



Short models & long magnets quality control harmonization

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11T Dipole Collaring Task Force Meeting
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CERN

Summary on agreed actions for winding

Spooling

- Definition of respooling parameters (speed, torque, break)
- Calibration of spooling parameters
- QA hold point after respooling – spool identification and control by QA officer
- Process safety & lab coat, overshoes, gloves

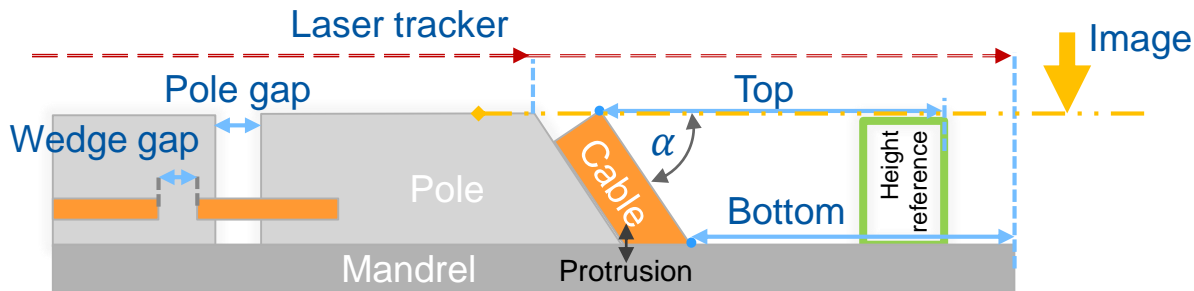
Winding

- Defined tightening torque on pole screws
- Gap measurement (Protrusion between cable and mandrel)
- Measurement from mandrel reference surface to the top pole
- QA hold points for QC
- Vector – consistent naming convention should be used to define coil positions (jump side etc.)

Geometrical QC MQXFB CR107

Additional geometrical measurements performed during MQXFB CR107 coil production.

Symbol	Device	Layer	Section	Description	W Inner			C Inner			W Outer			C Outer			R		I
					B	D	A	B	A	B	D	A	B	A	B	A	A		
Gp	Caliper	Inner	Straight	Total Gap between poles	x		x	x	x										
Gw	Caliper	Inner	Straight	Total Gap between wedges			x												
Db	Depth gauge	Inner	Head	Bottom distance i-th cable		x													
Dt	Depth gauge	Inner	Head	Top distance i-th cable		+													
P	Wedge	Inner	Head	Protrusion i-th cable		+													
It	Image	Inner	Head	Top position i-th cable			+	+	+										
Gp	Caliper	Outer	Straight	Total Gap between poles						x		x	x	x	x	x			
Gw	Caliper	Outer	Straight	Total Gap between wedges							x								
Lp	Laser Tracker	Outer	Straight	Pole length														x	
Db	Depth gauge	Outer	Head	Bottom distance i-th cable							x								
Dt	Depth gauge	Outer	Head	Top distance i-th cable							+								
P	Wedge	Outer	Head	Protrusion i-th cable							+								
It	Image	Outer	Head	Top position i-th cable								+	+	+	+	+			
Lc	Laser Tracker	Both	Coil	Coil length														x	



x	present in procedure
	not present
+	started with CR107

Curing procedure comparison

- Reference procedures

927	<u>Vector</u>
180	<u>EDMS (1427781)</u>

Importance

Small	Medium	Significant
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Category	927	180	Comment
Procedure	Ceramic binder 3-component CTD-1202X	Ceramic binder 2-component CTD-1202 (EDMS: 1556624)	Reason given by the supplier ?
	25g of ceramic binder used on the coil head	21.3g of ceramic binder used on the coil head. On the straight section 263g	Different amount of binder
	Curing cycle: 1st plateau 80deg (1h), 2nd plateau 150deg (2h). The same for both layers	Curing cycle: 1st plateau 80deg (2h), 2nd plateau 160deg (3h). The same for both layers	According to CTD 1202 binder technical specification, the initial cure cycle should consist of: 1st plateau 80deg (for 1h), 2nd plateau 150deg (for 2h)
	Applied pressure of 100bar for inner layer curing, and 200bar for outer layer curing	Applied pressure is 80bar in the middle and 50bar at the extremities. The same pressure set for inner and outer layer curing	Different pressure and distribution between the labs
	Ensuring no gap between the top and bottom part of the curing mould	Ensuring no gap between the top and bottom part of the curing mould	No difference
	Pushers are vertically positioned with use of the screws	Pushers are vertically positioned with use of the lever	Different fastening method
	Pushers fixed consecutively in the direction of winding	Pushers fixed consecutively in the direction of winding	No difference

Curing procedure comparison

Category	927	180	Comment
Procedure	Order of closing half-shells (Straight, COC, CC) 	Order of closing half-shells (Straight, CC, COC) 	Different fastening order between the labs
	Order of opening half-shells (COC, Straight, CC) 	Order of opening half-shells (COC, CC, Straight) 	Different opening order between the labs
	Interlayer is held on the azimuthal extremities with the scotch tape	Interlayer is held on the azimuthal extremities with the screwed ~5cm long sheet of aluminium	
QA and safety	Measured pole gap before and after curing	Measured pole gap before and after curing	No difference
	Key to key distance measured	Key to key distance measured	
	n/a	Measured total gap between wedges	
	n/a	Distance between spacer holes before and after curing	
	Measured saddle to saddle length	Measured saddle to saddle length	No difference
	Binder is applied while wearing gloves and coat	Binder is applied while wearing gloves, coat and mask	According to CTD 1202 binder technical specification, the contact with eyes, skin and clothing should be avoided
Calliper measurement of the distance between the keys before and after releasing the central pole	End-poles are instrumented with the position comparators in order to record the relative displacement while releasing the central pole	Measured differently due to coil-length difference	

Conclusion

Proposal:

Organize a meeting in order to show the results from the additional measurements and conclusions.

Winding:

- Differences were identified and solutions proposed
- Additional measurements are required to verify the process repeatability (Protrusion and top pole measurement)

Curing:

- Differences mainly given by the fastening sequence and curing pressure
- Geometrical verification of the wedge and saddle gaps shall be added to the process of short model winding
- Analysis of RHT procedure is ongoing

Additional slides

Measurement nomenclature

State of the coil:

- Nominal (N)
- Winding Inner
 - Before (WIB)
 - During (WID)
 - After (WIA)
- Winding Outer
 - Before (WOB)
 - During (WOD)
 - After (WOA)
- Curing
 - Before (CB)
 - After (CA)
- Reaction
 - Before (RB)
 - After (RA)
- Impregnation
 - Before (IB)
 - After (IA)

Position of the coil:

- Inner Return (IR)
- Inner Lead (IL)
- Outer Return (OR)
- Outer Lead (OL)
- Jump Side (J)
- Opposite Jump Side (OJ)

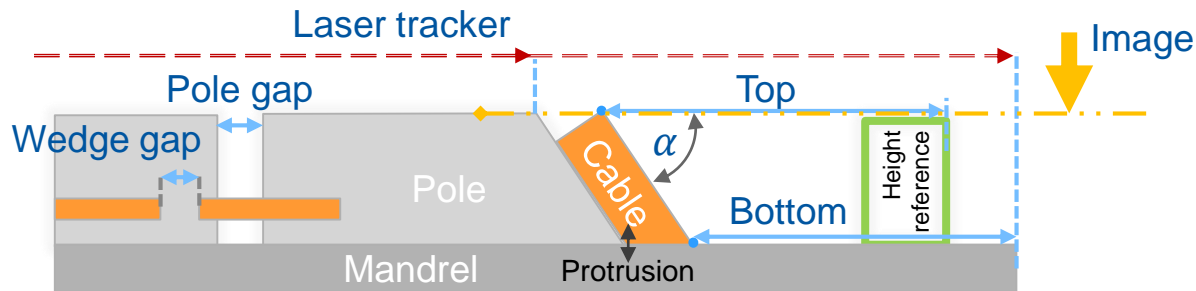
Example of measured value:

Value_{State_Position} e.g. B_{WOD_OR}

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Gw	Caliper	Inner	Straight	Total Gap between wedges			x												
Db	Depth gauge	Inner	Head	Bottom distance i-th cable		x													
Dt	Depth gauge	Inner	Head	Top distance i-th cable		+													
P	Wedge	Inner	Head	Protrusion i-th cable		+													
It	Image	Inner	Head	Top position i-th cable			+	+	+										
Gp	Caliper	Outer	Straight	Total Gap between poles						x		x	x	x	x	x			
Gw	Caliper	Outer	Straight	Total Gap between wedges								x							
Lp	Laser Tracker	Outer	Straight	Pole length														x	
Db	Depth gauge	Outer	Head	Bottom distance i-th cable							x								
Dt	Depth gauge	Outer	Head	Top distance i-th cable							+								
P	Wedge	Outer	Head	Protrusion i-th cable							+								
It	Image	Outer	Head	Top position i-th cable								+	+	+	+	+			
Lc	Laser Tracker	Both	Coil	Coil length														x	



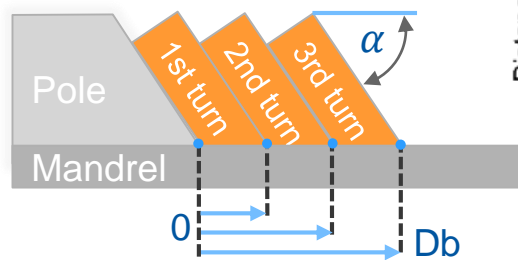
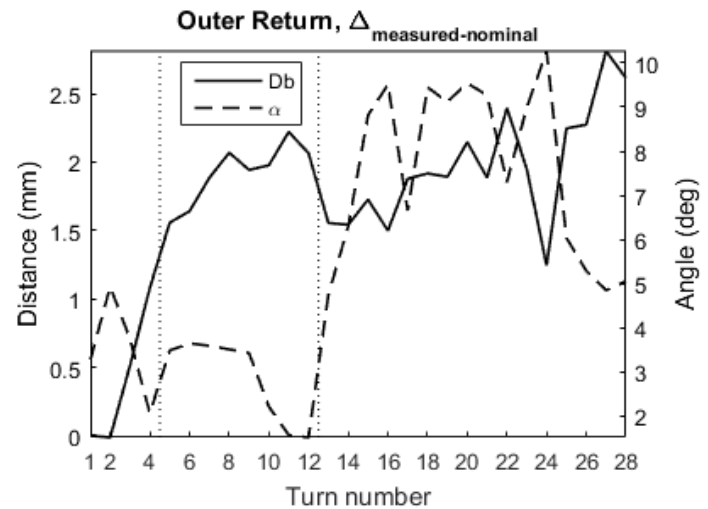
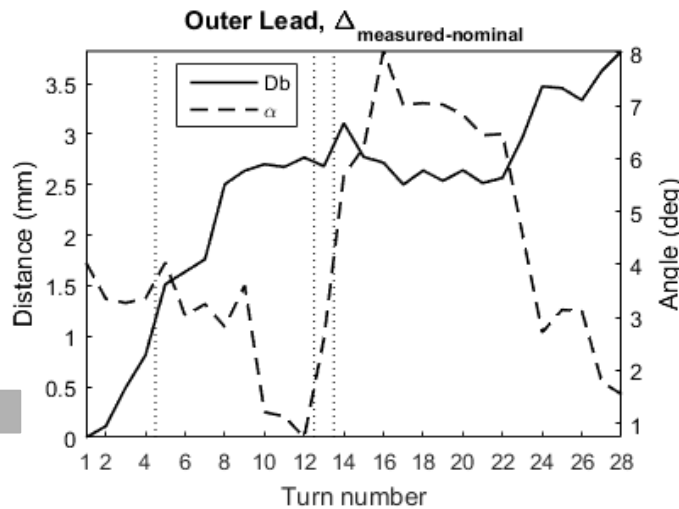
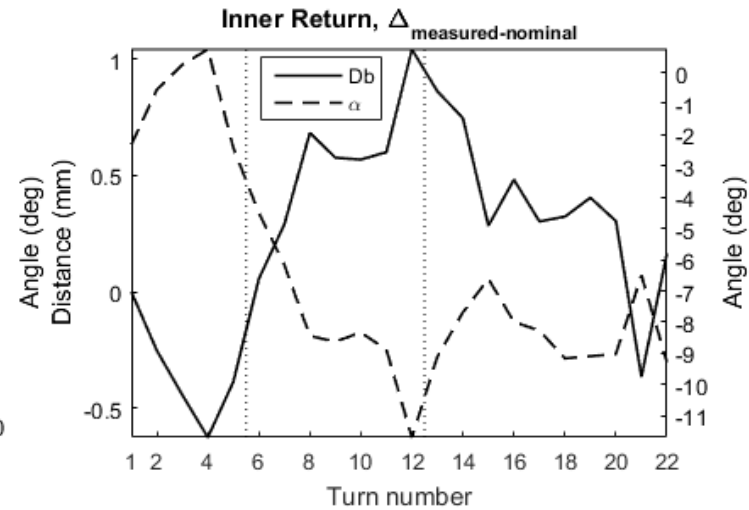
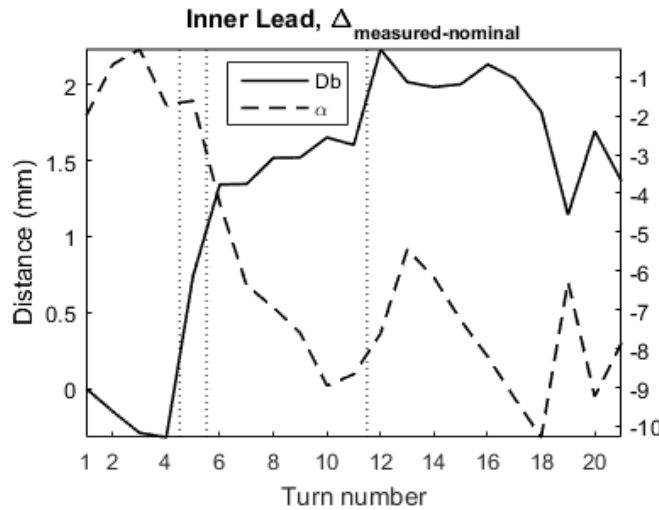
x	present in procedure
	not present
+	started with CR107

Bottom position deviation from nominal during winding

Difference between values measured during winding and nominal:

- bottom distance D_b
- computed angle α

Spacer position marked with dotted line.



Protrusion measurement during winding

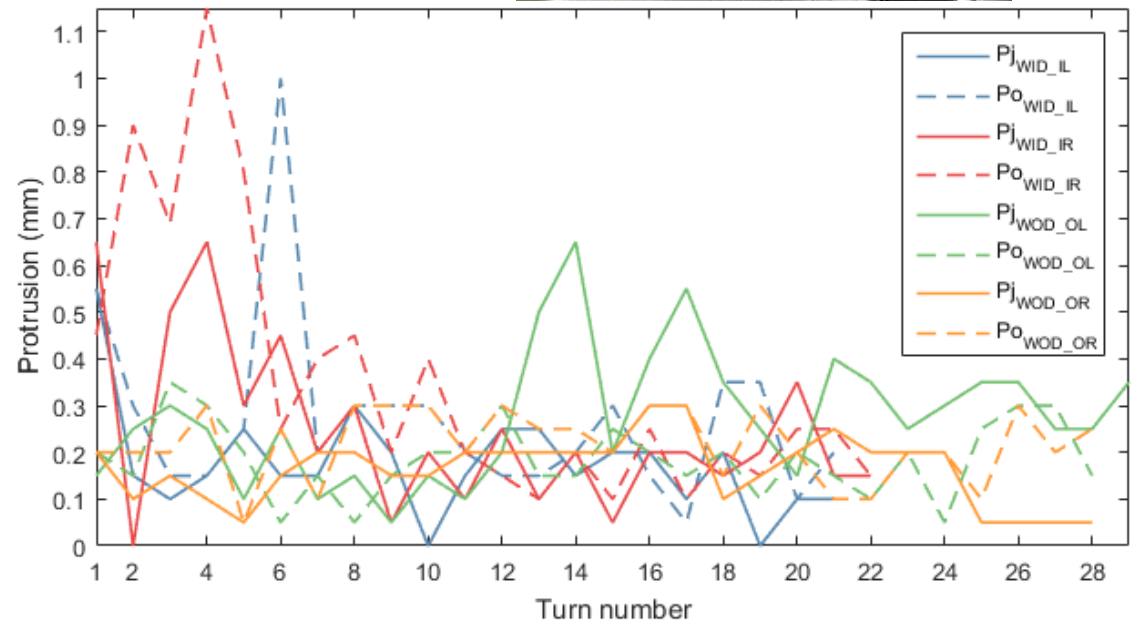
Distance from mandrel measured with the wedge gauge during winding, on the:

- jump side: P_j
- opposite jump side: P_o



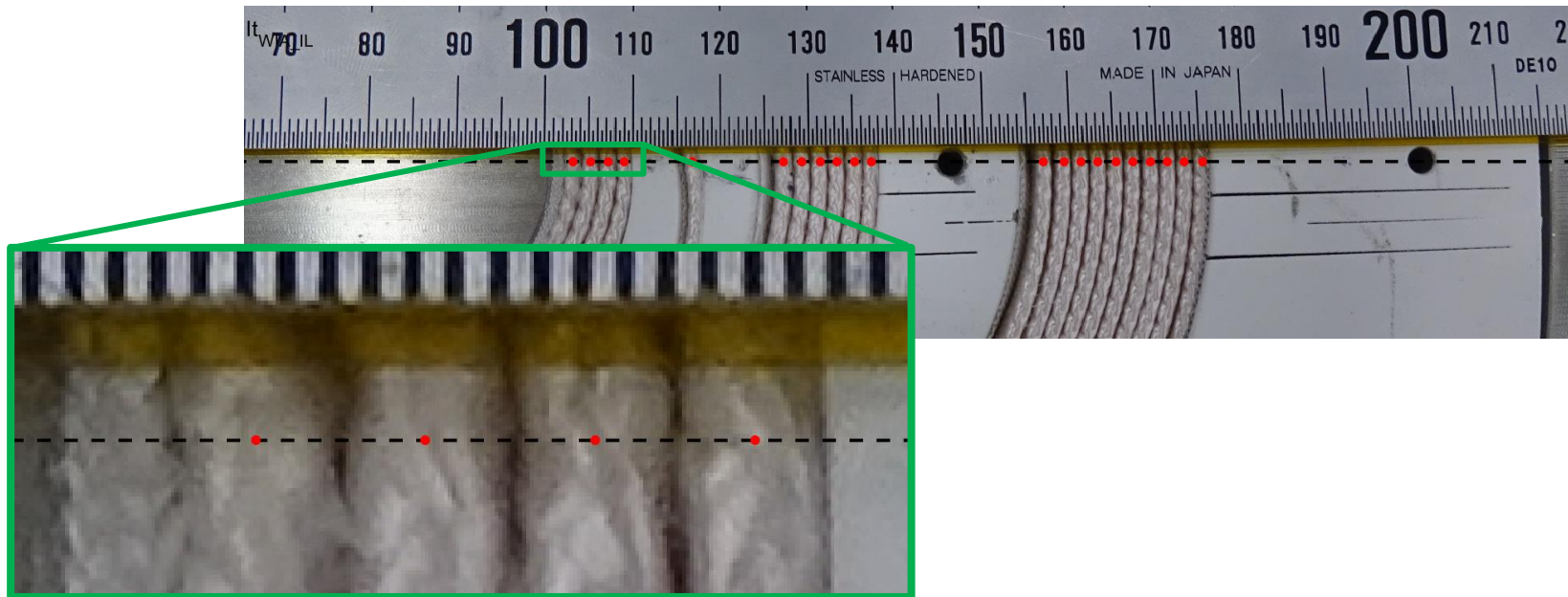
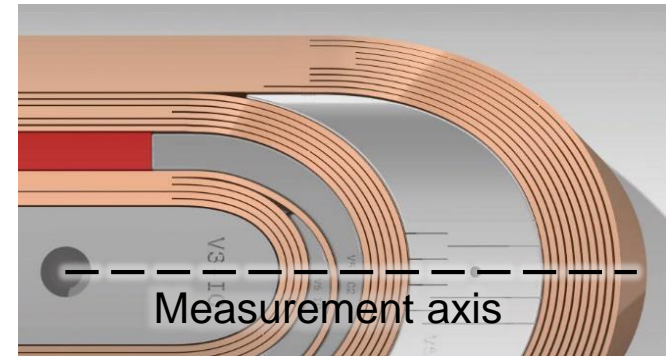
		Sum (mm)	Avg (mm)
IL	P_j	3.70	0.18
	P_o	5.70	0.27
IR	P_j	5.40	0.25
	P_o	7.79	0.35
OL	P_j	7.95	0.27
	P_o	5.20	0.19
OR	P_j	4.55	0.16
	P_o	6.10	0.22

winding direction



Cable position after winding and curing

Measuring the position of the cable in the longitudinal axis after winding and curing with use of image analysis.



Turn position deviation on the coil head

Difference from nominal:

- During winding (measured with depth gauge)
- After winding (image analysis)
- After curing (image analysis)

Spacer position marked with dotted line.

