A.Porhiel – 14th March 2013

JLAB – UBS n°15 – test report

Objectives

- Determination of Young's Modulus and Yield Strength in traction in axial direction.
- Determination of Young's Modulus and Yield Strength in compression in radial direction.
- Determination of the Shear Stress between Stainless Steel spacers and the coil pack (sandblasted surface).
- Preparation of samples for tests in CEA Saclay at 77K.

Summary of Test Results

- According to these tests and the previous one, the following values can be taken for the orthotropic modelization of the coil **at room temperature**:

Direction	Young's Modulus (Gpa)	Yield Strength (Mpa)
Azimuthal	20	100
Radial	20	100
Axial	160	130

- There is no difference of mechanical properties in radial and axial directions between consolidation at 2,95mm and at 3mm. Yield Strength and Young's modulus are slightly better in azimuthal direction with the conductor consolidated at 2,95mm.
- There is no significant difference of Young's modulus in traction in axial direction between bare conductors and vacuum impregnated stacks of ten layers. Consequently the characterization in axial direction for each reel used for the dipole manufacturing can be performed on bare conductor.
- The shear stress between the coil and stainless steel spacers is 19 MPa with sandblasted spacers. This value is generally inferior to the shear stress observed between coil and stainless steel spacers in the ANSYS simulation. Consequently it can be assumed that there is sliding between coil and stainless steel spacers and we suppose that the coefficient of friction is 0,2.

Future tests

- For each reel used for the dipole manufacturing:
  - Consolidation of 5 meters at 2,95mm.
  - Dimensions (width and thickness with micrometer) before and after consolidation.
  - 3 traction tests on bare conductor.
  - 3 compression tests in azimuthal direction.
- Shear stress between the coil and G11 spacers.

Samples Preparation

- Manufacturing of several assemblies:

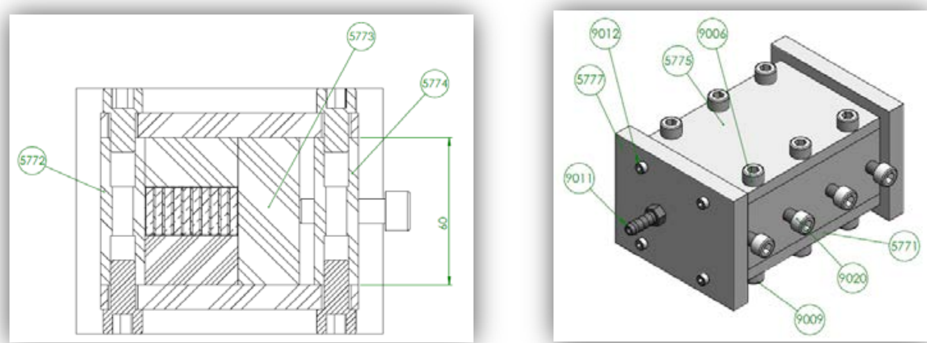


Figure 1: Mold for vacuum impregnation of bigger samples

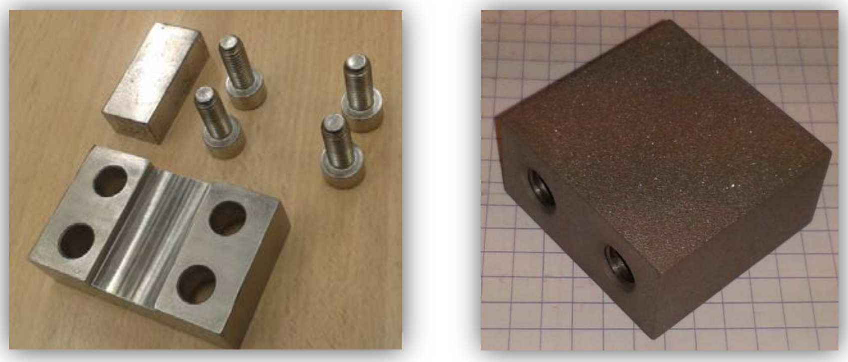


Figure 2: fixture system and sandblasted stainless steel parts for shear test

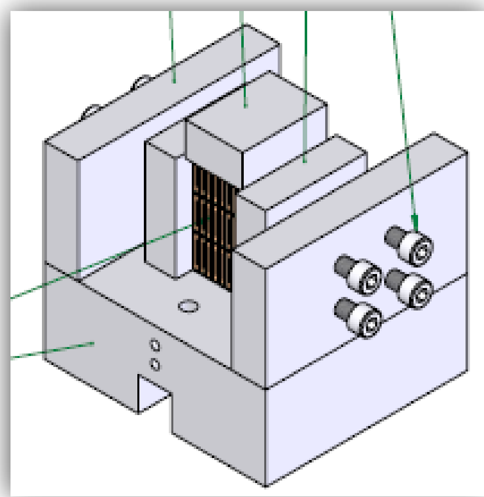


Figure 3: fixture system for compression test in radial direction

- Consolidating of **<u>14 meters</u>** at 2.95mm and **<u>12 meters</u>** at 3mm with the temporary consolidation press.

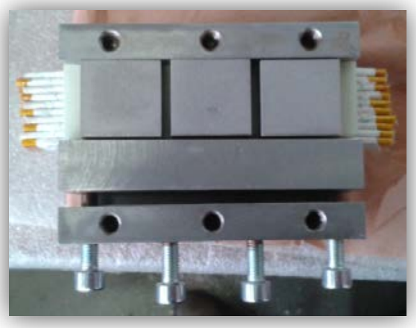
- Preparation of samples for traction tests:
    - Wrapping of 200mm bare conductors at half-covering (wrap thickness = 0.2mm)
    - For each value of consolidation (2,95mm – 3mm):
        - Precompression of the conductor thanks to screws at 20 MPa (30 N.m)
        - Etancheity & molding: *See molding process (David RAMAUGE, 13/02/14)*

Figure 4: traction samples after test

- Preparation of samples for compression test in radial direction:
    - Wrapping of 200mm bare conductors at half-covering (wrap thickness = 0.2mm)
    - For each value of consolidation (2,95mm – 3mm):
        - Disposition of three stages of conductor, each one is composed of ten layers.
        - Precompression of the conductor thanks to screws at 10 MPa (45 N.m)
        - Etancheity & molding: *See molding process (David RAMAUGE, 13/02/14)*
        - Cutting samples at 40mm.

Figure 5: sample for radial compression before test

- Preparation of samples for shear test:
    - Wrapping of 200mm bare conductors at half-covering (wrap thickness = 0.2mm)
    - Disposition of three stainless steel blocks separated thanks to G11 wedges.
    - Disposition of ten layers of conductor consolidated at 2,95mm.
    - Disposition of three other stainless steel sandblasted blocks.
    - Etancheity & molding: *See molding process (David RAMAUGE, 13/02/14)*
    - Cutting samples at 40mm: the junction between the coil and spacers is not damaged thanks to a slow cutting.



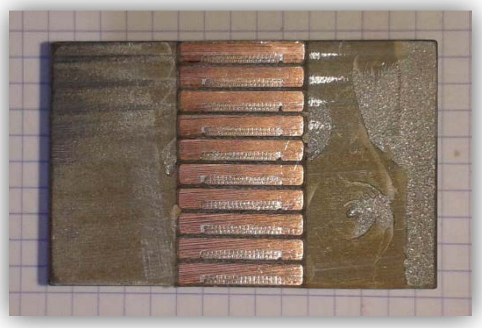


Figure 6: preparation of three samples for shear test

Designation of samples

Samples	Consolidation (mm)	Precompression (Mpa)	Test
Sample 15-11	2,95	20	Traction test at RT
Sample 15-12	2,95	20	Traction test at RT
Sample 15-13	2,95	20	Traction test at RT
Sample 15-21	3,00	20	Traction test at RT
Sample 15-22	3,00	20	Traction test at RT
Sample 15-23	3,00	20	Traction test at RT
Sample 15-31	2,95	10	Radial Compression at RT
Sample 15-32	2,95	10	Radial Compression at RT
Sample 15-33	2,95	10	Radial Compression at 77K
Sample 15-41	3,00	10	Radial Compression at RT
Sample 15-42	3,00	10	Radial Compression at RT
Sample 15-43	3,00	10	Radial Compression at 77K
Sample 15-51	2,95	0	Shear test at RT
Sample 15-52	2,95	0	Shear test at RT (with ARAMIS)
Sample 15-53	2,95	0	Shear test at 77K
Sample 15-61	2,95	-	Traction test on bare conductor
Sample 15-62	2,95	-	Traction test on bare conductor
Sample 15-63	2,95	-	Traction test on bare conductor

Tests performed

- **<u>Traction test at room temperature on bare conductor:</u>**

Figure 7: traction test on bare conductor consolidated at 2,95mm

- **<u>Traction test at room temperature on impregnated samples:</u>**

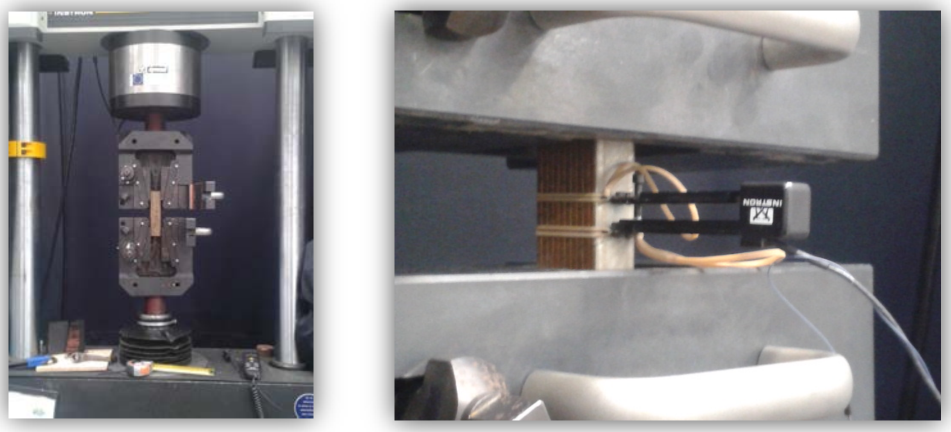
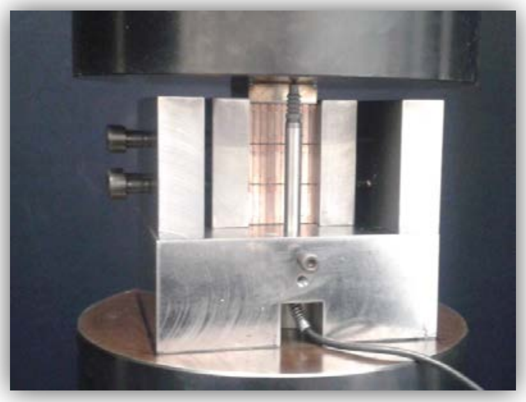


Figure 8: measurement of the deformation with an extensometer

- **<u>Compression test in radial direction at Room Temperature:</u>**

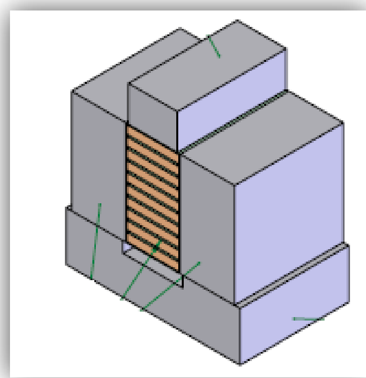
Samples for radial compression are positioned as shown on the following figure and the eight screws are tightened at 3 N.m in order to be in the same configuration for all tests. The following load/unload cycle is applied on samples. After loading the force comes back to 0kN.

- 80 MPa (112 kN)
- 100 MPa (140 kN)
- 120 MPa (168 kN)
- 140 MPa (196 kN)
- 160 MPa (224 kN)



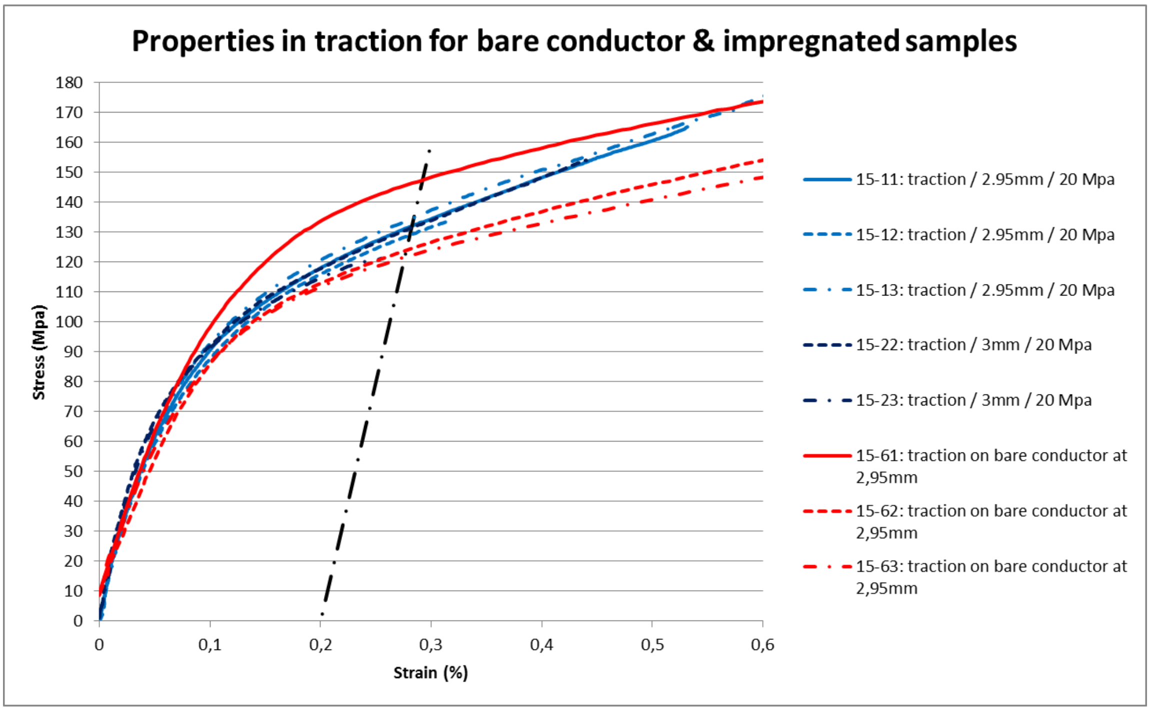
- **<u>Shear test at room temperature:</u>**

The objective of the shear test is to determine the maximum allowable shear stress between the coil and stainless steel spacers. 304L parts are sandblasted in order to have a better fixation with the resin.

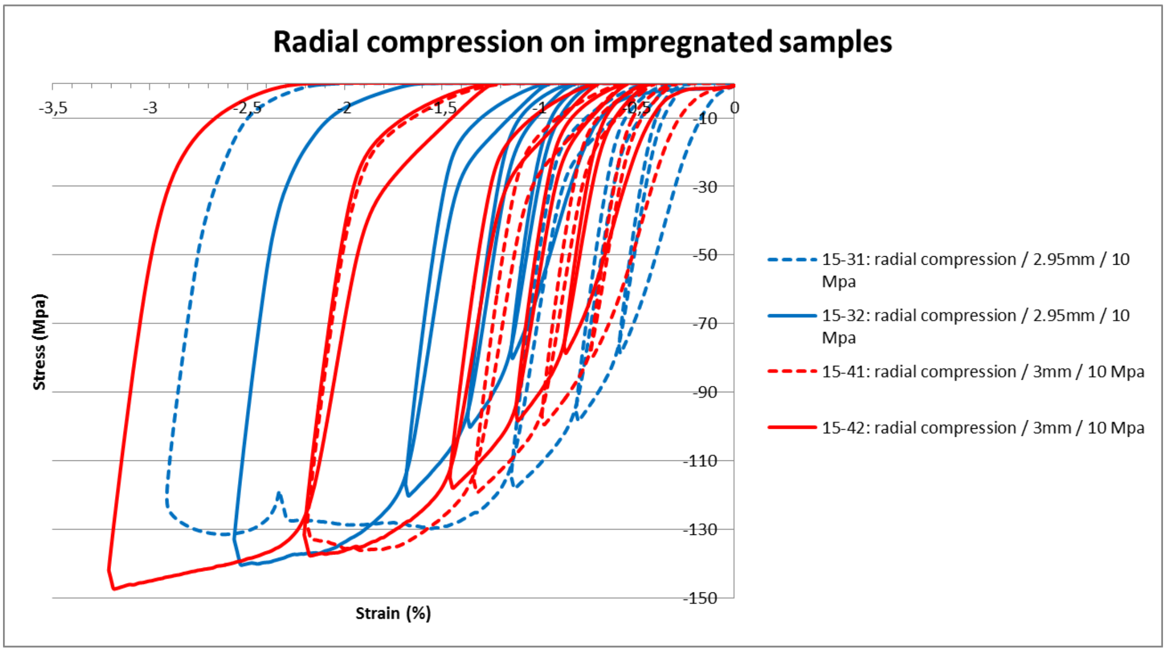


Results

- **Mechanical properties in traction:**
  - There is no difference of mechanical behavior between consolidation at 2.95 mm and at 3mm.
  - The Young's Modulus of the coil pack is 160 GPa and the Yield Strength is 130 MPa.
  - There is no significant difference between results for bare conductor and for impregnated samples. Consequently the characterization of each reel for the dipole manufacturing can be performed on bare conductor.



- **Mechanical properties in radial direction:**



- There is no difference of mechanical properties in radial direction between consolidation at 2,95mm and at 3mm.
- The initial lack of stiffness comes mainly from blocking the sides of the sample.
- The Young's Modulus in compression in radial direction is 20 GPa and the Yield Strength is 100 MPa.
- Buckling of samples clearly appears at 130 MPa. Consequently it's important to never reach this value:

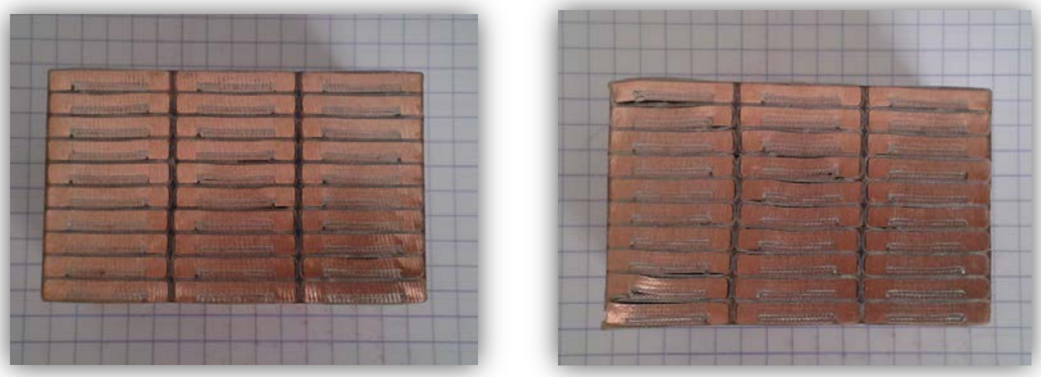


Figure 9: Samples 15-41 & 15-42 after compression test in radial direction

- **Shear test between coil & stainless steel sandblasted spacers:**
  The shear stress which separates the coil from stainless steel spacers is 19 MPa. This value is generally inferior to the shear stress observed between coil and stainless steel spacers in the ANSYS simulation. Consequently it can be assumed that there is sliding between coil and stainless steel spacers and we suppose that the coefficient of friction is 0,2.

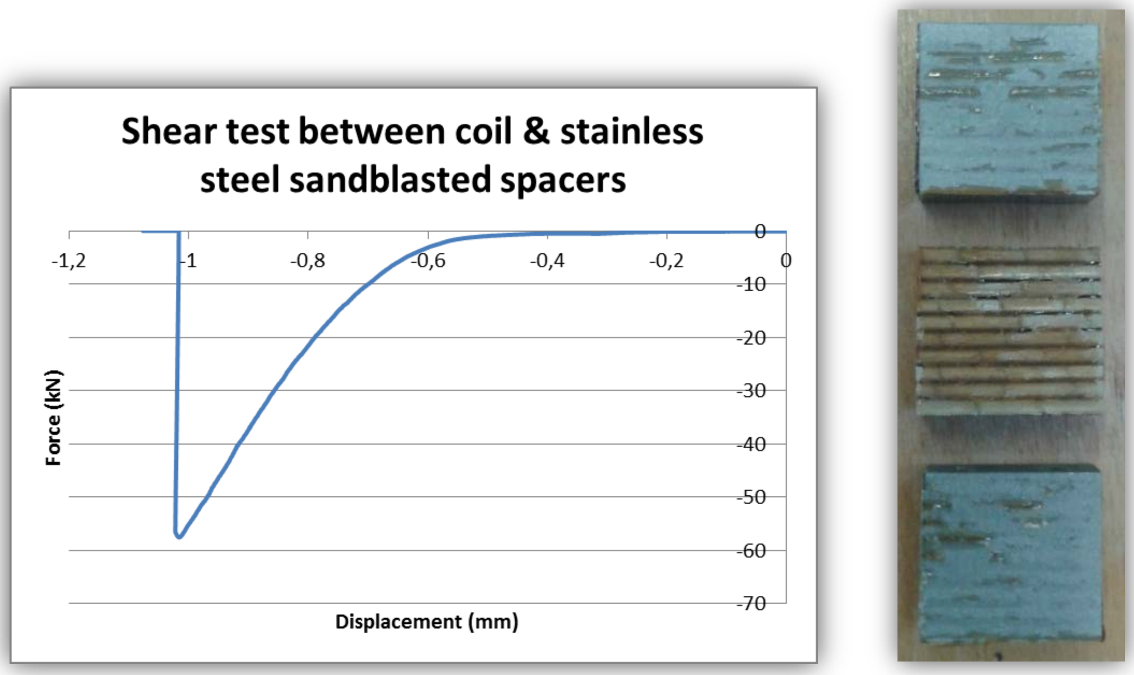


Figure 10: resin on stainless steel blocks after shear test