FINAL

MINUTES	PSD Meeting on the EUROfusion workplan for the transition of JT60-SA to W - #1
Organizer	Carlo Sozzi / David Douai
Date	Friday Jul 19, 2024, 9:00 AM → 11:00 AM Europe/Berlin
Documents	https://indico.euro-fusion.org/event/3203/
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Apologies	RICHOU Marianne
Minutes	Carlo Sozzi / David Douai

AGENDA		
9:00	1. Introduction	Carlo Sozzi
9:05	2. Activities within / view of WP TE¶	Jeronimo Garcia
9:25	3. Activities within / view of WP PWIE	Sebastijan Brezinsek
9:45	4. Activities by / view of WP DIV	Rudolf Neu
10:05	5. Status and planned modelling activities in view of a W JT60-SA	Gloria Falchetto
10:25	6. Upgrade/adaptation of subsystems (heating, diagnostics etc) to support W-wall operation	Carlo Sozzi
10:45	7. Discussion	all

1. Introduction

Background: Actively cooled C divertor “no longer” in the JT-60SA schedule. Conclusions from the last BA Coordination Meeting (April):

- Investigation has started regarding transition to tungsten PFC
- Report prepared by Experiment Team (see JG presentation for a summary of the content)
- Project Plan updated (documents not yet available at the time of the meeting)

Purpose of this meeting is

- Develop the items, the sequence and the time schedule of the actions to be performed to support the transition C=>ACW (Assuming for the time being the installation of the W PFCs after OP4~2028)
- Agree on the EuF main interests and priorities to drive the change

- Identify the already existing tasks in EuF contributing to the workplan
- Identification of the key contact persons in each one of the contributing WPs or other EuF areas
- Identify possible gaps and how to fill them [for the 2025 programme]
- Proposal for the organization of the work [2024]

2. Activities within / view of WP TE¶

Previously discussed and agreed priorities for the exploitation of JT-60SA in EUROfusion are

- Development and investigation of high-performance scenarios compatible with future W-PFCs;
- Avoidance and mitigation of disruptions and runaways;
- Fast-ion physics;
- Development and validation of high-level real-time control strategies

Also, a number of technology goals are a priority for the JT-60SA project (see slides)

Given the impact of the wall material on the scenario development, and the plan of contributing to the ITER and DEMO physics and operation, JT-60SA Experiment Team Leaders suggested to skip the phase of the C-ACD and to proceed to the W-ACD and W wall, taking care of minimizing the risks. This view is not yet accepted at the highest level in Japan.

JT-60SA with a W wall can give a specific contribution in demonstrating the compatibility between high β and metal wall for long plasma pulses, in particular developing:

- Ne/Ar seeded radiative scenario in a V-shaped W divertor
- W first wall sources with relevant clearance
- W screening with a large Tped
- W control in the core
- Divertor detachment

A risk mitigation strategy should include

- Upgrade of the core electron heating (first evaluation: 3-7 MW needed to prevent impurity accumulation. More detailed modeling being organized within the ET)
- Reinforcement of diagnostics for detachment control, for impurity monitoring, for first wall and divertor W sources, for divertor protection.
- Preparatory experiments to assess aspects of the W transport either in JT-60SA C-phase (test W tiles, Tespel, …) or in other machines

A dedicated modeling group that will cover the following topics is being organized within the Topical groups of Transport and Confinement; (L. Garzotti) and Divertor, SOL, PMI (T. Nakano). The working group shall include members of TSVV 6 (W from the source to the core modelling => PI Ciarolo) and TSVV 7 (full-W PWI in full-W devices: transients and steady-state => PI Matveev) and SP-D (W PWI for ITER => SPL Kirschner). This would cover two aspects. Note RE damage simulation is under PWIE with Ratynskaia from VR included.

- Level of W expected in the plasma core of typical JT-60SA scenarios

- W screening in the pedestal - W sources expected
- Level of central heating required to control W penetration in the core
- Damage in PFC due to plasma disruptions and RE beam

A working session on the W modelling is being planned in 2025.

*Among the points to be assessed there is also the definition of which are the essential goals of the phase with the inertially cooled C divertor and its minimum duration since there may be important objectives not achievable in W. Simulations of high performance scenarios are important already now in this perspective.

3. Activities within / view of WP PWIE

Already performed activities: Test of pre-series W sample from Japanese origin (provided by R.Neu)

Possible further support for the W divertor

- Divertor optimisation with SOLPS-based algorithm from KU-Leuven: optimisation on heat flux reduction, target temperature: standard SN solution with variation of curvature targets, strike-line position, leg distance
    - Need to clarify the remaining degrees of freedom to apply the optimization
    - Resources needed to recover this competence
- W divertor PFC qualification and characterisation (combined plasma and heat load tests) via exposure in MAGNUM-PSI or PSI-2 to divertor-like plasma conditions under steady-state load expected in JT-60SA (see slides for the details of the qualification program). Some material solution already qualified for other purposes.
- W erosion modelling of divertor PFCs
    - Need to set the details of time scale, plasma backgrounds, divertor types etc.
- Simulation of W sources and W migration
    - Workflow in TSVV-6 (SOLEDGE3X + ERO, EMC3-EIRENE + ERO) and TSVV-7 (SOLPS-ITER + ERO). Additional resources for plasma background and PWIE modelling. Input for required W PFC thickness and potential W influx from divertor and main chamber
- Sub-divertor neutral particle modelling (DIVGAS)
- Neutral particle Divertor and SOL modelling (EIRENE)
- Wall conditioning related to Boron and other techniques
- Spectroscopic diagnostics related to W at the firstwall and the divertor
- RE beam modelling (workflow like for ITER)

4. Activities by / view of WP DIV

Ongoing activities:

- support to F4E to run the C-ACD series manufacturing (thermo-mechanical analysis, Electromagnetic loads analysis, mechanical testing, high heat flux tests)
- design and develop the W-ACD by full scale prototype manufacturing and high-heat-flux testing (without plasma) of PFCs compatible with industrial fabrication
    - first assumption is to keep the same interfaces and boundary conditions taken for the design of C-ACD
    - * Need to clarify which parameter (geometry) of the divertor can still be changed with acceptable impact on the fabrication process
    - *cassette and heat sinks are already fixed. Inclination (poloidal shape) has still some freedom W-divertor poloidal and shape can be optimized.
- Assessed PFCs concepts
    - Flat tile, 10-15 MW/m^2,
        - Mature fabrication for W/CuCrZr
        - Design limit defined in 2023
        - Under study by F4E (mock-up manufactured)
    - Monoblock, 20 MW/m^2, Cu interlayer, CuCrZr tube
        - Mature fabrication
        - Design limit for JT-60SA defined in 2024
        - Under study by F4E (mock-up planned to be manufactured)
    - Enhanced concept 10-25 MW/ m^2, manufacturing under study in WPDIV – main focus
        - Fabrication maturity under investigation
        - Design limit defined in 2024
        - First manufacturing autumn 2024

- WPDIV can provide support in
    - development of hydraulic set-up (innovative concepts, experiments)
    - conventional and innovative manufacturing (CuCrZr additive manufacturing, W/W alloy), joining (CuCrZr to SS, CuCrZr to W…)
    - Design (Thermo-mechanical analysis complying with RCC-MRx types rules, Shaping of plasma facing surface, ectromagnetic analysis (estimation of forces
    - during transient events)
    - Diagnostic to measure evolution of the W-PFCs (surface temperature, strain, erosion…)
    - PFC qualification by non-destructive testing (ultrasonic and infrared thermography) and high heat flux testing (neutral beam and electron beam) for targets and coated components
    - Mechanical testing of envisaged materials (CuCrZr…)

5. Status and planned modelling activities in view of a W JT-60SA

Ongoing task to support the specification of the W PFCs: Assessment of SOL and divertor plasma conditions in JT-60SA with W wall in high performance scenarios (see slides for details)

- Output up to now:
  - power exhaust is a critical issue (power density < 10MW/m^2 only at high density and at the cost of high impurity concentration)
  - in attached conditions, sputtering is a major issue even for acceptable power load
  - possibility of increase of the pumping rate acting on the geometry or position of the strike points
  - Compatibility with core being assessed (T&C TG)
- Previous work related to seeding in scenarios in W and W/C comparison to take into account (Galazka PPCF 2017, Zagorski NF 2017, Rubino NME 2021)

6. Upgrade/adaptation of subsystems (heating, diagnostics etc) to support W-wall operation

Transition to W wall involves a number of modifications and upgrades to be taken into consideration, besides the choice of the technology solution for the PFCs, the physics modeling and preparation experiments

- Upgrading of the heating mix toward more central electron heating, and consider risks (NBI shinethrough, EC stray)
  - Core impurity control requires 3-7 MW ECRF in the core
  - NTM control requires at least > 3 MW ECRF on 2/1 surface
  - => more ECRF, perhaps specializing sources and antennas for core and outer region power deposition
- Extend divertor and wall monitoring diagnostics
  - Erosion rate
  - Melting
  - Redeposition
  - Cameras (IR and Vis)
  - Bolometry
- Extended revision of the spectroscopy diagnostics for W source and transport
  - W souce influx, W Transport and W core concentration
  - Radiated power and Zeff
  - CXN neutrals in the main chamber and impurity concentrations in the SOL
- revision/upgrading of the protection system, including disruption management (prevention, avoidance, mitigation, runaway electrons)
  - Thermal monitoring of the first wall (IR cameras) and surface temperature and power deposition calculation
  - Integration with plasma boundary and strike point control
- Longer term upgrades
  - Long pulse operation also requires
    - Upgrade of the primary water cooling system
    - Motor generator for high power-long pulse

- Remote handling
  - Not necessary for the installation of W PFCs (tbc)
  - Necessary after campaigns with high performance, long pulses (tbc)

7. Discussion

*Some points were discussed during the presentation and are reported above

- Remarked the need of "One team" approach with WPSA, WPTE, WPDIV, WPPWIE, WPMAT, F4E and clear definition and hand-over points
- Need of define the priorities and the need time for actions and objectives
- Need to specify how long the time window is open for changes in the design of the PFCs (within the limits specified)

8. Proposed actions

#	Proposed actions	Who	Target date	Status
1	Set parameters of the divertor (shape, etc) open for optimization without unaffordable impact on the procurement (issue brief document)	V.Tomarchio	15 Sept	completed
2	Quantify resources /time needed for divertor optimization	S. Brezinsek	30 Sept	?
3	Propose how to coordinate the activity of modeling (ET, WPSA, TE…)	C. Sozzi, G. Falchetto, J. Garcia, TE TFL	30 Sept	ongoing
4	Draft a workplan	C. Sozzi/D.Douai	30 Oct	ongoing