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Human Chemistry, Human Solutions

Teijin Aramid

Engineering with aramid fibers for RTP applications

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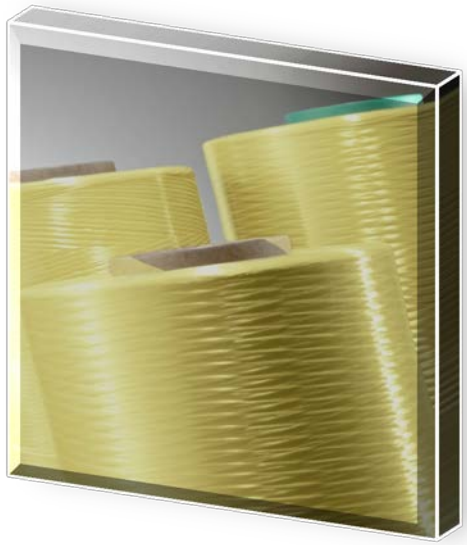
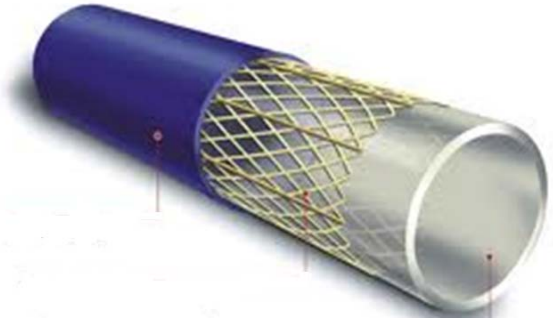
Twaron® | Technora®

The power of Aramid

Content

- Teijin Aramid
- Background - applications
- Quality control properties
- Long-term properties
  - Static loading
  - External influences





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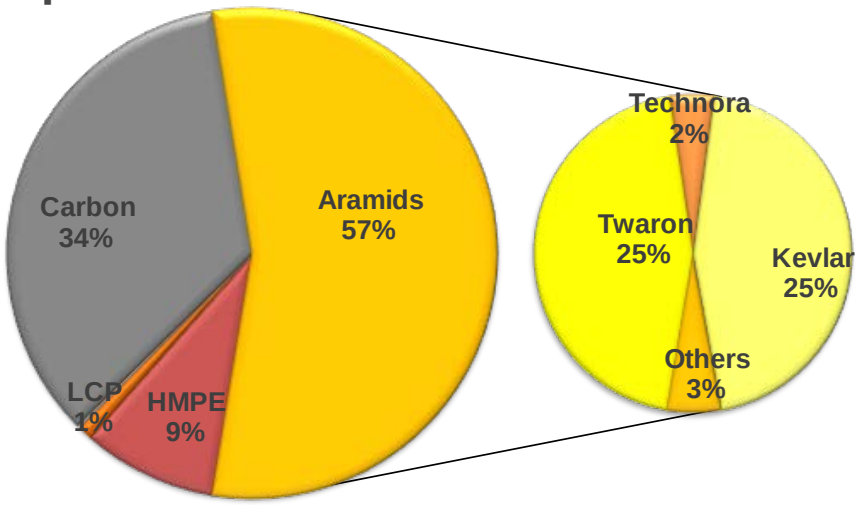
Teijin Aramid BV - Market

Some fiber market volumes:

Glass fiber (E-glass) :	~	3.000.000 tons / yr (99% composites)
Total synthetic fiber market:	~	45.000.000 tons / yr (>90% clothing)
Industrial synthetic fibers:	~	2.500.000 tons / yr (PET, PA66 etc)
High performance fibers:	**~**	**100.000 tons / yr**



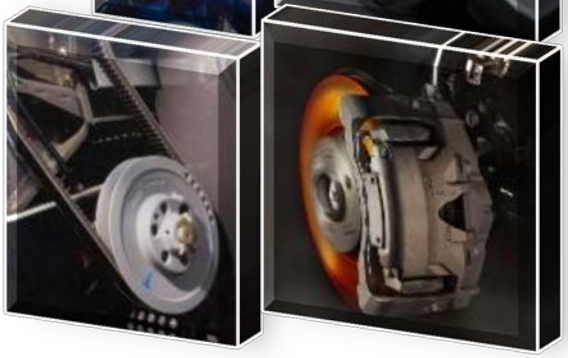
Teijin Aramid BV - Applications

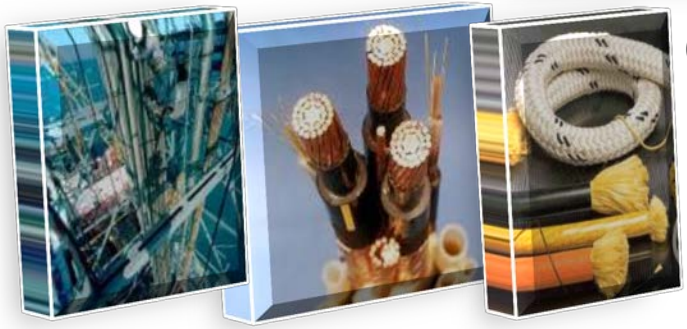
Protection

Telecom

Automotive

Aerospace





Oil&Gas

Leisure

Construction

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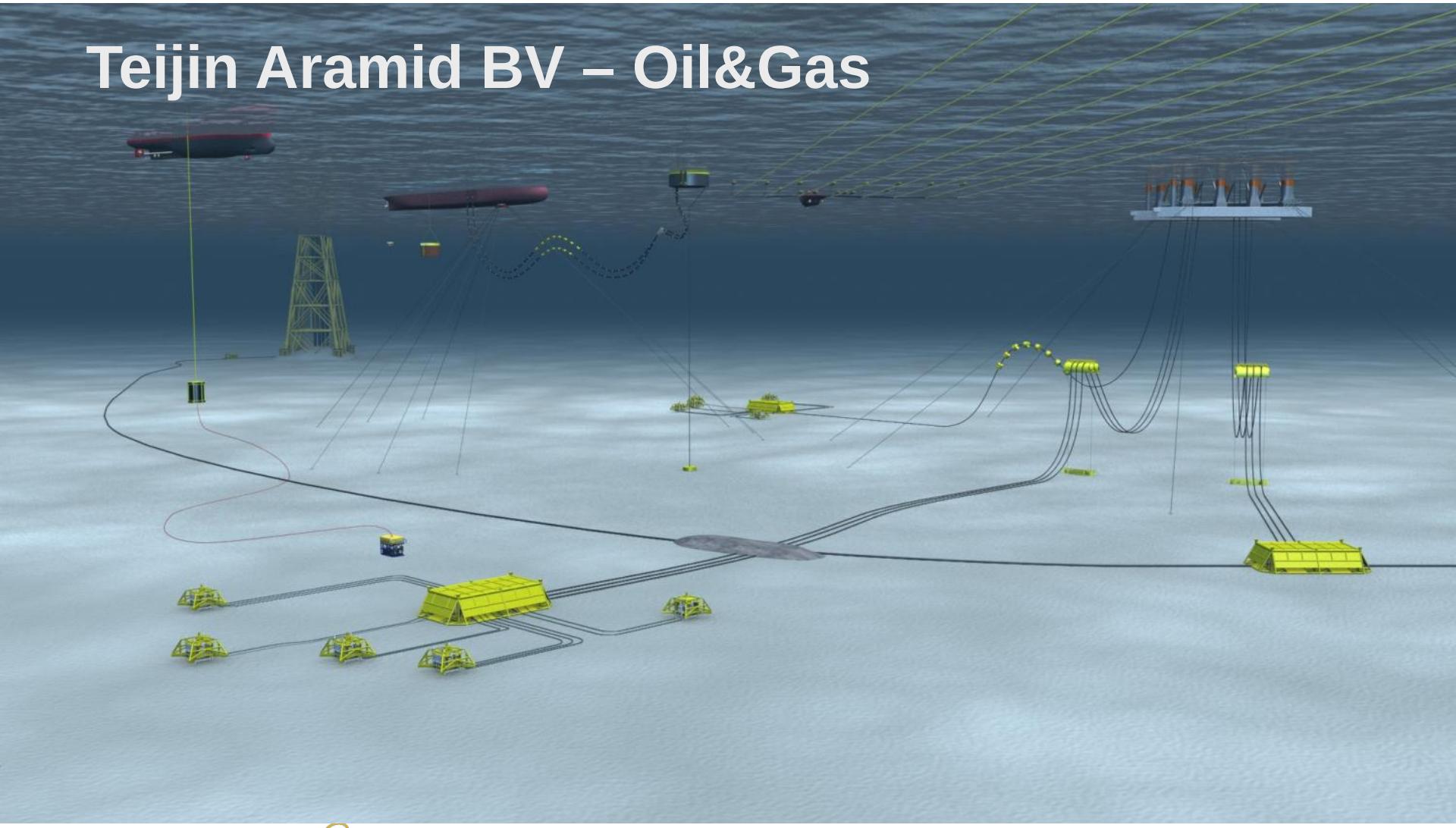
Teijin Aramid BV – Oil&Gas



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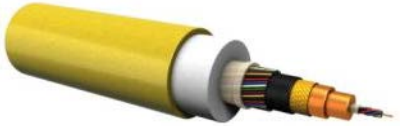
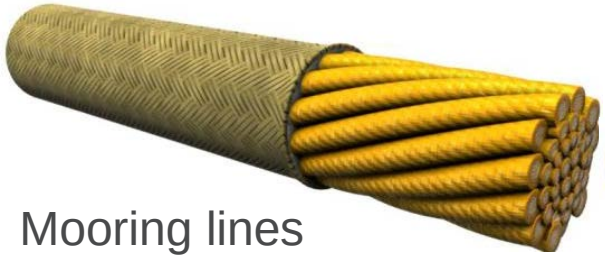
Teijin Aramid BV – Oil&Gas

Seismic streamers

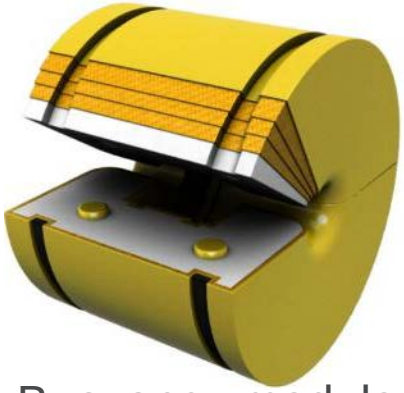


Hoisting ropes



Mooring lines

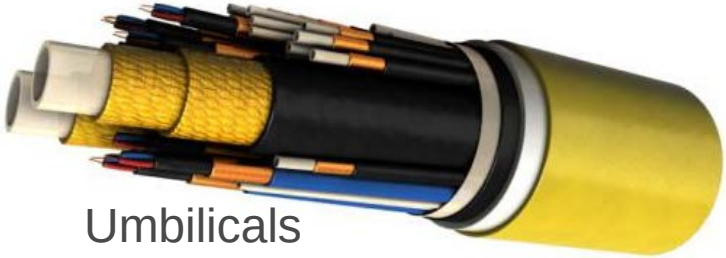
Buoyancy straps



Buoyancy modules

Static pendants

Marine hoses



Umbilicals

Flexible flowlines

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Background (1)

- **Many synthetics move to replacing steel**
  - Steel has history of ~200 years
  - Dataset of material behavior required to compete successfully

- **High performance synthetics should last long**
  - Offering a reliable and sustainable solution
  - Prediction required how material performs on long term

→Reliability = Predictable performance development over time

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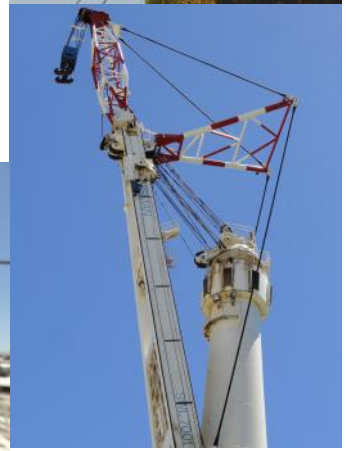
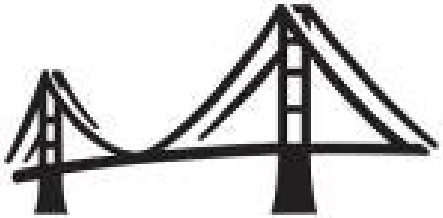
Background (2)

- **Prediction important for many applications**
  - **Construction:**
    - Geo-grids
    - Tower guys
    - Antenna guys
    - Crane pendants
    - Bridges
    - Concrete reinforcement





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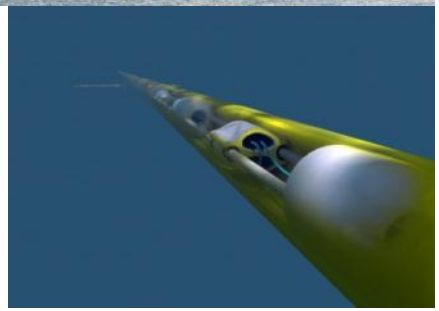
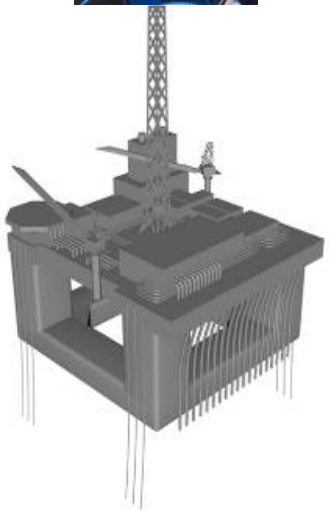
Background (3)

- **Prediction important for many applications**
  - **Oil&Gas:**
    - Ropes & cables
    - Mooring tendons
    - Hoses and pipes
    - Umbilicals
    - Orbit straps





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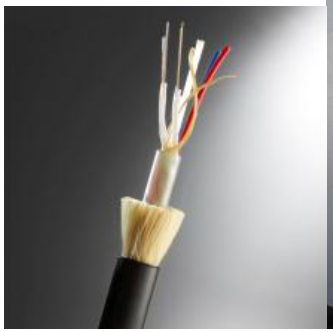
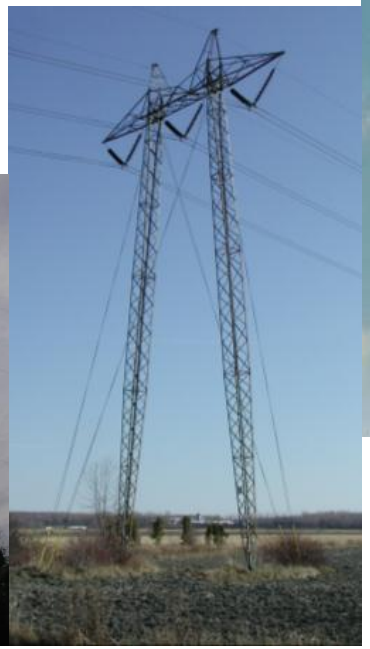
Background (4)

- **Transmission towers/cables**
  - Collserola tower, Barcelona (1991)
  - Sutro tower, San Francisco (2007)
  - Many smaller others
  - ADSS





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Background (5) – hoses/pipes

Riser / flowline anti-birdcaging

- Many years experience, aramids used since 80's as anti-bird-caging material. Typical design life is again 20 years.
- The new **API 17J** is including testing requirements for aramids as one of the polymer materials. (Elevated temperature in low pH-environments).

Hydraulic hose reinforcement in umbilicals

- Aramids are used since 70's as. Proven track record (20 years design life), typically in contact with water.
- **API 17E** (hydraulic hoses) requirement: cycling 200.000 pressure cycles in a 180° bend at 1.33x MWP.
- Temperature = 55°C (API) up to 90°C (SAE J343)

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Background (6) – hydraulic hoses

Transferrable know-how

- >35 years of industry experience
- Big revision of API 17E in 1980s
- Smaller sizes, higher pressures: 35kpsi (1”) / 60kpsi (¼”)
- Safety factor = 4
- Survival test requires very good material fatigue life
- Elevated temperatures, 20 years design life
    - Temperature = 55°C (API 17E) up to 90°C (SAE J343)
- Aramid is the only used/certified material, next to steel

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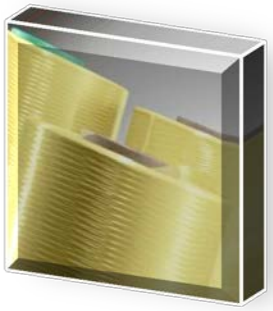

Quality control properties (1)

Standard property determination:

- **Used for quality control & property datasheets**
  - Strength (force at break)
  - Modulus (stiffness between certain stress levels)
  - EAB (Elongation at break)
  - FASE (Force at specified elongation)
  - Miscellaneous (moisture/finish content, yarn count etc)

D 885

Designation: D 7269

→ Properties of 'as produced' material

→ According to standards (ASTM, BISFA, company standard)

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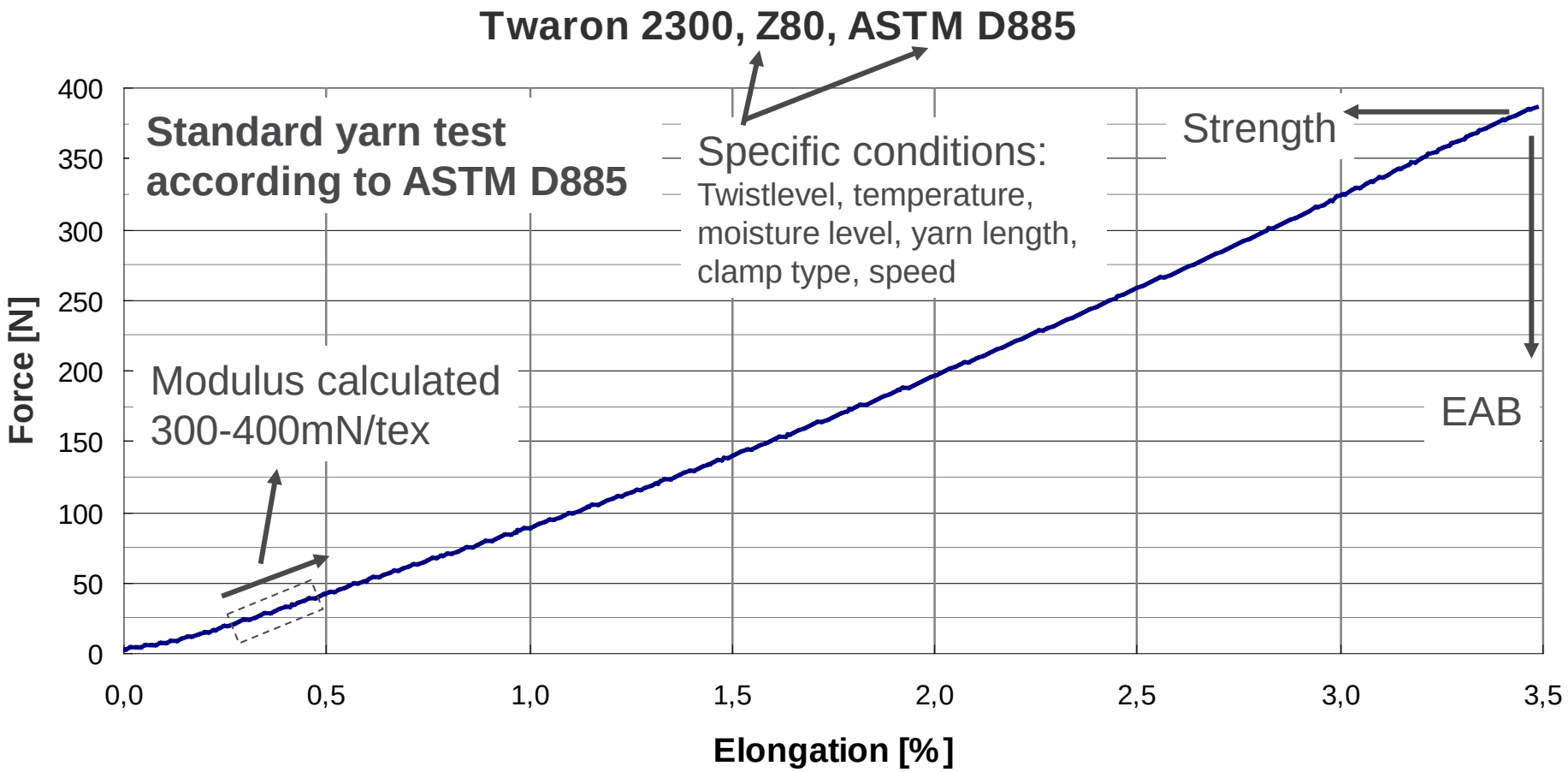
Quality control properties (2)



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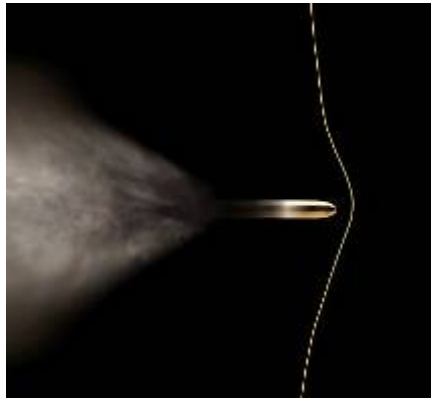
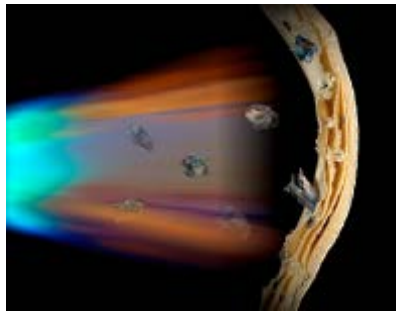
Quality control properties (3)



Non-standard properties:

- **Required for engineering purposes**
- **Different conditions** → High / low temp, rate, time
- **Lateral compression** → ‘pin-loop’ strength
- **Dynamic properties** → creep, **modulus**, hysteresis
- **Failure modes** → Time to rupture, tension-tension, chemicals, etc



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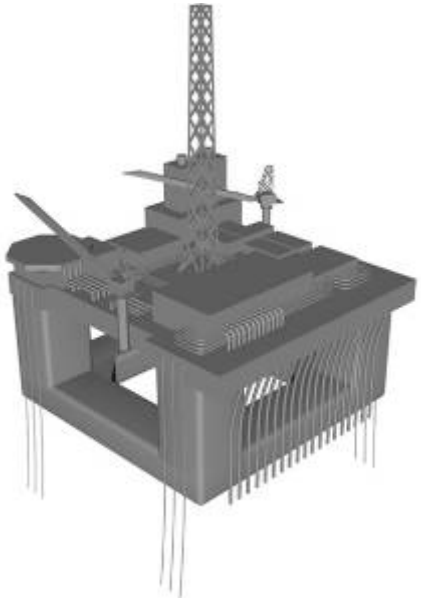
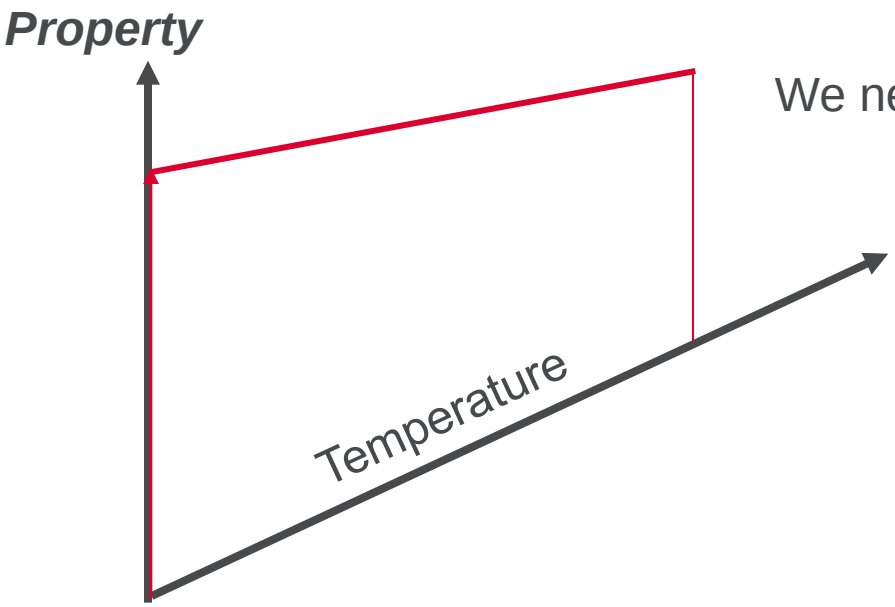
Long-term properties (1)

- **How to perform reliable engineering?**
  - Understanding the materials behavior
  - Temperature and time influence
  - Other influences
  - Translation from raw materials to actual product
  - Many safety rules based on steel material properties

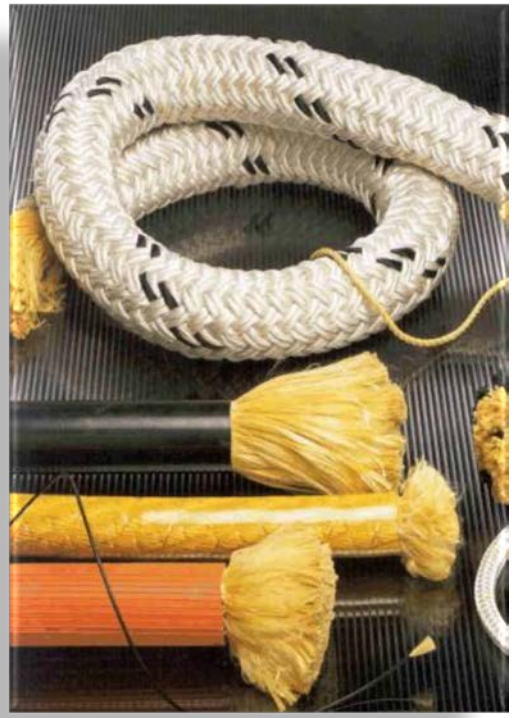
→ **Synthetics have other failure modes than steel!**



Long-term properties (2)



We need to know the influence of **temperature**



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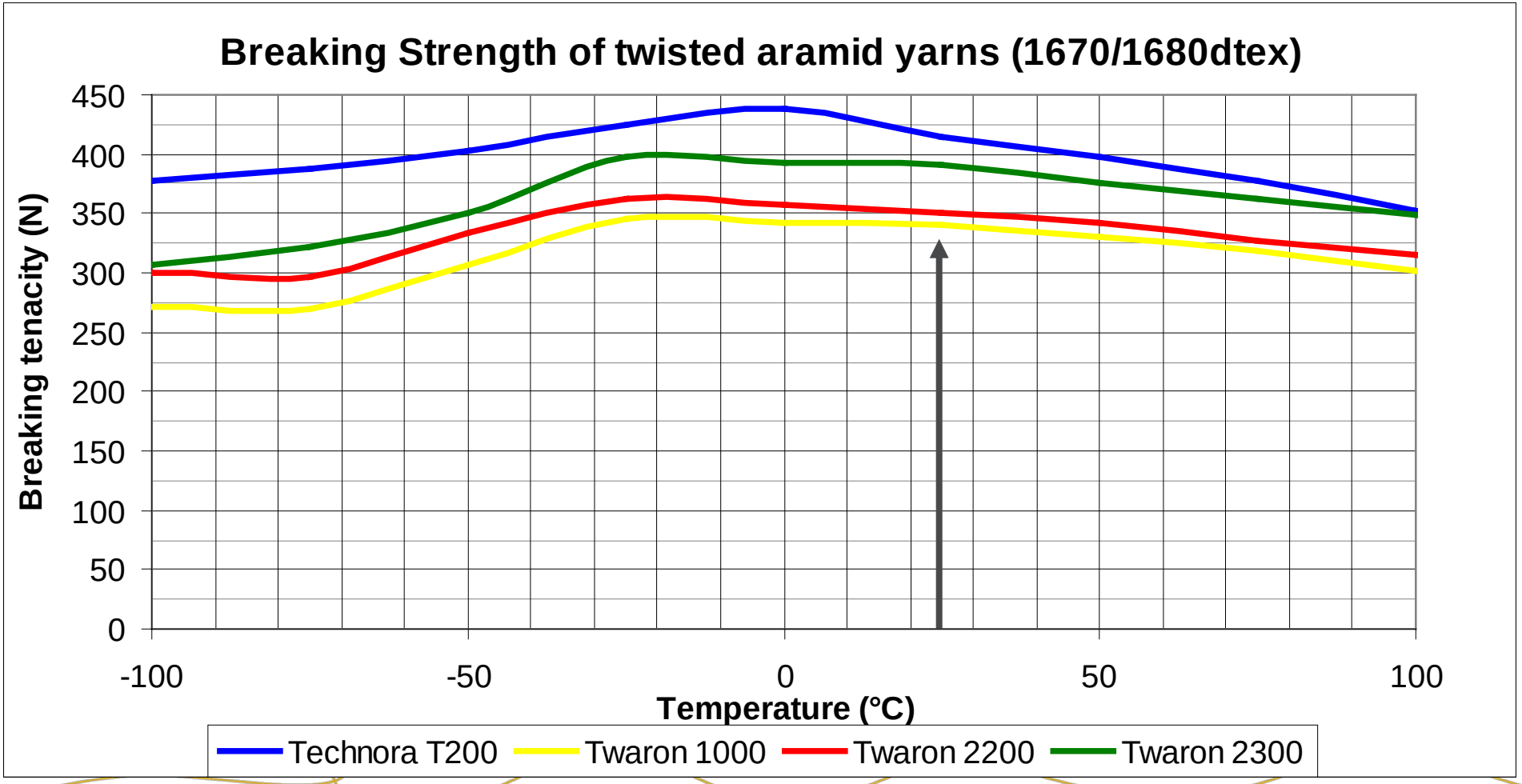
Long-term properties (3)



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Static – Long-term BL (1)

Long-term Breaking Load (LTBL):

- All materials fail after certain time at high sustained load
  - The reason may be different

- Teijin Aramid did extensive tests to study this behavior for aramids.
  - Mathematical model is used to predict longer periods
  - Regression lines are used for engineering

→ **This property is called Long-term Breaking Load (LTBL)**
(also called Time-to-failure)

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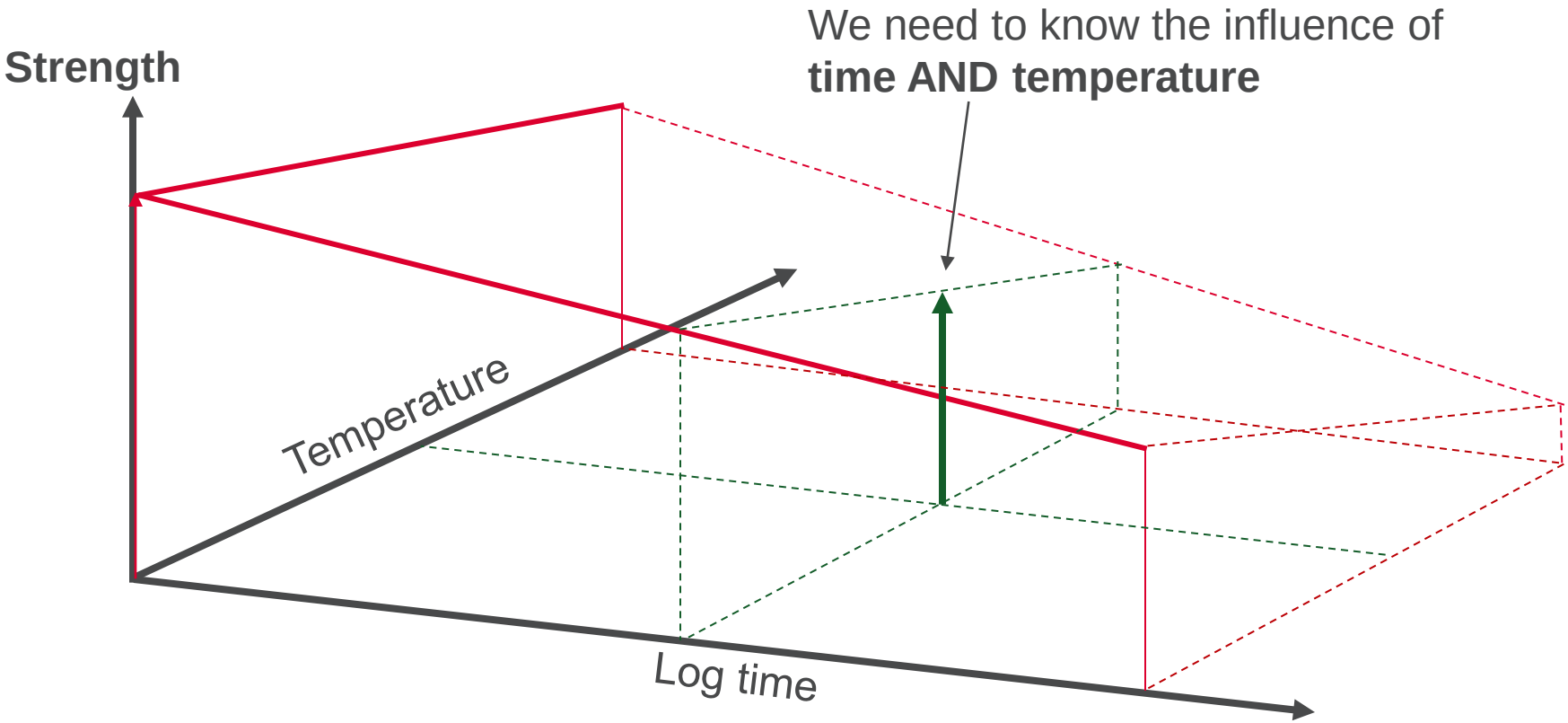
Static – Long-term BL (2)



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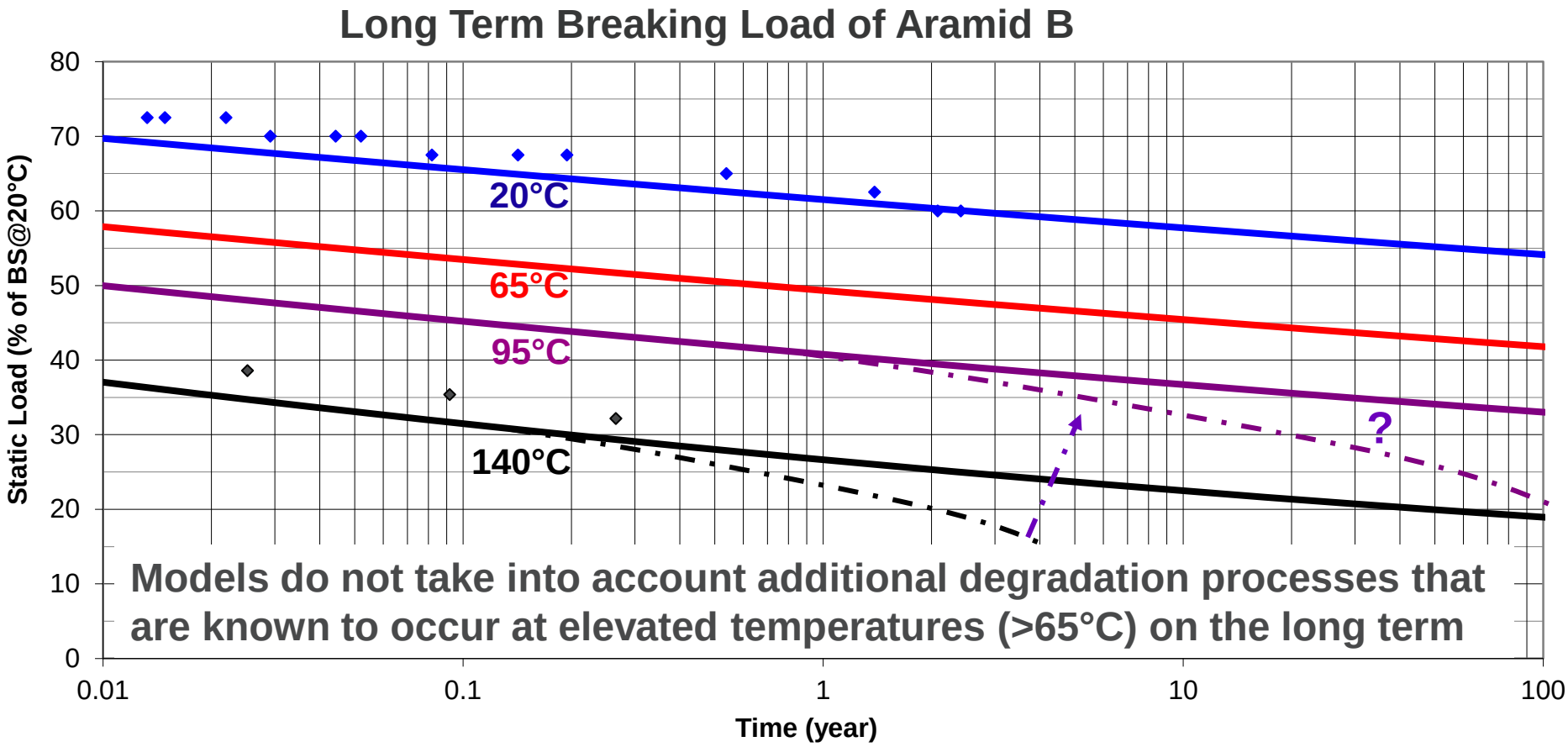
Static – Long-term BL (3)



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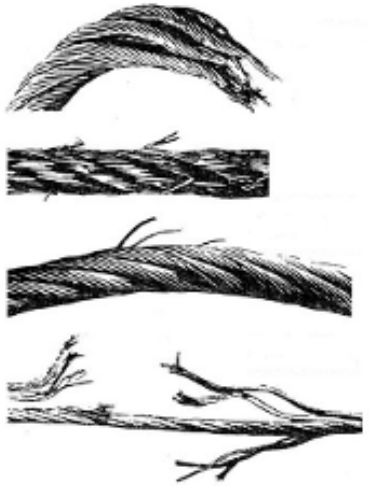
External – Engineering conditions

External factors

- **Chemicals / UV** -> external influences
- **Temperature / Fire** -> heat degradation
- **Mechanical** -> external wear / impact



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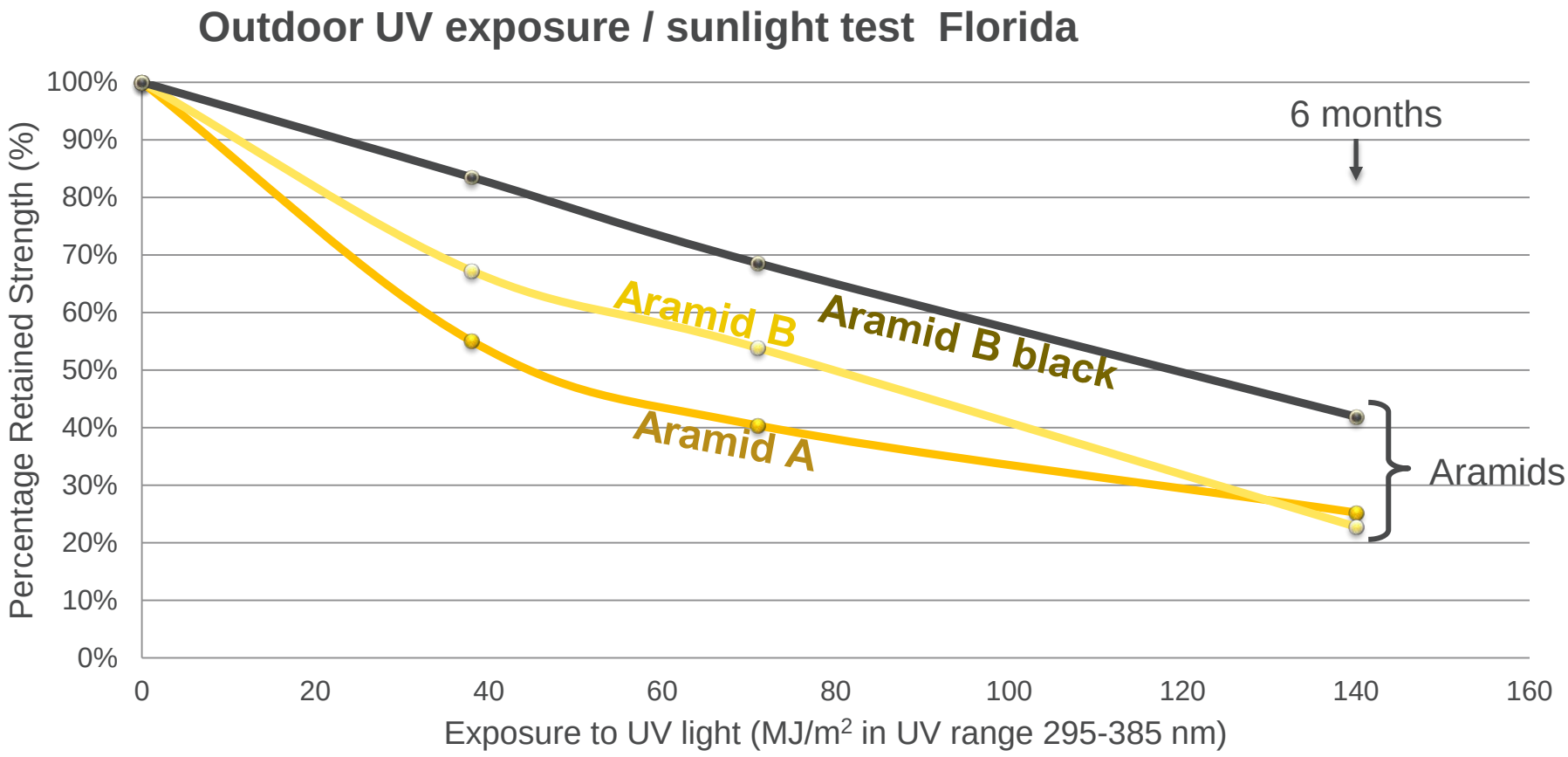
External – UV (1)



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External – Chemicals (1)

Aramid long term strength is influenced by:

- Strong acids and bases
- Long term UV exposure (should be protected)
- Hydrolysis → Water + temperature or H_2O + >80°C

  - **Hydrolysis Aramid B at** 50°C **is negligible**
    → Residual BS is >97% after 2 years in 50°C water

    → Hydrolysis is no issue at ambient temperatures, even for design life of >50 years

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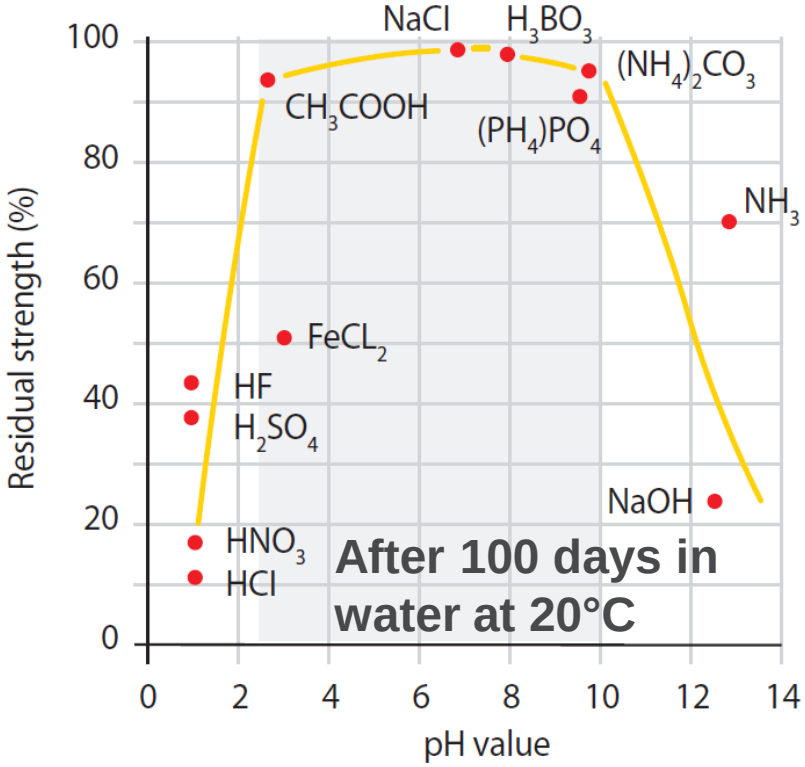
External – Chemicals (2)

Chemical resistance of Aramid B:



Crude Brent at 60°C:
Twaron immersed in Crude Brent:

- 60°C
- 30% load of its BS

→ no measureable degradation after 240 days (0,66 years)

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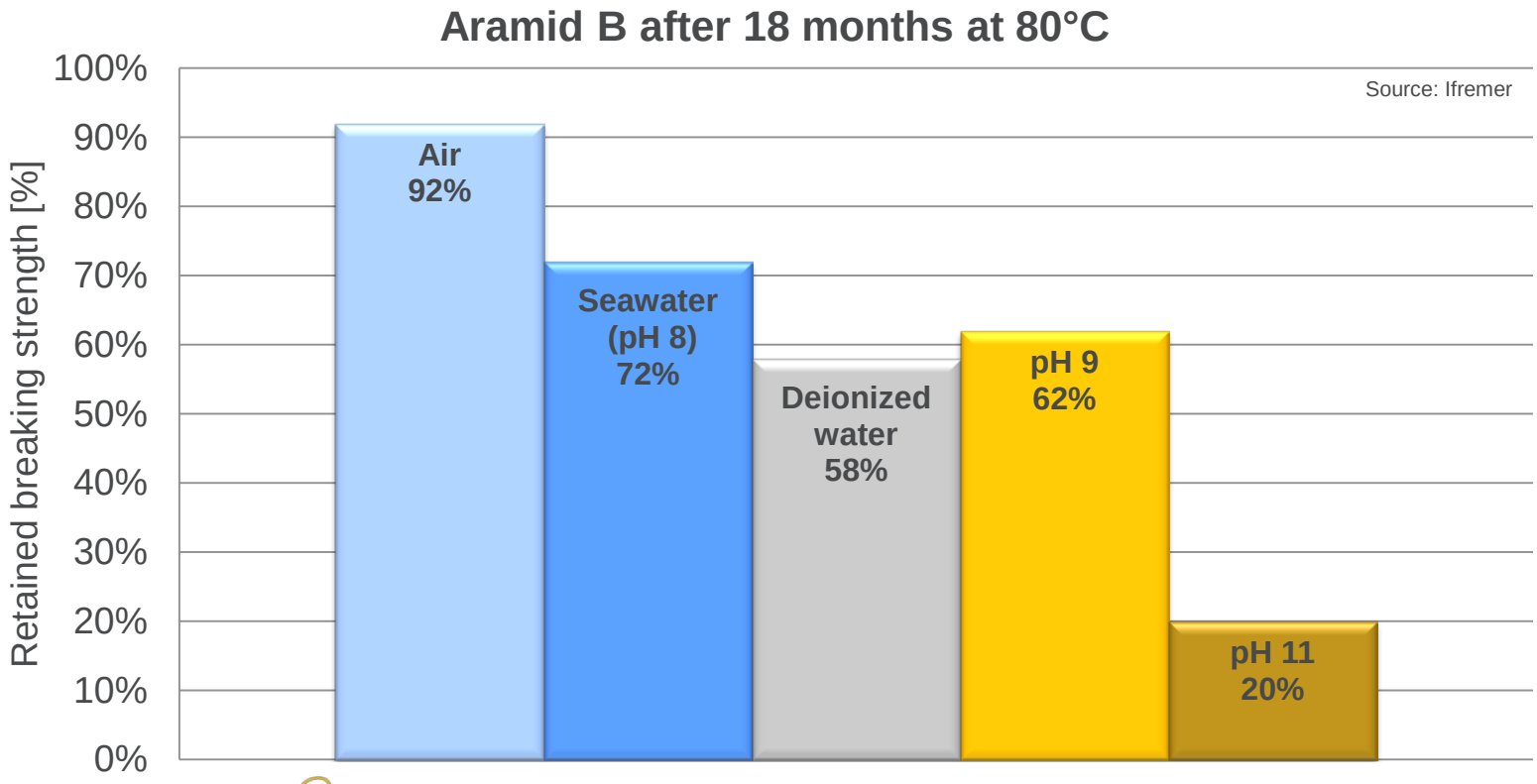
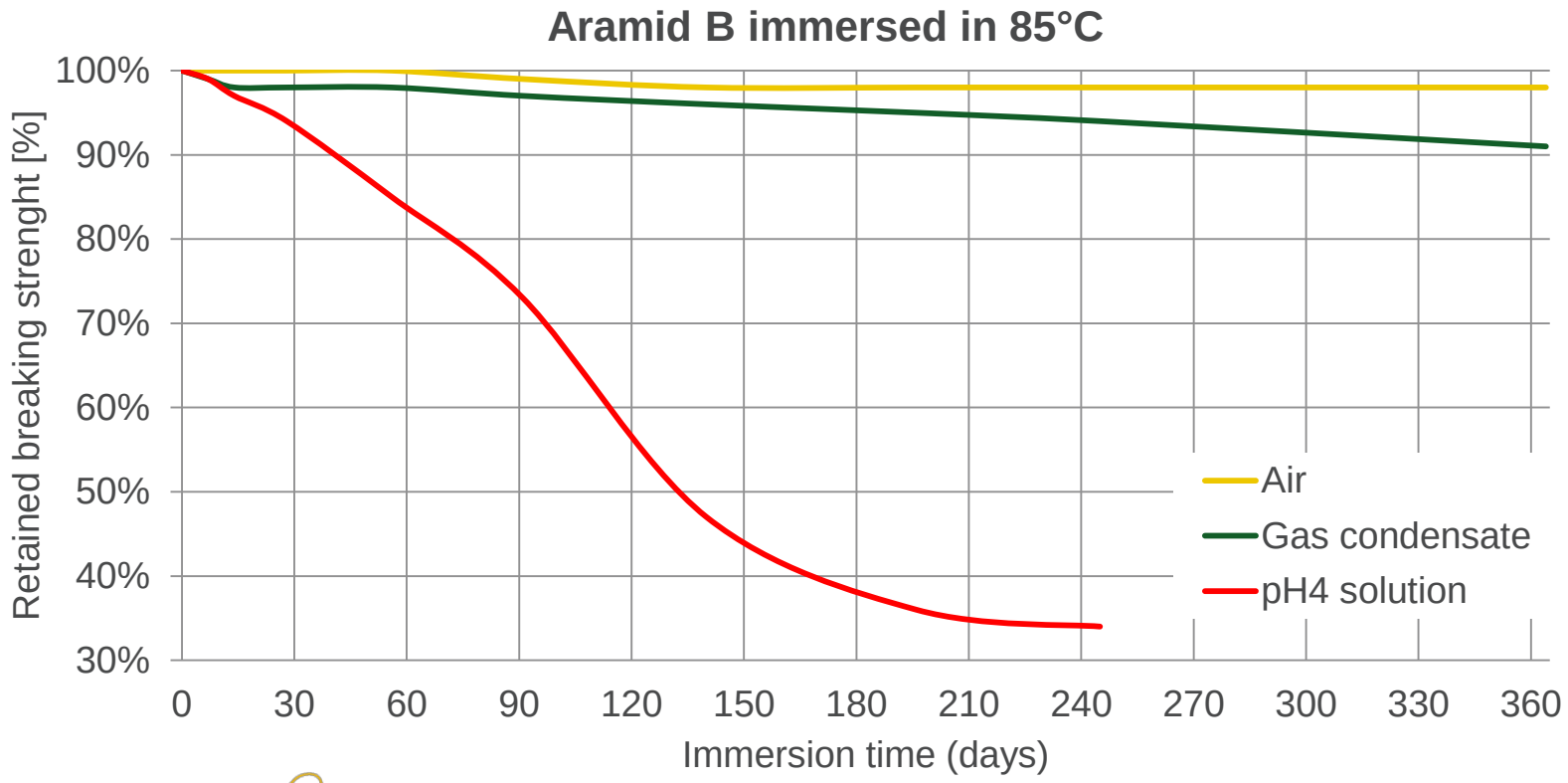
External – Chemicals (3)

Hydrolysis resistance of aramid:



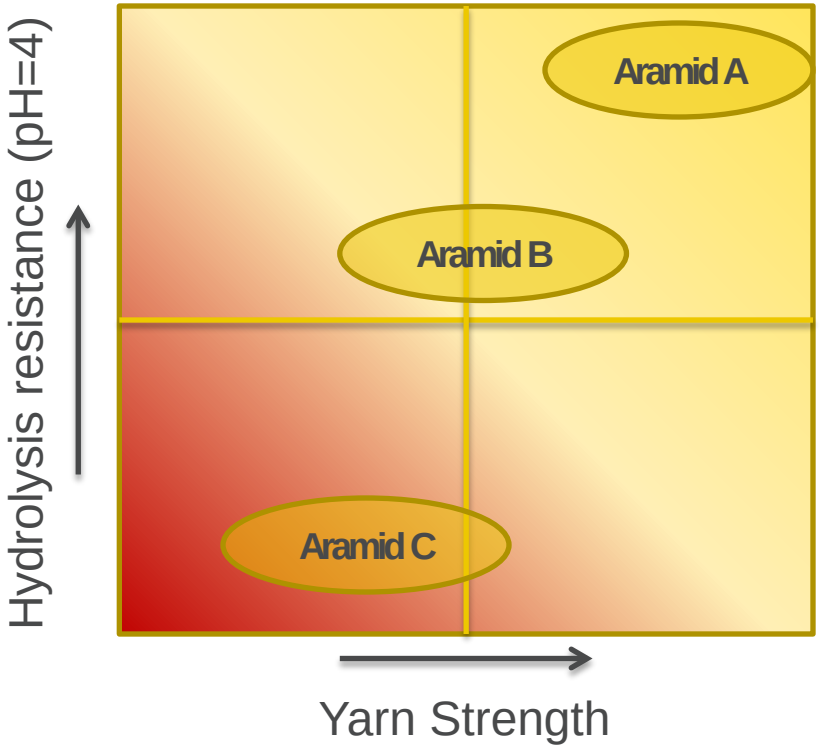
External – Chemicals (4)

Hydrolysis resistance of aramids at low pH:



External – Chemicals (5)

Hydrolysis resistance of aramids at low pH:



Acidic conditions:
Yarn immersed in sour fluid (pH=4) at elevated temperature

→ Aramid B significantly outperforms other p-aramids

→ Aramid A significantly outperforms Aramid B

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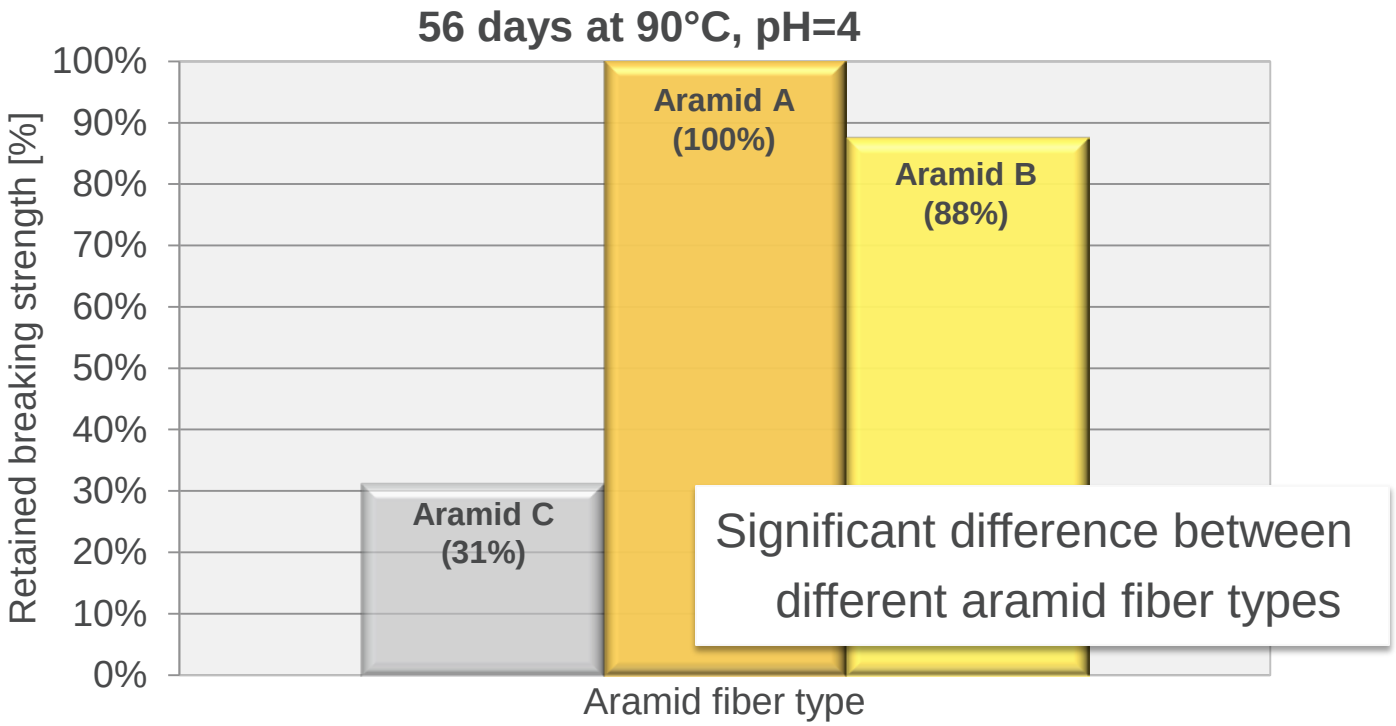
External – Chemicals (6)

Hydrolysis resistance of aramids at low pH:



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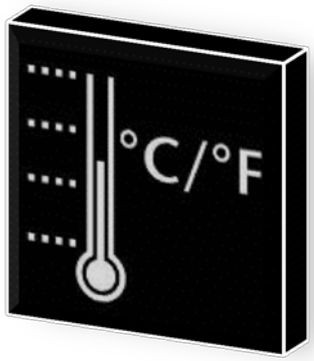
External – Temperature / Fire

Breaking strength at 250°C:

→ ~50% of BS@20°C for Aramid A&B



Residual BS@20°C after 550 hours @150°C (e.g. heat):

- Aramid B: 80%

Residual BS@20°C after 1 hour @250°C (e.g. fire):

- Aramid A: 99%
- Aramid B: 87%

Residual BS@20°C after 1 hour @350°C (e.g. fire):

- Aramid A: 80%
- Aramid B : 65%

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Conclusions

Aramids are durable, but some are more durable

- Aramid types can significantly differ on long-term performance
- Aramids are widely used in long-term applications

Aramids have long-term track record in pipes/hoses

- >30 years experience in hydraulic hoses, aramids are the only synthetic material used in umbilical hoses
- >20 years experience in flowline applications
- >10 years experience in RTP applications

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Safety – Reliability – Confidence

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