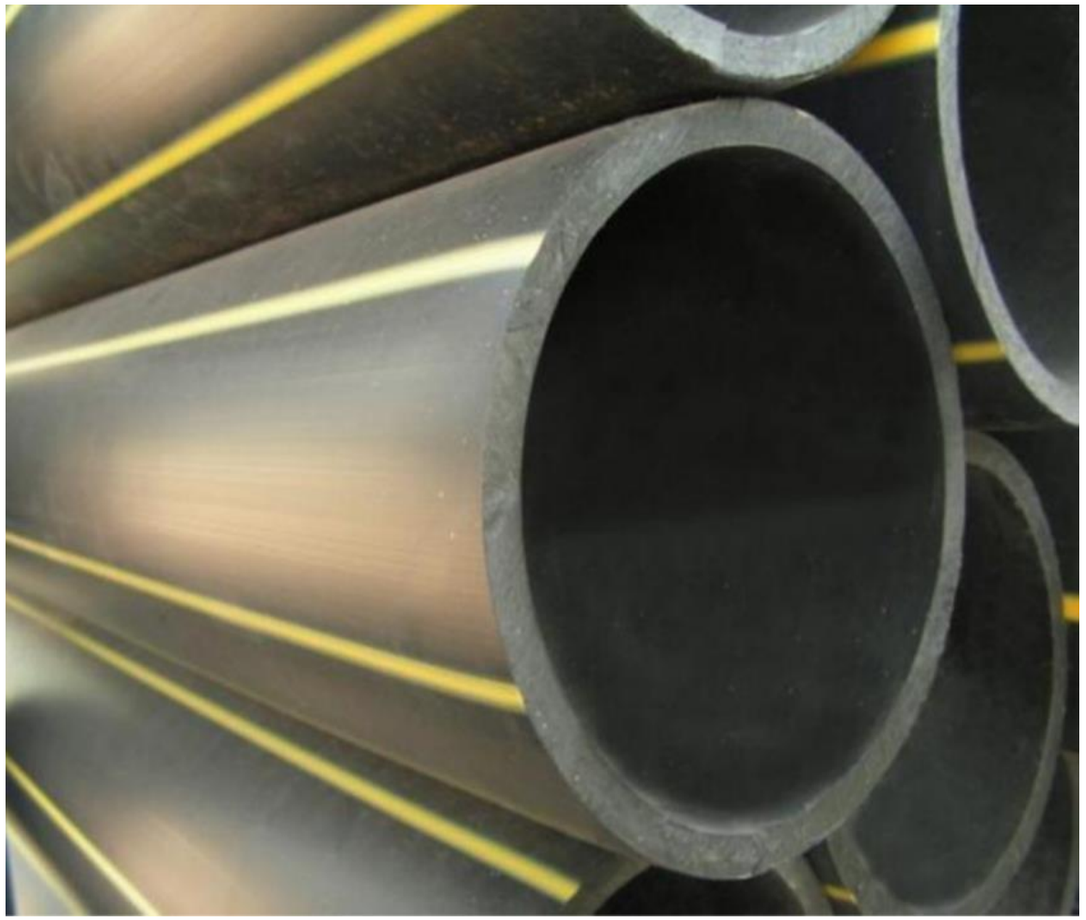
GRAFT POLYMER
COMBINE INCOMPATIBLE

Innovative manufacturing of polyethylene PE125 for multifunctional applications.



Stages of polyethylene pipes development

Generation	Period	Developments
1st	~ 1970's	LD (PE32, PE40)
2nd	~ 1980's	HD (PE50, PE63) MD (PE80) ~ 1990's
3rd	~ presents	MD (Bimodal PE80) HD (Bimodal PE80, PE100, PE100+)
~	~ **FUTURE**	**PE125**

What is PE125?

This is a multimodal mix:

1) ***LOW MOLECULAR*** fraction, which gives:

- Good processability
- High stiffness
- High crystallinity

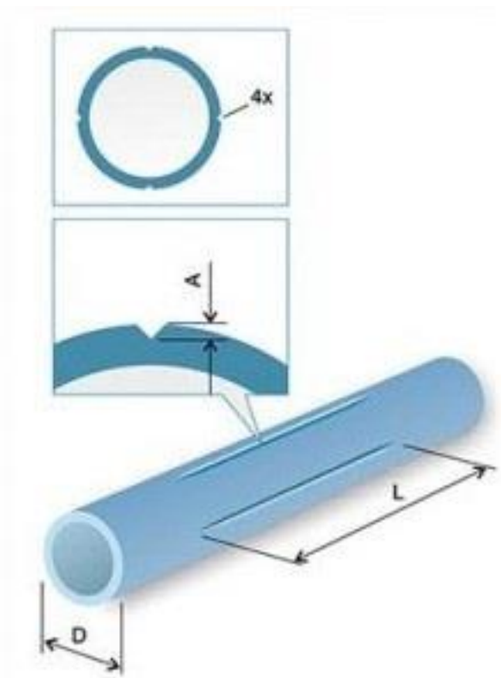
2) ***HIGH MOLECULAR*** fraction, which gives:

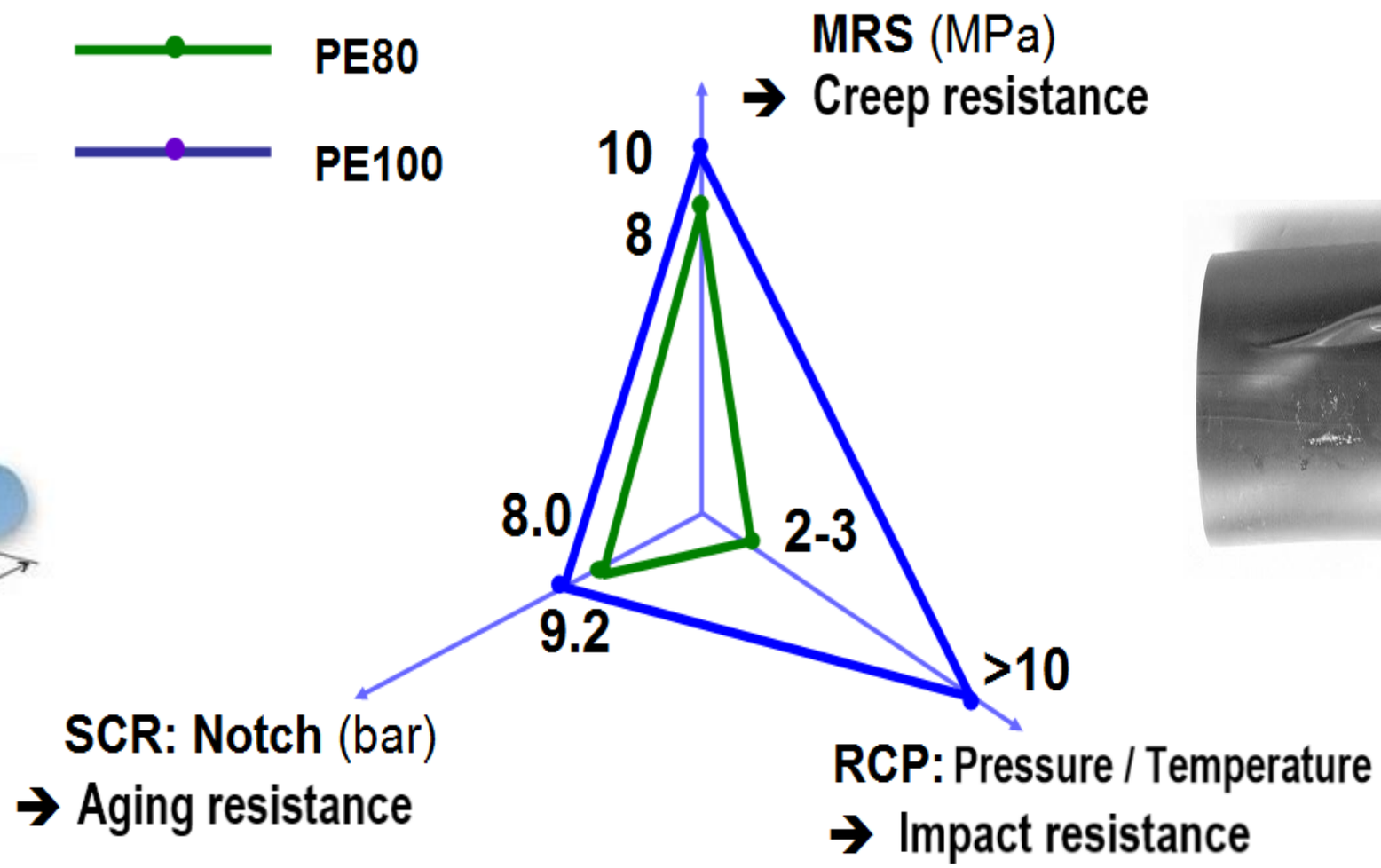
- High resistance to SCG (slow crack growth)
- High creep resistance

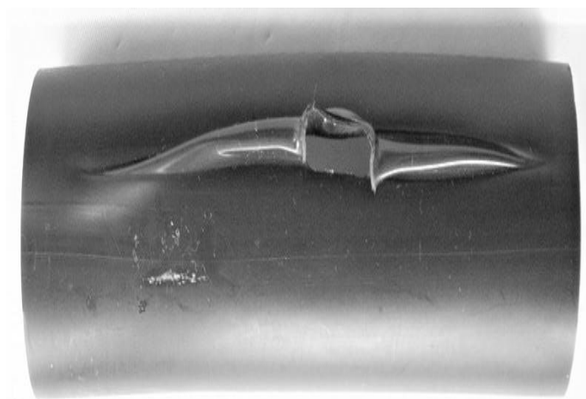
3) ***SUPER-HIGH-MOLECULAR*** fraction, which gives:

- High MRS (minimum required strength)
- High creep resistance
- High toughness
- Increased wear resistance

The triad of basic market requirements for Polyethylene Pipe





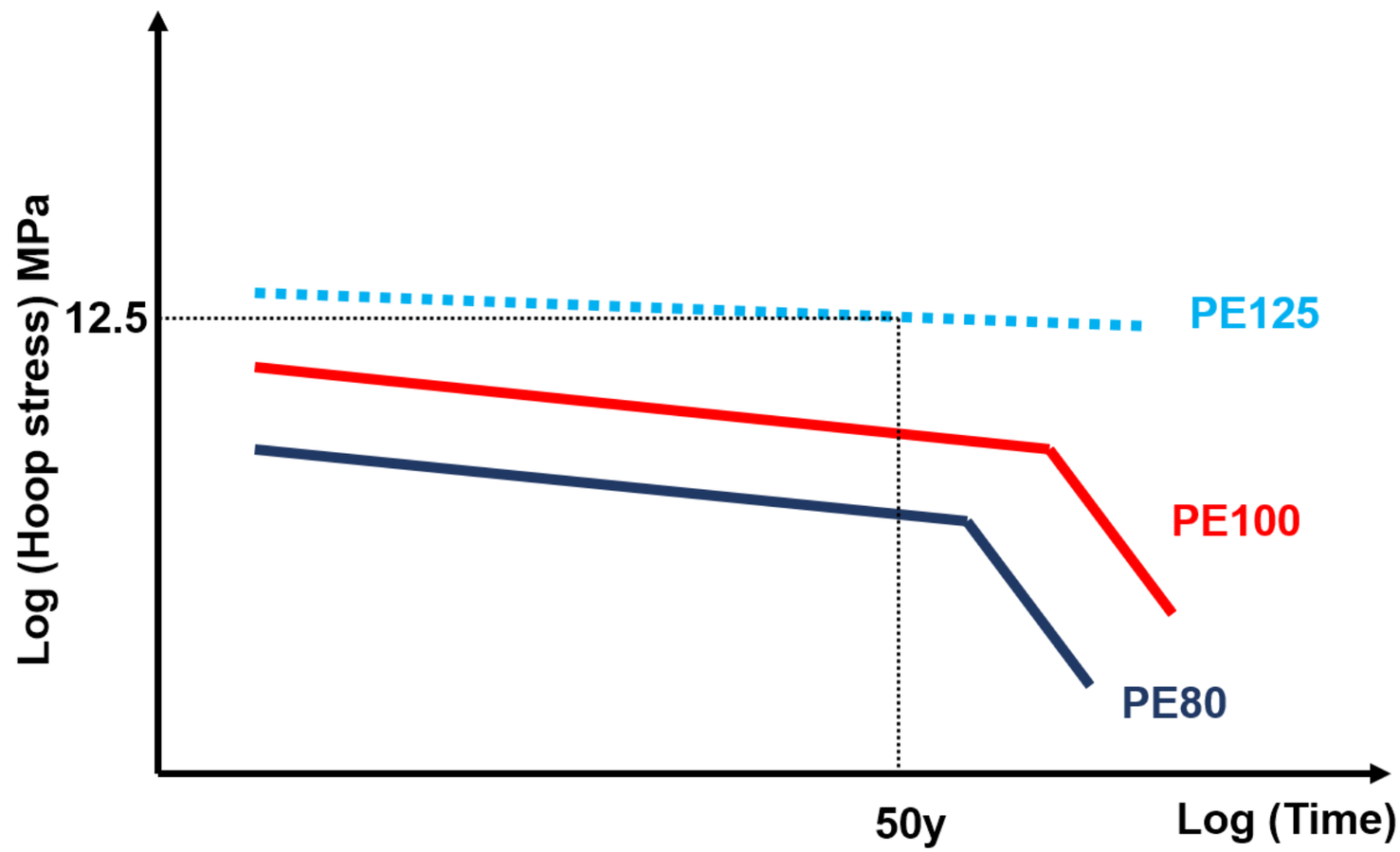


MRS (Minimum Required Strength) PE125

Pressure test ISO 1167-1:2006 MRS (Minimum Required Strength)

2.000 hours at 13.9 Mpa

100 hours at 14.5 MPa



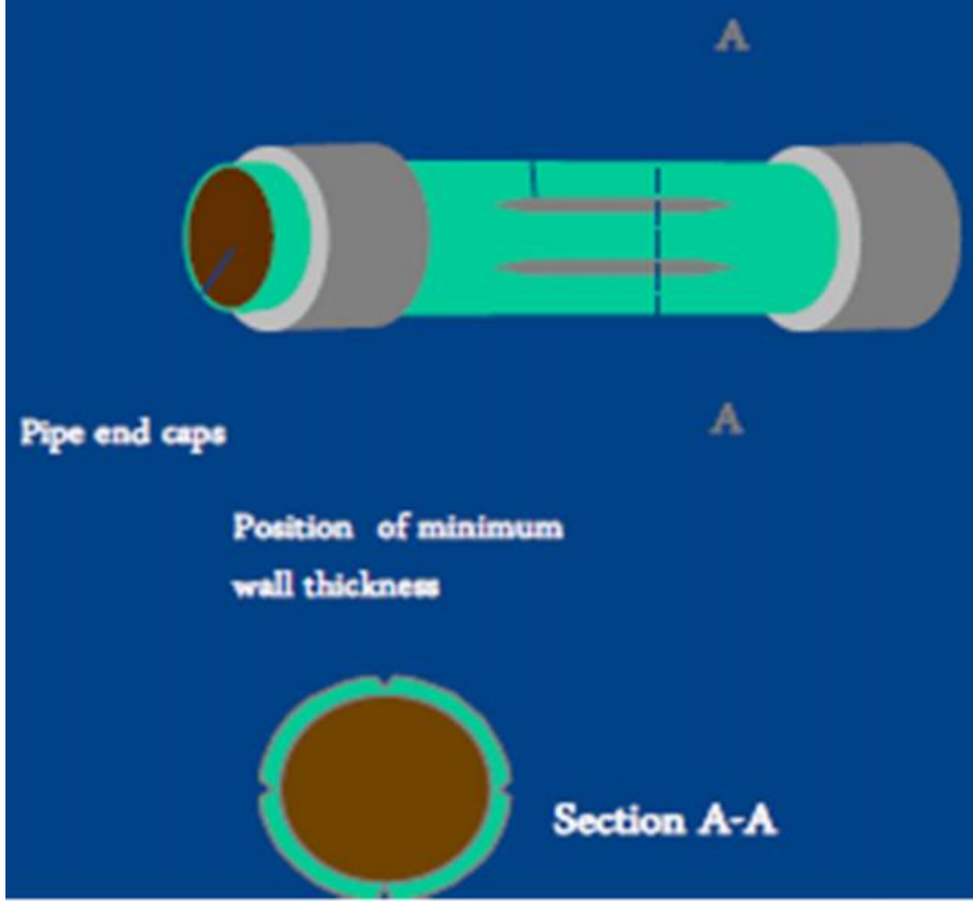
SCG (Slow Crack Growth) or ESCR (Environmental Stress Cracking Resistance)

What is SCG / ESCR:
- Long-term aging process leading to brittleness and cracking
- Increased by scratches and stones

How is SCG / ESCR measured:
- Test with 4 cuts on the tube

4 equi-spaced notches around circumference.

Remaining wall thickness: 78 - 82 % of wall thickness



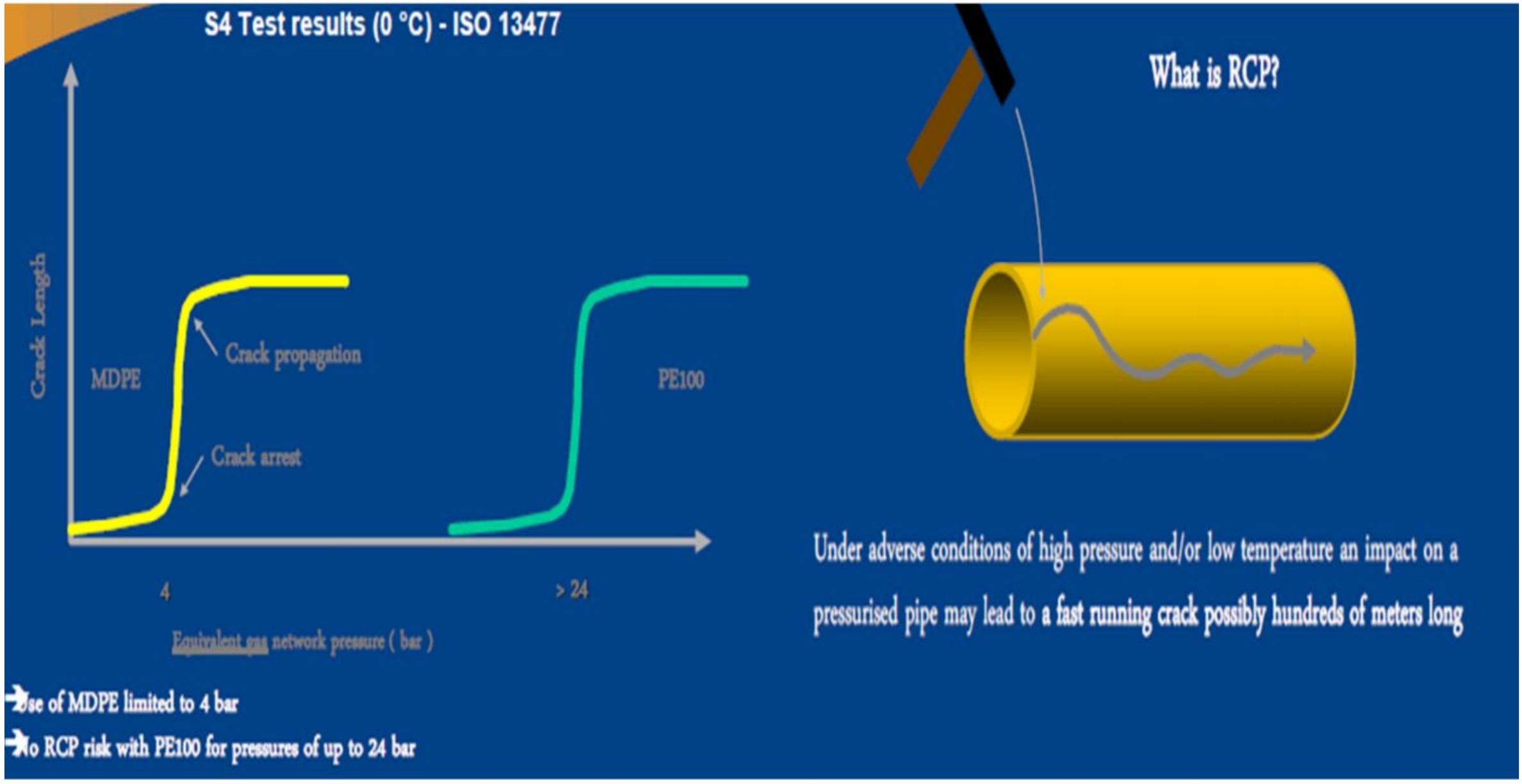
Test Requirements

PE-class	Test temp. °C	Hoopstress MPa	Test period h
PE80	80	4.0	500
PE100	80	4.6	500

RCP (Rapid Crack Propagation)

What is RCP:

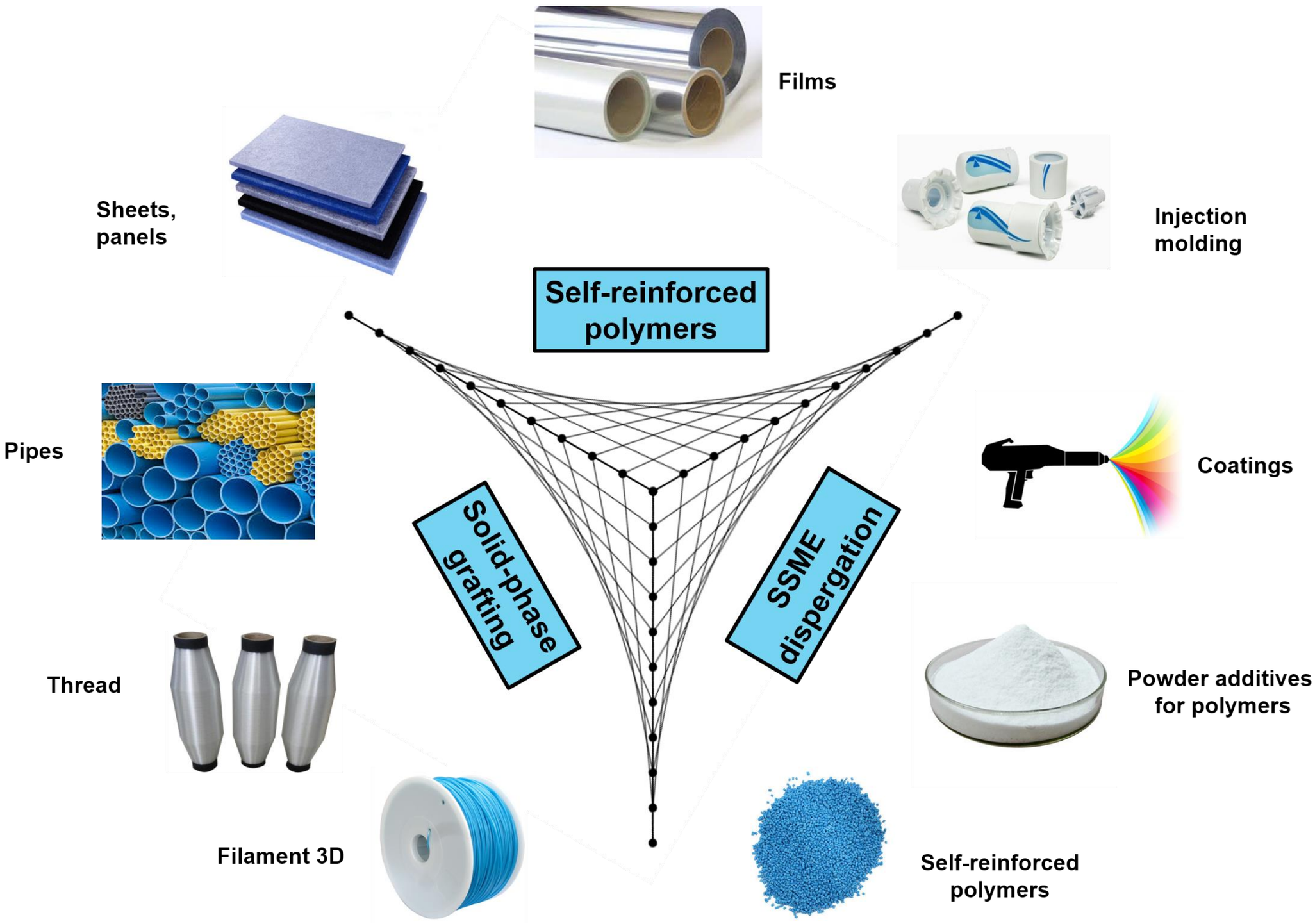
• Under extremely adverse conditions of high pressure and/or low temperature, exposure to - a blow to a pipe under pressure can lead to the rapid formation of cracks up to hundreds of meters in length.



Basic requirements for PE125

Indicator	Optimal value
Density of ISO 1183 at 23C	950-960 kg/cm3 (max 980)
Melt flow index ISO 1133 at 21 kg load	0,2-5 g/10 min
Melt flow index ISO 1133 at 5 kg load	Less 0,2 g/10 min
UHMWPE content in the blend (2-3,5 mil g/mol)	***8-15% (Optimal)*** ***45% (Maximum)***
Carbon black content	1,5-3 w
Pressure test ISO 1167-1: 2006 (Minimum Required Strength, MRS)	2000 hours at 13.9 MPa 100 hours at 14.5 MPa
Resistance to «Sagging» effect (creep) so-called «Eta747 value»	10 times more than that of HDPE

Triad of technologies Graft-Polymer and applications

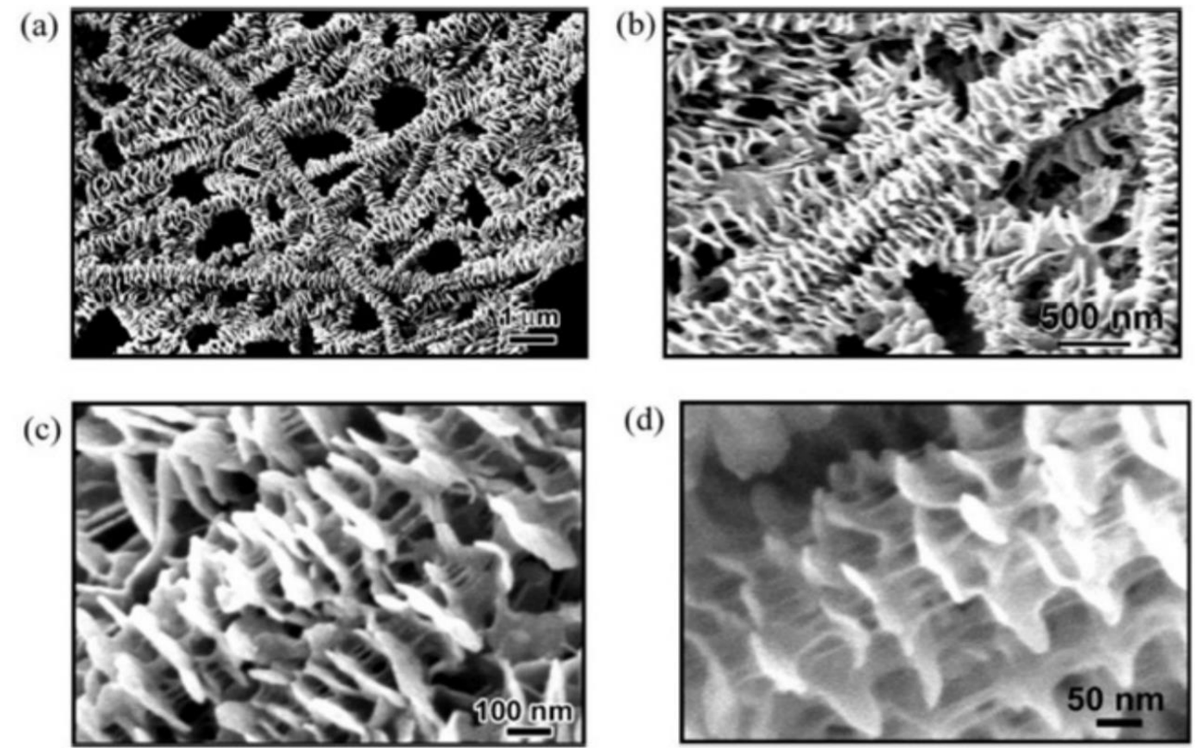


Production of MP-UHMWPE

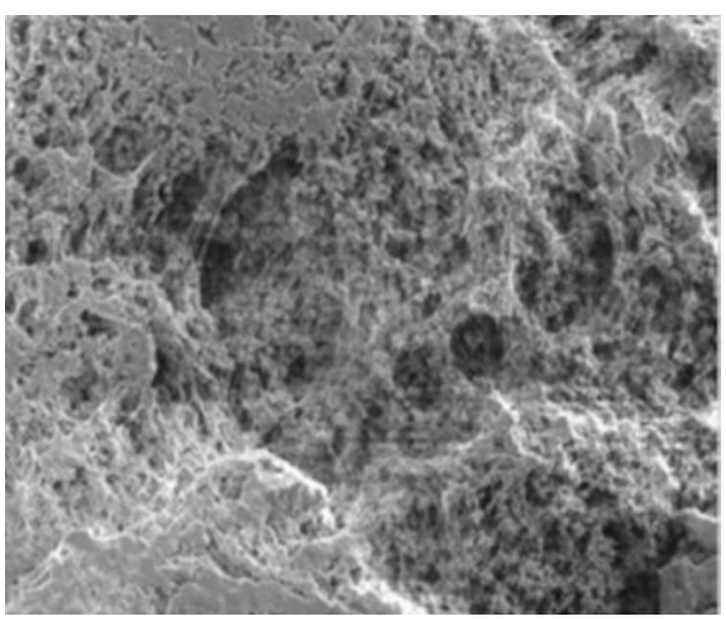
The Graft Polymer specialists have developed a technology for the extrusion synthesis of melt-processed MP-UHMWPE.

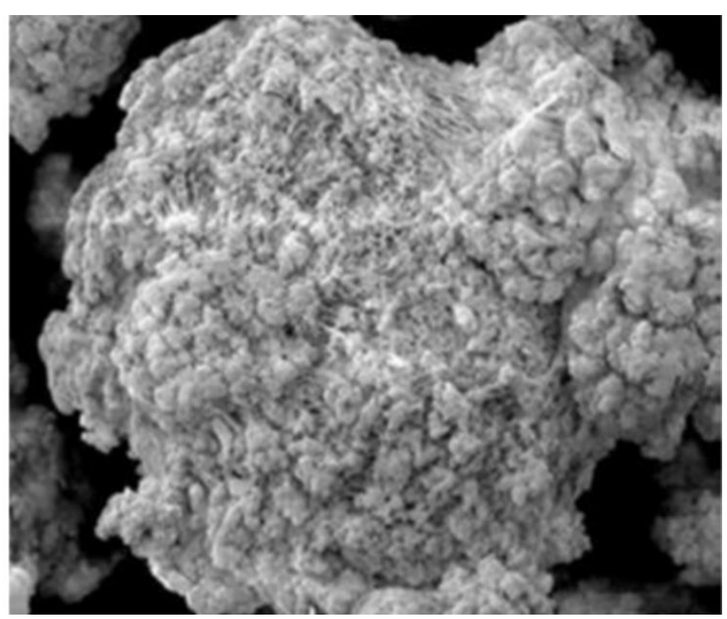
Properties of material MP-UHMWPE:

1. Easily processed (in the melt) into any products on a standard polymer
equipment (extruder, injection molding machine, calender)
2. Physical and mechanical properties are significantly higher than those of standard UHMWPE (ultra high molecular weight polyethylene)
3. Tribological properties are the same as for standard UHMWPE
4. High crystallinity (94% compared to 60-85% standard)
5. Excellent biocompatibility (for medical applications)
6. Easily welded (unlike standard UHMWPE)
7. Easy stretchable
8. Homogenized (fully combined) with different HDPE grades.
9. Efficiency of grafting (vaccinations) in the solid phase of UHMWPE of a new generation significantly higher than standard (due to morphology)



Changes in the morphology and structure of UHMWPE



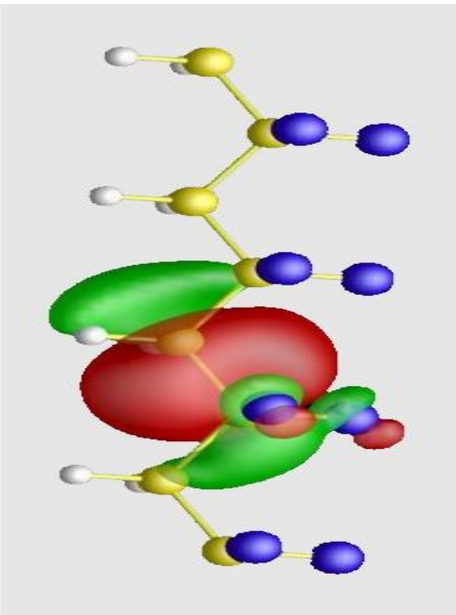


Particle morphology of standard UHMWPE (right) and New-UHMWPE (left) - spongy structure is clearly visible

Process Flow Diagram production MP-UHMWPE

Basic HDPE

Graft Copolymer



Chemical reagents

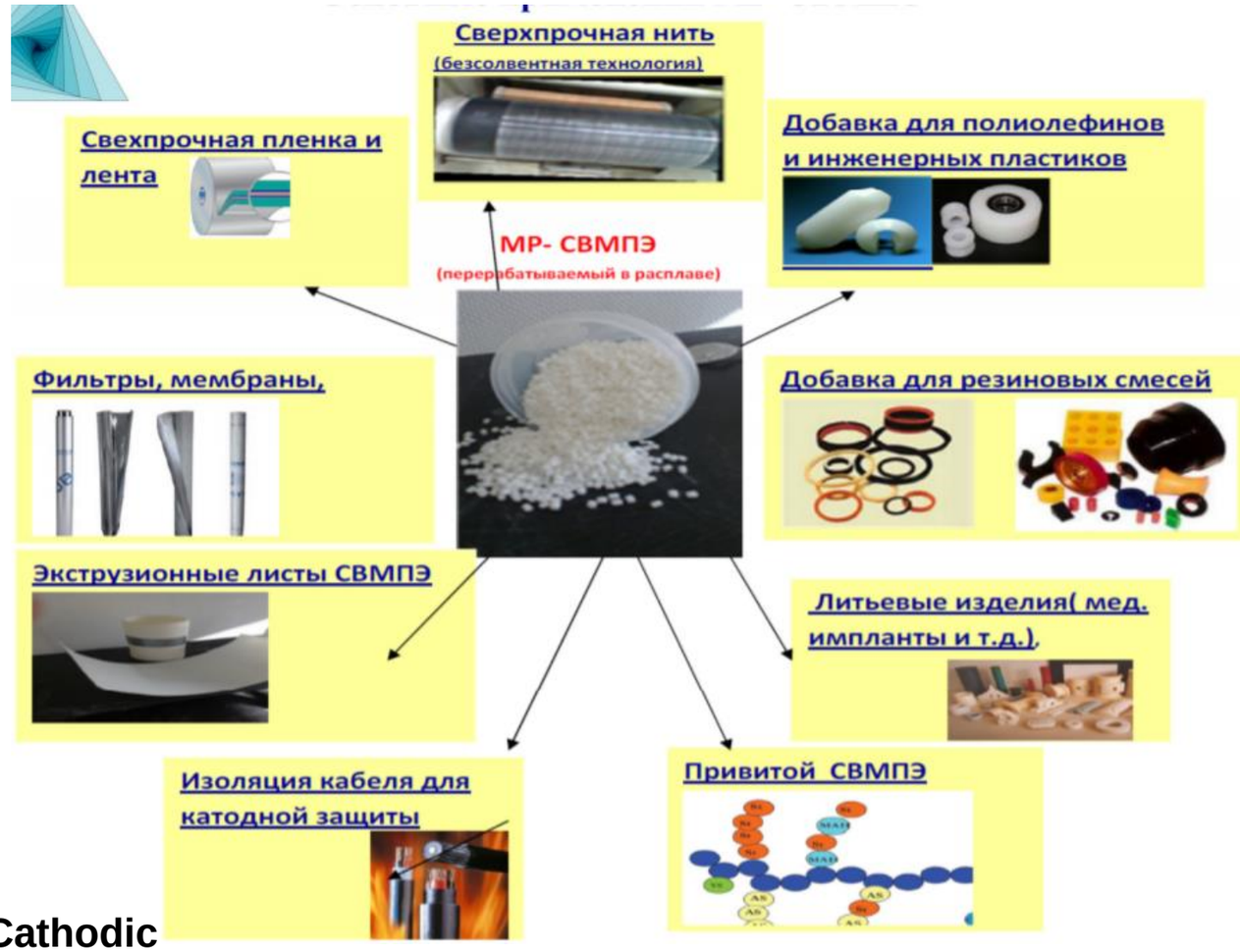
Powder UHMWPE

Extrusion cascade line

Main applications of MP-UHMWPE

Heavy-duty thread
(solvent free)

Heavy Duty Tape
and Film



Additives for polyolefins
and engineering plastics

Filters and
membranes

Additive for rubber

Extrusion sheets

Injection molding parts
(medical implants)

Insulation Cathodic
Protection Cable

Grafted
UHMWPE

Challengies in PE125 manufacturing

So, for example, to obtain polyethylene according to the standards PE125 (with an indicator of minimum strength MRS> 13.8-14 MPa, in comparison PE100 has MRS only 10 MPa), a significant improvement in resistance against hydrostatic pressure is required.

For the usual bimodal HDPE, this indicator is difficult to achieve, since it directly correlates with the impact strength / density indices and with simple extrapolation it turns out that the required index for PE125, it’s just not realistic to achieve a bimodal HDPE matrix.

There is another problem - it is the difficulty in maintaining the geometric stability of the pipe (the thickness at the top of the pipe is often less than at the bottom) due to the "sagging" effect (phenomenon gravitational flow of polymer melt).

This phenomenon is more pronounced for thick-walled pipes. Specific MP-UHMWPE solves these aforementioned problems.

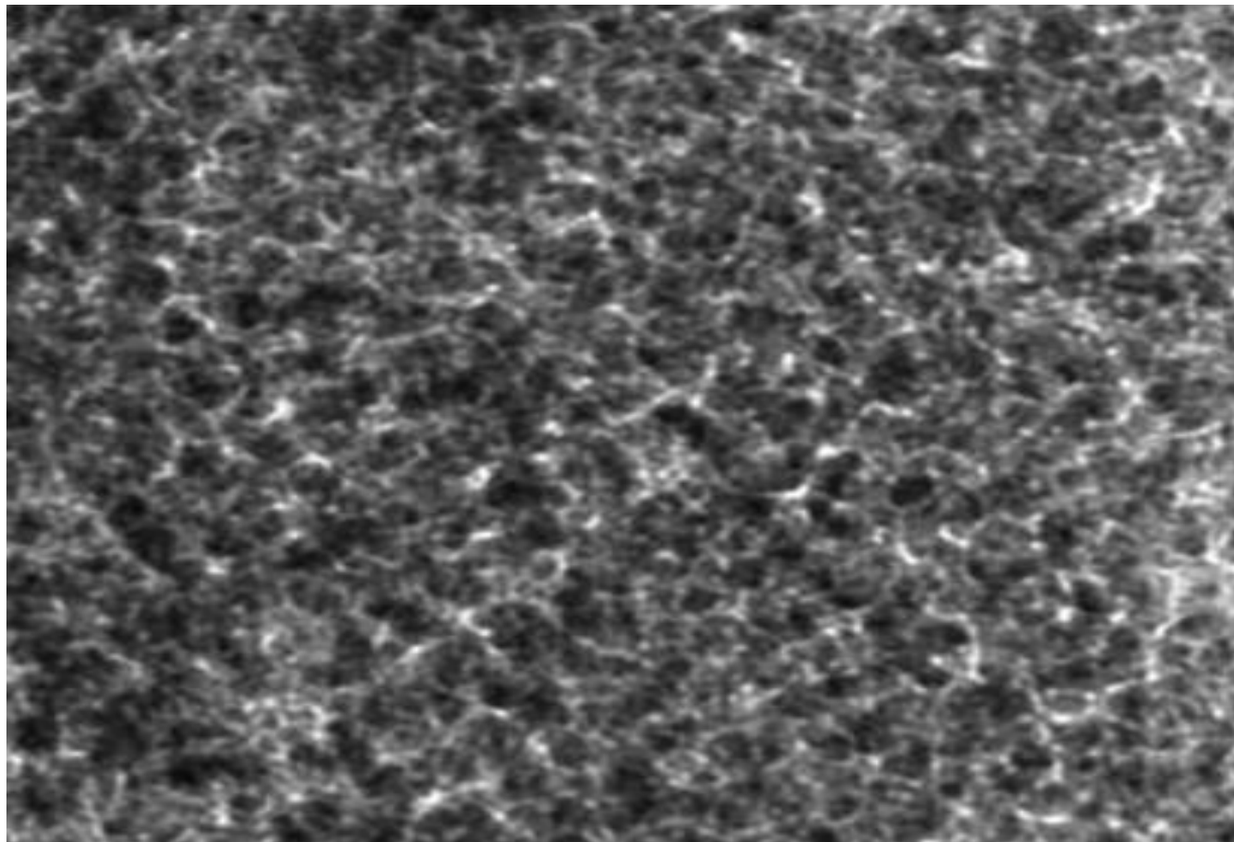
Process Flow Diagram of PE125 manufacturing

Basic HDPE

Chemical reagents

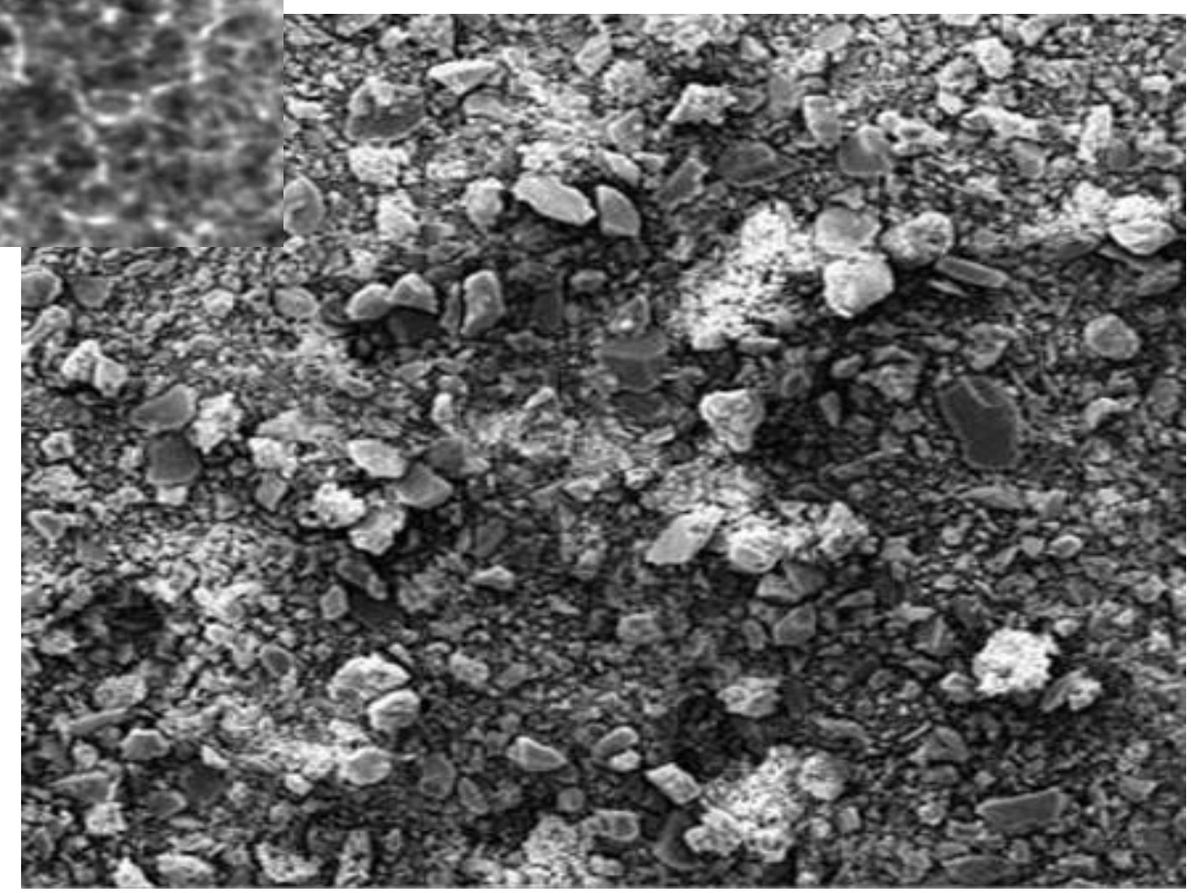
Compound MP-UHMWPE

Microphotos of materials comparison



Dispersed compound MP-UHMWPE
using Graft Polymer technology

The dispersion of the compound UHMWPE
using standard extrusion technology



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