CI 1503 YOY Testing PA

Agenda

1. Test Results PA 371
2. Additional tests PA 371 MF
3. Results Ifremer
4. Initial results & schedule
5. Practical test conditions

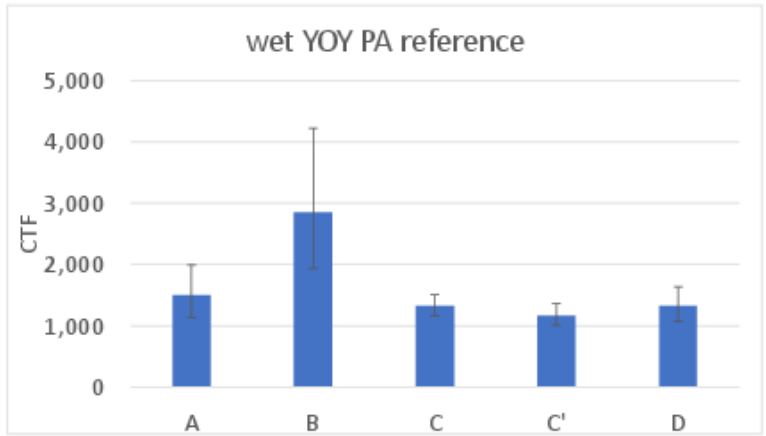
YoY tests on PA 371

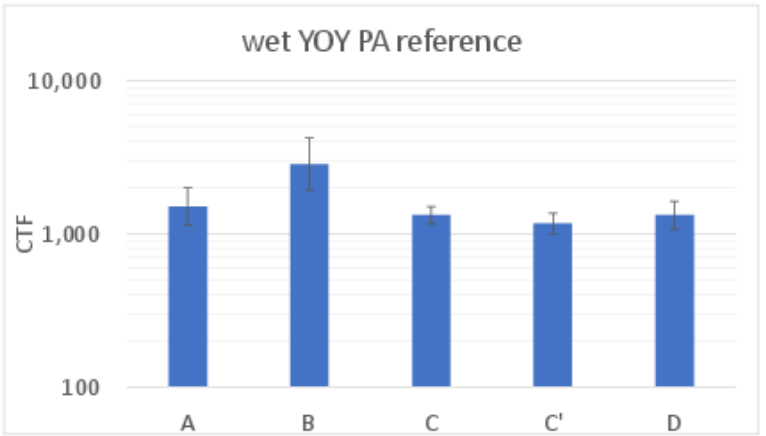
Wet Test Results as of May 2022

	Test conditions					load		Results				
	pulley size	wrap dir	Turns in twist zone	soak (hr)	cond	gram	mN/dtex	n	Ave	M lg(x)	SD lg(x)	CV lg(x)
A	35mm		3	24	wet	400	27.81	8	1,572	1,503	0.146	4.6%
B	20mm		3	24	wet	400	27.81	8	3,121	2,857	0.203	5.9%
C	25.4mm		3	24	wet	400	27.81	7	1,332	1,320	0.062	2.0%
C'	25.4 mm		3	24	wet	400	27.81	7	1,181	1,166	0.073	2.4%
D	35mm		3	24	wet	400	27.81	7	1,352	1,323	0.100	3.2%

YoY tests on PA 371

Wet Test Results as of May 2022





YoY tests on PA 371

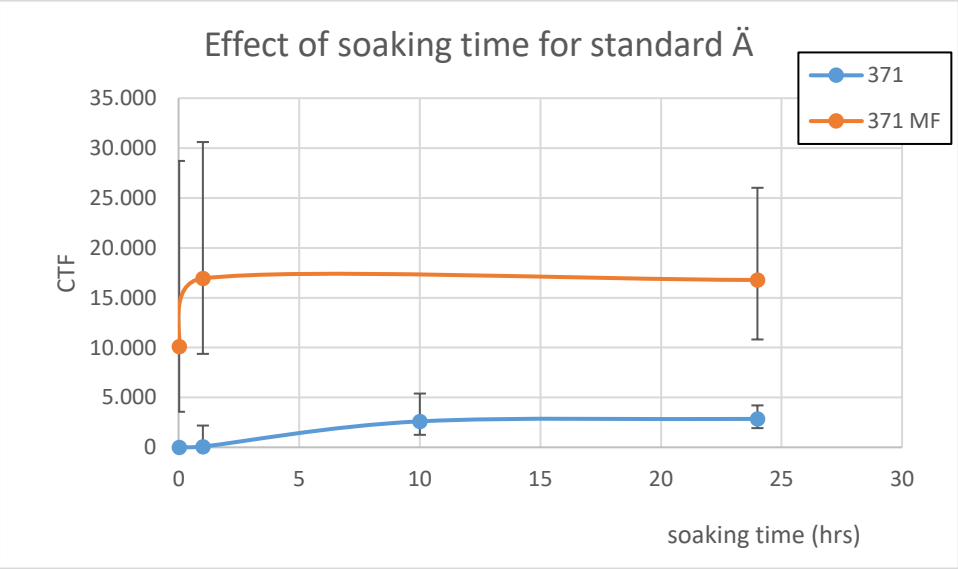
Effect of soaking time on Wet Test Results

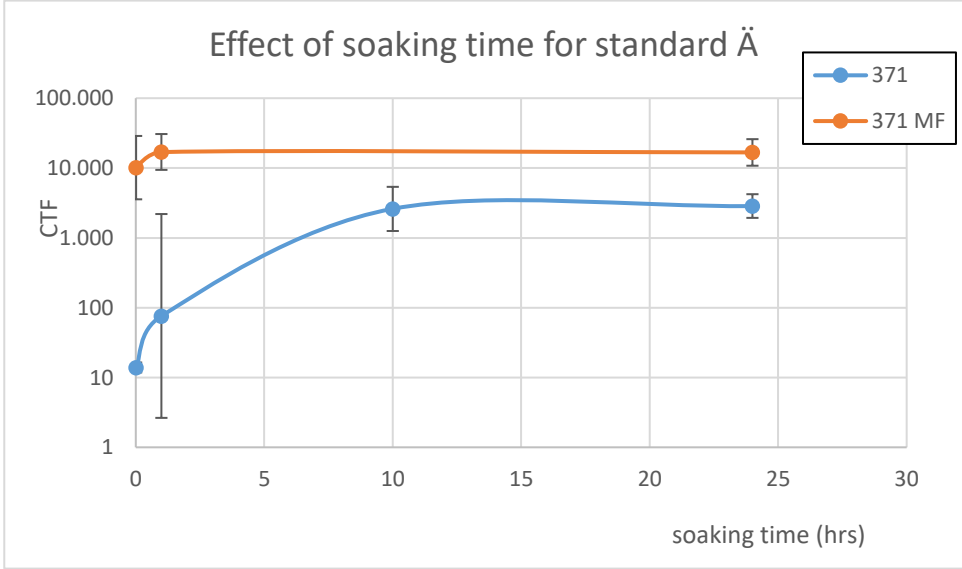
Standard 371		Test conditions				load		Results				
	pulley size	wrap dir	Turns in twist zone	soak (hr)	cond	gram	mN/dtex	n	Ave	M lg(x)	SD lg(x)	CV lg(x)
B	20mm		3	0.17	wet	400	27.81	8	14	14	0.085	7.4%
B	20mm		3	1	wet	400	27.81	4	286	76	0.916	48.7%
B	20mm		3	10	wet	400	27.81	4	2,804	2,612	0.199	5.8%
B	20mm		3	24	wet	400	27.81	8	3,121	2,857	0.203	5.9%

371 with MF	Test conditions					load		Results				
	pulley size	wrap dir	twist zone	soak (hr)	cond	gram	mN/dtex	n	Ave	M (lgx)	SD lg(x)	CV lg(x)
B	20mm		3	0,017	wet	400	27,81	4	11.787	10.102	0,285	7,1%
B	20mm		3	1	wet	400	27,81	6	18.969	16.944	0,245	5,8%
B	20mm		3	24	wet	400	27,81	7	18.320	16.789	0,206	4,9%

YoY tests on PA 371

Effect of soaking time on Wet Test Results





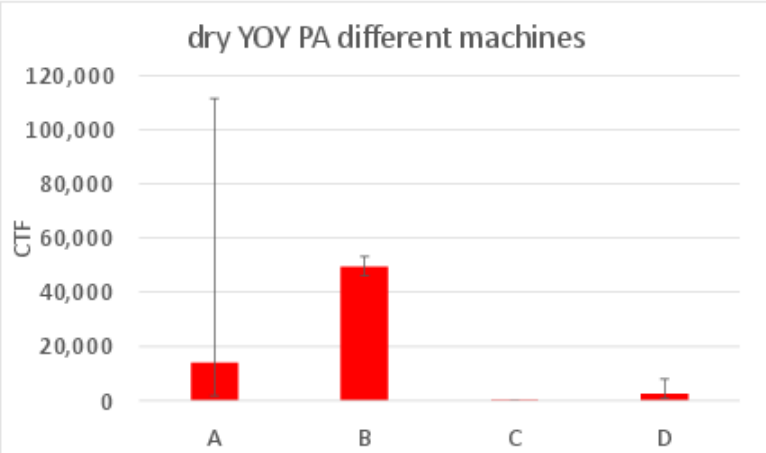
YoY tests on PA 371

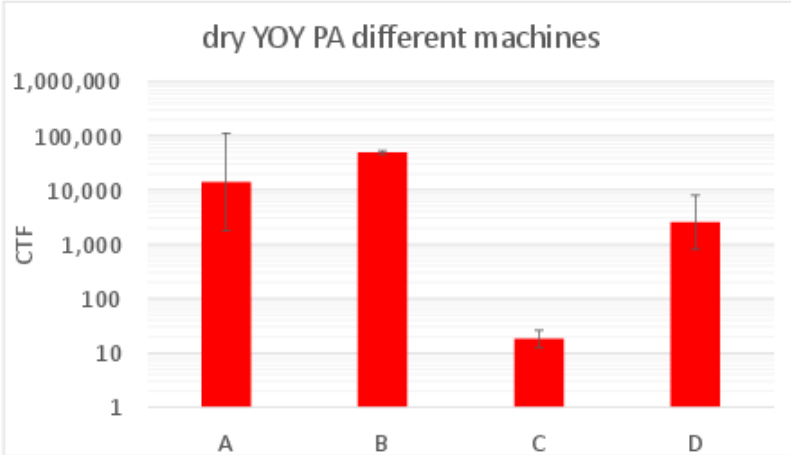
Dry Test Results as of May 2022

		Test conditions				load		Results				
	pulley size	wrap dir	turns in twist zone	soak (hr)	cond	gram	mN/dtex	n	Ave	Ave lg(x)	SD lg(x)	CV lg(x)
A	35mm		3		dry	400	27.81	6	34,596	14,112	0.856	20.6%
B	20mm		3		dry	400	27.81	8	49,624	49,468	0.037	0.8%
C	25.4mm		3		dry	400	27.81	8	19	18	0.190	15.2%
D	35mm		3		dry	400	27.81	14	8,892	2,540	0.863	25.3%

YoY tests on PA 371

Dry Test Results as of May 2022

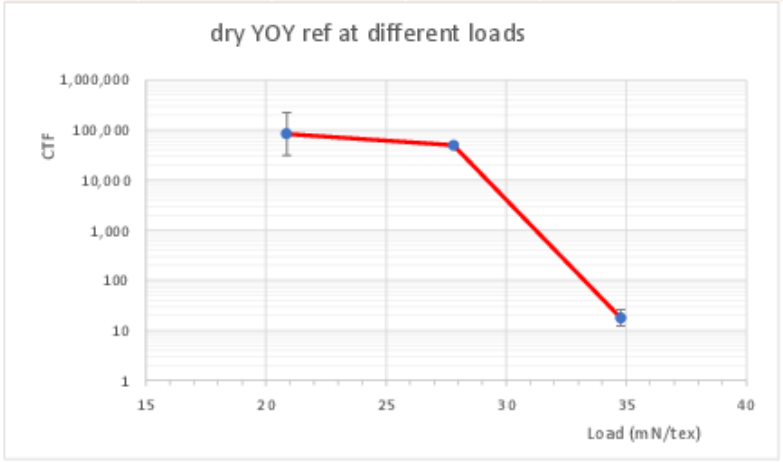




YoY tests on PA 371

Dry Test Results at different loads as of May 2022

		Test conditions				load		Results				
	pulley size	wrap dir	turns in twist zone	soak (hr)	cond	gram	mN/dtex	n	Ave	Ave lg(x)	SD lg(x)	CV lg(x)
B	20mm		3		dry	300	20.86	4	94,748	83,478	0.267	5.4%
B	20mm		3		dry	400	27.81	8	49,624	49468	0.037	0.8%
B	20mm		3		dry	500	34.76	12	14	18	0.177	16.1%



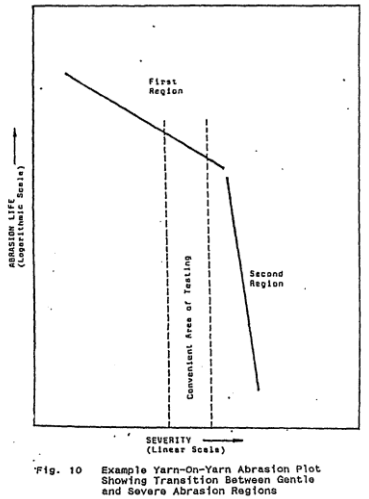


Fig. 10 Example Yarn-On-Yarn Abrasion Plot Showing Transition Between Gentle and Severe Abrasion Regions

See also CI 1503
§A 2.8

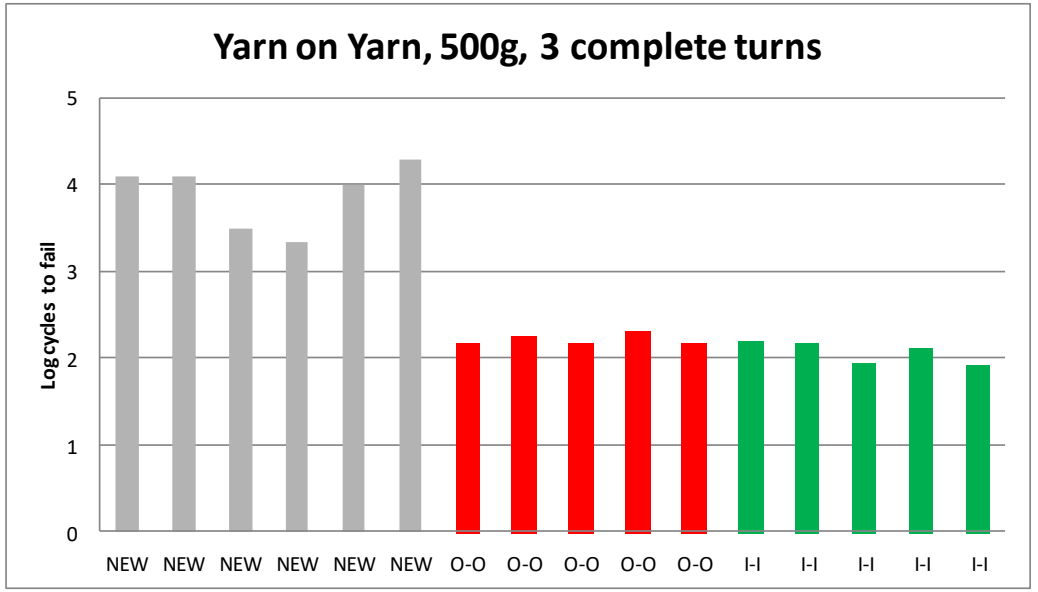
Additional tests on 371x6 S25 MF

- Nexis will made an additional samples available of twisted 371: Z&S twist 25 turn per meter without and with Marine Finish.

- This sample will be tested by I–Coats, Ifremer & Nexis @ load conditions to be confirmed after the meeting

Yarn-on-Yarn testing

Previous studies on Nylon SPM hawsers (OHP JIPs) after 2 years at sea



Instrumented YoY test to measure friction coefficient (3 options in standard)

Also based on work by Flory, Goksoy, Hearle

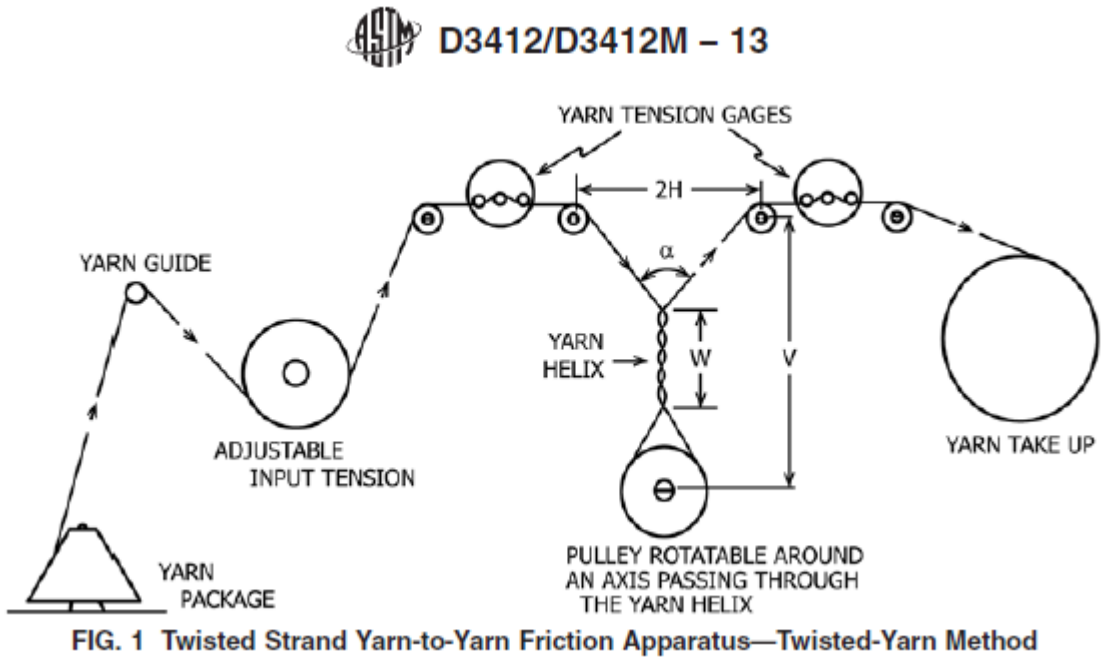


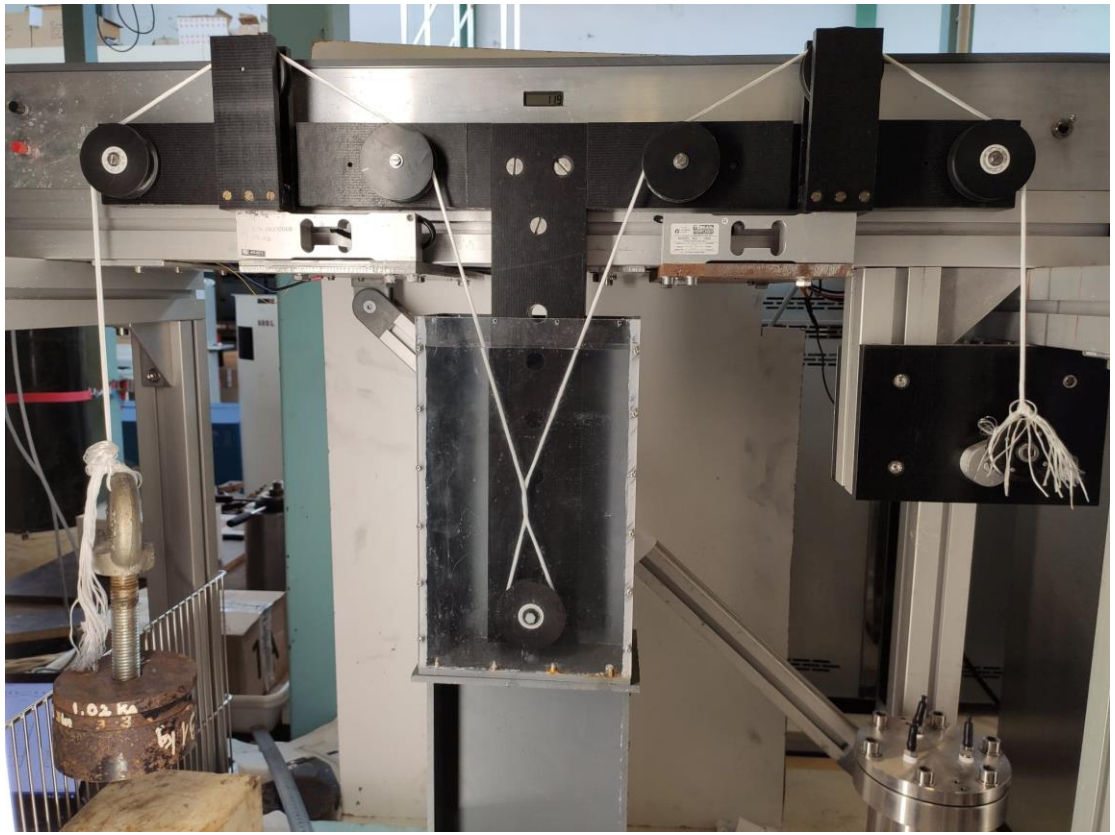
FIG. 1 Twisted Strand Yarn-to-Yarn Friction Apparatus—Twisted-Yarn Method

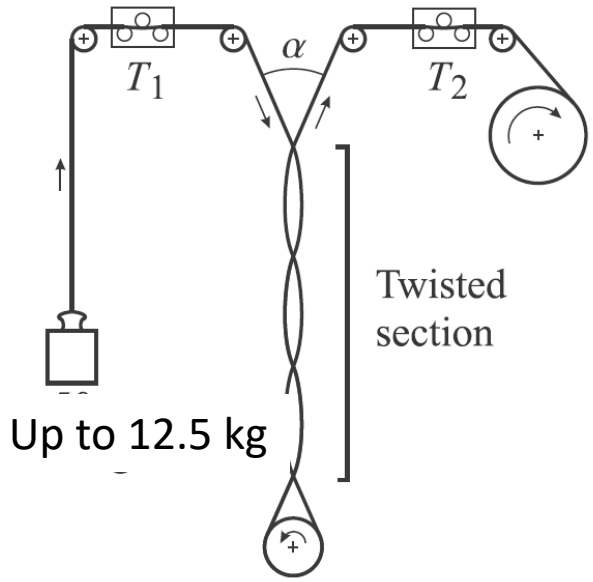
Up to 400 tex

Set of data for yarns in Tethers 2000, Flory (1994)

Available in many companies but few recent studies.

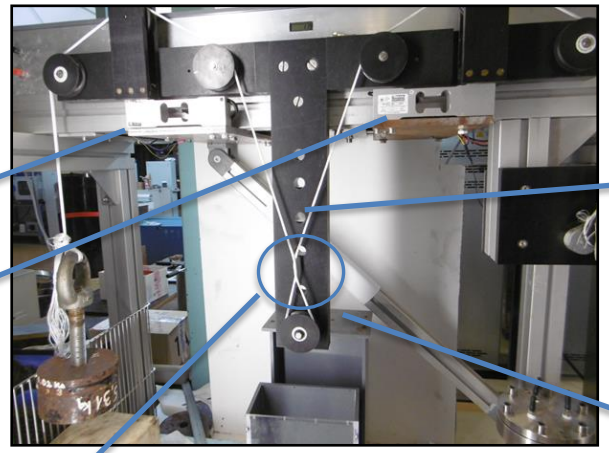
Designed machine to test Rope Yarns (2400 tex)



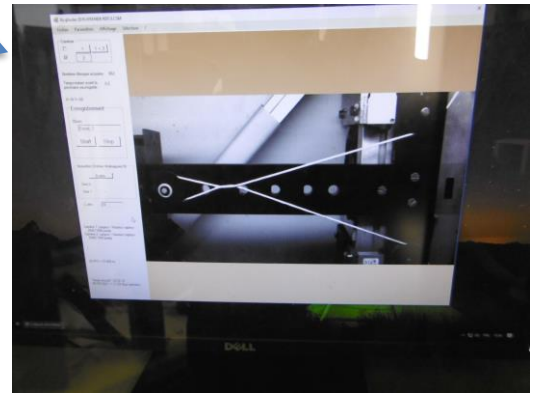


Measurements

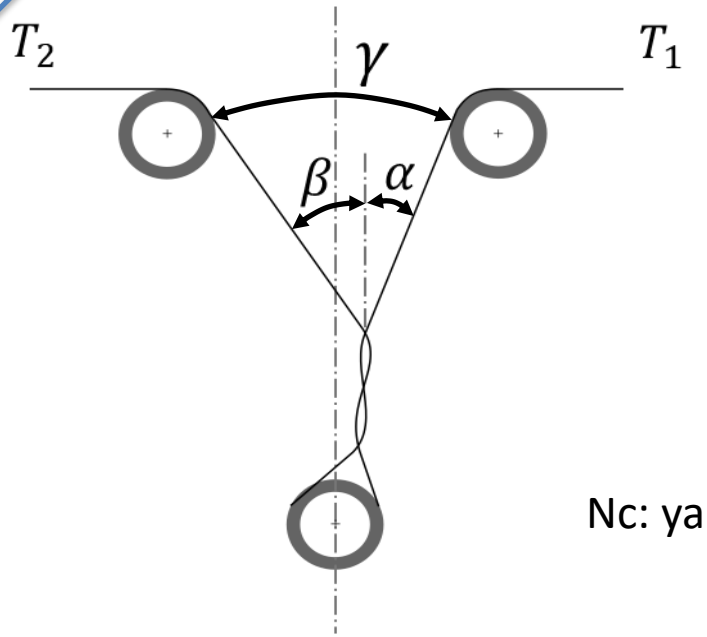
Tension measurements
T_1 and T_2

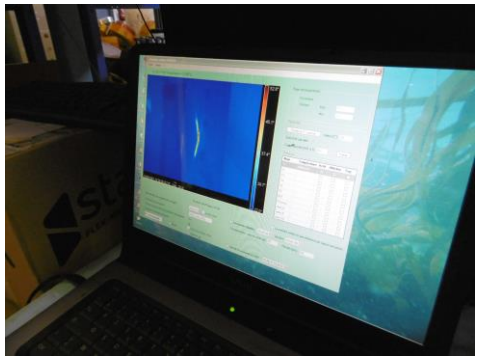


φ



Angles from image analysis
α, β, γ

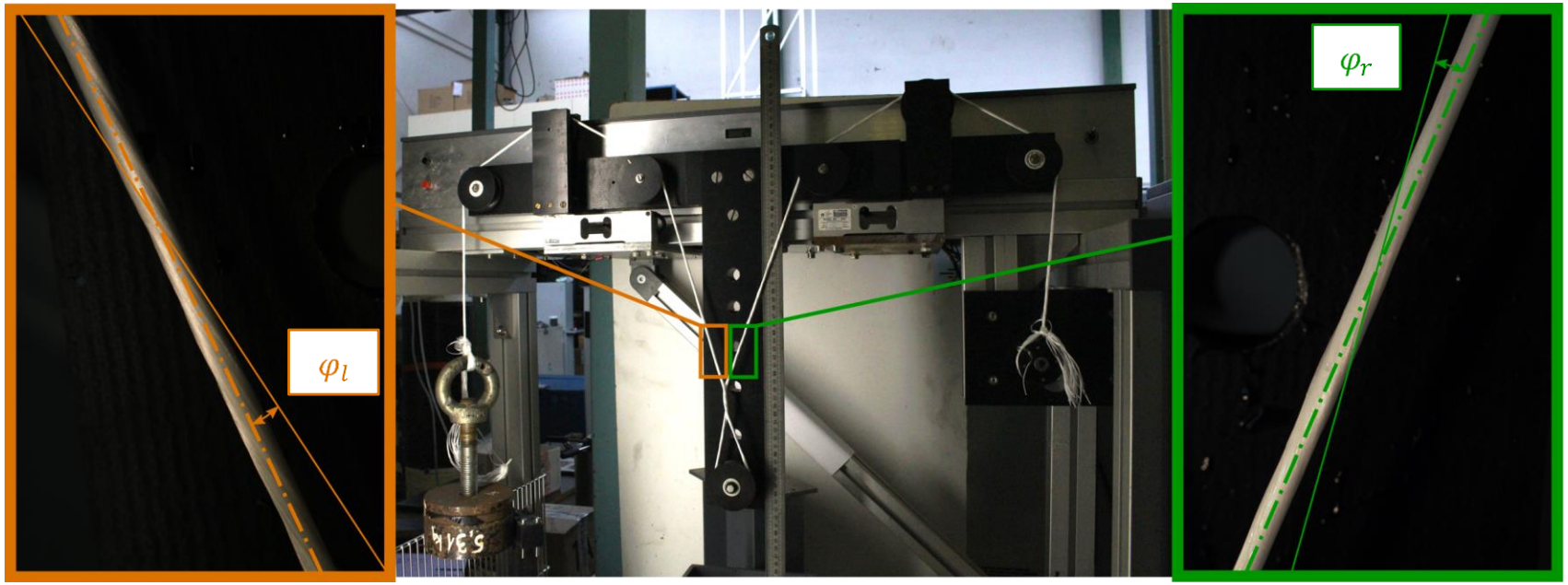




IR camera for dry tests

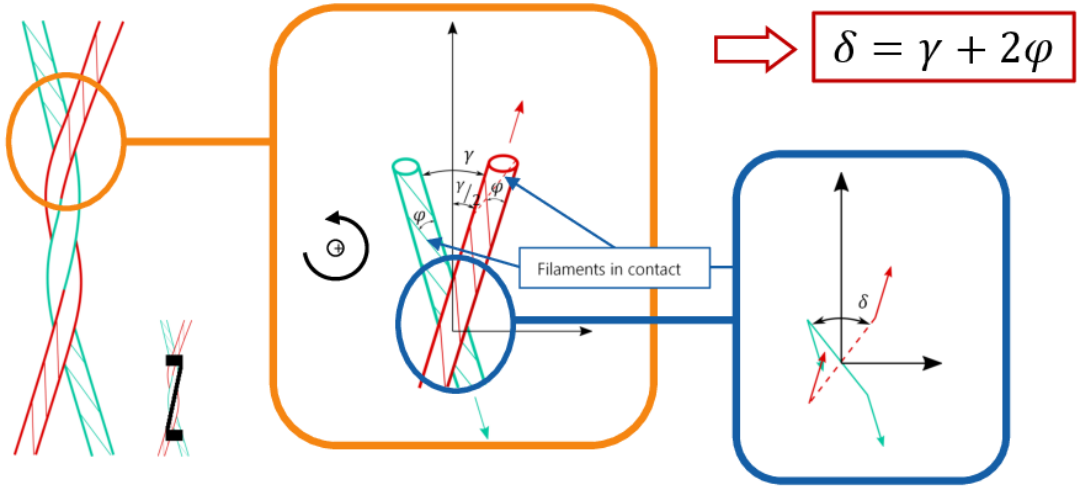
Nc: yarn crossings

So measure rope yarn twist angles

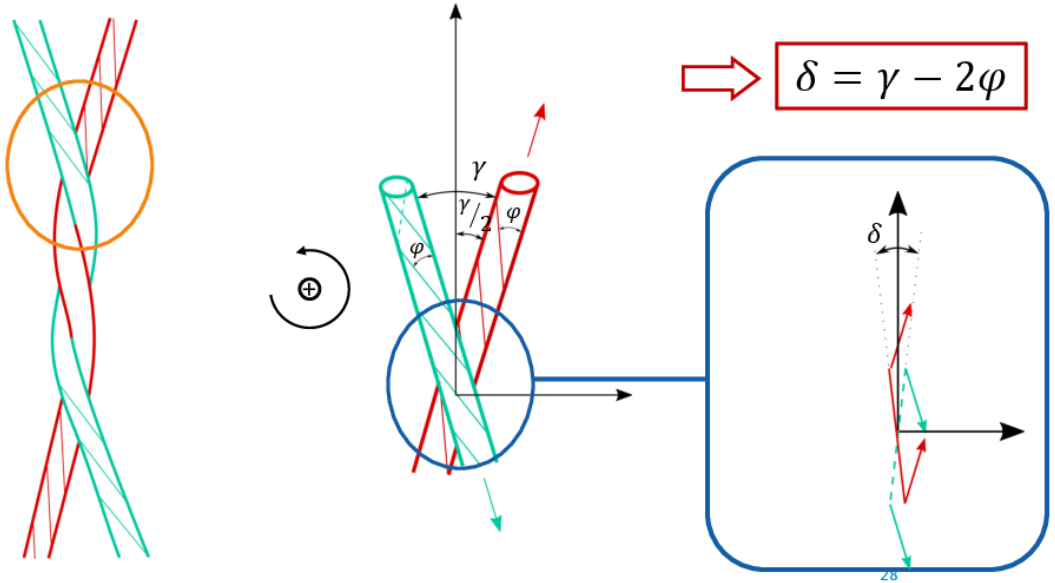


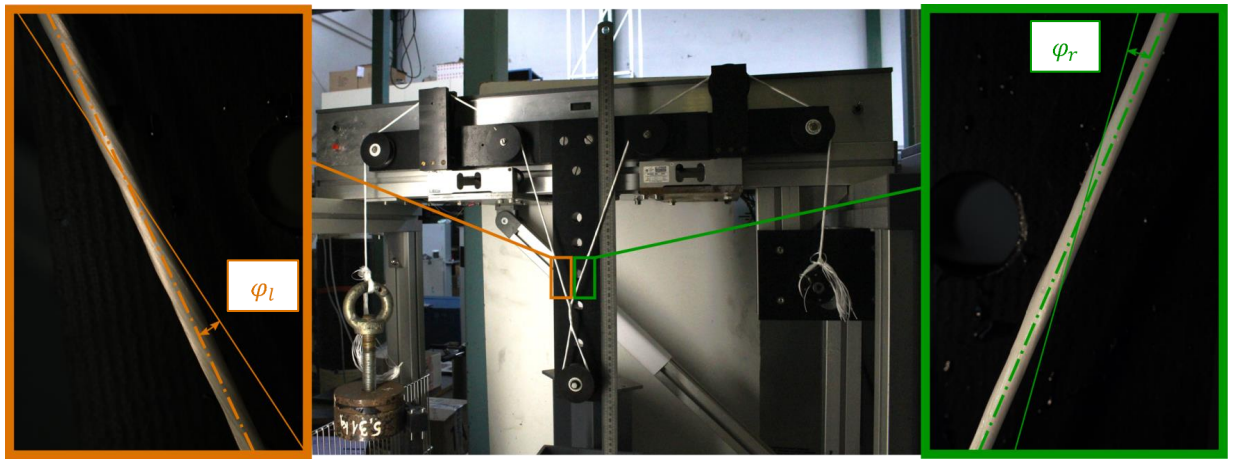
Rope yarn helix angles φ Initially and after 80 seconds

Local contact geometry Z-wrap yarns



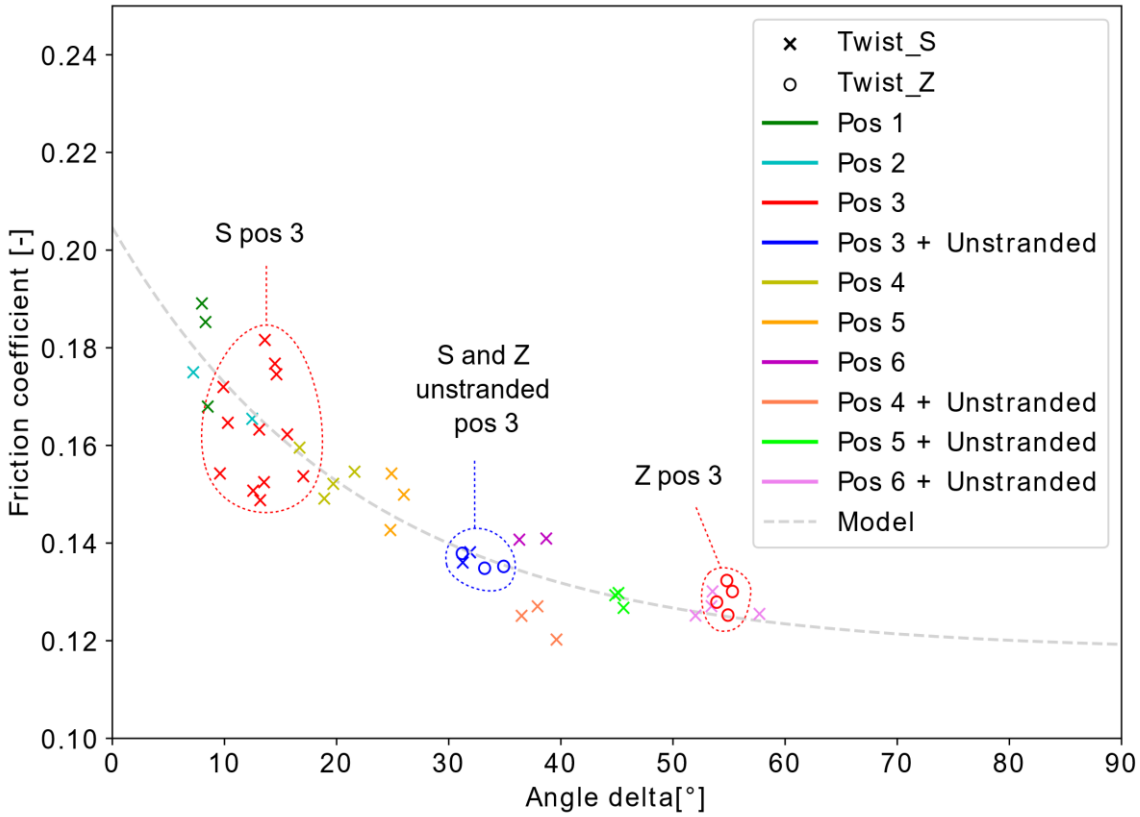
Local contact geometry S-wrap yarns

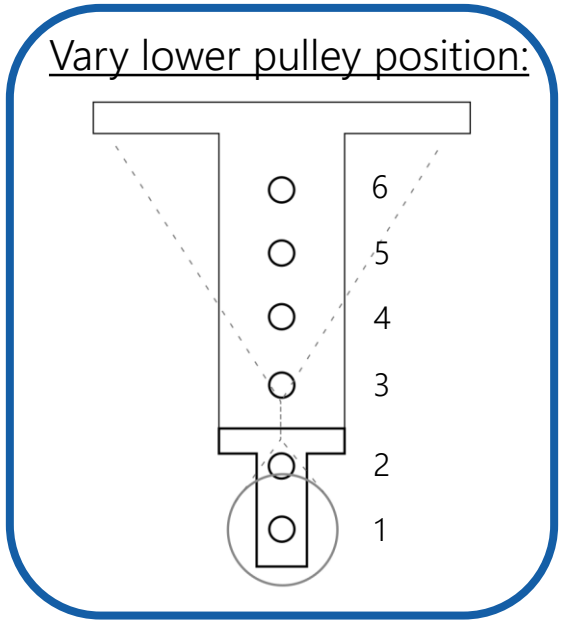




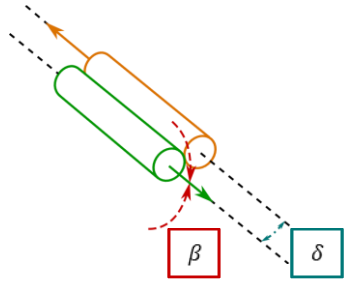
Friction coefficients versus δ for S- and Z-wrap rope yarns

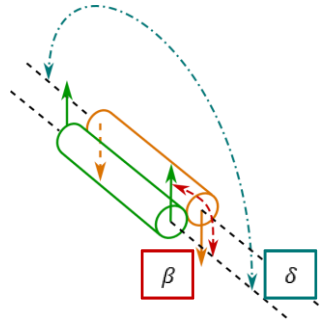
S-twist rope yarns





An additional parameter to distinguish slip modes with different movements:





Same $\delta = 0°$

Longitudinal-longitudinal

Transverse-Transverse

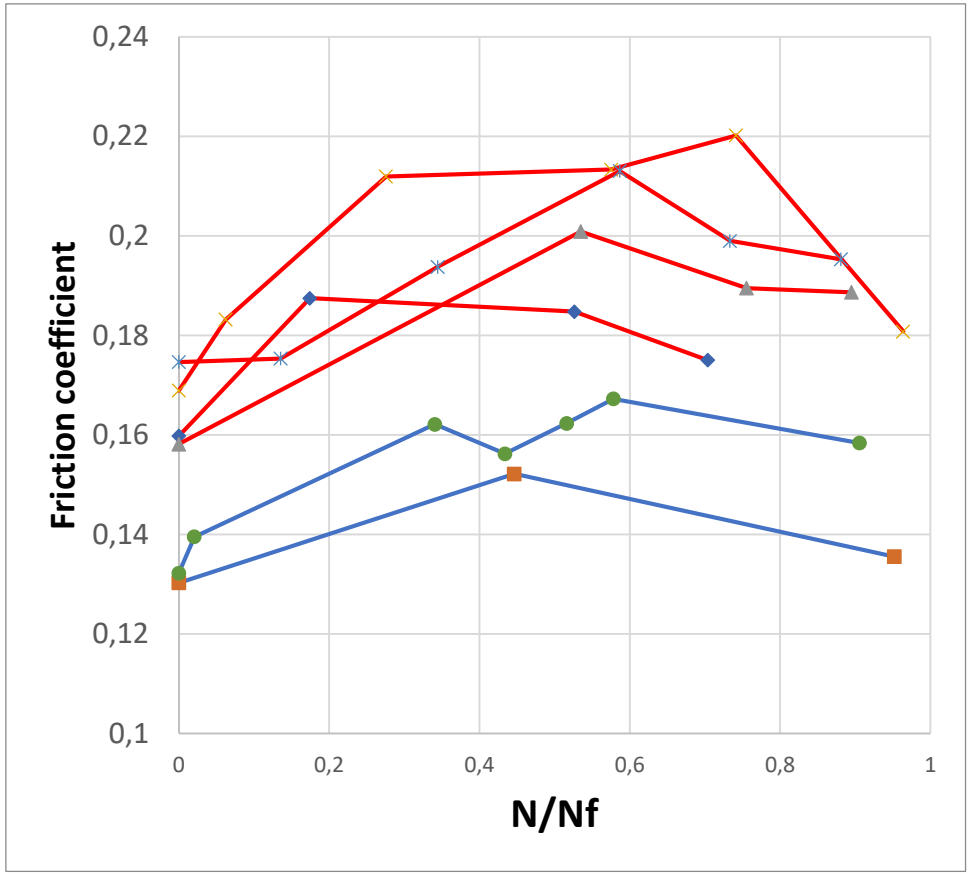
Both have same δ, so introduce a modified parameter β, the friction angle, based on the vector sum of the relative movements

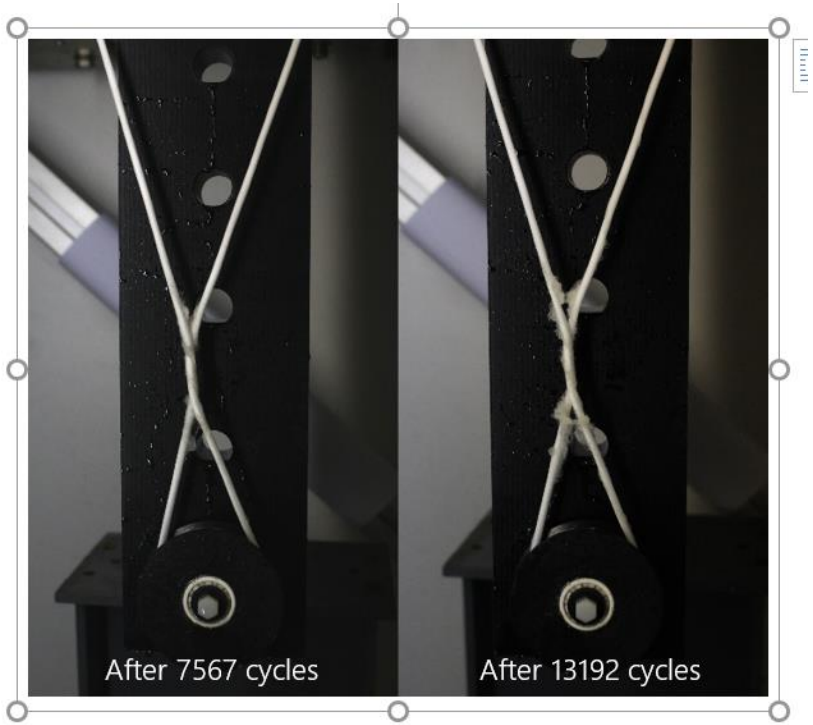
Influence of wrap direction on RY/RY cycles to fail for S-twist rope yarns

Samples number	Number of cycles to failure for S wrap	Number of cycles to failure for Z wrap
1	31 531	141 260
2	35 333	162 500
3	33 717	162 577
4	26 583	154 412
5	33 530	152 066
Mean	**32 139**	**154 463**

Number of cycles to failure for abrasion tests with rope yarns twisted together assembled in S and Z configurations.

Influence of wrap direction on RY/RY cycles to fail





Local contact angle governs friction and abrasion lifetime.

Some conclusions Ifremer

- In order to optimize floating offshore wind turbine moorings reliable models are needed.
- Friction measurements are difficult to find and tests are complicated and consider only one condition.
- The ASTM test method has been adapted to provide friction coefficients for varying contact angles.
- These fall on a single curve, which can be integrated in numerical rope models.
- The YoY test offers many possibilities but questions remain. A Cordage Institute Round Robin is underway.

Test results 321

Two scaling methods were proposed initially:

- Scaling with the yarn size: CI 1503 §A.2.3 & ASTM D6611 § A.2.3
  - Load in grams/denier or mN/tex should be comparable for two different sizes

- Scaling with the yarn diameter (similar to twist):
  - Use system from twist-factor : $Load_2 = Load_1 * \sqrt{(count_2 / count_1)}$

See also ASTM D1423/D1423M − 16: Eq 3

	dtex	ASTM	diameter
standard	1440	400	400
T321x6 S25	8723	2423	984
T321x6 S50	8809	2447	989
T321x6 S100	9150	2542	1008

Test results 321x6 standard; scaling size

Test conditions				load		Results					
yarn	twist factor	wrap dir	cond	gram	mN/dtex	n	Ave	SD	Ave lg(x)	SD lg(x)	CV lg(x)
321x6 S25	0,69	Z	dry	2 500	28,12	8	78	75	1,773	0,323	18,2%
321x6 S50	1,39	Z	dry	2 500	27,84	8	111	145	1,841	0,410	22,3%
321x6 S100	2,83	Z	dry	2 500	26,80	7	169	125	2,136	0,303	14,2%
321x6 S25	0,69	S	dry	2 500	28,12	8	34	6	1,525	0,067	4,4%
321x6 S50	1,39	S	dry	2 500	27,84	8	19	9	1,242	0,176	14,2%
321x6 S100	2,83	S	dry	2 500	26,80	8	36	14	1,538	0,146	9,5%
321x6 S25	0,69	Z	wet	2 500	28,12	locks					
321x6 S50	1,39	Z	wet	2 500	27,84	locks					
321x6 S100	2,83	Z	wet	2 500	26,80	locks					
321x6 S25	0,69	S	wet	2 500	28,12	locks					
321x6 S50	1,39	S	wet	2 500	27,84	locks					
321x6 S100	2,83	S	wet	2 500	26,80	4	848	479	2,883	0,219	7,6%

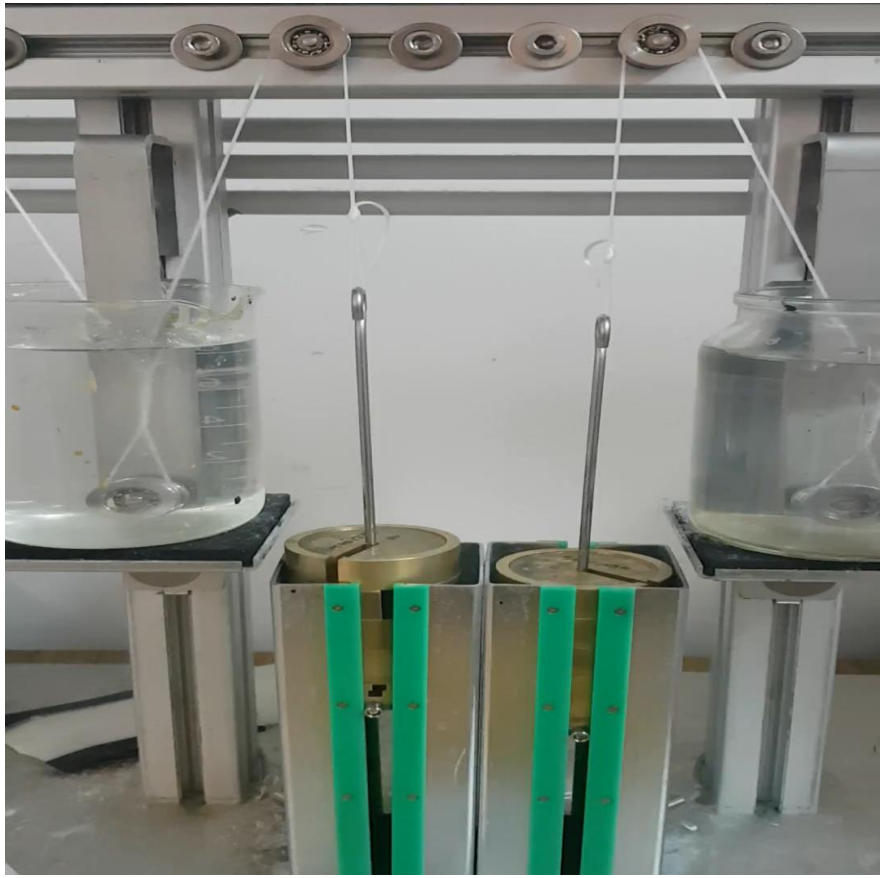
- Dry testing clearly is in the severe abrasion mode
- Wet testing of twisted yarn did not give realistic results; broken filaments would lock. This prevents further movement.

Test results 321x6; scaling size wet tests

Untreated, twisted yarn locking in the wet test.

In the PA meeting it was decided that this condition should be excluded. An initial definition has been proposed.

Further verification is underway to make sure it not machine dependent



Practical Test conditions

Effect of soaking time & soaking conditions:

- 1 hr is enough for a 1440dtex yarn with MF, but not enough for untreated yarn.
- what will it be for heavier yarns?
- ASTM D1776 suggest higher values, but also gives a method to optimize conditioning time. What acceptance criteria should we use?

TABLE 1 Standard Atmospheres for Conditioning and Testing Textiles

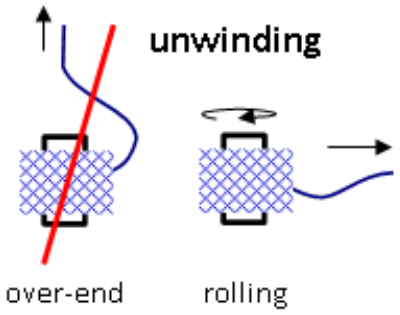
Material	Preconditioning[A] Time (h), minimum	Temperature, °C [°F]	Relative Humidity %	Time (h), minimum	ASTM Standard
Textiles, general[B]		21 ± 2 [70 ± 4]	65 ± 5		D1776
Textiles, specific[C]					
Cotton fiber classification and testing	4	21 ± 1 [70 ± 2]	65 ± 2		D1776, D5867
Tire cords:					
Polyamide	Not applicable	20 ± 2 [68 ± 4]	65 ± 5	16	D885
Polyester	Not applicable	20 ± 2 [68 ± 4]	65 ± 5	2	D885
Rayon		20 ± 2 [68 ± 4]	65 ± 5	8	

Practical Test conditions

Separate soaking:

- Yarns have been kept together during soaking (specimen are cut prior to mounting)
- Care should be taken not to change the twist..

Overhand handling in the system does not change the average twist. Hence average CTF does not change, but variation increases.



Over-end winding should not be used for twisted yarn

Conclusions

- Wet test of reference yarn is very comparable between participants.
- Dry tests conditions are too severe for comparison.

- Initial results show that Z wraps on S twisted yarns give a higher result than S wraps.
- With increasing twist differences between S & Z are more extreme.

- Test conditions and limits should be more detailed in the test

Conclusions

Next:

- Verification of locking
- Additional test of lower twist: 371x6

- Intermediate size 321x3 or 371x3? (2BD)