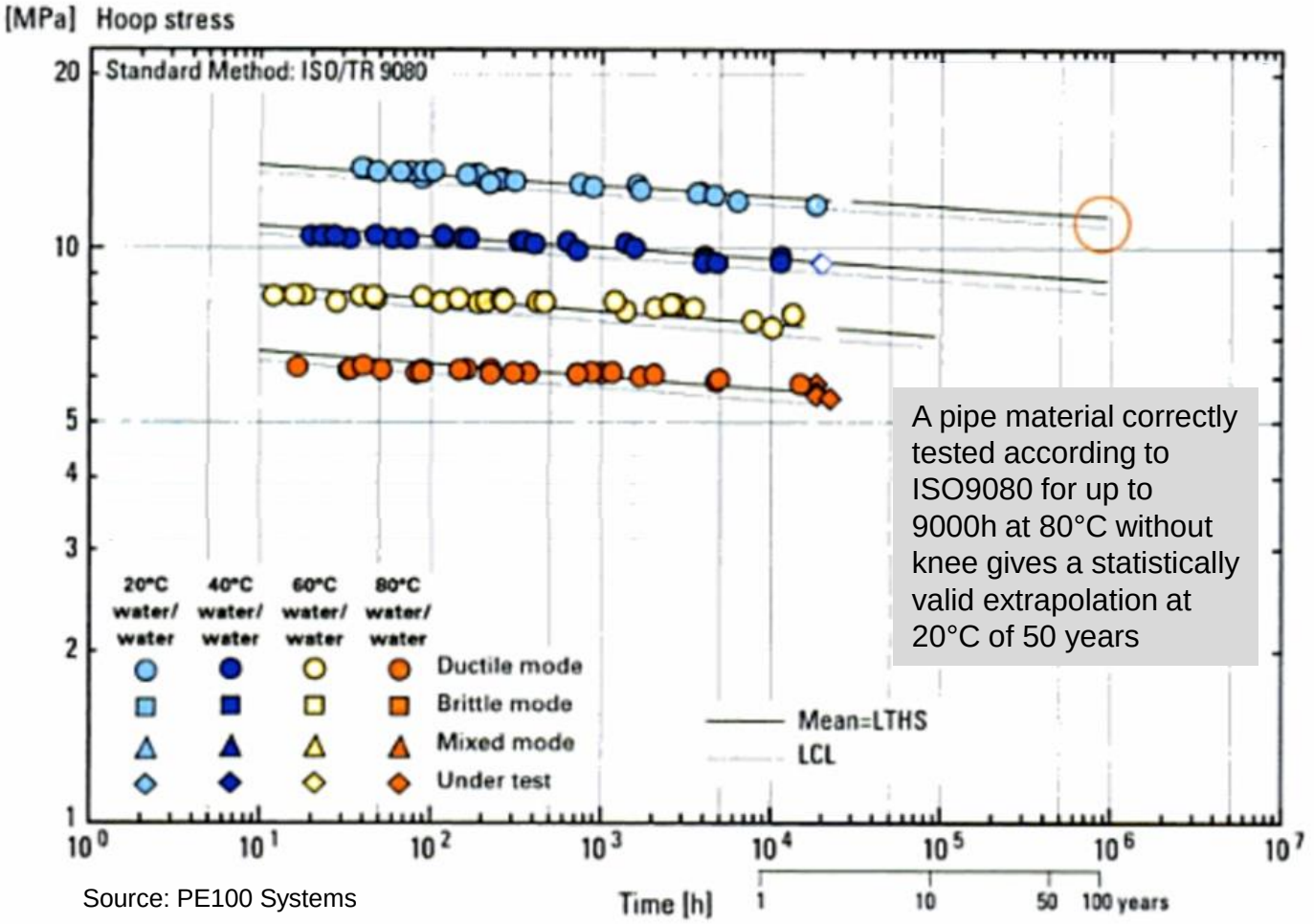
Service Life & MRS

$$log(t_{fi}) = C(1) + C(2)/T_i + C(3)\ log(\sigma_i) + C(4)\ log(\sigma_i)/T_i$$



A pipe material correctly tested according to ISO9080 for up to 9000h at 80°C without knee gives a statistically valid extrapolation at 20°C of 50 years

Source: PE100 Systems

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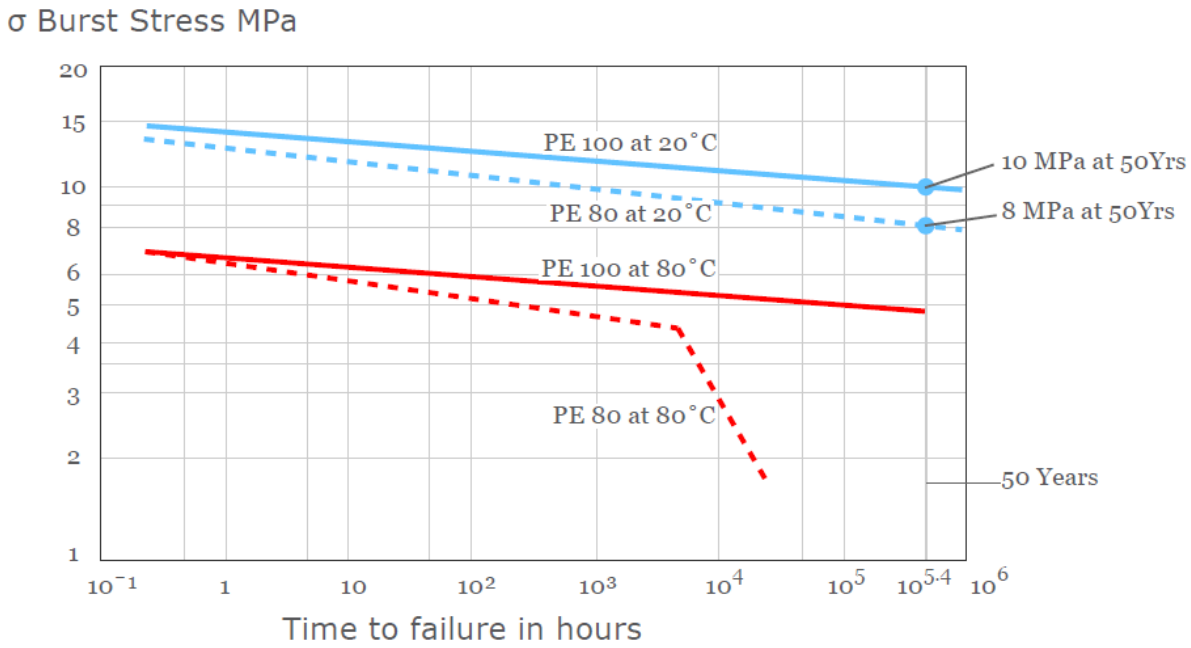

Designation of material	MRS at 50 years and 20°C Mpa	Maximum allowable hydrostatic design stress, σ – Mpa
PE 100	10	8
PE 80	8	6.3
PE 63	6.3	5

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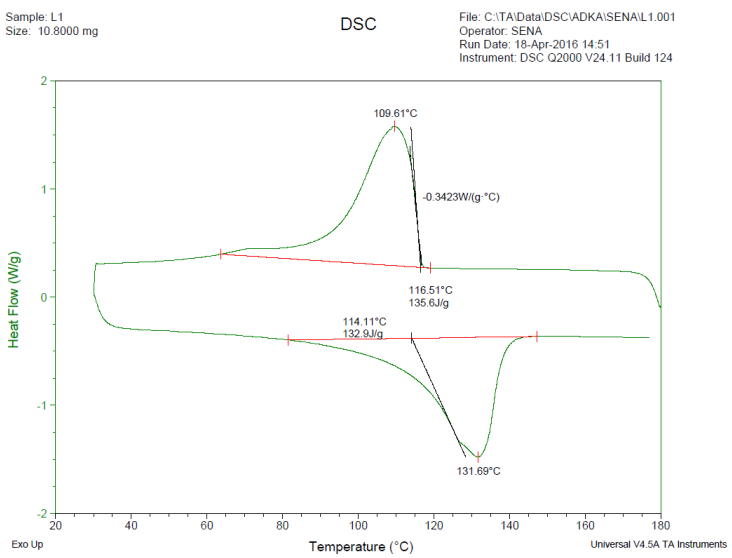
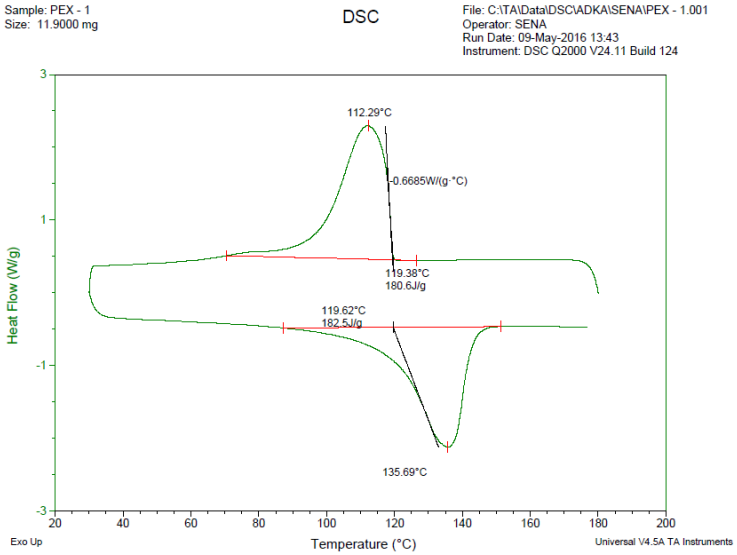
Differential Scanning Calorimetry (DSC)





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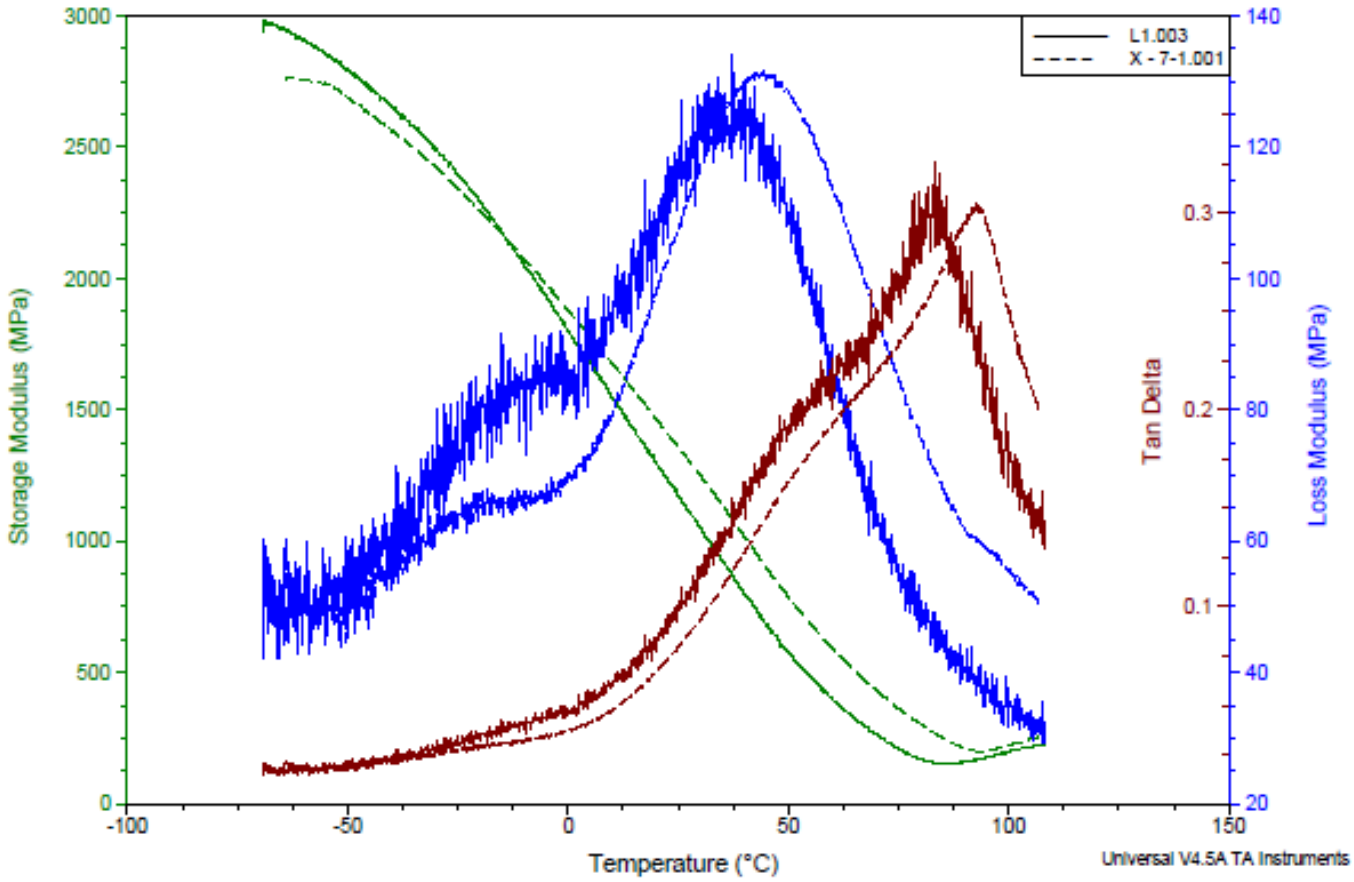
Dynamic Mechanical Analysis (DMA)



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PE Pipe Properties

Characteristic	*Standard*	*PE 80*	*PE 100*
Minimum Required Stress, MRS	EN ISO 9080	8 MPa	10 MPa
Density to 23° C	ISO 1183	0.94 g/cm^3	0.95 g/cm^3
Melt mass- flow rate (MFR)	EN ISO 1133	± 20% RM	± 20% RM
Min. Tensile strength	EN ISO 6259	15 MPa	19
Elongation at break	EN ISO 6259	350 %	350 %
Oxidation induction time - OIT	ISO 11357-6	>20 min	>20 min
Hydrostatic strength 20°C, 100 h	EN ISO 1167	10 MPa	12.4 MPa
Hydrostatic strength 80°C, 165 h	EN ISO 1167	4.6 MPa	5.5 MPa
Hydrostatic strength 80°C, 1000 h	EN ISO 1167	4 MPa	5 MPa
Resistance to slow crack growth e ≤ 5mm – Cone test	ISO 13480	s ≤ 10 mm/day	s ≤ 10 mm/day
Resistance to slow crack growth e > 5 mm – Notch test	EN ISO 13479	SDR 11 – 8 bar	SDR 11 – 9.2 bar
Resistance to rapid crack propagation – Critical pressure P_c	ISO 13477	1.5 MOP	1.5 MOP
Longitudinal reversion	EN ISO 2505	≤ 3%	≤ 3%

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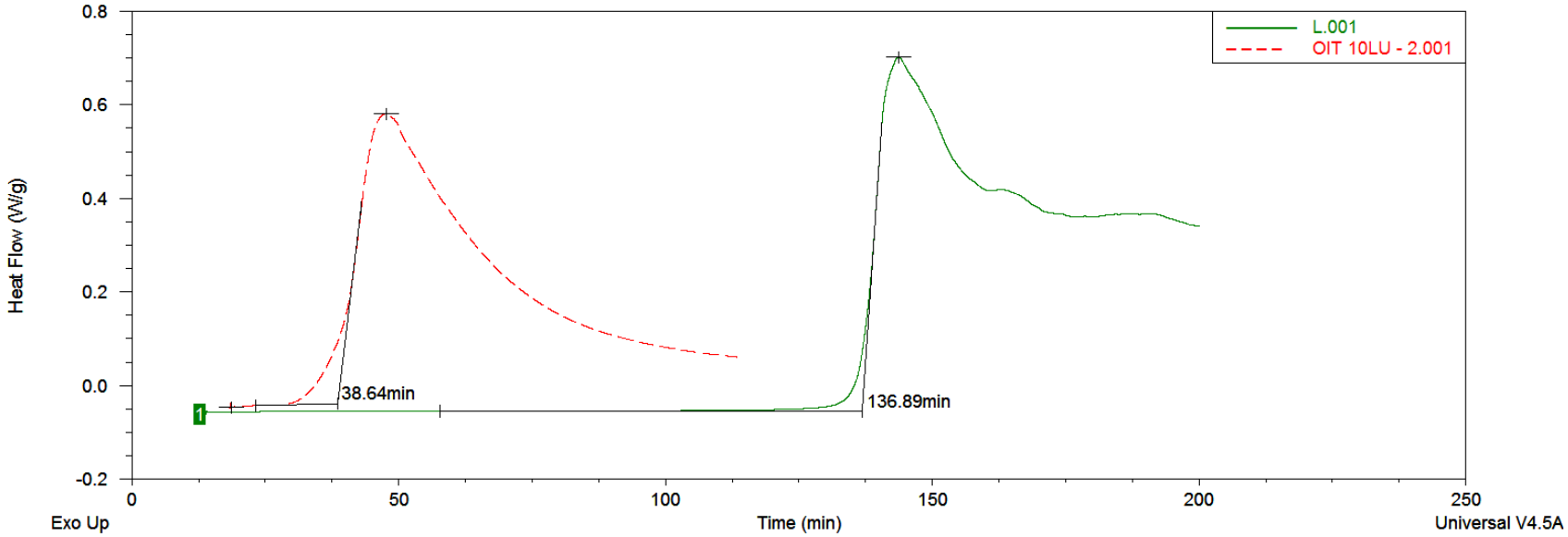
Oxidation Induction Time (OIT)



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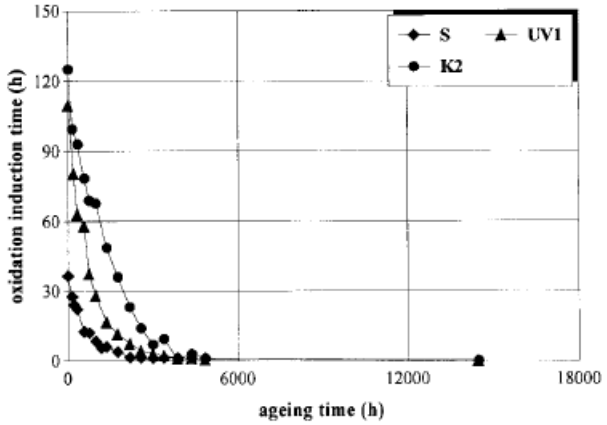
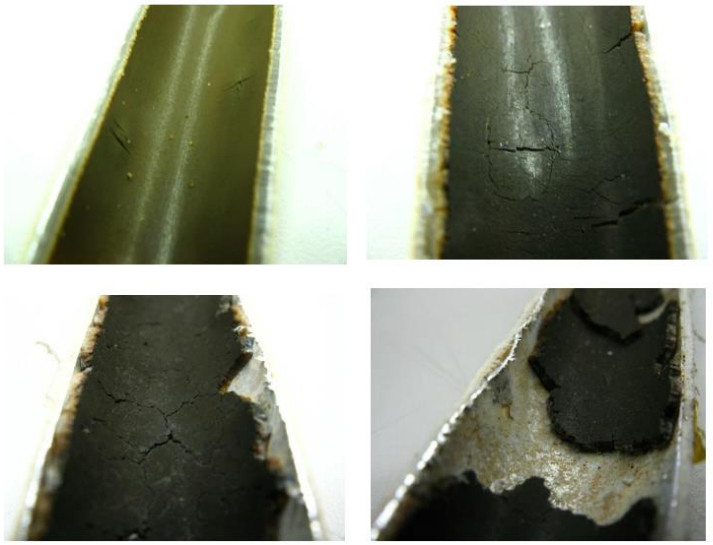
High Temperature Condition



OIT at 170 ˚C versus ageing time in hot water at 105 ˚C

Ref. :http://dx.doi.org/10.1016/S0141-3910(98)00048-2.



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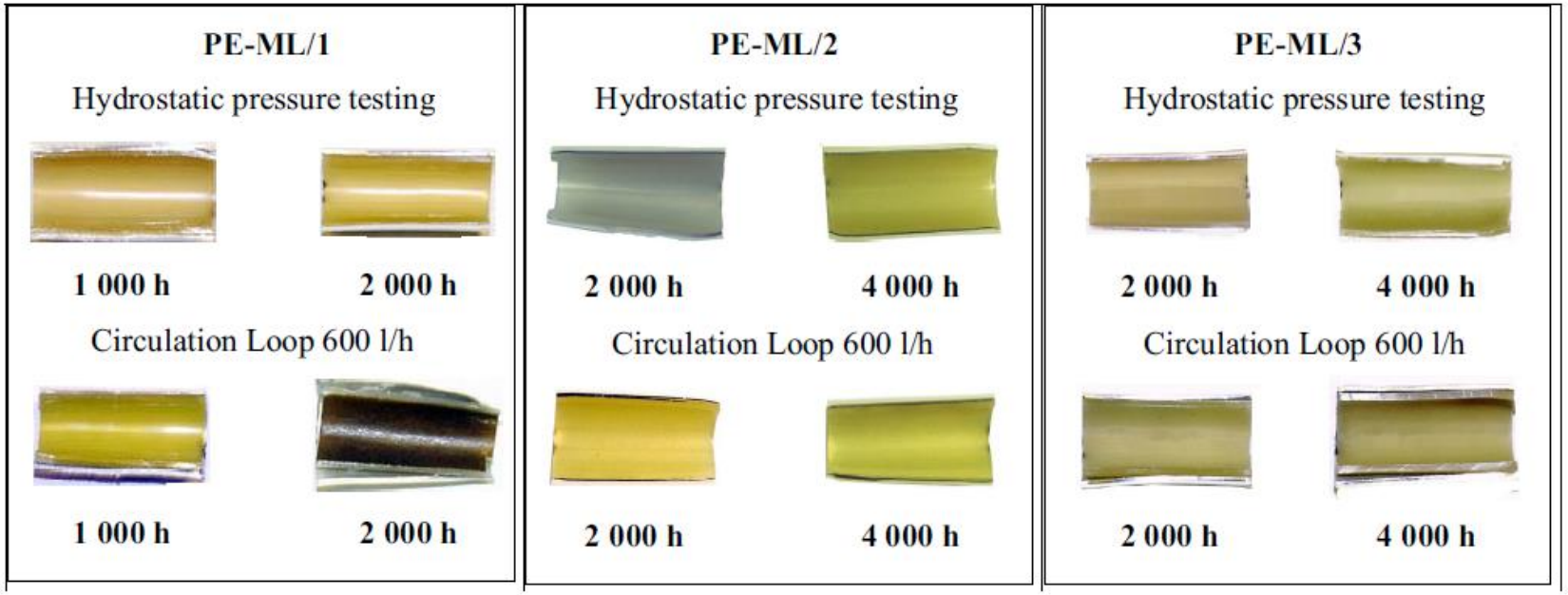
Test Method on Life Time



PE-ML/1		PE-ML/2		PE-ML/3	
Hydrostatic	Circulation	Hydrostatic	Circulation	Hydrostatic	Circulation
>100 years	11 years	>100 years	49 years	>100 years	34 years

Ref.: Andersson Ulrika, Bodycote Polymer AB ,Plastic pipe conference , Milan 2004

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Conculsion

- Validation of a material based on ISO 9080 is time consuming
- Limitation on cross linked materials due to welding process
- Antioxidants wash out very soon in high temperature
- More collaboration and academic research

For technical support and questions contact us:
adib.kalantar@muovitech.com

Thank you!

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