Fuel Cycle: update on technical and procurement status

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Fusion For Energy

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Scope

• Fuel Cycle components to be procured by F4E are part of the following systems:
  o Vacuum Pumping.
  o Tritium Plant.
  o Radiological and Environmental Monitoring Systems.
  o Waste Management Systems.

• Those components are defined by IO at the conceptual design, preliminary design or final design level and then procured by F4E.

• Consequently F4E procurement packages can be of three types:
  o functional specification (from preliminary design to on-site delivery) or
  o detailed design (from final design to on-site delivery) or
  o build-to-print (manufacturing and on-site delivery).

• The procurement packages sometimes extend to on-site installation and test.
Vacuum pumping (1/6)

• Equipment:
  o Cryopumps = vacuum pumps which trap gases and vapours on a cold surface.
  o Cold valve boxes and cryolines.

• Duties:
  o To provide torus and cryostat with clean, ultra high vacuum at large pumping speed.
  o To pump the gas fed to the ion sources and neutralizers of the neutral beams.
  o To distribute helium to and from the cryopumps.

• Procurement plan:
  o Contracts for design.
  o Contracts for manufacturing (including final design for the cold valve boxes and cryolines).

• Experience required:
  o For design: vacuum, cryogenics, construction codes.
  o For manufacturing: welding and machining, helium leak detection, metrology, cleanliness, coating, pressure equipment.
Vacuum pumping (2/6)

Warm Regeneration Lines

- Status: Contract signed.
- Scope: Procurement includes final design, manufacturing and on-site delivery of approx. 26 pieces corrugated lines of various lengths and 28 field joints.
- Duty: transferring helium for cryopump regeneration.
Cold Valve Boxes (CVBs)

• Status: Call for tender in preparation.

• Scope: Procurement includes final design, manufacturing and on-site delivery of twelve CVBs and their auxiliaries.

• Duties:
  o Control the necessary supply and return of helium to the pumps so as to guarantee the “on-demand” cooling and regeneration.
  o Provide the necessary valves for the safe operation of the pumps.

• Main features:
  o Network of pipes and valves with operating temperatures from 4.5 K to 470 K.
  o Vacuum vessel of 1.8 m diameter, 2.3 m height.
  o Twenty-five control and on-off valves, seventeen pressure relief valves, eight Johnston couplings and a thermal shield.
  o Fixed interfaces to match connecting lines and systems.
MITICA cryopump (neutral beam cryopump type)

- Status: Call for tender in preparation.
- Scope: Build-to-print procurement for MITICA test facility (Padova, Italy); will be produced and tested so as to minimize any risk related to the neutral beam cryopumps.
- Main features:
  - A frame supports panels that are cooled down to 80 K (thermal shields) and to 4 K (cryopanels).
  - Thirty-two pumping sections: top manifolds and support structures, stiffener brace, bottom manifolds.
  - For each of the two circuits, the panels are connected by means of manifolds and pipes.
  - Inlet/outlet of the fluid is ensured thanks to Johnston couplings welded on the main vacuum flange.
  - Other sub-assemblies: the top stiffener, the passive radiation shields.
Pre-Production Cryopump (Torus and cryostat cryopump type)

- Status: Contract signed.

- Scope: Build-to-Print procurement; is being built and will be tested so as to minimize any risk related to the Torus and Cryostat cryopumps i.e.,
  - Address technological challenges;
  - Specify the instrumentation needs of these vacuum pumping systems;
  - Analyze their performance and incorporate safety provisions.

- Main features:
  - Composed of two cryogenic circuits:
    - Radiation shields;
    - Charcoal coated cryopanels.
  - Panels enclosed in a vacuum chamber made up of:
    - Pump casing;
    - Pump plug;
    - Front flange.
  - A valve moves along the vacuum chamber’s axis in order to isolate the pump.
### Cryopumps

<table>
<thead>
<tr>
<th>Scope</th>
<th>Timescale - Call to be launched in:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design of the cryopumps</td>
<td>√ (done; tasks completed)</td>
</tr>
<tr>
<td>Pre-production cryopump</td>
<td>√ (done; manufacturing in progress)</td>
</tr>
<tr>
<td>MITICA cryopump</td>
<td>End 2015</td>
</tr>
<tr>
<td>Torus and cryostat cryopumps (x 8)</td>
<td>2017</td>
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<tr>
<td>Neutral Beam cryopumps (x 4)</td>
<td>2019</td>
</tr>
</tbody>
</table>

### Cold valve boxes, cryolines

<table>
<thead>
<tr>
<th>Scope</th>
<th>Timescale - Call to be launched in:</th>
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</thead>
<tbody>
<tr>
<td>Cold valve boxes and auxiliaries preliminary design</td>
<td>√ (done; task completed)</td>
</tr>
<tr>
<td>Warm regeneration lines procurement</td>
<td>√ (done; final design in progress)</td>
</tr>
<tr>
<td>Cold valve boxes (x 12) and auxiliaries procurement</td>
<td>2016</td>
</tr>
</tbody>
</table>
Tritium Plant (1/6)

- Equipment:
  - Water detritiation system (WDS).
  - Isotope separation system (ISS).

- Duties:
  - To provide on-site interim storage of tritiated water.
  - To detritiate water.
  - To produce pure deuterium as well as 90% tritium/10% deuterium mixture.

- Procurement plan:
  - Contracts for conceptual design.
  - Contracts for preliminary design.
  - Contracts for final design and manufacturing.

- Competences required:
  - Chemical component separation (cryogenic distillation, catalysts).
  - Experience in handling of tritiated gases, large component manufacturing.
Tritium Plant (2/6)

ITER WDS: System Layout

- 2x100 m³ Emergency Tanks
- 4x20 m³ Tritiated Water Holding Tanks
- High level tritiated water holding tanks
- Feeding Tanks
- ISS
- LPCE-columns
- Electrolyser units
- TEP decay tanks
Tritium Plant (3/6)

ITER WDS: 100 m³ Emergency Tanks

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Alain Teissier  IBF 2015
Reactions in the equilibrators
• \( \text{HT} + \text{D}_2 \leftrightarrow \text{DT} + \text{HD} \)
• \( 2 \text{ DT} \leftrightarrow \text{D}_2 + \text{T}_2 \)
ITER ISS: R&D on packing material

- ISS design needs optimization to avoid too high a tritium inventory in the columns.
- Performance tests have been carried out on different packing types for the ISS cryogenic columns.

**CY SULZER packing**
- SS Gauze structure
- Diameter 50 mm
- Volume 5300 cm³

**SULZER Heli-Pak C packing**
- 5x5x0.3 mm
- Material: stainless steel
- Packing type: random
- Geometry: helical
## Water detritiation system (WDS)

<table>
<thead>
<tr>
<th>Scope</th>
<th>Timescale - Call to be launched in:</th>
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</thead>
<tbody>
<tr>
<td>WDS conceptual design</td>
<td>√ (done; task completed)</td>
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<tr>
<td>WDS “Main” preliminary design</td>
<td>√ (done; study in progress)</td>
</tr>
<tr>
<td>WDS tanks (2 x 100 m³ and 4 x 20 m³) procurement</td>
<td>√ (done; factory acceptance tests and on-site deliveries in progress)</td>
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<tr>
<td>WDS “Main” procurement</td>
<td>2017</td>
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## Isotope separation system (ISS)

<table>
<thead>
<tr>
<th>Scope</th>
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<tr>
<td>ISS conceptual design</td>
<td>2016</td>
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<tr>
<td>ISS preliminary design</td>
<td>2018</td>
</tr>
<tr>
<td>ISS procurement</td>
<td>2020</td>
</tr>
</tbody>
</table>
• Equipment:
  o Radiological detectors and process systems.
  o Personnel control and environmental monitoring systems.
  o Specific tritium detectors.

• Duties:
  o To provide health and radiological monitoring for workers.
  o To provide environmental monitoring.
  o To provide tritium accident detection monitoring.

• Procurement plan:
  o Many components are off-the-shelf items but need to be adapted to ITER requirements.
  o Procurements split into two phases: preliminary design; final design, manufacturing, on-site installation and tests.

• Competences required:
  o Sensors and detectors for nuclear use.
  o Experience in radiological and environmental safety.
  o System integration (electronics, software).
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<tbody>
<tr>
<td>REMS conceptual design</td>
<td>✔ (done; task completed)</td>
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<tr>
<td>REMS preliminary design</td>
<td>✔ (done; task in progress)</td>
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<tr>
<td>Environmental monitors</td>
<td>2018</td>
</tr>
<tr>
<td>Beryllium monitors</td>
<td>2023</td>
</tr>
<tr>
<td>HVAC monitors</td>
<td>2023</td>
</tr>
<tr>
<td>Nuclear monitors</td>
<td>2023</td>
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</table>
• Equipment:
  o Radwaste building process equipment for low and intermediate level-short lived (Type A radwaste).
  o Site services building process equipment.

• Duty: To package and condition waste materials (Type-A) so that they do not require any further processing prior to disposal by the host.

• Procurement plan:
  o Mostly industrial items to be adapted to ITER requirements.
  o Procurement split into three phases: preliminary design; final design; manufacturing, on-site installation and tests.

• Competences required: radioactive and activated waste management.
### Waste Management Systems (2/2)

<table>
<thead>
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</thead>
<tbody>
<tr>
<td>WMS conceptual design</td>
<td>V (done; task completed)</td>
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<tr>
<td>Radwaste preliminary design</td>
<td>2016</td>
</tr>
<tr>
<td>Radwaste final design</td>
<td>2018</td>
</tr>
<tr>
<td>Radwaste procurement</td>
<td>2021</td>
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**Type-A WMS pre-conceptual design**

- **Radioact. Liquid** 150 m³/y Tokamak & RWF CVCS maintenance Condensate TSWS vault
- **Radioact. Oil** 7 m³/y Oil from pumps & machine TCWS leak
- **Spent resins** 14 m³/y FW/BL/PHS DIV/LM PHS MIB PHS
- **Solid Radwaste** 150 m³/y Combustible 150 m³/y Non-combustible 30 m³/y Metallic (materials) 5 m³/y Large metallic 8 m³/y
- **Spent resin storage tank**
- **Dewatering system**
  - **Cementation in CBF C1 (0.3 m³)**
    - Spent resins 14.5 m³/y
    - Concentrate 1.54 m³/y
    - Oil sludge: 0.3 m³/y
- **Cementation in CBF C2 (1 m³)**
  - Combustible
  - Non-combustible
  - Metallic
  - Large metallic
- **Compactor** Super-compactor (20T)
- **X-ray**
- **Sorting & segregation**
- **Band Saw cutting**
- **Drain to liquid waste tank**
- **Filling 5 compacted 200 l drums into 1 CBF-C2**
Thank you for your attention

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