

# Norden Maritim AS Bend Restrictors



# What is a bend restrictor ?

- A bend restrictor acts like the vertebrae of the spine protecting the central nervous column.

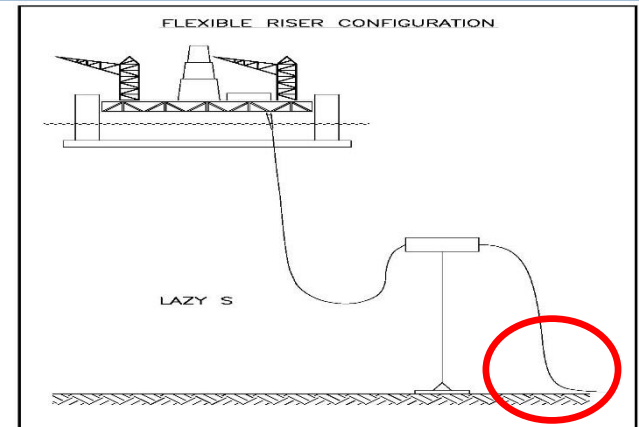


# What is a bend restrictor ?

- A bend restrictor element comprises of two identical half shells bolted together which fit around a umbilical cable or a flexible flow line which lockout at a predetermined minimum radius so preventing the flow line from collapse, strain or restricted flow.
- The half shell form allows the restrictor to be fitted at the fabrication yard or on board the vessel/platform as the line is being deployed.
- Once the elements have locked together the bending moment present is transferred into the elements so protecting the internal pipe from potentially damaging loads.
- Bend restrictors are used both onshore and subsea at the interface between flexible and rigid structures. Such as a flowline to rig or FPSO (floating production storage offload).

# Bend Restrictors

- Used for Static / Quasi Static Applications
- Typically used on seabed connections to manifold etc
- Series of interlocking vertebra design to lock out at radius  $\geq$  Minimum Bend Radius (MBR)
- Used to protect riser from over bending during installation and service
- Polymer or steel elements



# Load Testing

Two types of load test can be conducted:-

- **Proof load testing.**

A fully assembled string of elements is subjected to the calculated maximum in service loading.

The load is held for a defined time period and the string is examined for any signs of damage.

- **Destructive load testing**

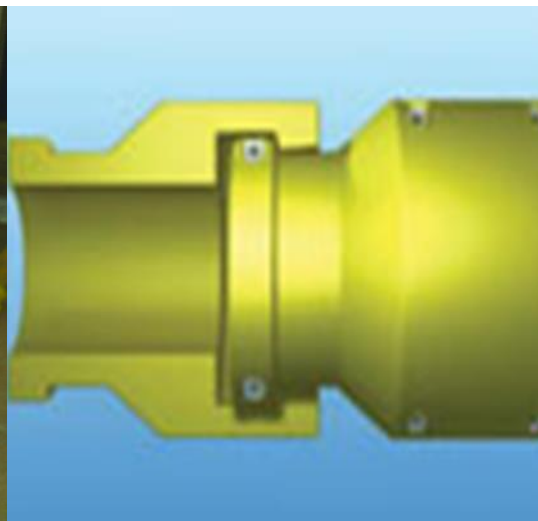
If a destructive load test is specified the restrictor is first proof load tested then the load is increased until failure of one or more of the element occurs. The failure load is recorded and compared to the load anticipated by calculation.



# Bend Restrictor

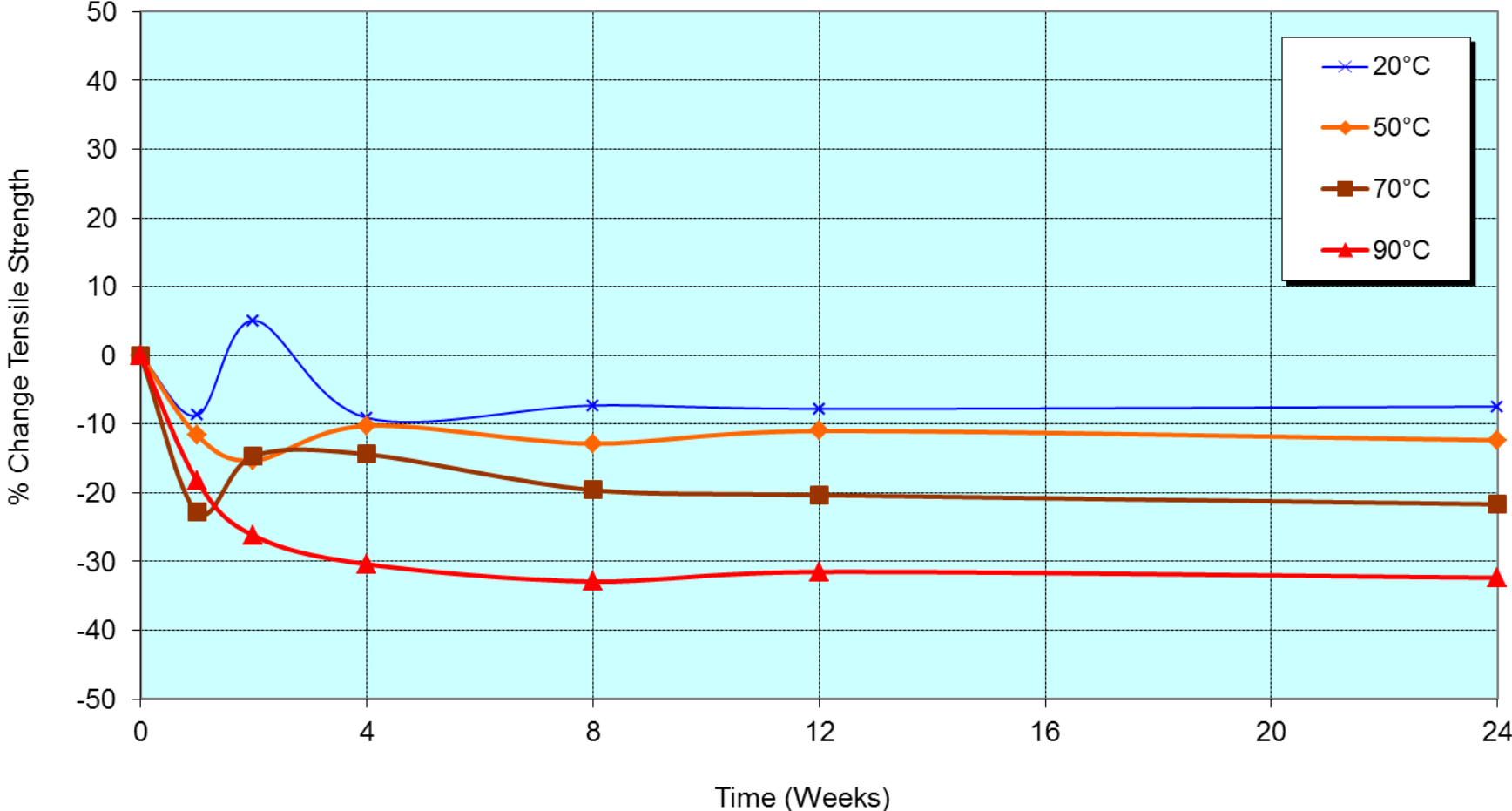
## Qulen 6805/115/D80

- ▶ Hardness - 80D
- ▶ Tensile Strength – 48MPa
- ▶ Elongation at Break – 17%
- ▶ Young's Modulus – 2430 MPa
- ▶ Gel time 8 - 20 minutes
- ▶ Mix Ratio 100:85 (Polyol: Iso by wt)



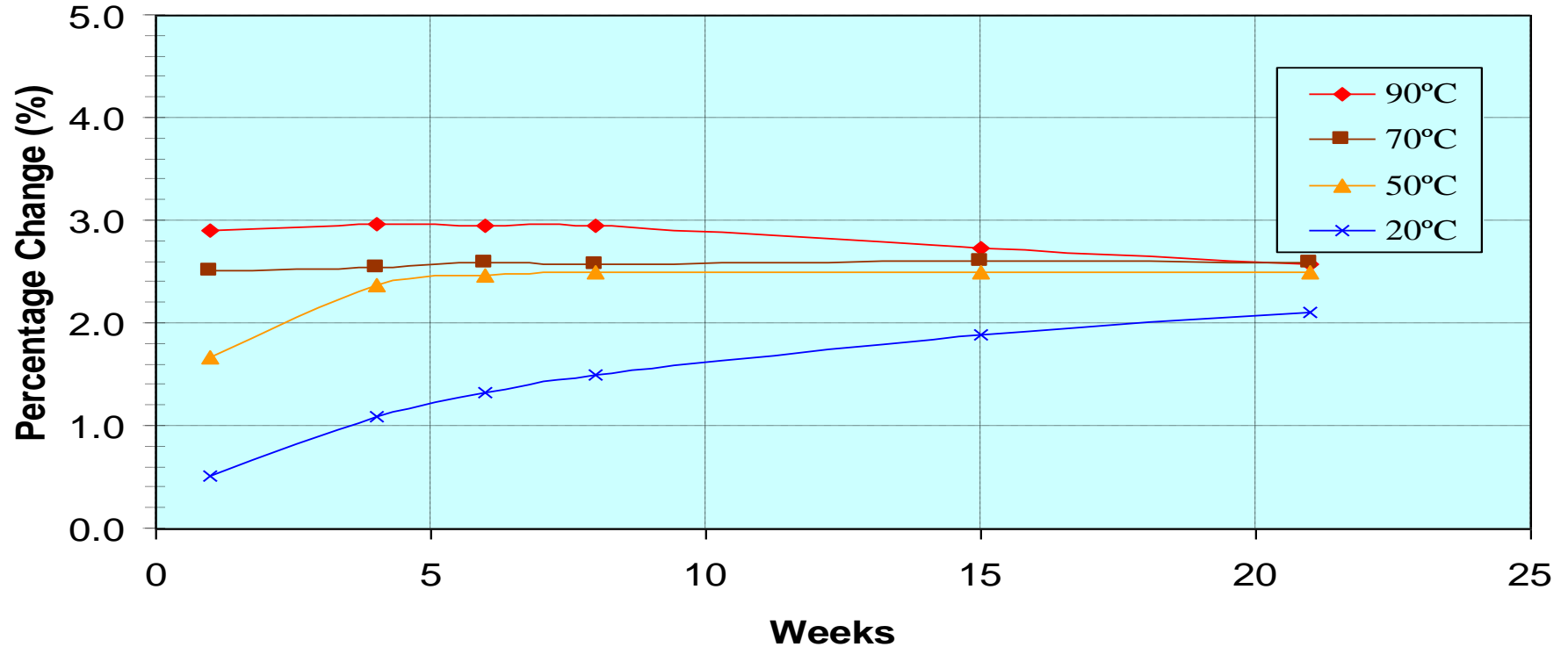
# Bend Restrictor Hot/Wet Ageing

6805/115/D80  
% Change in Tensile Strength



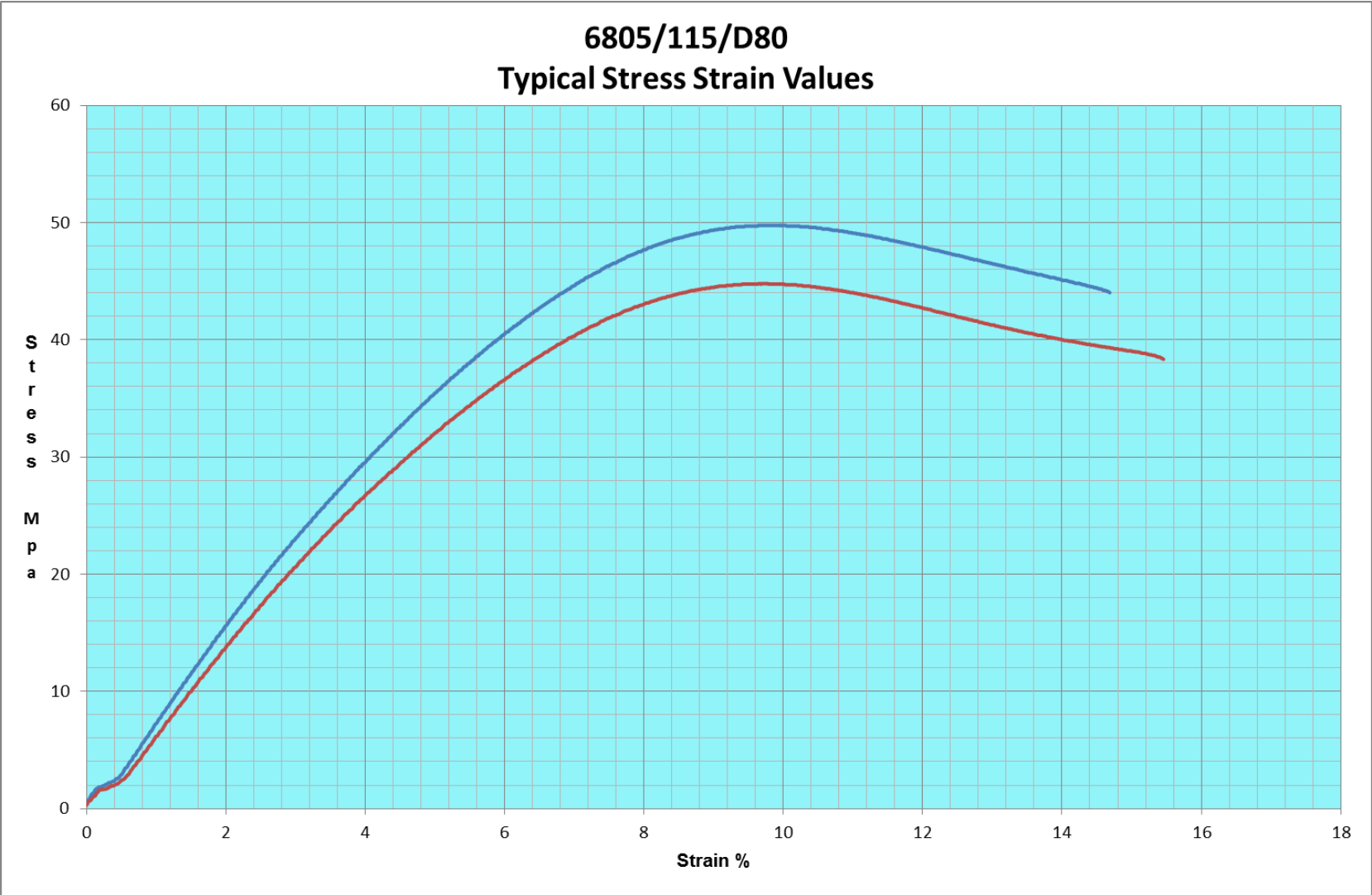
# Bend Restrictor System Water Absorption

## 6805/115/D80 Water Uptake %Change



- Overall water absorption of between 2.5 – 3.0%

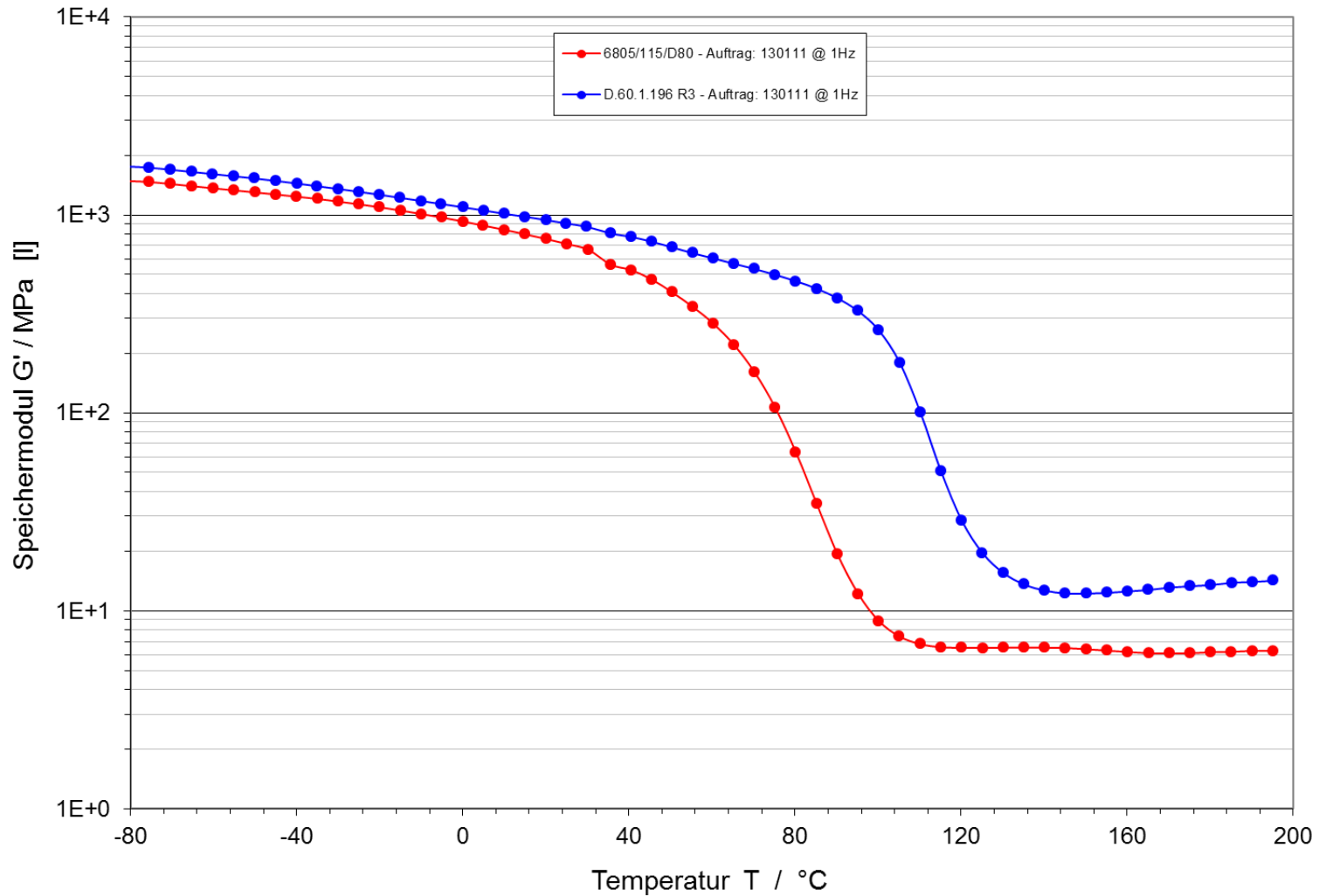
# Bend Restrictor Stress/Strain Values



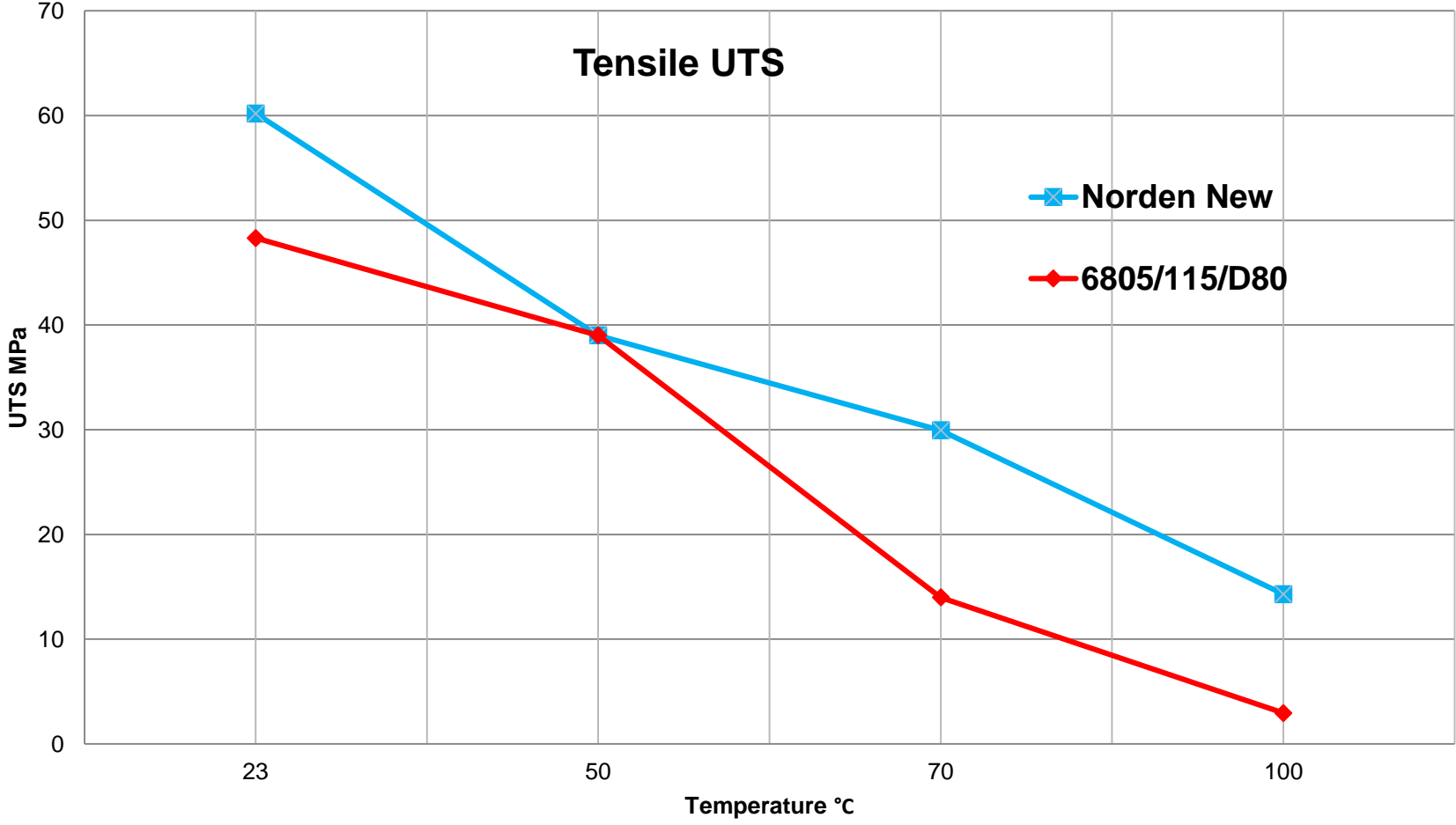
# New Bend Restrictor Required Improved Properties

Test	Required
Tg	>75C
Hardness	> 80 D
Hardness	> 65 D @ 80C
Tensile Strength	> 55 MPa
EAB	~ 10%
Young's Modulus	> 2000 MPa @23°C, can reduce up to15% @ 50°C
Yield Stress	> 50MPa @50°C
Compression Set	> 96% 72hours@23C
Izod Impact notched	>7.0 KJ/m <sup>2</sup>
Hot/Wet capability	> 50°C, ideally 80°C
Water Absorption	< 3.0%

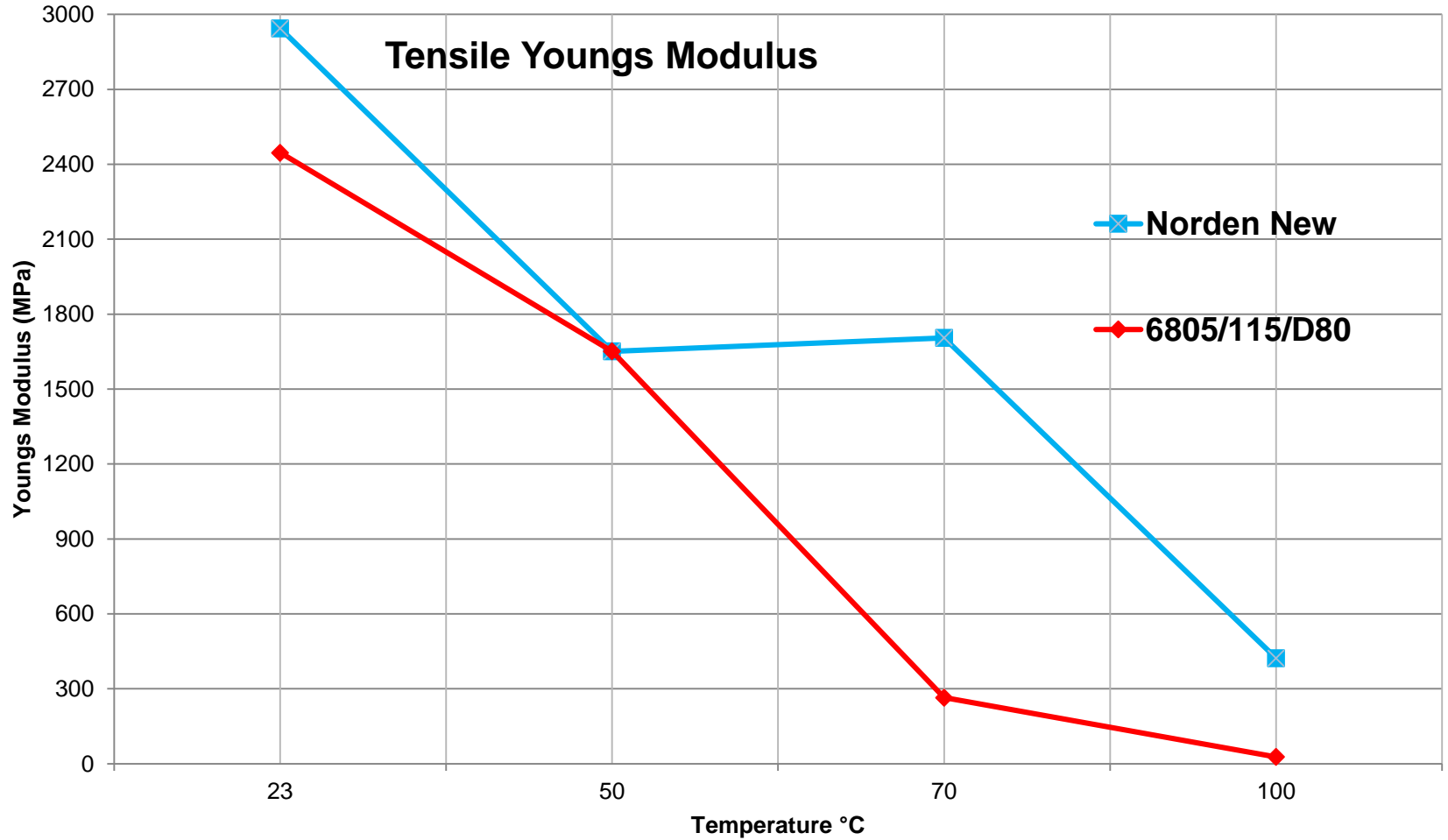
# Bend Restrictor Improvement Next.....



# Improvement Tensile Strength MPa



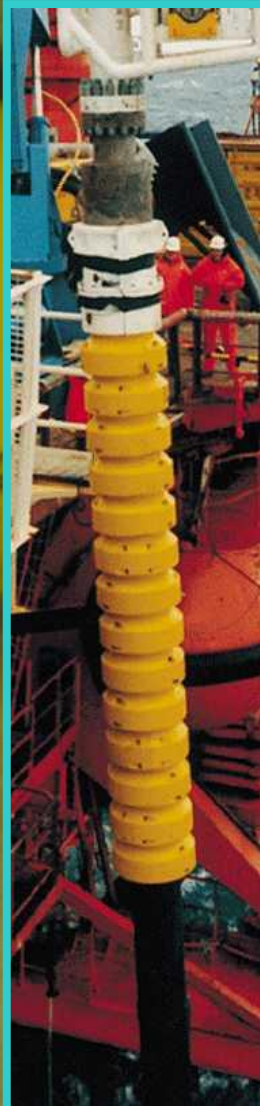
# Improvement Youngs Modulus



# Improvement - now available

A new Norden Maritim bend restrictor system with improved temperature capability.

available now



# Next Stage Required Properties

Test	Required
Tg	$\geq 110^{\circ}\text{C}$
Hardness	$> 80 \text{ D}$
Hardness	$> 65 \text{ D @ } 80\text{C}$
Tensile Strength	$> 50 \text{ Mpa @ } 45^{\circ}\text{C}$
EAB	$\sim 10\%$
Young's Modulus	$> 1800 \text{ MPa @ } 70^{\circ}\text{C}$ , can reduce up to 15% @ $90^{\circ}\text{C}$
Yield Stress	$> 50 \text{ MPa @ } 100^{\circ}\text{C}$
Compression Set	$> 96\% \text{ 72hours @ } 23\text{C}$
Izod Impact notched	$> 7.0 \text{ KJ/m}^2$
Hot/Wet capability	$> 80^{\circ}\text{C}$ , ideally $110^{\circ}\text{C}$
Water Absorption	$< 3.0\%$