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U.S. LARP

# Axial Gaps in HQ

05/16/2011

Collaboration Meeting 16, Montauk - NY – May 16<sup>th</sup> to 18<sup>th</sup> 2011

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# Parameters affecting the gap sizes



## **Winding tension relaxation**

- winding tension
- Young modulus of the cable: Brett's measurements

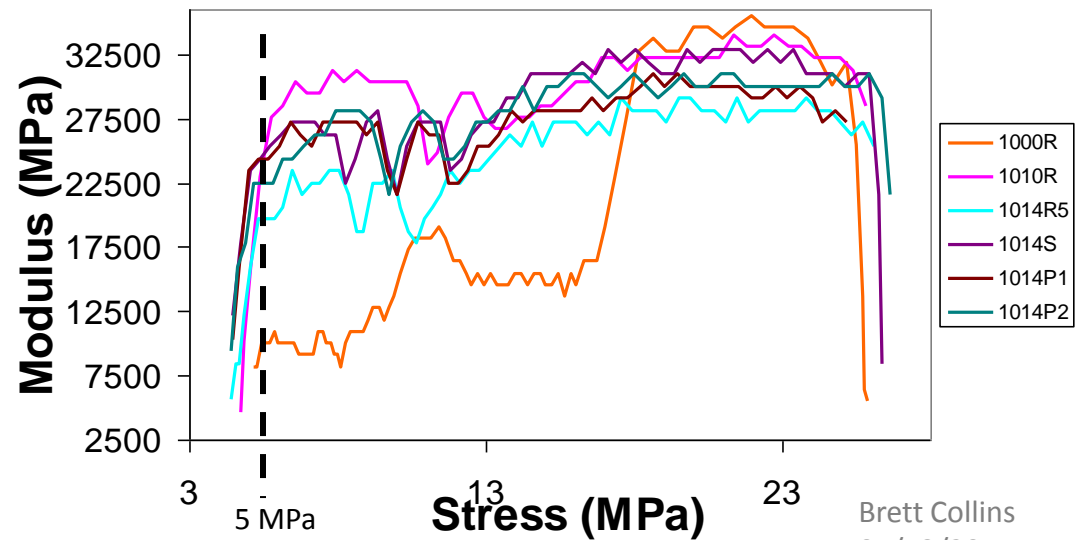
## **Dimensional changes during reaction**

- Bare cable dimensional changes: Jyothi's measurements
- experience on HQ coil 13 and LQ coils

# Winding tension relaxation

- Baseline gap in HQ: 30 mils = 0.76 mm
- Closed after curing in all coils 3 to 12 but coil 5
- Winding tension used in HQ winding: 20 lbs => 5 MPa in HQ
- Young modulus measured on various HQ cables: large spread from 5 to 20 GPa

**Modulus vs. Stress for 100lb Cycle**



Brett Collins  
04/13/2011

# Winding tension relaxation

- Baseline gap in HQ: 30 mils = 0.76 mm
- If we consider the range of Young modulus

E <sub>young</sub>		Expected relaxation			
5.00	GPa	-1.01	mm/m	28	mils
12.00	GPa	-0.42	mm/m	12	mils
20.00	GPa	-0.25	mm/m	7	mils

- For a 5 GPa modulus: in agreement with the gap in HQ coils closed after curing
- For larger modulus: need to justify the 30 mils gap closure in all HQ coils

**As a lower bound** we can consider 1 mm/m of gap to allow for winding tension relaxation

- Measurement performed by Jyothi on **unconfined** HQ cables

Coils	strand	Sample ID	Change in Length			If applied in the coil		
4/5/6/7	108/127	HQ-1000R-1	-0.08	%	-0.8	mm/m	-28/-0.7	mils/mm
		HQ-1000R-2	-0.11	%	-1	mm/m		
8/9/2010	54/61	HQ-996R	-0.17	%	-1.7	mm/m	-50/-1.3	mils/mm
13	54/61	HQ-1008-1	-0.23	%	-2.3	mm/m	-81/-2.1	mils/mm
		HQ-1008-2	-0.31	%	-3.1	mm/m		
R&D cable	108/127	HQ-1014-H1	-0.27	%	-2.7	mm/m		
		HQ-1014-H2	-0.09	%	-0.9	mm/m		

Cable annealed  
for 16h

- Data from coils:

HQ13	54/61	OL	-0.3	%	-3	mm/m	1 pass cable
		IL - gap closed	-0.27	%	-2.7	mm/m	
LQ avg (7 coils)		OL	-0.14	%	-1.4	mm/m	2 pass cables
		IL - gap closed	-0.19	%	-1.9	mm/m	

**As a higher bound** we can consider the dimensional changes occurring in an unconfined cable.

In average: 2mm/m

# HQ14 gap size

In total if we take into account winding relaxation + contraction after reaction:

~ 3 mm/m => 90 mils (average of both layers)

Do we want to introduce an even greater gap in coil 14 to get a new data point (1 pass cable)?