

Harmonization of Curing and Reaction Heat Treatment procedures of 11 T

in MDT and LMF sections

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Outline

- Curing procedure comparison
- RHT procedure comparison
 - Reaction fixture assembly
 - Mold tightening order
 - Additional comments
- Conclusion

Curing procedure comparison

- Reference procedures

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

Importance

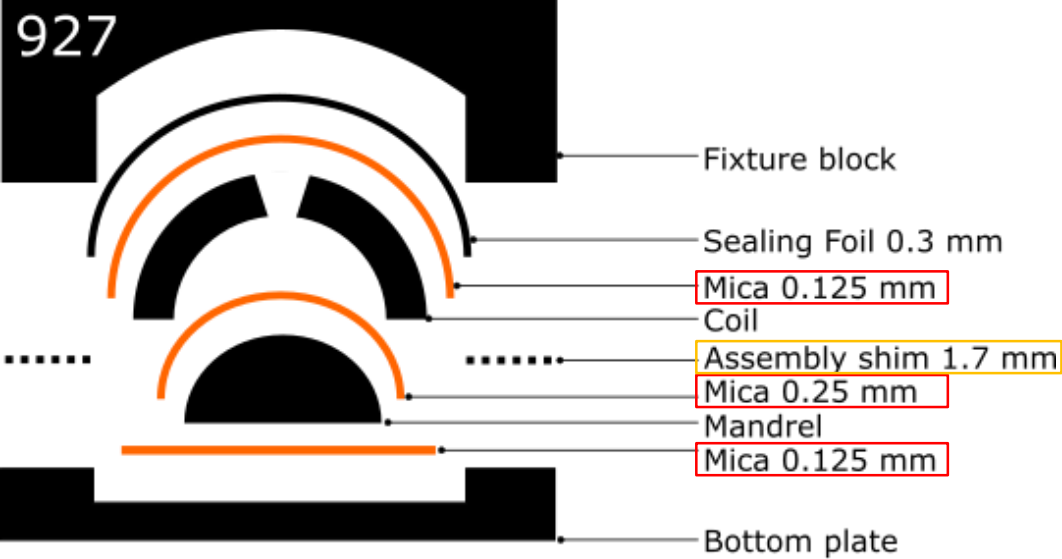
Small	Medium	Significant
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Category	927	180	Comment
Procedure	Ceramic binder 3-component CTD-1202X	Ceramic binder 2-component CTD-1202 (EDMS: 1556624)	Reason given by the supplier ?
	25g of ceramic binder used on the coil head	21.3g of ceramic binder 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

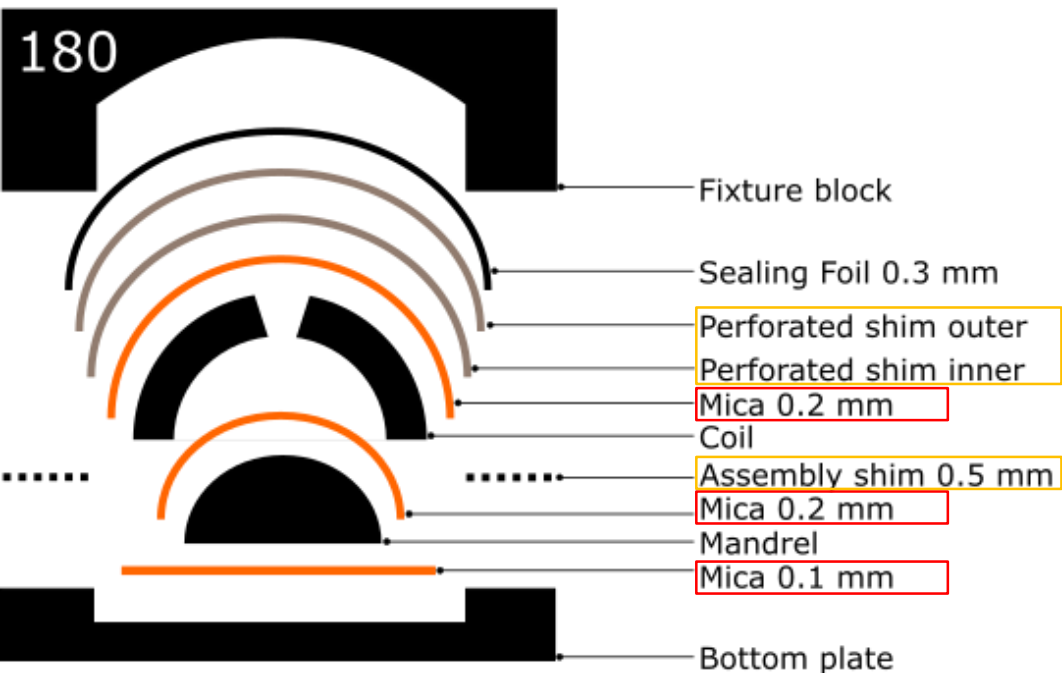
Curing procedure comparison

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

927



180

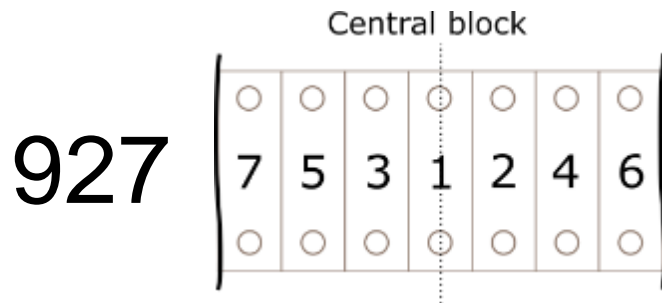
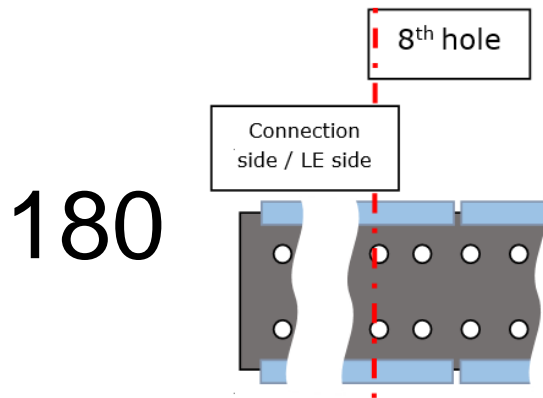


RHT

Schematic cross section of the reaction fixture assemblies in b.927 and b.180

1. Individual thickness of the Mica layers is different (total thickness equals 5 mm)
2. Assembly shim of different thickness (0.5 and 1.7 mm)
3. Two perforated shims are used in b.180

Reaction fixture tightening (and opening) order



- In 180 bolts are tightened starting from 8th screw (~above the layer jump), than consecutive towards COC, than CC.
- In 927 bolts are tightened starting from the central block, than consecutively one bolt per side (COC, CC, COC, CC, etc.).
- Performed in 3 steps until closure of a mold.
- Final tightening torque is not stated in the procedures.

RHT summary

Importance Small Medium Significant

927	180	Comment
Difference in shimming plan of the coil		<ul style="list-style-type: none"> • Individual thickness of the Mica layers is different • Assembly shim of different thickness is used • Two perforated shims are used in b.180
Difference in tightening (and opening) order		May result in coil geometry variations (following the experience in 180)
Leeds are protected with 0.125 mm of Mica, bottom and top	Leeds are protected with 0.1 mm of Mica, bottom and top	Different Mica thickness
Side bars ('regle') are slid in after pre-tightening of the top plate	Side bars ('regle') are put after positioning a Mica layer on top of a coil	Different assembly order
No cable support during removal of a steel core	During removal of a steel core, the cable is secured with a Delrin clamps	Risk of damaging the cable
Insulation layers should be clearly marked (or numbered) in the procedure in form of a list, allowing to easily determine their final position and thickness		Suggestions
CDD number of the main assembly and crucial elements should be included in the procedure in form of a list		

Conclusion on Curing

Measurements added

Requiring further verification

Clarified points

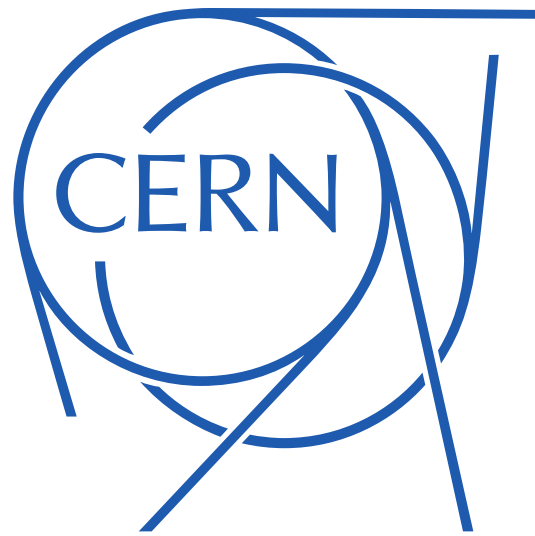
- a. Details of the CTD-1202X and CTD-1202 ceramic binder will be clarified by Andrea Musso.
- b. Amount of ceramic binder put in the coil head region should be clarified.
- c. Curing cycle in 180 is longer in order to ensure the correct pre-curing and compensate for the larger thermal inertia than short coil.
- d. Load is taken by tooling, higher pressure is better for press in 927 (control system). Differences in a cavity size needs to be double check.
- e. Closing and opening sequence is considered insignificant and stays not modified.
- f. Measurement of total gap between wedges after curing will be added in 927 procedure.
- g. Measurement of distance between spacer holes before and after curing will be added in 927 procedure.
- h. Mask while applying ceramic binder will be considered in 927.

Conclusion on RHT

Immediate action for #120 11T
Measurements added
Requiring further verification
Clarified points

- a. Mica thickness and assembly shim differences are a result of a design differences and will be maintained unchanged.
- b. Pre-tightening and final closing of a reaction mold is considered giving negligible effect on coil geometry, therefore will be maintained unchanged.
- c. Opening of the reaction mould will be performed from the COC (opposite connection side) consecutively towards CC (connection side). Additionally, the dial gauges will be positioned on the coil extremity in order to measure the longitudinal expansion of the inner and outer layer of the coil during the opening. This includes opening of the #120 11T short model.
- d. The amount of Mica layers insulating leads should be clarify in the procedure.
- e. Different assembly order of side pushers ('regle') is due to differences in the mould design.
- f. During the leads preparation, i.e. cutting of the cable core, the mechanical support will be considered in 927 procedure, as shown in p.6.6 in 180 procedure.
- g. The shimming plan summary should be given in the procedure.
- h. The CDD numbers of assemblies and drawings should be included in form of a list in the procedure.
- i. Measurement of total gap between wedges after curing will be added in 927 procedure.
- j. Measurement of distance between spacer holes before and after curing will be added in 927 procedure.

Thank you



Regle



Picture from 180 Reaction procedure

Additional coil measurements

QC for winding and curing

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)

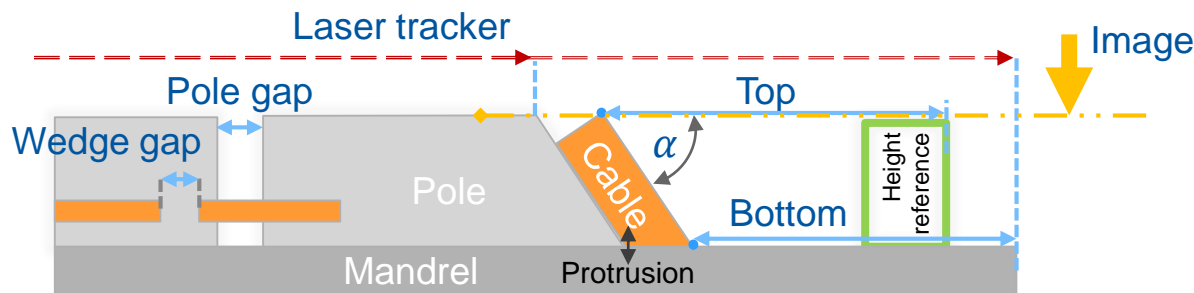
Example of measured value:

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

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



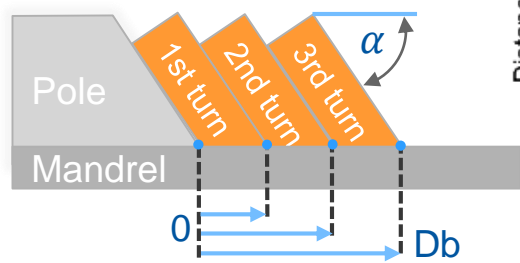
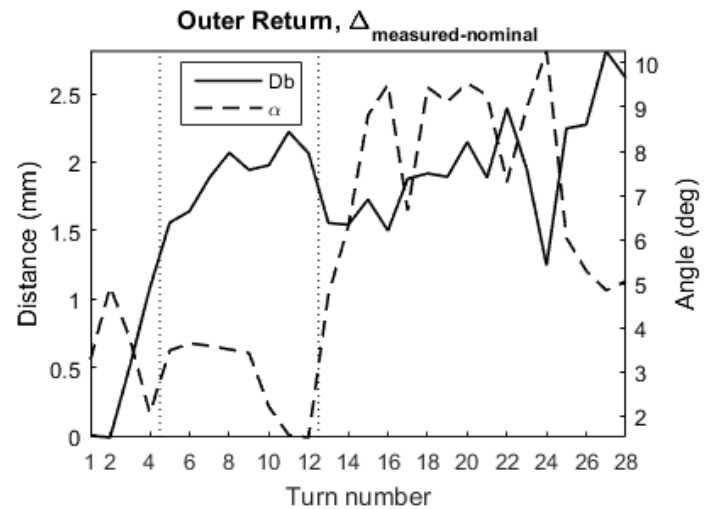
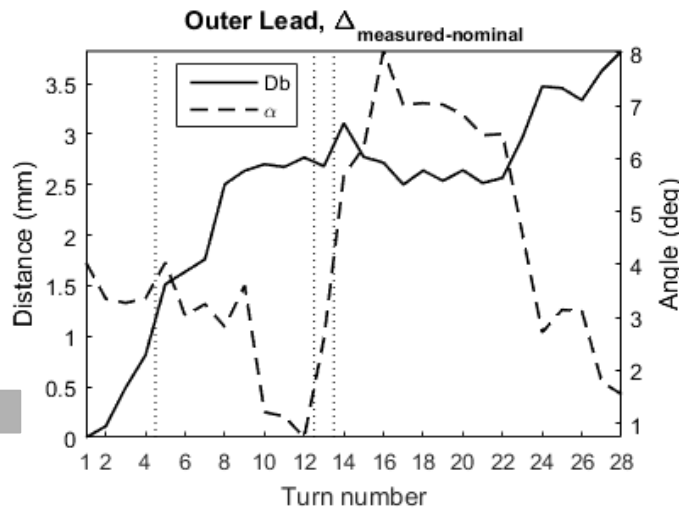
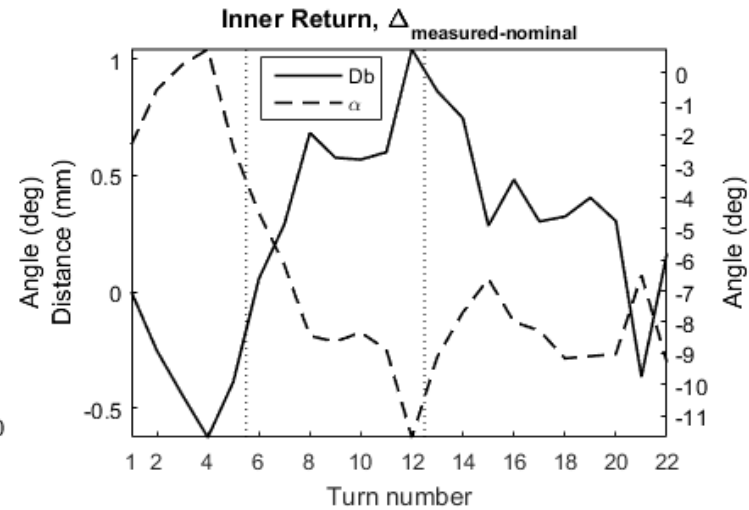
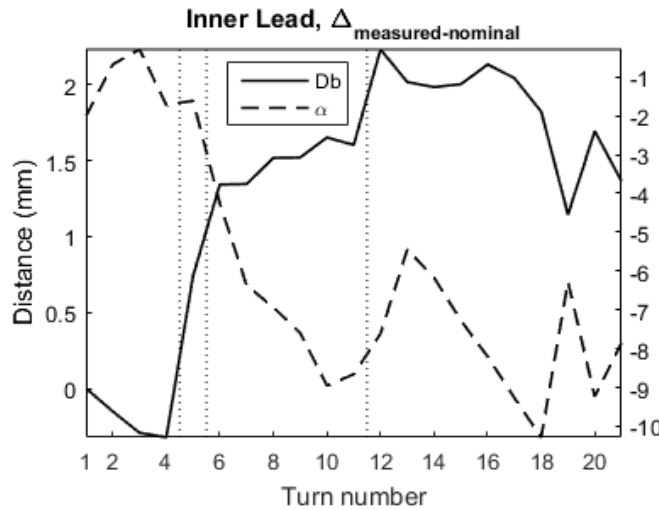
x	present in procedure
	not present
+	started with CR107

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

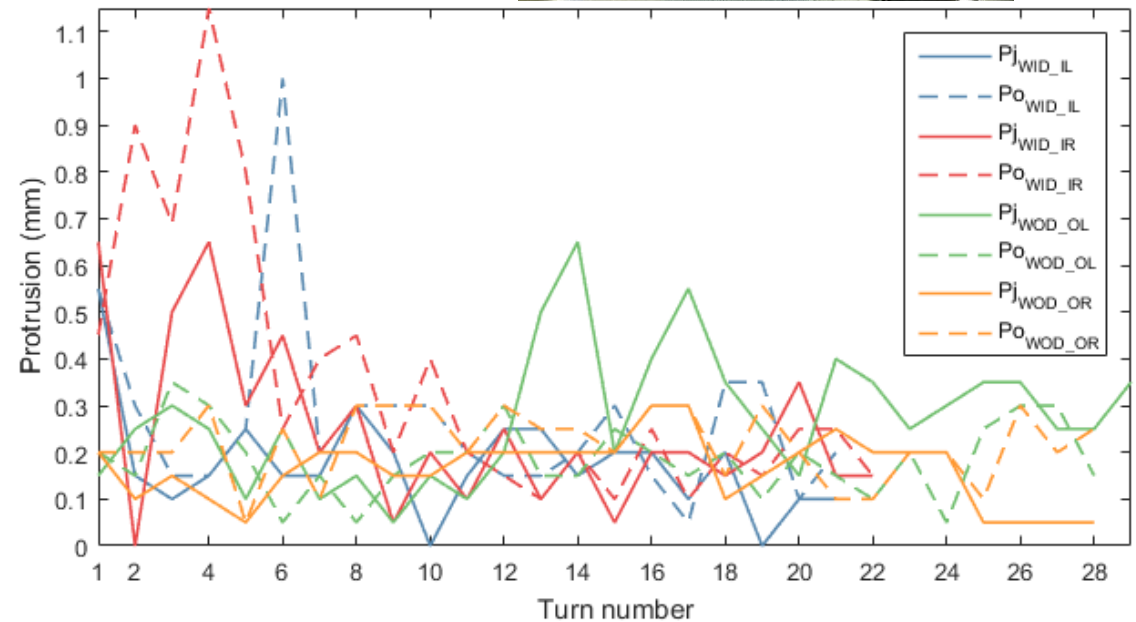
Distance from mandrel measured with the wedge gauge during winding, on the:

- jump side: P_j
- opposite jump side: P_o



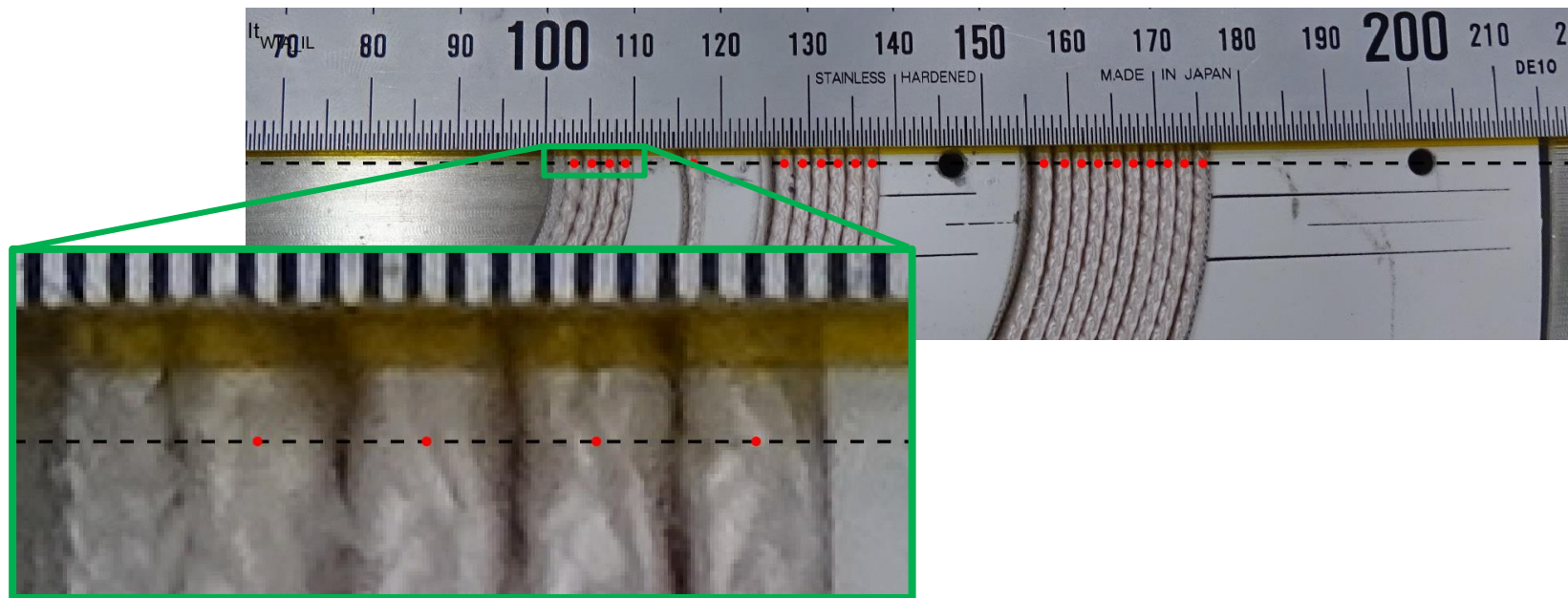
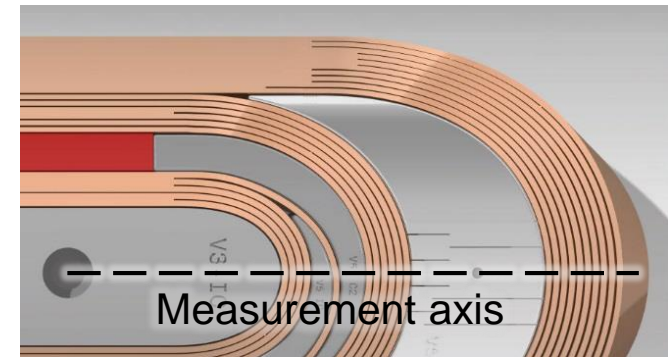
		Sum (mm)	Avg (mm)
IL	P_j	3.70	0.18
	P_o	5.70	0.27
IR	P_j	5.40	0.25
	P_o	7.79	0.35
OL	P_j	7.95	0.27
	P_o	5.20	0.19
OR	P_j	4.55	0.16
	P_o	6.10	0.22

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.

