Partnership and Performance HMPE Mooring Lines

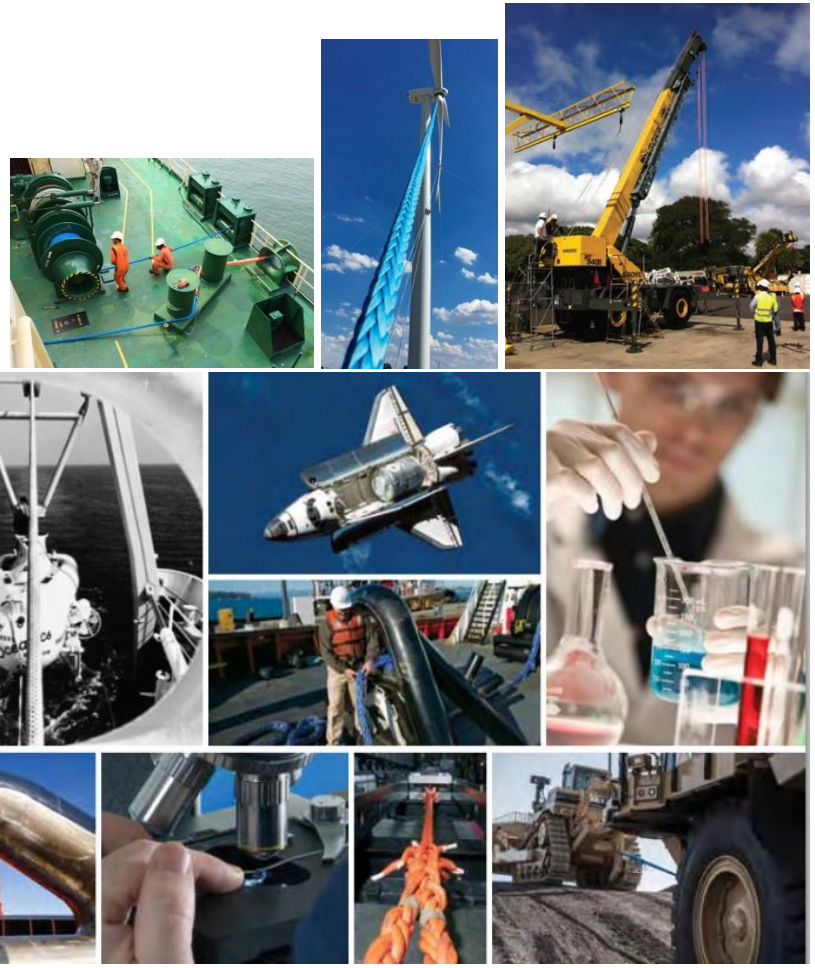
Robin Collett, General Sales Manager EMEA

OUTLINE

- **Samson Intro**
  - *Advantages of HP synthetics*
- **OCIMF MEG4 Update**
- **Performance Considerations**
  - *Primary wear mechanisms*
- **Effective product selection**
  - *Mainlines, Pendants, Chafe Gear*
  - *Fit for purpose solutions*
  - *Consultative approach*
- **Rope Management Plan**
  - *Inspection criteria & maintenance*
  - *Service life & retirement*
  - *Testing & risk management*
- **Summary**

ABOUT SAMSON

- Founded in 1878 in Boston
- History based in innovation
- Largest high performance rope producer in the world
- HQ in Ferndale, WA USA
- Manufacturing locations in Ferndale & Lafayette, LA USA
- 320 employees world-wide
- Global distribution
- Products sold in 50+ countries



SAMSON MANUFACTURING

- **Two Manufacturing Locations**
  - *Lafayette, Louisiana, USA*
  - *Ferndale, Washington, USA*
    - Worldwide stocking distributors
  - *Shipping worldwide*

WHAT IS OUR JOINT GOAL

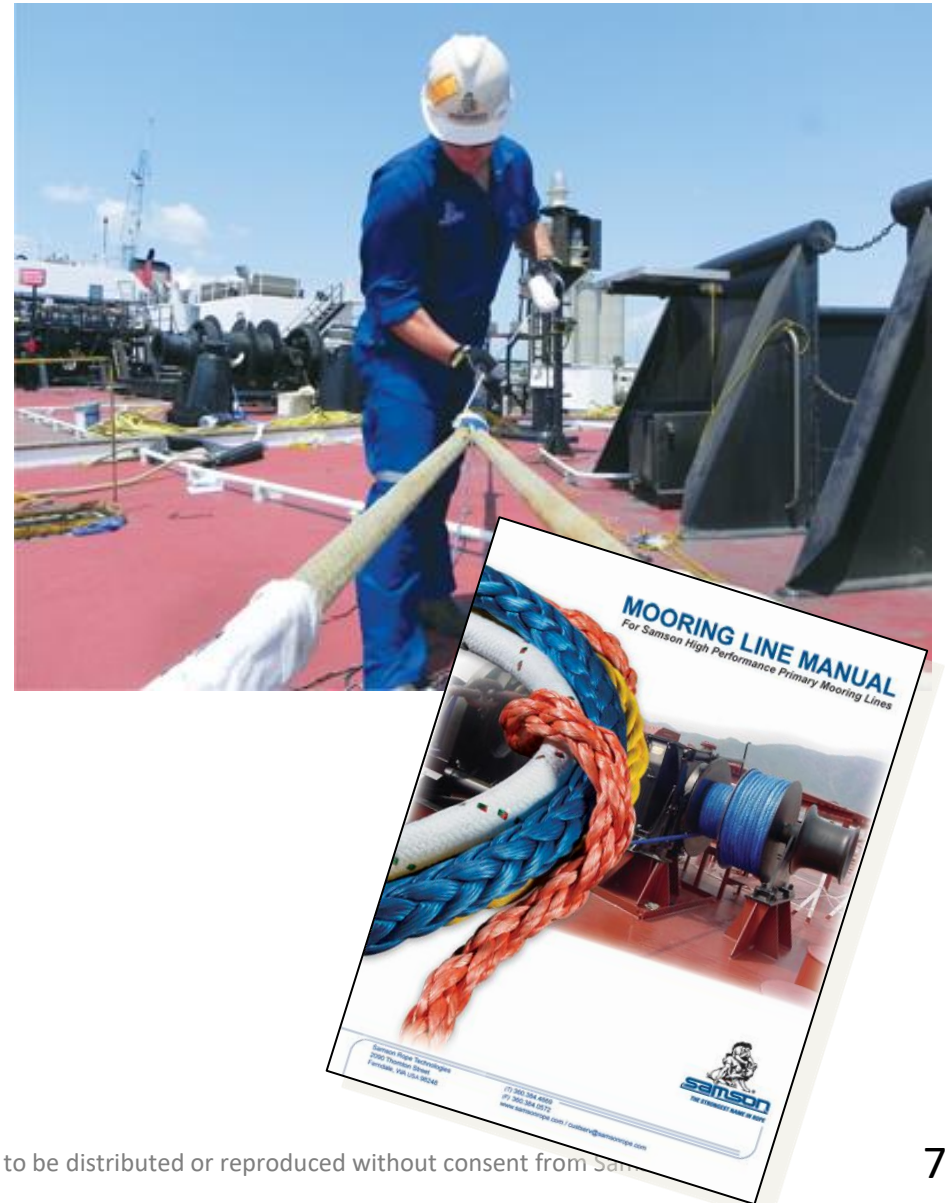
Maximize value and reliability and minimize risk

SOME OF SAMSON'S PARTNERS

THE SAMSON ADVANTAGE

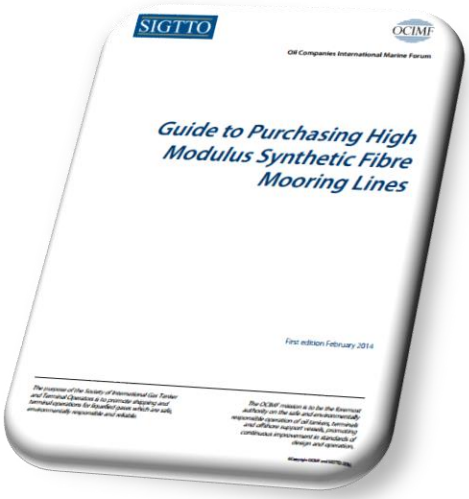
Quality products is only a piece of the Samson offering:

- **On-board inspection of equipment**
- **Advice and assistance in installation**
- **Splice training**
- **Dedicated technical support – application engineers & field service**
- **Care and maintenance of ropes**
- **Repeat visits for follow-up**
- **Residual testing**
- **Online customer portal**



Structure, Players involved & Our Involvement

- **OCIMF's published literature related to mooring lines has resulted in the need for review/revision/consolidation**



Guide to Purchasing HMSF Mooring Lines
Developed in 2011-2012 as initial/temporary guidance in response to TTI-lead HMPE User's Group project after rash of Bridon failures

Mooring Equipment Guideline
3rd revision of guidelines (Published 2008) that serve as a de-facto "standard" for vessel designers, shipyards, owners and operators

Effective Mooring
Condensed operator-focused brochure to support vessel crews and terminal operators – dated and likely to be revised after MEG4 is completed

OCIMF MEG4 UPDATE

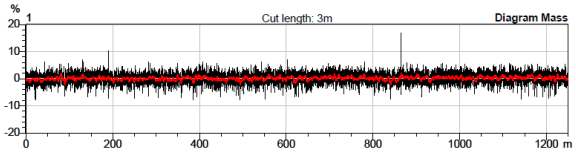
- **Expecting release of MEG4 Q1 2018**
  - ***Currently under final review***
- **Key changes**
  - ***Standardized Line design terminology***
  - ***Line maintenance & retirement guidance***
  - ***Line manufacture performance indicators***
    - Break force, angled break force, linear density, tension fatigue, etc.
  - ***Improved guidance on tails & connections***
- **Samson can review impact of changes to operations (Q1-Q3 2018)**

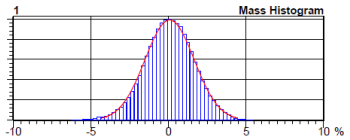
ADVANTAGES OF HIGH PERFORMANCE SYNTHETIC ROPES

- **Higher strength/weight (vs wire) or strength/diameter (vs polyester)**
  - ***Ease of handling***
    - *Safer & faster*
  - ***Weight savings***
- **Greater tension fatigue resistance**
  - ***Longer life***
- **Torque neutral and low elasticity**
  - ***More predictable recoil***
  - ***Safer operations***

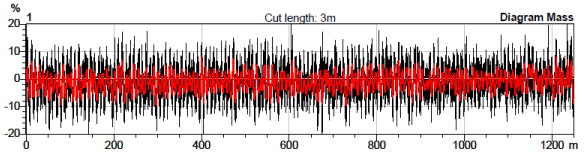
NOT ALL HMPE IS THE SAME

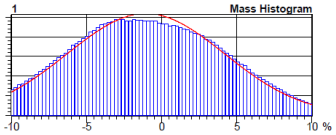
Dyneema®



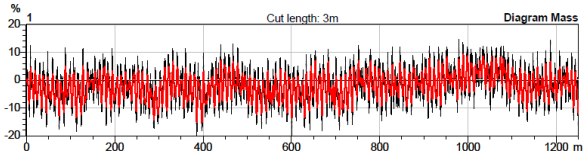


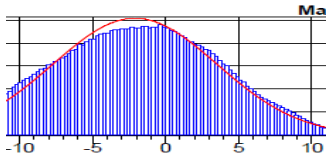
Generic HMPE 1



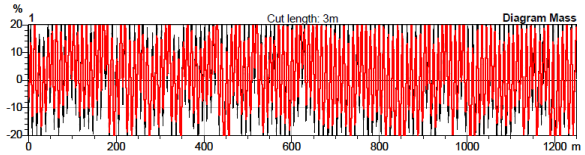


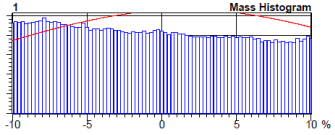
Generic HMPE 2





Generic HMPE 3





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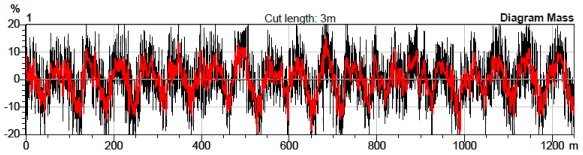
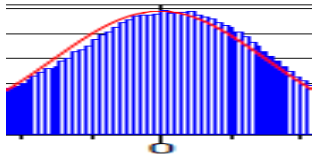




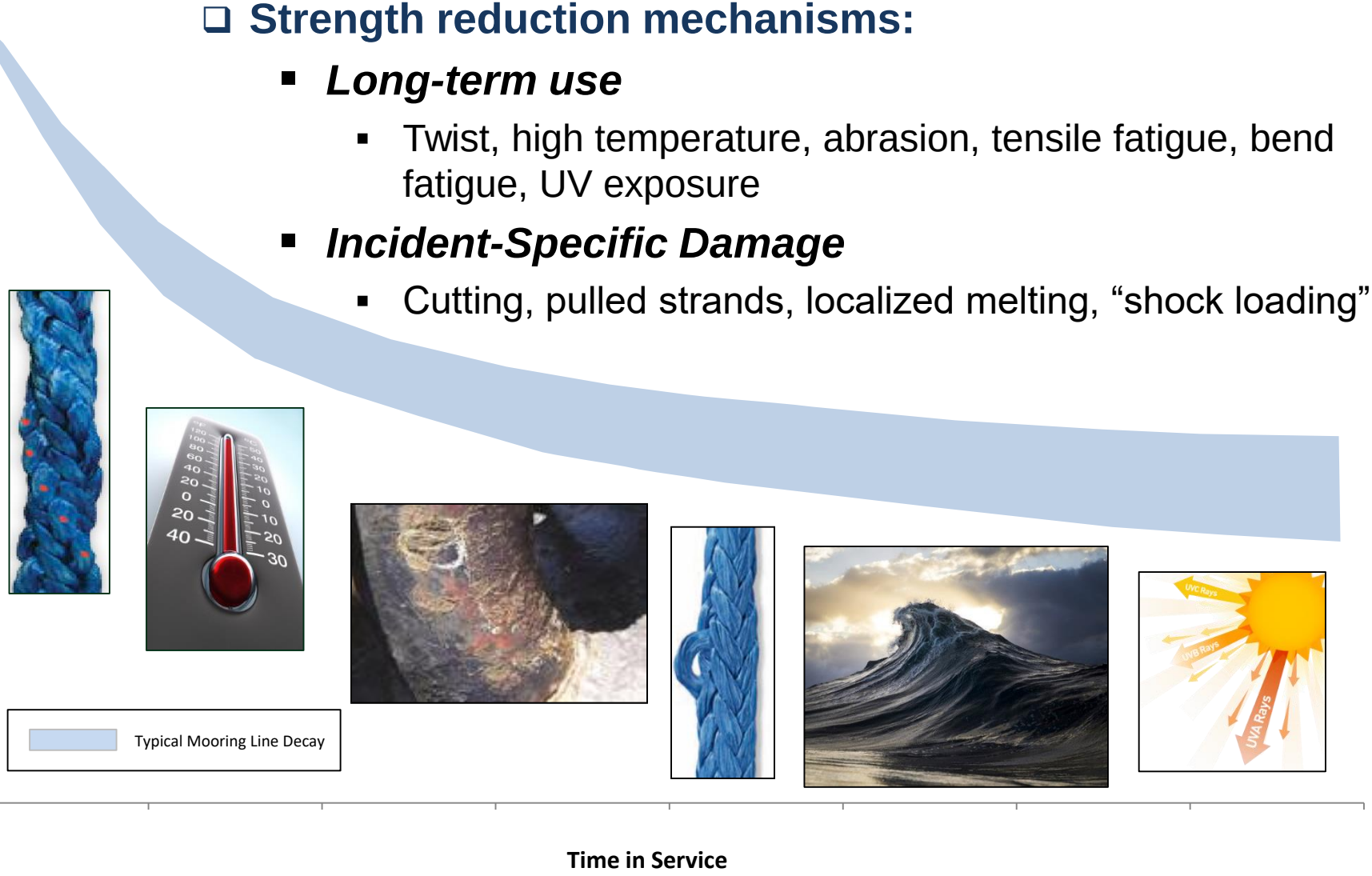
Single Braid vs Jacketed Lines

Operational Consideration & Trade-offs:

- Inspections / Condition Monitoring
- Localized Damage Prevention
- Repair Complexity

	ADVANTAGES	DISADVANTAGES
 Jacketed	• Load-bearing core is completely protected by outer jacket • Firm, round profile • Higher coefficient of friction (CoF) possible • Typically less expensive	• *Impossible to inspect the core (strength member)* • *Difficult to repair or splice* • *Jacket maintenance/repairs*
 Non-Jacketed	• Stronger size-for-size • Easy to inspect, repair, and splice • High fatigue resistance • No jacket maintenance • Chafe protection can be used and replaced as needed	• *Exposure to sharp edges must be prevented* • *Higher content of load-bearing fiber increases cost*

- **Strength reduction mechanisms:**
  - ***Long-term use***
    - Twist, high temperature, abrasion, tensile fatigue, bend fatigue, UV exposure
  - ***Incident-Specific Damage***
    - Cutting, pulled strands, localized melting, “shock loading”

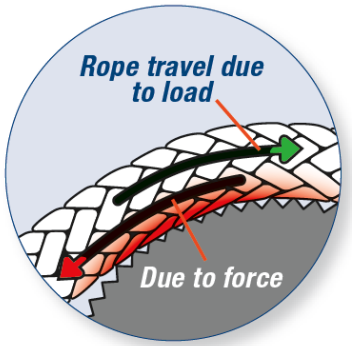


ROPE WEAR MECHANISMS

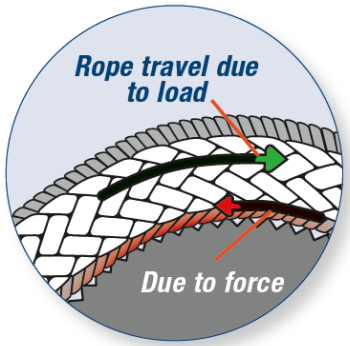
- **Mechanical damage**
  - ***Twist***
  - ***Cutting***
  - ***Compression at drum***
  - ***Localized melting***
  - ***External Abrasion***
    - High pressures and cycling over deck hardware: decks, chocks, bitts, roller pedestals

ROPE WEAR MECHANISMS

- **Internal abrasion is a degradation of the internal yarns of the rope caused by fiber-to-fiber interactions.**
- **Two main causes:**
  - ***Cyclic tensile loading***
    - *Induced by wave interactions*
  - ***Cyclic bending***
    - *Induced by non-linear requirements and deck hardware*



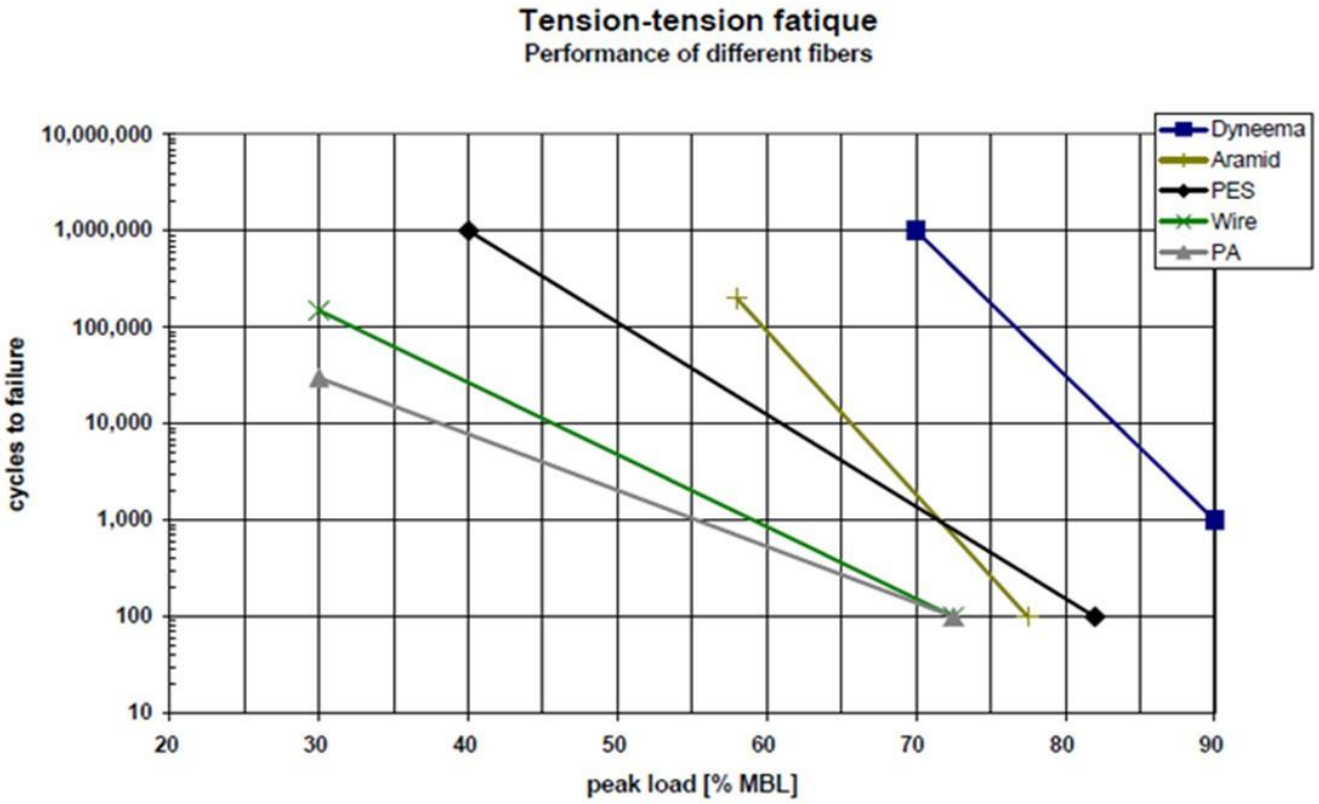
Without Chafe Gear



Without Chafe Gear

CYCLIC TENSION FATIGUE

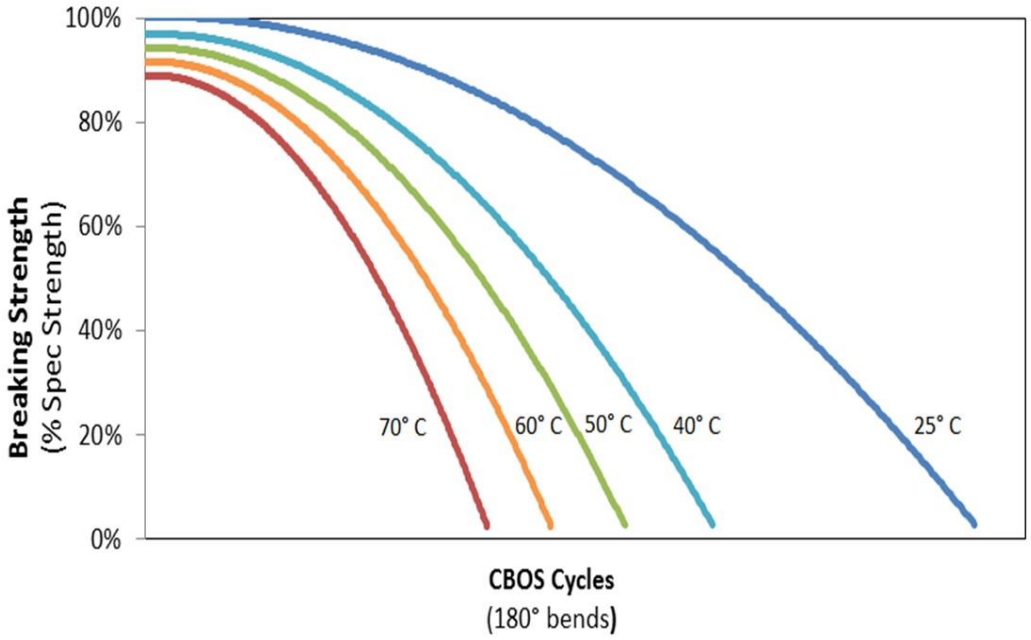
- Damage caused by relative motion between yarns and strands, as well as heating resulting from load and unload cycles.
- HMPE is highly resistant to cyclic tension fatigue damage – per OCIMF TCLL testing



CYCLIC BEND FATIGUE

- **Cyclic bend fatigue combines external and internal abrasion, and can also generate temperatures capable of damaging fibers**

- **Best practices to mitigate impact:**
  - ***Maximize D/d ratios***
  - ***Select appropriate fibers, coatings, rope constructions, and safety factors***



DYNAMIC LOADING

- **Minimize dynamic loads wherever possible;**
  - *Appropriate selection of Factors of Safety*
  - *Define operating limits for vessel mooring*
    - *Harsh winds, currents, waves*
    - *Vessel excursion*
  - *Elasticity through system design - Minimizing peak loads*
    - *Tail type (fiber, construction) and length selection*
    - *Greater elastic elongation, greater energy absorption*

SHOCK LOADING

- **Any time the load on a rope exceeds the residual strength of the rope, the rope will part.**
- **Complete visual inspection after encountering high dynamic loading events and prior to being returned to service.**
- **Individual events do not have a catastrophic effect on rope life, but repeated exposure to excessive dynamic loads may accelerate the previously mentioned wear mechanisms.**

MITIGATE ROPE DAMAGE

- **Methods of Addressing Degradation:**
  - *Rope construction*
  - *Rope/fibre coatings*
  - *Chafe gear*
  - *Crew awareness and line management*
  - *Surface conditioning*

SYSTEMS APPROACH

Mooring line key considerations

- *Vessel and equipment design*
- *Mooring requirements – frequency, terminal variation*
- *Lifetime expectations and maintenance requirements*
- *Retrofit or new build*
- *Product and manufacturer*
  - Tail and mainline compatibility
  - Fiber type and quality
  - Fiber content
  - Rope construction (Jacketed vs 12-strand)
  - Coating
  - Determine chafe protection requirements

CHAFE PROTECTION

- **Sliding chafe gear (DC Moor-Gard)**
  - *Coating designed for abrasion resistance and reduced friction*
  - *Easily moved for inspection*

- **Fixed chafe gear**
  - *Tightly braided HMPE cover (DC Gard)*
    - *Maximum protection, flexible*
    - *Must remove for inspection*

  - *Open-weave HMPE cover (Dynalene)*
    - *Excellent durability, lightweight*
    - *Easy inspection*

- **100% HMPE solutions offer the highest protection against external abrasion**

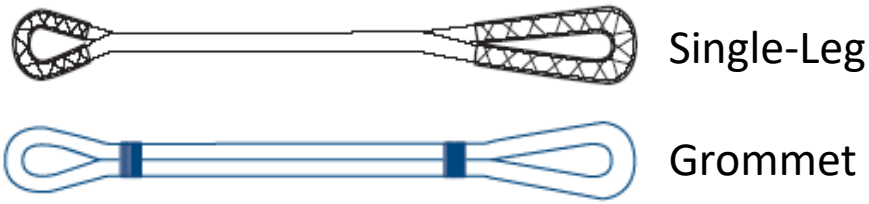
MOORING PENDANTS

Purpose: manage lower peak loads and mean stresses seen by mainline to extend service life

- **Understanding mooring tail characterization & performance**
  - *Elasticity & energy absorption*
  - *Strength reductions*
  - *Degradations & retirement*
- **Extensive field testing & product knowledge**
- **Meeting OCIMF MEG requirements**
  - *Guidance for appropriate product selection & usage*

PENDANT PERFORMANCE CONSIDERATIONS

- **Tensile strength**
- **Stiffness behavior (elasticity)**
  - *Fiber type, pendant length, configuration*
- **Fatigue life & fiber type**
  - *Thousand Cycle Load Limit (TCLL)*
- **Connection efficiency – Cow-hitch**
- **Wet vs. Dry performance**
  - *Nylon wet strength reduction ~10%*
- **Single leg vs. Grommet configurations**
  - *Grommet Bend loss – often insufficient D/d ratio*
  - *Stiffness change*



PENDANT SOLUTIONS

- **8-strand fiber blend (MP-1)**
  - *Polyester/polyolefin blend that provides a 10% lower linear density (lbs./ft.) compared to traditional 100% polyester fiber pendant constructions*
  - *Excellent abrasion, wear resistance, and superior strength retention with extensive use*

- **12-strand Polyester (HTP-12)**
  - *Optimum performance in static bending situations by allowing even distribution of loads across the bend*
  - *Good flex-fatigue resistance and shock absorption*

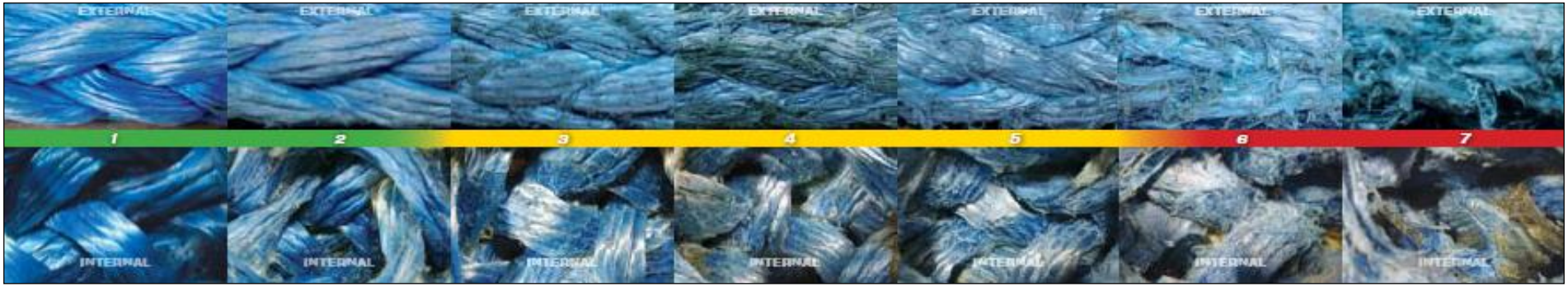
- **12-strand Nylon (RP-12 Nylon)**
  - *Reduced wet-strength loss*
  - *High energy absorption for exposed terminals*
  - *Good strength and shock-load capacities*

ROPE MAINTENANCE PLAN

- **User-defined service life expectations**
- **End-of-life retained strength / FoS (target)**
  - *Supported by residual strength test data*
- **Planned maintenance schedule**
  - *Routine inspections (crew)*
  - *Detailed inspections (expert)*

- **Mitigation of risks associated with localized damage;**
  - *Swap used end with un-used end (End-for-end)*
  - *Remove damaged mainline sections (Cropping)*
  - *Line rotation with detailed line tracking*
  - *Define discard/repair criteria*

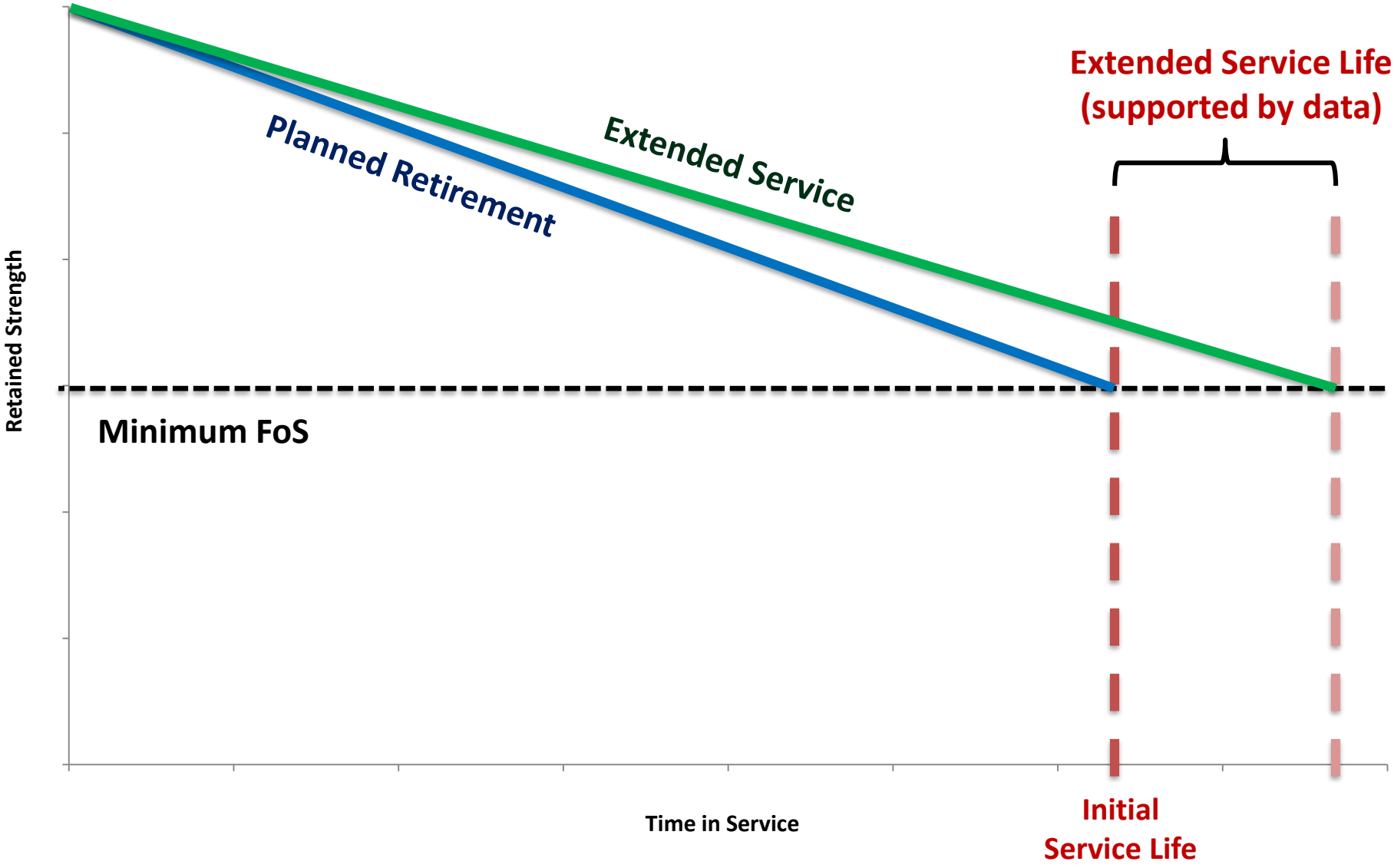
ABRASION MEASUREMENT



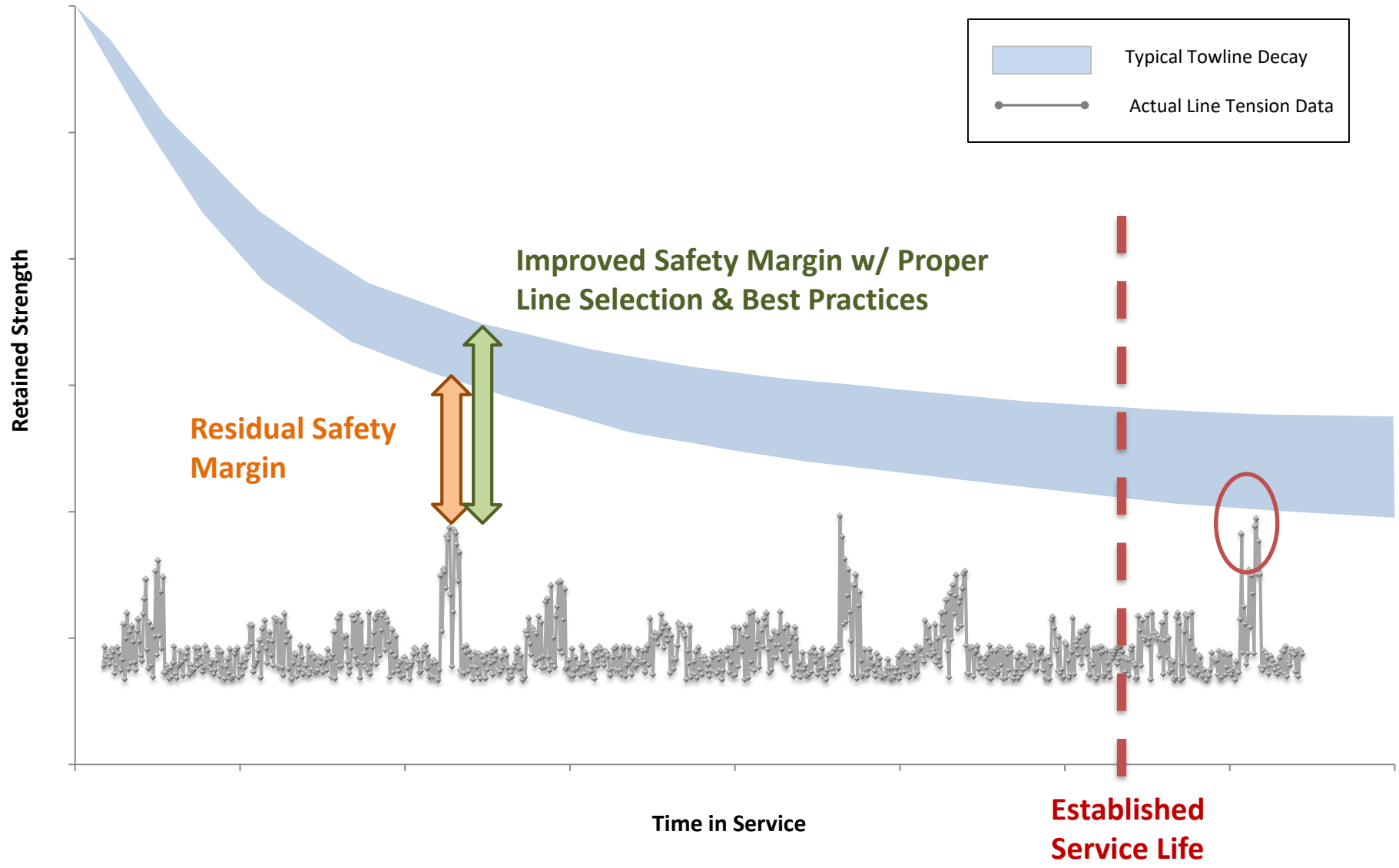
- **Visual comparison guide**
  - ***1 million+ individual filaments per rope***
  - ***Operator can effectively rate level of rope wear***
- **Retirement or required action to be determined by qualified person based on the following:**
  - ***Internal/External abrasion level (higher than 3)***
  - ***Excessive twist in braided rope (greater than 2 turns/meter)***
  - ***Gross damage or deterioration of the end connections***

The Pocket Guide includes information on proper rope inspection techniques and a visual guide to internal and external abrasion

LINE POLICY MANAGEMENT

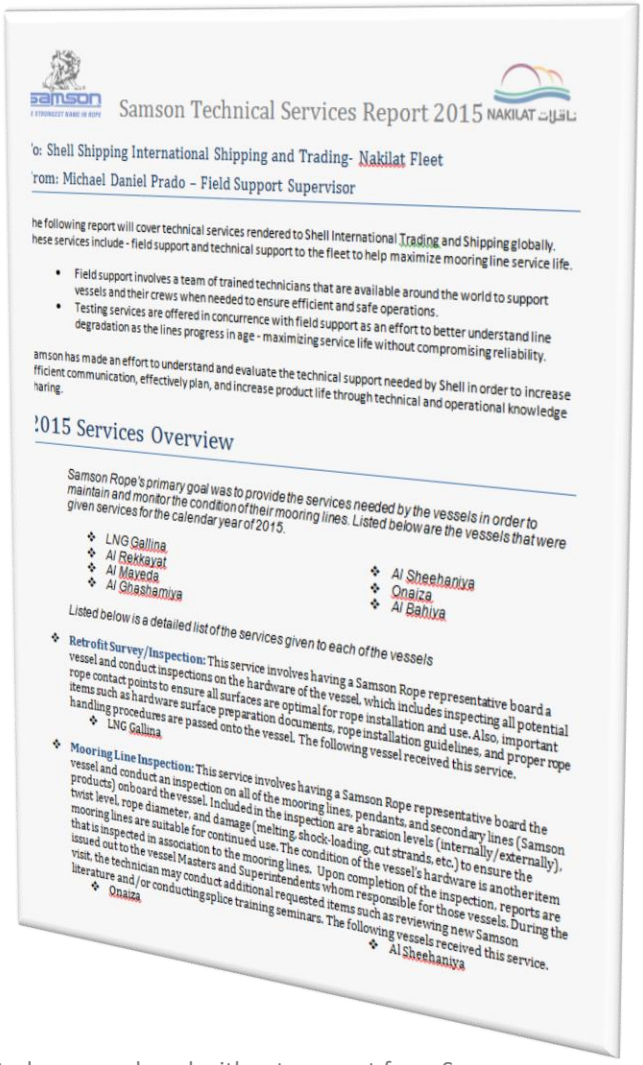


LINE RISK MANAGEMENT



PERIODIC FLEET SUMMARY

- **Fleet-wide trend analysis**
- **Early identification of damage**
- **Mechanism for documentation**
- **Retirement policy assessment**



Samson Technical Services Report 2015

To: Shell Shipping International Shipping and Trading- Nakilat Fleet

From: Michael Daniel Prado – Field Support Supervisor

The following report will cover technical services rendered to Shell International Trading and Shipping globally. These services include - field support and technical support to the fleet to help maximize mooring line service life.

- Field support involves a team of trained technicians that are available around the world to support vessels and their crews when needed to ensure efficient and safe operations.
- Testing services are offered in concurrence with field support as an effort to better understand line degradation as the lines progress in age - maximizing service life without compromising reliability.

Samson has made an effort to understand and evaluate the technical support needed by Shell in order to increase efficient communication, effectively plan, and increase product life through technical and operational knowledge sharing.

2015 Services Overview

Samson Rope's primary goal was to provide the services needed by the vessels in order to maintain and monitor the condition of their mooring lines. Listed below are the vessels that were given services for the calendar year of 2015.

- LNG Gallina
- Al Rekkayat
- Al Mayeda
- Al Ghashamiya
- Al Sheehaniya
- Onaiza
- Al Bahiya

Listed below is a detailed list of the services given to each of the vessels

- **Retrofit Survey/Inspection:** This service involves having a Samson Rope representative board a vessel and conduct inspections on the hardware of the vessel, which includes inspecting all potential rope contact points to ensure all surfaces are optimal for rope installation and use. Also, important items such as hardware surface preparation documents, rope installation guidelines, and proper rope handling procedures are passed onto the vessel. The following vessel received this service.
  - LNG Gallina
- **Mooring Line Inspection:** This service involves having a Samson Rope representative board the vessel and conduct an inspection on all of the mooring lines, pendants, and secondary lines (Samson products) onboard the vessel. Included in the inspection are abrasion levels (internally/externally), twist level, rope diameter, and damage (melting, shock-loading, cut strands, etc.) to ensure the mooring lines are suitable for continued use. The condition of the vessel's hardware is another item that is inspected in association to the mooring lines. Upon completion of the inspection, reports are issued out to the vessel Masters and Superintendents whom responsible for those vessels. During the visit, the technician may conduct additional requested items such as reviewing new Samson literature and/or conducting splice training seminars. The following vessels received this service.
  - Onaiza
  - Al Sheehaniya

SUMMARY

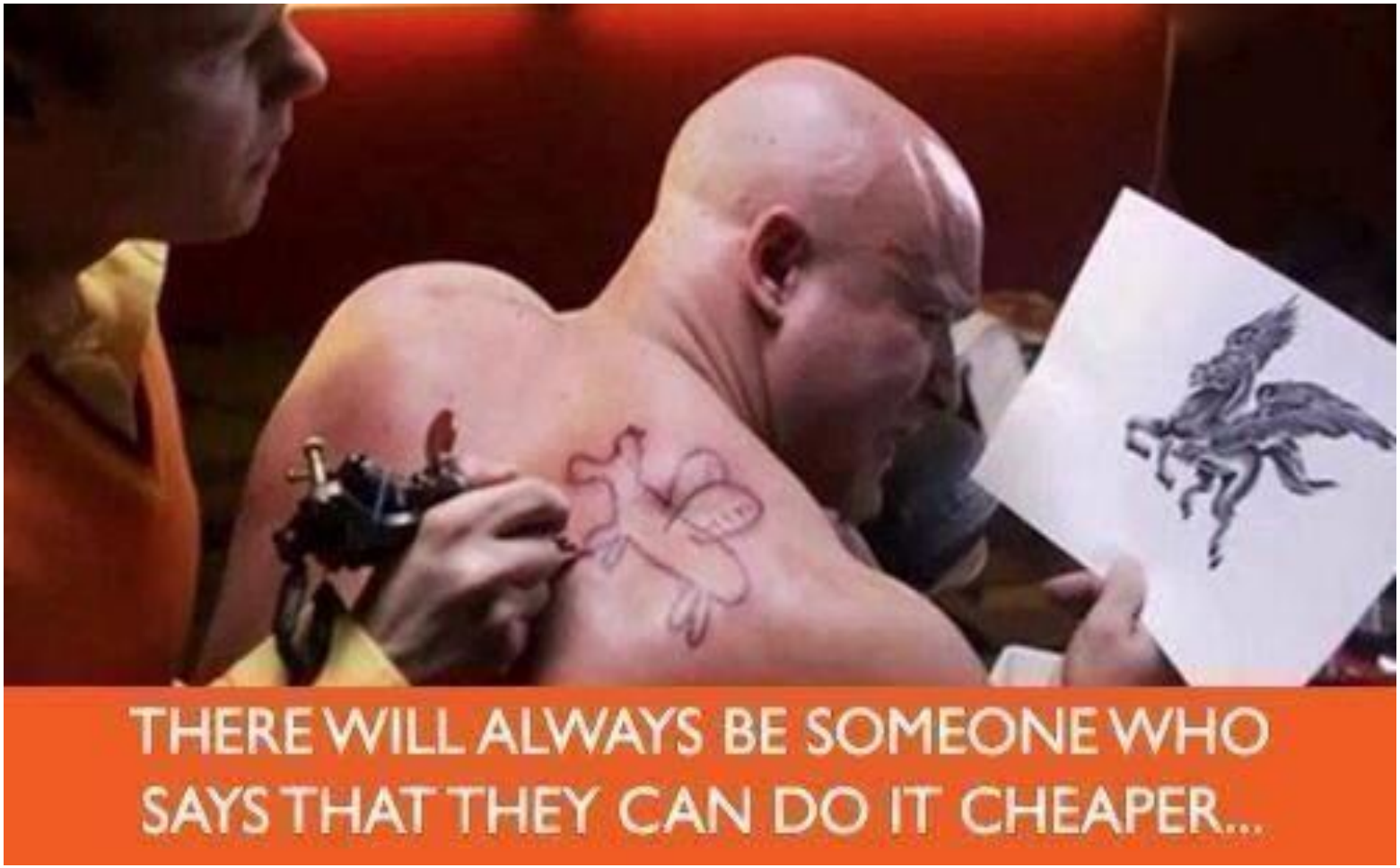
- External wear modes associated with dynamic applications are well understood and can be mitigated
- Resistance to internal wear modes have been taken into account to develop fit for purpose solutions
- There is a high performance synthetic solution for almost any operating condition and environment

Most Important!

- Proper selection of mooring system (mooring/tail/chafe gear) and a robust, systematic residual testing program is the most reliable method to extend service life of high performance mooring ropes

VULCAN ETOPS

- Worlds only Fibre ETOP
- Patented design
- Nominated for Seatrade award 2015
- 60- 70% lighter than wire
- Easier to deploy and store
- Reduced injury risk
- Maintenance free



THANK YOU FOR LISTENING