Completion of ENEA’s procurement for 9 TF coils of JT-60SA tokamak

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Contract between ENEA and ASG Superconductors for the supply of 9+1 TF coils of JT-60SA

KOM 20/09/2011

Completion within May 2018

I = 25.7 kA
B = 5.65 T (2.25 T on plasma axis)
T_op = 4.4 K
L_hyd = 114 m
N_NbTi = 324
N_Cu = 162
Mdot = 4 g/s

M_WP = 6400 kg
M_case = 9400 kg
M_coil = 15800 kg
M_frame = 8000 kg
M_tot = 23800 kg

h_WP = 7.3 m
w_WP = 4.4 m
h_coil = 8.4 m
w_coil = 4.5 m
Contract phases

Phase 0 → engineering ~ 2 years
- Manufacturing drawings
- Tooling design procurement
- Qualification activity
- QA set-up (QCP, procedures)

Phase 1 → WP manufacturing ~ 2 years (~ 6 months per WP)
- Conductor testing
- DP winding
- DP Stacking (and joints insertion)
- VPI and curing
- Final acceptance test

Phase 2 → final integration ~ 2 years (~ 6 months per coil)
- WP insertion into casing
- Casing welding
- Embedding impregnation
- Mechanical final machining
- He cooling piping insertion
- Final acceptance tests

Afterwards:
- Cryogenic acceptance tests at CEA Saclay
- OIS preassembly at CEA Saclay
- Assembly in tokamak in NAKA
Phase 0: qualification activity on WP manufacturing

1. Shear strength of insulation
2. VPI Impregnation beam
3. He inlet welding and insulation
4. Electrical joint
5. dummy DP
Phase 0: qualification activity on TFC integration

1. Insertion
2. Transverse weld
3. Cover weld
4. Insertion
5. Embedding
6. Testing
Phase 1: WP manufacturing

1. CICC
2. Conductor testing
3. DP winding
4. DP Stacking
5. VPI Impregnation
6. WP finishing
7. WP Testing

- 6 months per WP
- 2 weeks per DP
Phase 1: management issues

WP manufacturing showed a sensible acceleration starting from WP-05 due to learning process and doubling of tooling to meet original schedule.
Phase 2: TFC integration

1. WP in tooling
2. WP insertion
3. Transverse welding
4. Cover welding
5. Embedding
6. Machining
7. Testing
Phase 2: management issues

TFC integration have been accelerated due to improvements in welding, machining and testing.

6 months per TFC from casing set reception
Phase 2: operations improvement

Calendar days per step of fabrication

<table>
<thead>
<tr>
<th>Production step</th>
<th>Calendar days</th>
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</thead>
<tbody>
<tr>
<td>Insertion &amp; Welding</td>
<td>100</td>
</tr>
<tr>
<td>Machining</td>
<td>150</td>
</tr>
<tr>
<td>Piping &amp; Testing</td>
<td>200</td>
</tr>
<tr>
<td>TOTAL</td>
<td>350</td>
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</tbody>
</table>

No. of weld defects per TFC

- TFC-01: TRANSVERSE 10, LONGITUDINAL 5
- TFC-02: TRANSVERSE 5, LONGITUDINAL 2
- TFC-03: TRANSVERSE 3, LONGITUDINAL 1
- TFC-04: TRANSVERSE 1, LONGITUDINAL 0
- TFC-05: TRANSVERSE 0, LONGITUDINAL 0
- TFC-06: TRANSVERSE 0, LONGITUDINAL 0
- TFC-07: TRANSVERSE 0, LONGITUDINAL 0
- TFC-08: TRANSVERSE 0, LONGITUDINAL 0
- TFC-09: TRANSVERSE 0, LONGITUDINAL 0
Glass transition temperature

Tg is a simple parameter to judge the quality of the embedding process. It is dependent on the cure schedule, then a tight temperature control during embedding is essential.

Product sheet of the epoxy employed provides a range 90-100 °C for Tg.
Dimensional issues: centerline deviation

Welding produce deformation on the coils that is visible also in terms of the deviation of the centerline of the straight leg from the nominal. Maximum error is below 0.1 %
Coil summary

- TFC-01
- TFC-03
- TFC-04
- TFC-05
- TFC-06

Coils already assembled in Japan

- TFC-07 at CTF: cryogenic test tbd
- TFC-08 at CTF: already tested

- TFC-09 to be shipped in Sept. to CTF
- TFC-19 casing will be received by ASG in Sept.: completion within 02/18
- TFC-02: will be completed within spring 2018
Thanks for the attention!