ITER Remote Maintenance

Overview on Remote Handling Procurement

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Contents

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- Situation related to DIV RH, CPRHS, NB RH
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Needs for ITER remote maintenance

Decay Co-60 (half life 5.27 y)

Radioactivity at the start of a shut down (Gy/h):
- Blanket remote handling (~500 Gy/h)
- Divertor remote handling (~100-150 Gy/h)
- Transfer Cask System (~50-100 Gy/h)
- In Vessel Viewing System (~1.5 KGy/h)
- NB remote handling (~10 Gy/h during operation)
- Hot cell (~100 Gy/h)

Radioactivity above the divertor:
- Blanket remote handling (~500 Gy/h)
- Divertor remote handling (~100-150 Gy/h)
- Transfer Cask System (~50-100 Gy/h)
- In Vessel Viewing System (~1.5 KGy/h)
- NB remote handling (~10 Gy/h during operation)
- Hot cell (~100 Gy/h)
Inspection, maintenance, removal/installation and refurbishment of ITER components that due to radiation levels cannot be performed hands-on (in-vessel, neutral beam, hot cell, transportation)

- ITER RH is made of 7 different systems + Cold Test Facility & Supervisory Control
- 4 of the systems are procured and delivered as in-kind contribution from EU-F4E to IO

- 23P1 Blanket RH System (IVT – In Vessel Transporter) → Japan
- 23P2 Divertor RH System (DRH)
- 23P3 Cask and Plug RH System (CPRH)
- 23P4 In-Vessel Viewing System (IVVS)
- 23P5 Neutral Beam RH System (NBRH)
- 23P6 Hot Cell RH System (HCRH) → IO (only design during ITER construction)
- 23P10 Multi Purpose Deployer System (MPD) → IO (tbc)
- + 23P9-Remote Handling Cold Test Facility & 23P7-Supervisory Control System - IO
Divertor Remote Handling

- **Primary Function:** Installation / Removal of divertor cassettes and auxiliary elements (diagnostics racks, primary closure plate)

- **Main Components:**
  - Cassette Multifunctional Mover (CMM)
  - Cassette Toroidal Mover (CTM)
  - Manipulator Arm (MAM)
  - Dust cleaner
  - Tooling: Cutting, welding, boring, etc.
  - End-effectors

- **System highlights**
  - Replacement of entire divertor in 6 months (3 times in ITER lifetime / single faulty cassette)
  - Tritium & contaminated dust / gamma radiation from activated in-vessel components (~100Gy/h)
  - High loads (9t-11t), millimetric accuracy / small clearances and limited viewing (use of VR)
  - Great variety of complex operations, man-in-the-loop and in a harsh environment: each cassette requires operations like cutting – welding – boring – alignment – inspection – cleaning etc. remotely controlled
Cask Plug Remote Handling

- **Primary Function:** Remote transport means of components between Hot Cell Facility and Vacuum Vessel, for maintenance and rescue operations.

- **Main Components:**
  - Cask envelope (confinement envelope)
  - Front / Rear double sealed doors
  - Pallet (I/F envelope & CTS)
  - Cask Transfer System (motorize platform)

- **System highlights**
  - Primary confinement functions (SIC1) when docked to VV (lower category SIC2/SR during transportation of components).
  - 50t payloads / total max 100t – 8.5x3.7x2.6m max.
  - Fleet of 15 units (final numbers including rescue units to be defined)

  - During transportation:
    - Autonomous power
    - Telemetry/Tele-command system
    - Small clearance with building
    - Lift maneuvers
Neutral Beam Remote Handling

- **Primary Function**: Remote replacement of Neutral Beam system components (at beam source – beam line – front end)

- **Main Components**:
  - 50t monorail crane + accessories (lifting…)
  - Transporters / Manipulators (BS / BL)
  - Swingable rails
  - Tooling: cut/weld/align/bolt/view…
  - Rescue crane

- **System highlights**
  - Reduced maintenance schedules
  - Manipulation of activated elements (~1 Gy/h during shutdown, ~10 Gy/h during ITER operation due to neutrons)
  - Great diversity of components, tools and operations to be performed remotely
  - Seismic loads of monorail crane
In-Vessel Viewing System

- Primary Function: Inspection of blanket first wall and divertor plasma facing components looking for damage; in-vessel viewing and metrology

- Main Components (baseline configuration under study!):
  - Probe + control / processing units (6x)
  - Plug housing / sealing (tank? next slide)
  - Deployment system
  - Spare

- System highlights
  - UHV, operation temp. up to 120°C (baking 200°C), gammas 5-6KGY/h, neutron flux up to \(4 \cdot 10^{17} \text{n/cm}^2\) (wide spectrum), up to 8T magnetic field, space constrains…
  - Viewing performance: spatial resolution <1mm (0.5 – 4m target distance), <3mm (>4m target distance)
  - Metrology performance better than millimetric (next slide)
  - Self illumination
  - Critical functions: dust inventory - wall erosion, damage of in-vessel components
  - Managed from CODAC control room
In-Vessel Viewing System probe

Example of the metrology function:
- The plasma facing components (PFC) material is tungsten.
- 20% of the PFC surface is eroded.
- The calculated total mass of mobilised dust must be ± 200 kg precise.
- The measures distribution must be in the $2\sigma$ interval.
  ⇒ The standard deviation of the measure must be less than 0.165 mm.

In-Vessel Viewing System layout

In case of excessive neutrons for the plug option, a fall back solution (tank option) is under study.

Plug option (above) and tank option (right)

Probe concept design:
- Scanning based on an amplitude modulation laser radar (LADAR).
- Scanning probe proof-of-principle prototype developed by ENEA.
- 2D and 3D pictures from intensity and phase shifting measurements.
- Post-processing error correction (special algorithms and software).
- IVVS plug composed by the scanning probe and the deployment system.
- Vertical tiers: 7 RH Systems -> Each a fully functional system

- Horizontal tiers:
  - High Level Control System (HLCS) – Operator interfaces, high level / complex / coordination functionalities
  - Low Level Control System (LLCS) – Control loops, embedded systems, field control equipment
  - Integration layer – Between RH systems (supervisory system) and to ITER central systems (Interlocks, Safety)

- Networks: Control – AVN – Real Time – Diagnostics -> Integration of heterogeneous components

Overall RH Control System (from ITER RHCS Design Handbook)
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• F4E will receive the RH procurement-in-kind obligation – at the signature of the PA – at the level of functional specifications supported by conceptual design
• For each RH package Europe will have to design, procure, deliver, install and site test until final acceptance and hand-over to IO the RH systems
• F4E will charge an industrial integrator to be responsible for that package from design until final acceptance
• A low risk/cost effective strategy has been defined:
  – Multiple framework contract in cascade, up to 7 year duration, with staged approach: implementation through specific contracts covering the various phases of the project lifecycle until hand-over
  – Implementation includes technological development and prototyping by the integrator up to the extent needed to validate the preliminary/final design
  – Standardisation across the packages will be promoted
  – Flexibility in the pathway to final acceptance
  – Possibility to pick up the other two contractors in case the 1st one is not delivering
  – The above strategy is applied to the 4 packages
  – On each package the tendering process includes: call for expression of interest, selection of (up to) 5 bidders and invitation to dialogue (on draft model contract), invitation to tender (including the business case), bidding and awarding
For DIV RH, CPRHS, NB RH the call for expression of interest has been published in November 2011 and closed in March 2012: OMF 340 lots 1, 2, 3.

The subsequent stages are carried out “in phase” with the overall RH project schedule (candidates are informed), considering events like Conceptual Design Review and Procurement Arrangement signature.

Currently we are working on OMF 340 lot 1:

- Selection of candidates to invite to the dialogue, among those who have applied, according to the criteria set out in the call for expression of interest
- Preparation of the draft model contract, dialogue rules
- Preparation of the tender documentation

Tentative schedule is:

- Dialogue start by Oct. (sending of docs) until Feb. 2013
- Tendering-awarding-signature phase until Jul. 2013

The other dialogue-tendering processes (OMF 340 lots 3 and 2) will follow:


To improve the start-up phase of the OMF lots, F4E is considering to launch preliminary, preparatory activities (e.g. with OMF 272).
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For IVVS the call for expression of interest is going to be published (OMF 383) as soon as a reference layout (in-vessel vs. ex-vessel option) has been decided, therefore should be in November 2012.

The call (endorsed by F4E Exco in April 2012) will be structured in a similar way to what has been done for OMF 340.

Candidates will be scrutinised taking into account – among others - the coverage of the technological areas relevant for IVVS (metrology, rad-hard nuclear grade design etc.)

The dialogue will follow the conclusion of the previous ones, and the tentative schedule is:

- Call for expression of interest launched in Nov. 2012
- Selection of candidates, preparation of dialogue-tender, and dialogue starts May 2013
- Tendering-awarding-signature phase until Feb. 2014

To improve the start-up phase of the OMF 383, F4E is considering to launch preliminary, preparatory activities (e.g. with OMF 272).

For OMF 340 and 383, a significant amount of design, technological development, prototyping and testing, manufacturing and site installation activities are foreseen on a rather long timescale (~7 years) → industrial opportunities
The preparation of the Procurement Package (functional specs, interfaces, scope, conceptual design) is IO-driven, with collaboration from F4E.

The post-PA Package design and procurement is F4E-driven, with collaboration from IO (in particular for the ITER site activities after delivery).

Final integration into the ITER plant and operation of the RH system is IO responsibility.
Questions ?