Rick Trask

UNOLS Wire Pool Manager

RVOC Meeting

April 2015

Wire Pool 2015

It's about operating safely and wisely preserving the resources

Topics to be presented:

- A True Story about a Specific Cable
- Actual Wire Breaking Strength vs. Nominal Breaking Strength
- Preliminary Test Results of Synthetic Alternatives to Trawl Wire Rope
- Experimenting with Reel Covers

True Story About A Specific Cable

- **R/V HASTILY**
- **Operated by the College of Hydrodynamics, and Ocean Physics at the University of** XXXXXXXXXXXXX **(CHOP)**
- .322 CTD cable that was purchased in 2009
- New cable distributed to the CHOP HASTILY in 2011
- Annual testing occurred in June/July 2011, 2012, and 2013 w/ breaking strengths of 13,340, 13,450, and 12,610 lbs. respectively with perfect e-kink test results.

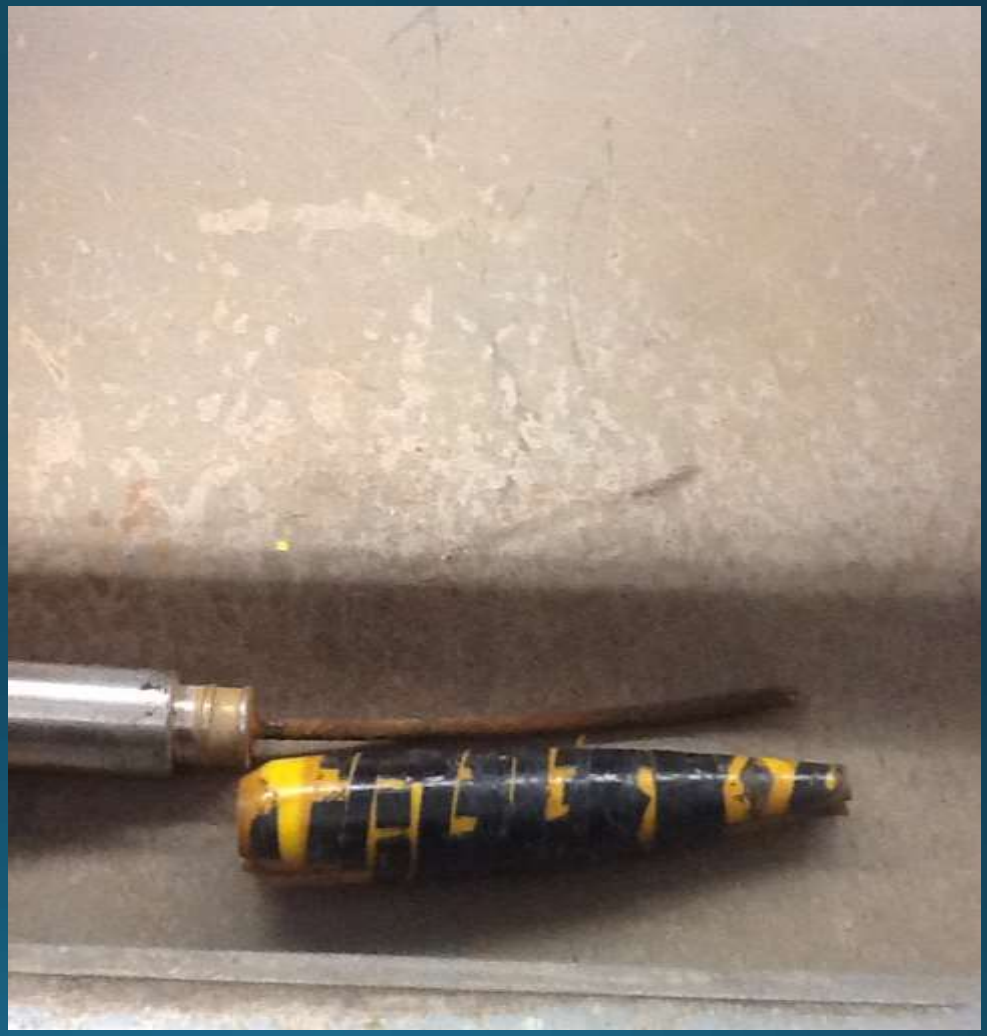
What is the e-kink test?

- .322 has 38 individual wires that make up the inner and outer armors
- E-kink test requires an 18-24" piece of cable
- Removal of each individual wire from the cable
- Holding each end of the wire, it is formed into a loop
- Pull the loop taut forming the shape of a small letter "e"
- A wire break indicates that the material may be brittle and not fit for service
- Failure of 30% or more of the metallic cross sectional area is reason for concern

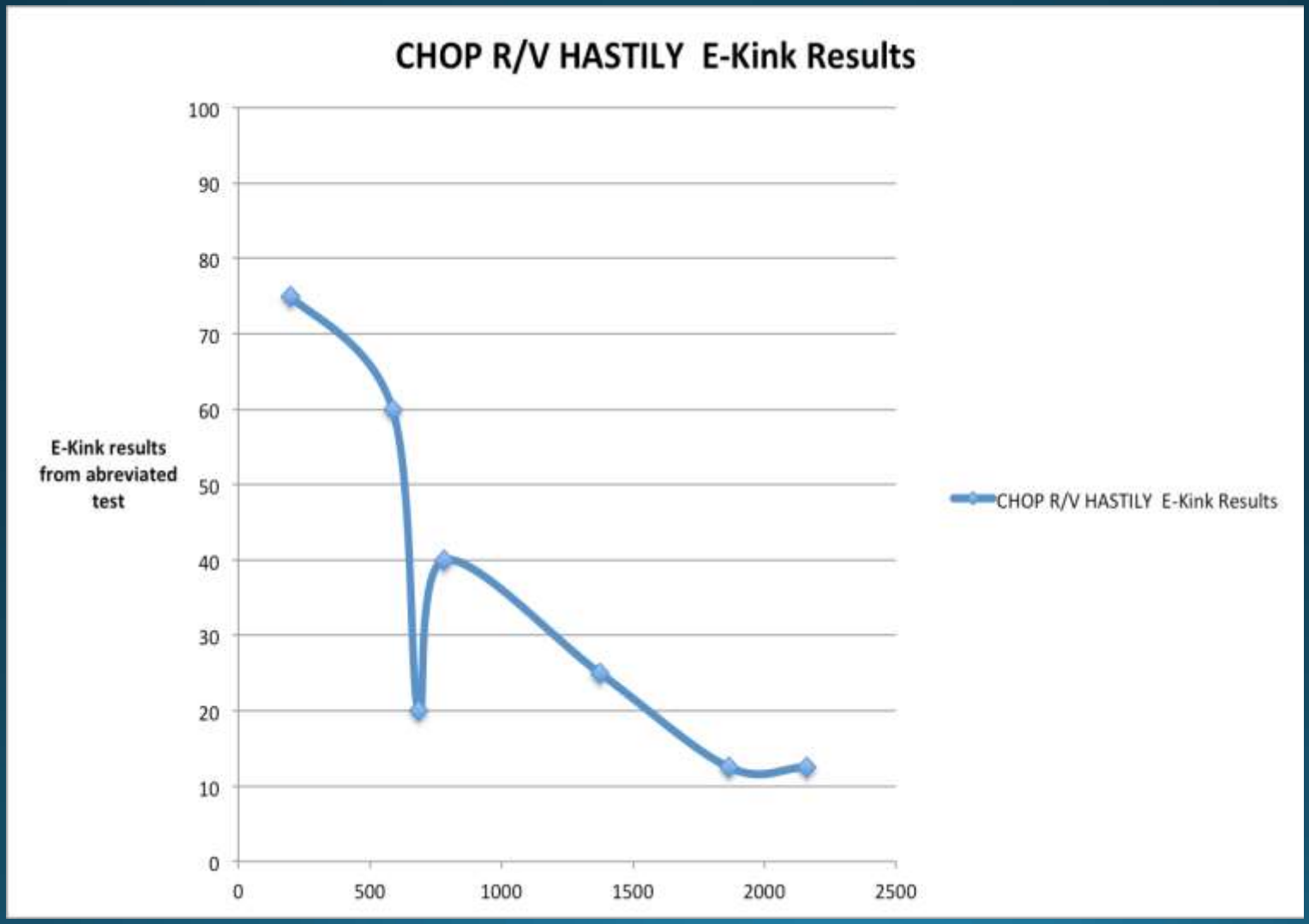
Oct 2013
R/V HASTILY sends sample to Wire Pool

- 3 months earlier Wire Pool was given a cable sample, terminated both ends and it broke at 12,610 lbs. and zero "e"-kink breaks.
- Despite satisfactory test results throughout its life, the cable reportedly had a history of surface rust. Quality of galvanizing?
- October sample had one end terminated by the HASTILY, other end wrapped around a dead man.
- Sample broke at 2460 lbs and had 50% "e" kink breaks.
- Failure occurred at the base of the strain relief boot .

R/V Hastily
Oct 2013 Break



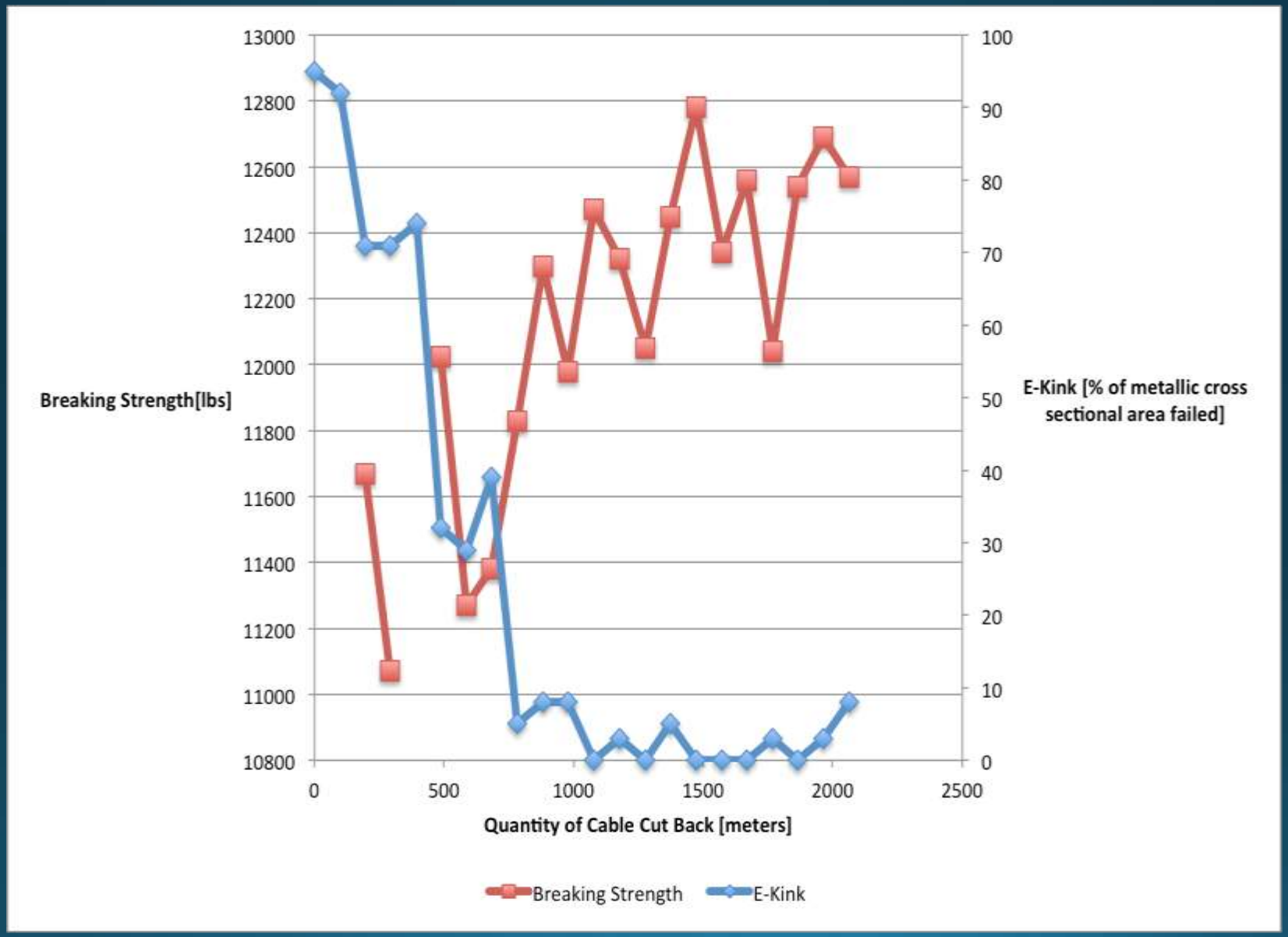
R/V HASTILY starts to cut back using modified "e" kink test procedure to decide whether to cutback further.



- Continued to cut back until they got 12.5% e-kink breaks
- Removed >2200 meters of cable
- Remaining length of cable was too short for upcoming work
- Had to request a new cable from the pool.
- Results skewed since they tested no more than 8 individual wires and in several cases only 4 or 5 wires instead of testing all 38 wires.
- Decisions to continue to cut back were based on testing an inappropriate number of wires. (presumably to save time?)

An Opportunity to Learn

- Opportunity to evaluate a length of cable that presumably was of poor quality at one end to satisfactory at the other end.
- Pieces cut back by the CHOP HASTILY were in ~100 meter segments
- Wire stored inside after cut backs.
- Wire Pool conducted a series of break tests and e-kink tests on each piece to see if there was a relationship between the two
- Hypothesis: Poor e-kink results will correlate with low breaking strengths


13000
12800
12600
12400
12200
12000
11800
11600
11400
11200
11000
10800
Breaking Strength[lbs]
100
90
80
70
60
50
40
30
20
10
0
E-Kink [% of metallic cross sectional area failed]
0
500
1000
1500
2000
2500
Quantity of Cable Cut Back [meters]
Breaking Strength
E-Kink

What did we learn?

- Shortcuts taken when doing e-kink tests can result in misleading results. CHOP HASTILY disposed of more wire than was necessary - >1500 m.
- Relatively low breaking strengths do correlate with poor e-kink results; however the corresponding breaks were all above the manufacturer's minimum breaking strength.
- Breaking strengths alone do not tell the whole story.
- Is the nominal breaking load the best number to use for comparison purposes when evaluating a cable?
- Is it more informative when thinking about the condition of a cable to compare a breaking strength to the breaking strength when the tension member was new rather than to the manufacturer's minimum breaking strength?

Actual Breaking Strengths versus Nominal Breaking Strengths

New Wire Breaking Strengths vs. Minimum Breaking Strengths

- Question: How do they compare?
- Accessed data base information.
- Used only break tests conducted on new wire at the time of delivery.
- Terminations not always consistent with what is used in the field.
- Intent not to test a termination but rather obtain highest BS.
- Cables tested with one end free to rotate.
- Wire Rope tested with both ends fixed.
- Not a large number of data points but shows the trend.

TBL vs. NBL

Tension Member	Wire Pool Average Breaking Strength	Minimum Breaking Strength (NBL)	% > Minimum Breaking Strength
.322 EM Cable	12,691 lbs.	10,000 lbs.	27%
.680 Coax Cable	41,700 lbs.	37,000 lbs.	13%
.681 Power Optic	45,330 lbs.	42,000 lbs.	8%
1/4" 3x19 Wire Rope	7,413 lbs.	6,750 lbs.	10%
3/8" 3x19 Wire Rope	17,105 lbs.	14,800 lbs.	16%
1/2" 3x19 Wire Rope	27,310 lbs.	25,700 lbs.	6%
9/16" 3x19 Wire Rope	36,226 lbs.	32,500 lbs.	11%

What do the manufacturers say?

Tension Member	Wire Pool Average Breaking Strength	Manufacturer's Data
.322 EM Cable	12,691 lbs. (AVG Free) [127% NBL]	12,600 lbs. (Calc. Max Fixed) 11,719 lbs. AVG
.680 Coax Cable	41,700 lbs. (AVG Free) [113% NBL]	43,300 lbs. (Calc. Max Fixed) 41,286 lbs. AVG
.681 Power Optic Cable	45,330 lbs. (AVG Free) [108% NBL]	45,700 lbs. (Calc. Max Fixed) 42,587 lbs. AVG
¼" 3x19 TB Wire Rope	7413 lbs. (AVG) [110% NBL]	7576 lbs. (AVG)*
3/8" 3x19 TB Wire Rope	17,105 (AVG) [116% NBL]	15,300 lbs. (AVG)*
9/16" 3x19 TB Wire Rope	36,226 (AVG) [111% NBL]	33,328 lbs. (AVG)*

*"We pull a sample to test the rope to verify it meets the minimum requirements..... the breaking strength of the sample does not guarantee that we do not have variability within the rope. The rope may have sections that break lower."

Break Test to Break Test Variability

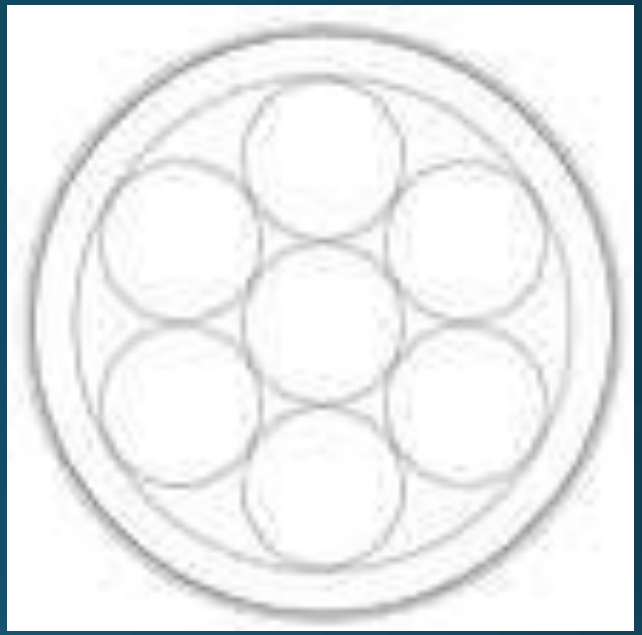
- Five .322 Cables
- Variability in Breaking Strength from Test to Test for each cable relative to the initial new breaking strength.
- For example: Cable NSF-11-C156 had the following history

Test Date	Breaking Strength Test Result (TBL)	% Relative to New Breaking Strength
17 Oct 2011	12870	New wire
2 May 2013	13250	3%
5 May 2014	12630	-2% (poor e-kink results)
26 June 2014	13500	5%

- Breaking Strength Results Overall fell within +/- 10% of the Cable's New Breaking Strength

- Moving forward, when possible, the Wire Pool will be assessing the condition of wire and cable samples based on several factors.
  - Break test results compared with the NBL
  - Break test results will also be compared with the cable's break test results when it was new.
  - E-kink results and mandrel wrap results

Synthetic Line Evaluation



- Break Tests
- Rotation Tests
- Tension-Tension Cyclic Tests
- Cyclic Bend over Sheave Tests

Lines Tested

- Manufacturer: Phillystran
- Product 1:
  - PSTB-T Torque Balanced Rope w/Technora®
  - Description: 36 strand counter-helic const. w/ Polyester /Twaron over-braid
- Product 2:
  - PST
  - Description: 7-strand Technora® “wirelay” construction with an Polyester/Twaron braided jacket

Breaking Strength

Seeking a nominal rope diameter of 9/16" and a MBS of 32,500 lbs.

PSTB sample diameter was .520", PST was closer to 9/16"

Three samples tested for breaking strength using both spliced and potted termination techniques.

Sample	PSTB Spliced BS (Potted BS)	PST Spliced BS (Potted BS)
1	29,040 lbs. (30,060 lbs.)	36,900 lbs. (25,620 lbs.)
2	29,110 lbs. (29,100 lbs.)	36,900 lbs.(27,880 lbs.)
3	29,830 lbs. (28,800 lbs.)	35,500 lbs. (31,060 lbs.)
Average	29,327 lbs. (29,320 lbs.)	36,433 lbs.(28,187 lbs.)

Rotation Test (How well is it Torque Balanced?)

- 9/16" Wire Rope has a 5° per ft. at 45% of Breaking Strength spec
- Three 70 ft. rope samples of PSTB were suspended from a crane and loaded to 13,170 lbs. and allowed to rotate. Used 45% of actual average breaking strength.
- Sample rotated clockwise and counter clockwise multiple times
- Net rotation determined

Sample	Net Rotation [degrees]	Degrees/foot
PSTB-1	2040° CC	29°/ft
PSTB-2	2790°CC	40°/ft
PSTB-3	3400° CC	49°/ft
Sample PSTB-1 repeat	1760° CC	25°/ft

Rotation Test PST not conducted yet

CC= Counter Clockwise

Tension – Tension Cycling

- Repeatedly tensioned from 0 to 45% of RBS
- Up to 50,000 cycles and then if sample survived, conduct break test
- Degradation < 5% in breaking strength after 50,000 cycles

Sample	PSTB (Peak load 12K lbs.)	PST (Peak load 14.6K lbs.)
1	Failed after 47,158 cycles	Failed after 39,525 cycles
2	Failed after 48,240 cycles	50K cycles-> 22,580 lbs.
3	Completed 50,000 cycles Additional 28,010 before failure. Residual strength not conducted after 50K	

9/16" and 1/2" TB WR failed after 22,573 and 20,728 cycles respectively during TMT testing in 2005.

Cyclic Bend over Sheave Testing

- Withstand 50,000 flexure cycles over sheaves 40 x the rope diameter at 35 to 40% of RBS without failure
- Test conducted at 7000 lbs. (max capacity of the CBOS machine)
- After 50,000 cycles break the sample. Degradation <5% of RBS

Sample	PSTB	PST
1	29,510 lbs.	30,000 lbs.
2	27,260 lbs.	29,600 lbs.
3	26,020 lbs.	29,800 lbs.
Average	27,597 lbs.	29,800 lbs.
% Change w/ respect to (BS)	-5.8% (29,320 lbs.)	+5.7% (28,187 lbs.)

½" 3x19 TB WR failed after 3964 cycles at 10,400 lbs. tension (40% of MBS)
9/16" 3x19 TB WR failed after 5242 cycles at 13,000 lbs. tension (40% of MBS)

PST Rope

- 7-strand Technora® “wirelay” construction with an overall braided jacket
- Thought to be preferable to PSTB for UNOLS application
- Used by the U.S. Navy contractors for salvage type operations
- Less expensive than the PSTB by 13%
- Still ~2 x more expensive than wire rope
- Best strength results from spliced termination (not as easy as a nicopress termination).
- Manufacturer can repair and/or add length with no increase in rope OD

Protecting the Resources: Reel Covers

Blah Blah Blah…. What did he say?

- E-kink tests done in the field must be done on *all* the wires to evaluate the condition of the wire.
- When assessing a tension member's deterioration, its new breaking strength may be a better value to use when comparing subsequent break tests than the manufacturer's minimum breaking strength.
- The evaluation of a synthetic line as a possible alternative for 3x19 wire for certain applications is looking promising. At sea testing is planned.

Wake up, it's over!

Got questions?