COMPLETION OF THE FRENCH JT-60SA TOROIDAL FIELD MAGNET CONTRIBUTION

Wed-Af-Po3.02-10

P. Decool[1], G.Gros[1], G. Jiolat[1], J.L. Marechal[1], A.Torre[1], J.C. Vallet[1], M. Nusbaum[2], G. Billotte[2], B. Crepel[2], A. Bourquard[2], S. Davis[3] , E. Di Pietro[3]

(1) CEA, IRFM, F-13108 Saint Paul-lez-Durance, France
(2) General Electric, Belfort, France
(3) Fusion for Energy, Garching, Germany

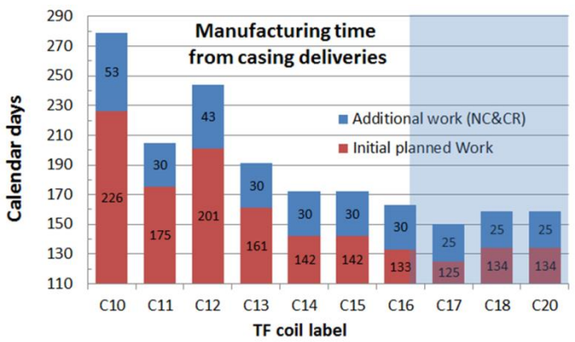
Introduction

The JT-60SA toroidal field coils (TF) magnet procurement is a part of the broader approach (BA) agreement. After preliminary and detailed design studies as French voluntary contributor, CEA has contracted in July 2011 with Alstom (now GE) for the manufacture of 9 + 1 winding and its integration in the casing. The conductors, as well as the casing being free components provided by F4E. The different production phases as well as the manufacturing status and achieved schedule are presented . A focus on the main issues during the qualification as well as production phases is made.

Global work execution and status

Workshop organization in 12 Workstations: global target < 40 days/ WSt

Phase 1: 07/2011 to 02/2012	Phase 2: 01/2012 to 12/2013	Phase 3: 01/2014 to end 2017?
manufacturing drawing Manufacturing process according PBS Tooling definition Workshop organization	Processes qualification Tooling procurement QA documentation definition	Coils production • 7 coils validated • 3 coils at final manufacturing stage

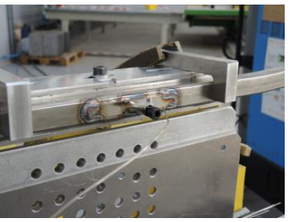


Planning mainly driven by casing elements delivery

Important impact of additional requirement and NCs on delivered components (conductor, casing) w. r. t. initial specification

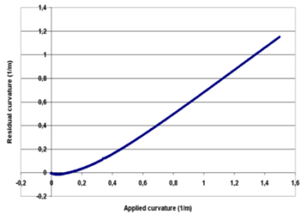
Main qualification phase issues

Conductor insulation shear strength
40 MPa and 20 MPa x 36000 cycles
Particular preparation highlighted



Helium inlets
Stress release

Winding
Full elastic-plastic conductor characterization
D shape reference and clamping needed



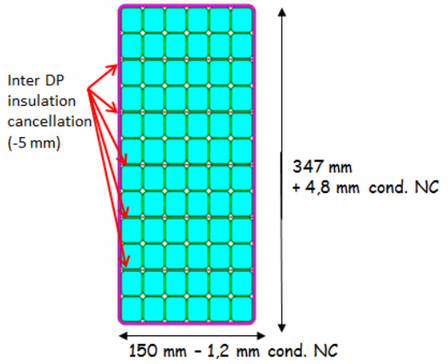
Casing welding
Welding process qualification
100% UT checks on relevant defects and geometry

Impregnation
Resin injection

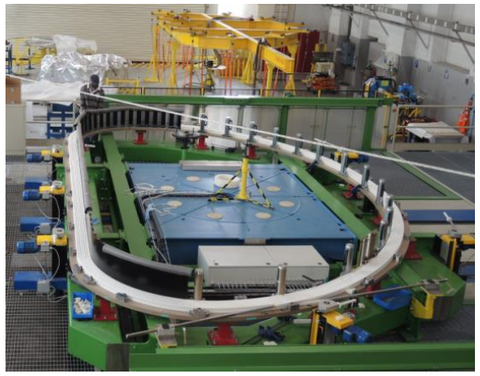
Production phase issues

Conductor cross section
NC on delivered conductor spools
+ successive straightening and bending (unspooling, straightening, bending)

26 x 22 ±0.1 mm theoretical
to 26.4 x 21.8 ±0.1 mm



DPs winding



Pancakes D shape:
use of continuous inner references and outer clamping system

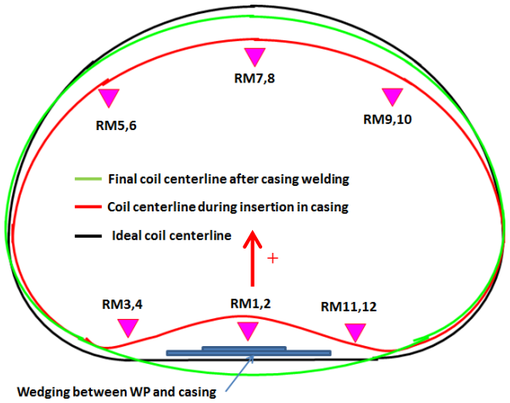
Induce WP cross section deformation of trapezoidal shape

Local defect at transition between smaller radius and straight part

Software bending anticipation
+ strong clamping
+ local additional ins.

Integration in casing

Coil n°	Counter bending applied	Final straight leg bending
10	0.5	-2.39
11	1.1	-2.75
12	2.8	-0.42
13	2.9	-2.01
14	2.7	0.53
15	3.4	-0.44
16	4.1	0.33
17	3.6	t.b.c.
18		t.b.c.
20	4.1	t.b.c.



Conclusion

The procurement of the 9 + 1 French JT-60SA TF coils is done by GE and followed by CEA.

After preparation and qualifications phases, the coils production should be completed end 2017.

7 coils are already delivered and installed in the tokamak and 3 remaining coils at final stage of manufacturing.

The coils production planning is driven by casing elements delivery. The learning curve demonstrate a reduction from 280 calendar days for the first coil to a nearly stabilized time of about 170 days after the 4th coil.

The qualification phase demonstrate the need for a strong qualification program helping identification of unforeseen issues and limiting the associated risks.

During production, unexpected issues linked to the winding operation of large D shaped coils and integration of the WPs inside their casing were experienced.

Finally, all these issues were successfully faced by GE team, thanks to their business and technical agility helped by strong CEA support. The JT-60SA French TF Coils manufacture is now near to be completed and the 10 coils set should be delivered without further significant delay and fully compliant with the requested performances.