Development of HMPE fiber for deepwater permanent mooring applications

Sérgio Leite — Lankhorst Ropes

Peter Davies — Ifremer

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Agenda

- Fiber properties
- Rope properties
- Why use it?
- Conclusions

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Three world class players teaming up

Lankhorst Ropes	Ifremer	DSM Dyneema
One of the largest rope manufacturers in the world	French Ocean Research Institute	Inventor of the Dyneema®, the world's strongest fiber™
Almost 2 decades working with Dyneema®	Over 20 years experience in testing of high performance fibers and ropes	Dedicated to innovation
Presence in Portugal and Brazil		Largest global supplier of HMPE fiber

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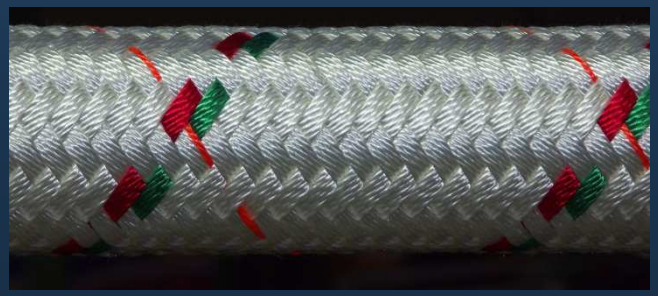
Development of HMPE fiber for deepwater permanent mooring applications

Stretch	2000 m	3000m
Polyester Rope	40 m	60 m
Rope with Dyneema®	8 m	12 m

- **Polyester creates greater horizontal offset**
- **Dyneema® will provide reduced values**



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HMPE to PET comparison
Lighter, compacter, stiffer

- Rope made with DM20, when compared with polyester will
  - Be 60% lighter
  - Have a 30% smaller diameter
  - Offer excellent fatigue properties
  - Be 3-4 times stiffer

MBL	Polyester kg/m	DM20 kg/m
630t	14,5	5,9
1250t	29,0	11,5
2000t	46,8	18,6

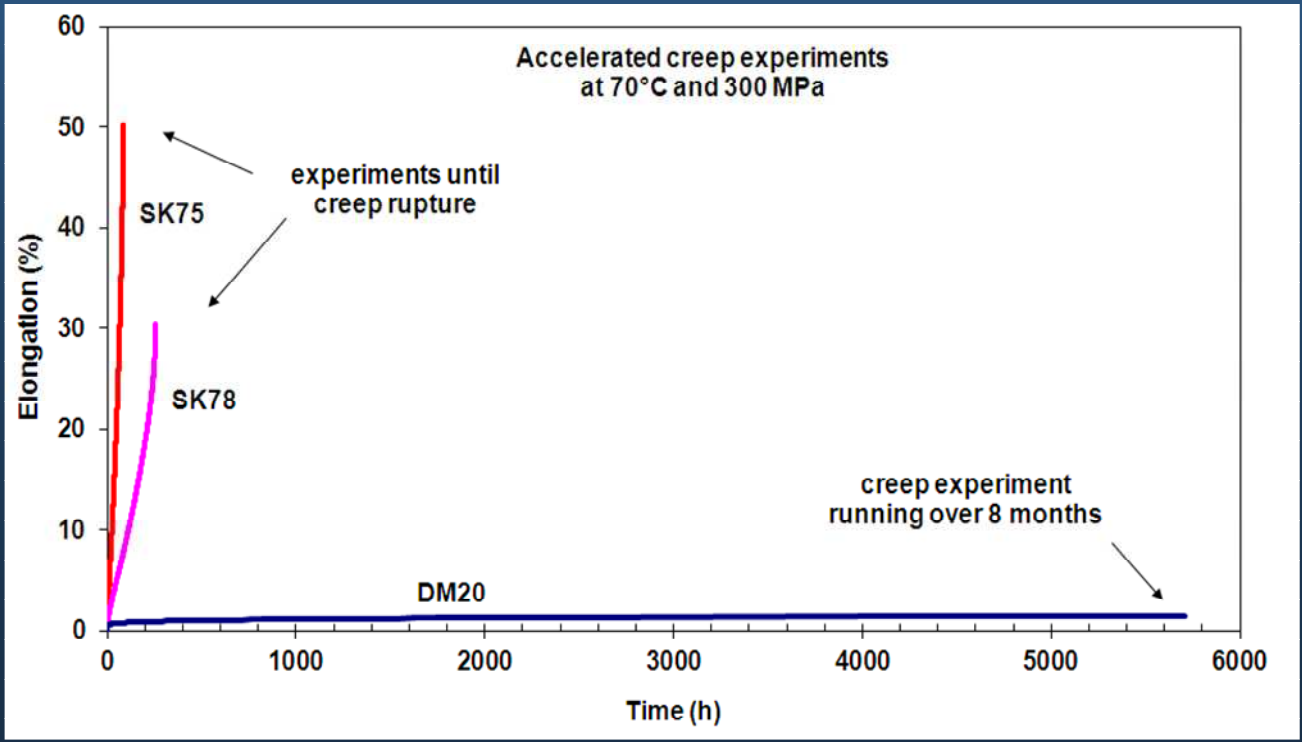
HMPE fiber grades

	General	Reduced creep	Further reduced creep
Dyneema® fiber	SK75	SK78	DM20
Titer	1740 dtex	1740 dtex	1740 dtex
Tenacity	35 cN/dtex	35 cN/dtex	31 cN/dtex
Modulus	1160 cN/dtex	1160 cN/dtex	920 cN/dtex
Elongation at break	3.5%	3.5%	3.6%
Typical use	**Work ropes**	**MODU mooring**	**Permanent mooring**

DM20 fiber

Step change creep properties – creep elongation

- Accelerated testing are performed at elevate temperatures to provide results in acceptable time frame: 70°C and 300 MPA = 20% MBL



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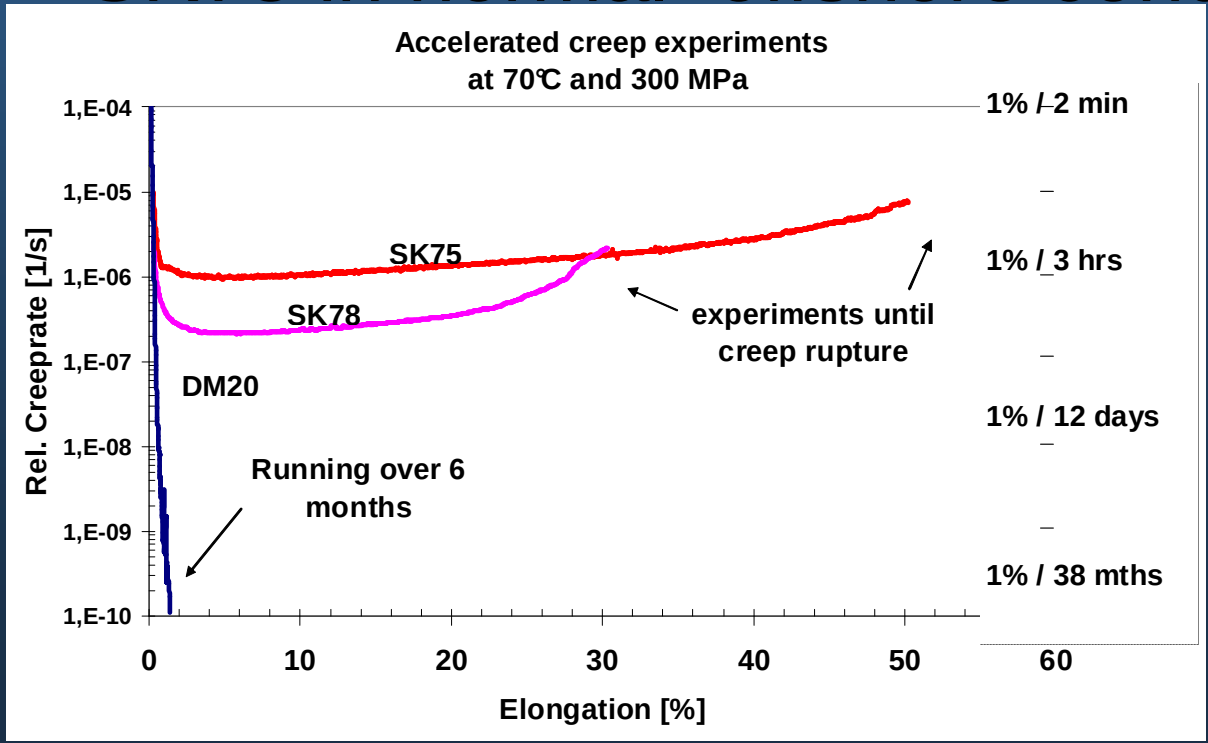
DM20 fiber
Step change creep properties – creep rate

- Creep: 70°C & 300 MPA = load of 20% MBL
- Creep rate DM20 is 50 times lower then SK78 in normal offshore conditions



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HMPE fiber
Rope samples

- 8 strand sub-rope samples (spliced)

Material	Ø	Break strength	Test	Location
SK78	29 mm	600 kN	Stiffness	Ifremer
			Creep	
DM20	34 mm	900 kN	Stiffness	
			Fatigue	DNV
	52 mm	1800 kN	Stiffness	Lankhorst Ropes

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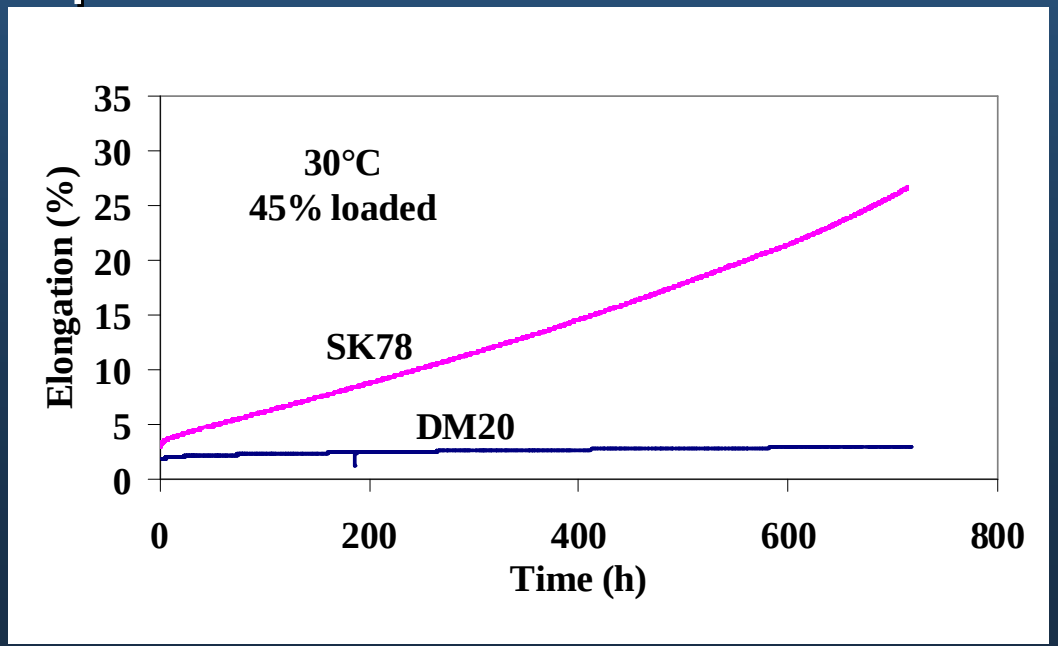
Rope with DM20 fiber
Excellent properties for permanent mooring

- Ifremer – France: Ø 29mm rope: 67 t MBL
- Test conditions: 30°C / 45%MBL
- SK78 creep failure at 30% elongation; DM20 showed 2,5% elongation; only minor part is creep



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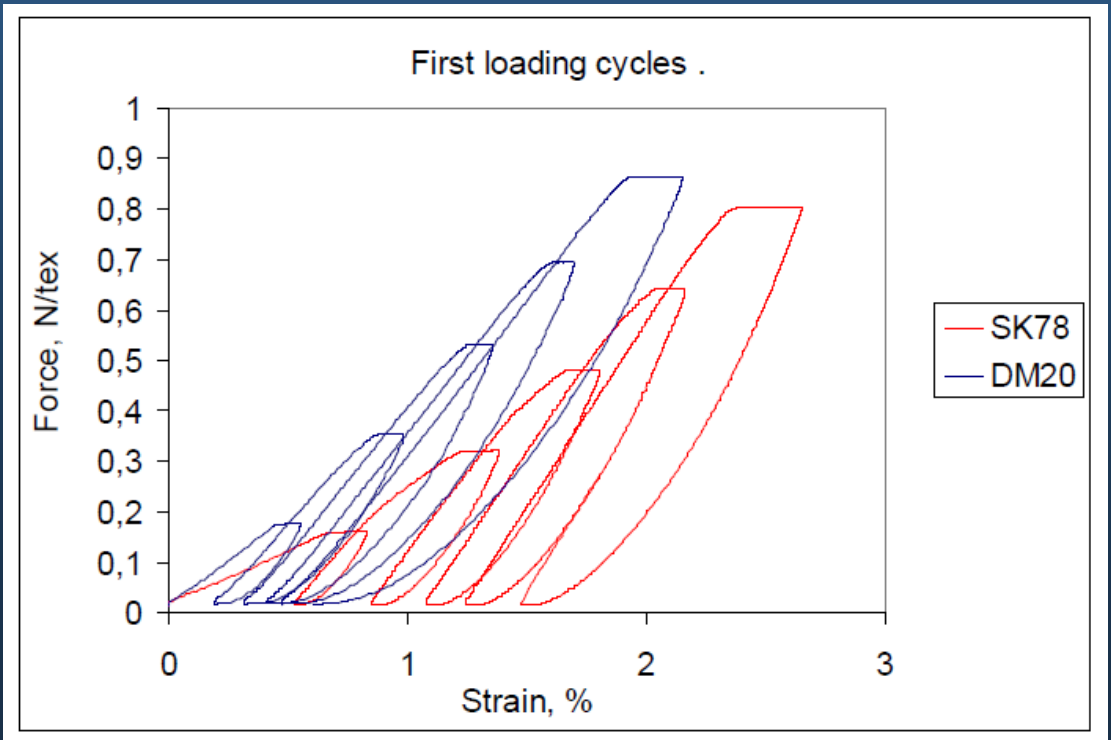
Rope with DM20 & SK78
Stiffness

- Initially DM 20 is stiffer then SK78
- DM 20 stiffens little after first loading 10% MBL
- After 100 cycles, DM 20 has a stiffness 10% lower then SK78



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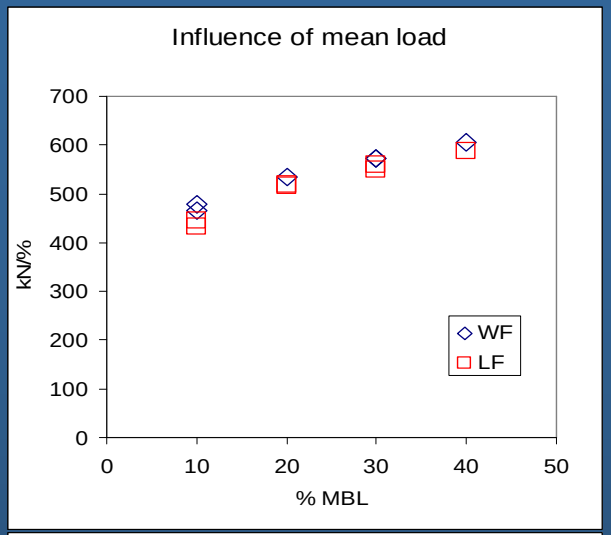
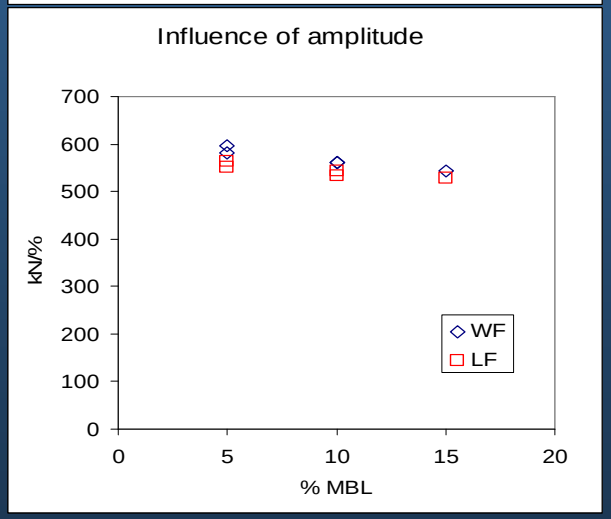
Rope with DM20 fiber
Dynamic Stiffness

- Increasing mean load
  = increased stiffness

- Increasing amplitude
  = decreasing stiffness





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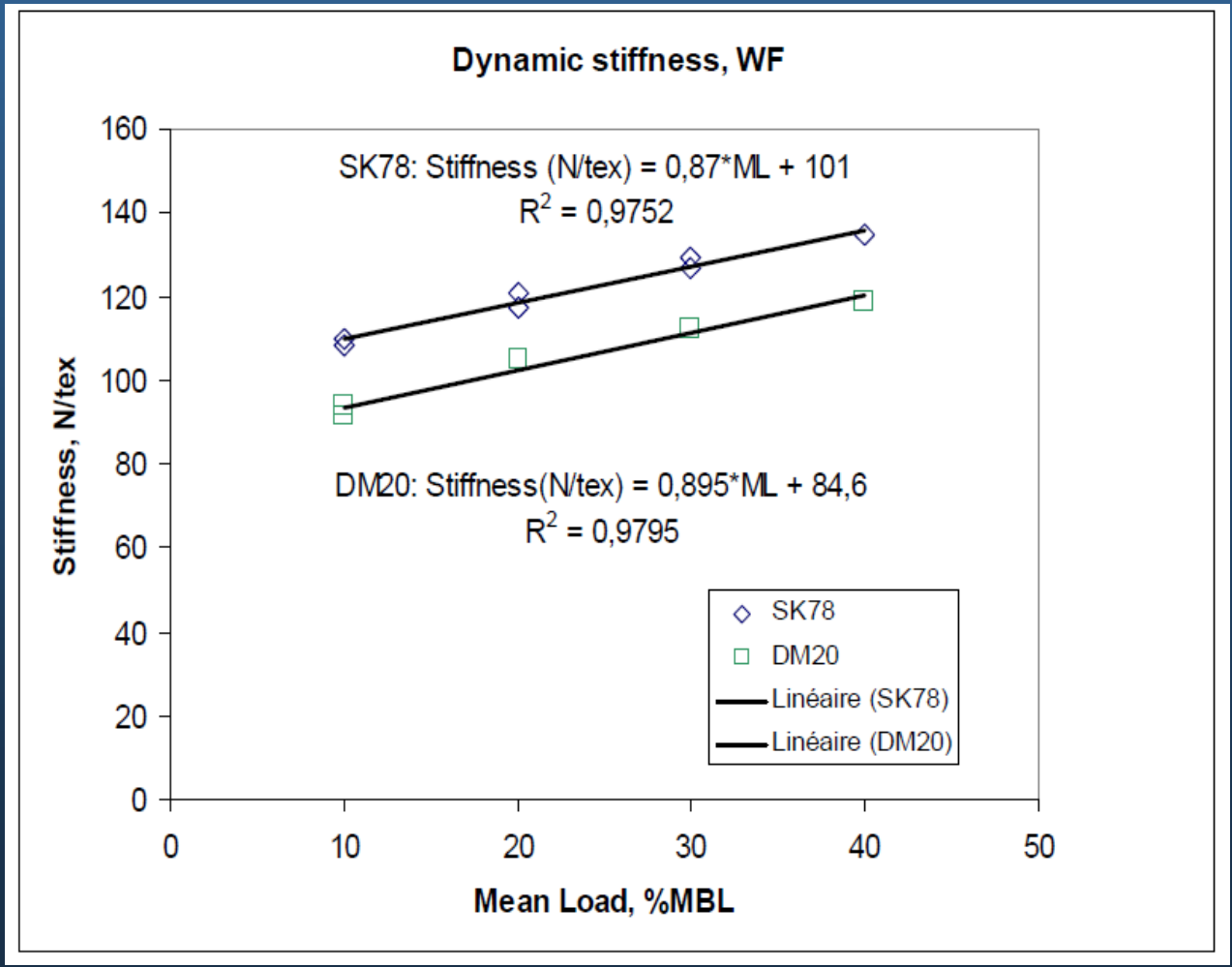
Rope with DM20 & SK78
Dynamic Stiffness

- Increasing mean load = increased stiffness



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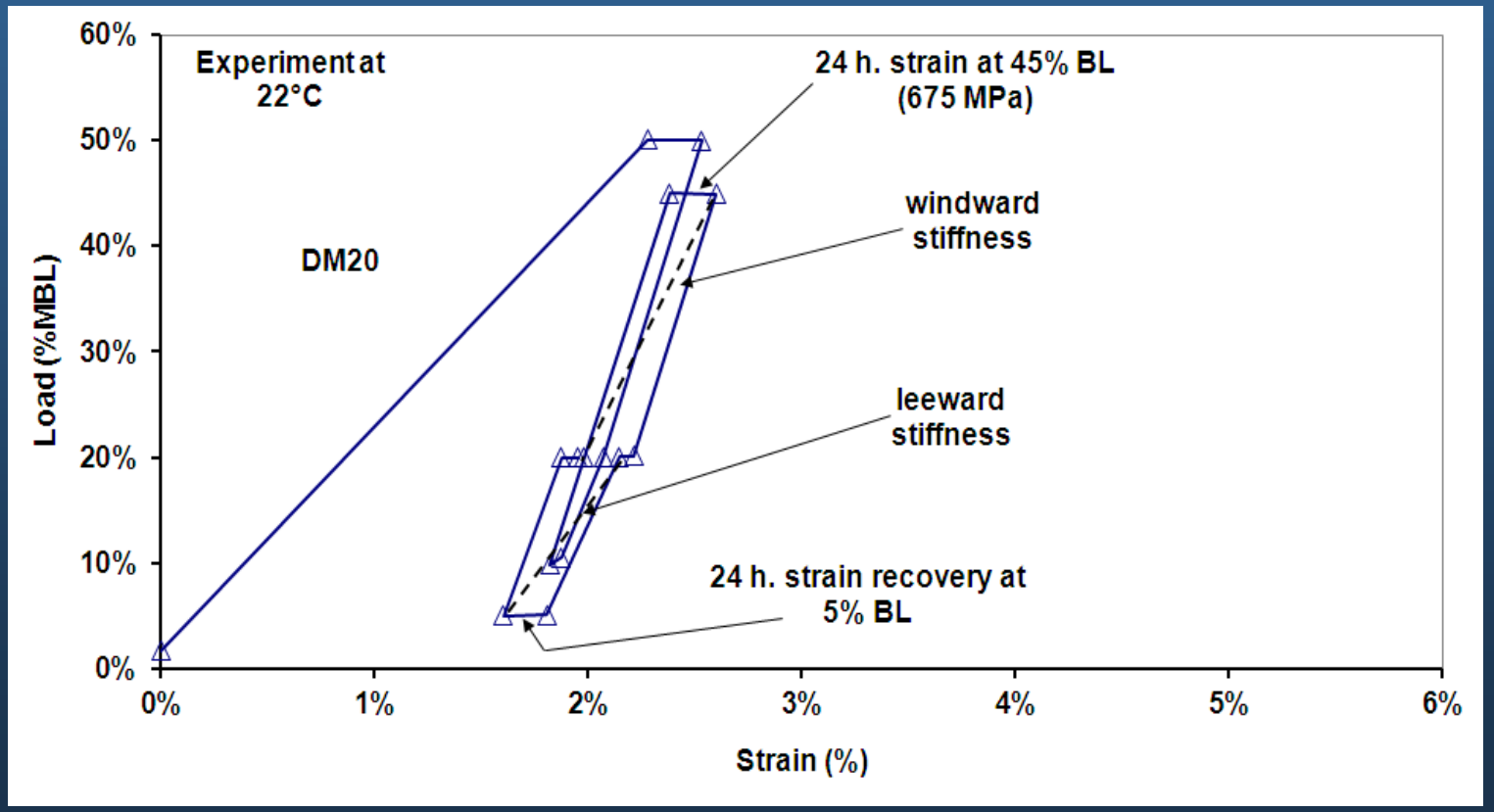
Rope with DM20 fiber
Stiffness testing

- After the stiffness testing a permanent strain of 1,5% was recorded



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Rope with DM20 fiber
Fatigue

- DNV : Ø 34 mm, after 10,000 cycles between 5-50% MBL – ISO Standard, the obtained break strength result is 118% of the break strength value of the non cycled rope = Excellent fatigue life DM20

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Why DM20 ?
Operational benefits in every project stage

Design stage

- Optimizing between riser type & mooring line stiffness
- More vessels of opportunity for transport & installation

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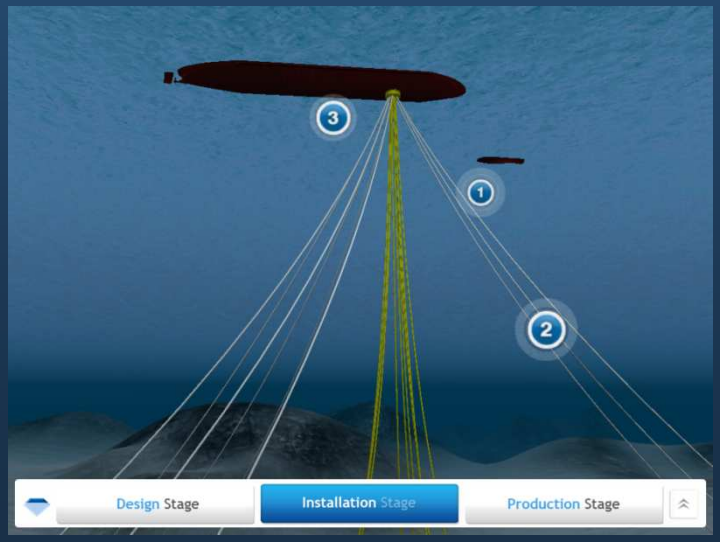
Why DM20 ?
Operational benefits in every project stage

Installation stage

- Smaller or fewer vessels required transport & installation
- Lower weights, thus faster & safer installation
- Longer rope lengths, thus fewer connections



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Why HMPE
Operational benefits

- The concept balancing OPEX savings & CAPEX investment has been proven by many in many applications….

- MODU mooring lines, seismic lines, offshore lifting slings, deepwater lowering and lifting lines

- Petrobras, Shell, Anadarko, ConocoPhillips, Transocean, Delmar, Statoil, SBM, APL, PGS, Prosafe

Conclusions

- DM20 new product in HMPE portfolio with the known product benefits of HMPE
- Ropes made with DM20 fiber match industry requirements for permanent mooring
- Creep prediction model is again available for DM20
- Mooring ropes with DM20 offer OPEX savings during design and installation stage of deepwater systems.

Thank you

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