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Metrology for WEST components design and integration optimization

C. Brun*, G. Archambeau[1], L. Blanc[1], J. Bucalossi, M. Chantant, L. Gargiulo, A. Hermenier[2], R. Le, A. Pilia

CEA, IRFM, F-13108 Saint-Paul-lez-Durance, France

HIGHLIGHTS

- Metrology methods.
- Interests of metrology campaign to optimize margins by reducing uncertainties.
- Assembly problems are solved and validated on a numerical mock up.
- Post treatment of full 3DScan of the vacuum vessel.

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ABSTRACT

On WEST new components will be implemented in an existing environment, emphasis has to be put on the metrology to optimize the design and the assembly. Hence, at a particular stage of the project, several components have to coexist in the limited vessel. Therefore, all the difficulty consists in validating the mechanical interfaces between existing components and new one; minimize the risk of the assembling and to maximize the plasma volume. The CEA/IRFM takes the opportunity of the ambitious project to sign a partnership with an industrial specialized in multipurpose metrology domains. To optimize the assembly procedure, the IRFM Assembly group works in strong collaboration with its industrial, to define and plan the campaigns of metrology.

The paper will illustrate the organization, methods and results of the dedicated metrology campaigns have been defined and carried out in the WEST dis/assembly phase. To conclude, the future needs of metrology at CEA/IRFM will be exposed to define the next steps.

1. Introduction

Tore Supra tokamak is currently turning to WEST platform (Tungsten (W) Environment in Steady-state Tokamak) and will become a test bench for ITER divertor target in order to minimize manufacture and operation risks [1]. To be relevant for ITER, high flux components have to be tested during long pulses and on X point plasma configuration. Thus, the main transformation of the platform consists to install 2 new poloidal field coils inside the vacuum vessel name “Divertor” [2]. This implementation requires the total removal of existing Plasma Facing Components (PFC), as well as the magnetic instrumentation and the inner baking system. Fig. 1 presents the final PFCs configuration layout when it will be fully achieved.

During the components design phase, real geometry of the inner vessel and ports has to be considered scrupulously to take account of real geometric dispersion. Tore Supra vessel has been built in the 80s and disparities up to some centimeters could be measured between real environment and theoretical CAD models.

In this context, the assembly group has to assure the mechanical interfaces between all designs data, which are constitute a batch of 200 complex components have to be assembled. This is achieved by a permanent exchange and check of the whole Tokamak numerical mock-up used by the Design Office (DO). In a first time, all the interfaces had to be checked to qualify components integration and, based on this result, a second metrology phase must be considered to optimize inner configuration. Thus, before WEST assembly, Tore Supra vessel real geometry was checked to validate conceptual margins. Then, with the goal to maximize the plasma volume,

* Corresponding author. Tel.: +33 442257200.
E-mail address: cyril.brun@cea.fr (C. Brun).
[1] Address: SETIS – GROUPE DEGAUD, F-38100 Grenoble, France.
[2] Address: HEXAGON METROLOGY, F-91978 Courtaboeuf, France.

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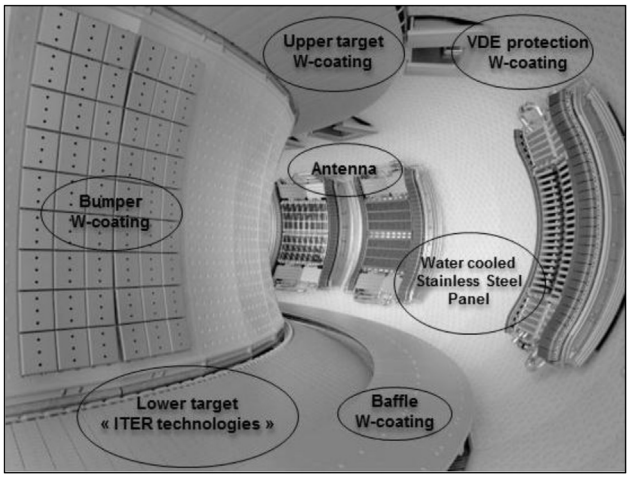

Fig. 1. WEST inner components configuration.

the two divertors will be set up with a minimum distance from the existing wall.

To achieve the metrology campaigns using edge technology, save time, money, effort and enhancing the quality of the measurements, the CEA/IRFM thanks to a partnership with companies skilled in the metrology techniques, metrology tools and having a good practice of their implementation.

2. Industrial partnership for metrology

For WEST components integration, a partnership between CEA and 2 expert companies has been signed. In this way, metrology equipment and software platform will be provided by Hexagon Metrology [3], the world leader manufacturer for metrology solutions. Metrology campaigns are defined and carried out by SETIS [4], a Degaud group company based in Grenoble (France) and expert for industrial measurement (EPR reactor, Jules Horowitz, LMJ chamber, CERN).

This partnership agreement started in the same phase than WEST components final design. Main objectives were to select the most convenient techniques and processes for all components integration and assembly phases. Industrials are fully involved in WEST sequences and offer assistance during metrology campaigns and data analysis.

During the previous Tore Supra assembly from eighties to 2000s the techniques used for positioning the components were mainly based on tapes and on theodolites [5]. A Leica theodolite was used to assemble and measure the position of the inner components in order to achieve 0.5 mm positioning accuracy (see Fig. 2). The theodolite has been used to adjust the nominal required position (radius, azimuth and height) of the main components toward the magnetic wall reference. The magnetic wall reference was defined in 1998 through a measurement of the magnetic field using MNR probes [6].

Thanks to the partnership, new metrology techniques have been implemented, such as tracking and scanning. Laser trackers (LT) are the most frequently used metrology tools. They are used for characterization of surfaces, metrology guided assembly, final (recording) measurements, comparisons of as built and CAD model, etc.... LTs are very flexible in use, and show a very high accuracy at the same time. Typical targets for LTs are 1.5″ and 0.5″ in corner cube reflectors (CCRs). A scanner system can be associated to the LT to digitize the area with a great accuracy <0.1 mm (Figs. 3 and 4).

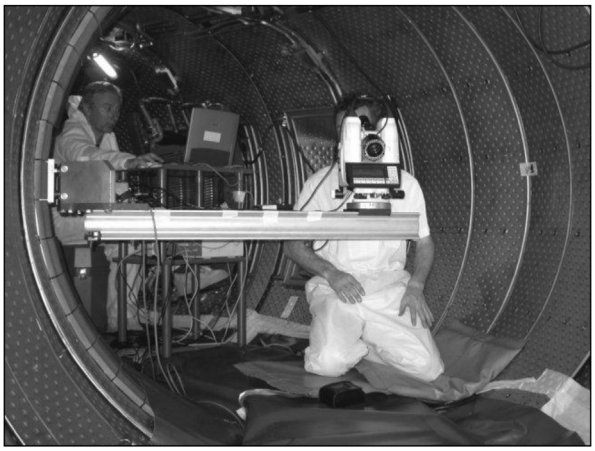

Fig. 2. Leica TM5100A Theodolite used in Tore Supra in 2000.

Fig. 3. Leica Corner Cube Reflector 0.5″.

3. Metrology campaigns planned for WEST

For WEST transformation achievement, more than 24 metrology campaigns were defined and started in 2013. Associated with the Tore Supra dismantling phase, firsts campaigns were dedicated on the comparison between the vacuum vessel As-Built geometry and the 3D CAD models (see Fig. 5). Metrology operations were also performed in the same time to keep the measurement referential witch was defined by metrology target placed on removed element. A temporary measurement referential has been built

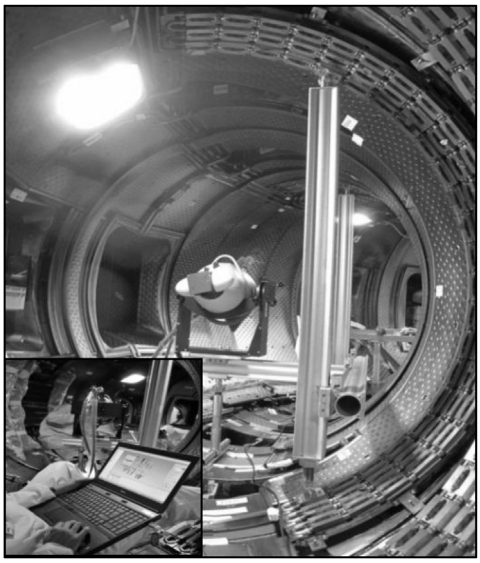

Fig. 4. Leica AT901 laser tracker during disassembly work in 2013.