Current design status of the diagnostic port integration in the ITER upper port #18

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26th Meeting of the ITPA Topical Group on Diagnostics
Pohang University of Science and Technology, 19-22 May 2014
Outline

- Introduction on port integration in ITER
- Approach on port integration and related issues
- Status in UP18 PI
- Summary
ITER Machine Layout
Diagnostic Integration in ITER Port

Upper Port 18

Port Plug
Interspace
Vacuum Boundary
Bioshield
Port Cell

Diagnostic Building
Diagnostic Integration in ITER Port

High neutron flux (~2e14 n/cm² s)
High plasma radiation (0.35 MW/m²)
High EM load (~5 T, ~100T/s)
High vacuum (1x e-6 Pa)

High activation level
(ITER target: 100 microSi/h in interspace
  10 microSi/h in port cell
  @ 12 hours after shut-down)

High stray field: ~1500 Gauss in port cell
Relative displacement with VV
  (rad. ~35 mm, vert. ~50 mm)

Accident load: Fire load

Confinement barrier
Vacuum barrier
  → SIC (safety important component)
Port Plug = DFW + DSM + Generic PP structure
Generic PP structure is a common platform for diagnostic integration; FDR done in June 2013.

Protection from plasma
Neutron shielding

Structural platform
Vacuum/confinement barrier
Physical interface

- Diagnostics in the port plug is mounted only on DSM
- Engineeringly-demanding DFW has no interface with diagnostics.
Feedthroughs on closure plate

Vacuum/confinement boundary
SIC component $\rightarrow$ INB Order (French Order 7$^{th}$ Feb. 2012), RCC-MR

Types of feedthrough
- Electrical
- Hydraulic
- gas/vacuum
- Mechanical
$\rightarrow$ Standardization preferable; proposal on IO & DAs collaboration

* Vacuum flange:
  standards developed by IO vacuum section

**Figure 3 Integrated UPP#18 concept**
**Interspace and Port Cell**

**Design-driving parameters**
- Shut-down dose rate $\rightarrow$ neutron shielding according to ALARA: as low as reasonably achievable)
- Maintenance issue: limited time, limited dose, limited access
- Radiation hardness: very limited electronics allowed ("shielded cabinet")
Maintenance

Port Plug
- Highly activated
- Contaminated with Tritium and Be
- Maintenance done by RH in the Hot Cell

Interspace
- Activated (~ 100 micro Si/h during maintenance)
- Controlled and time limited in-situ maintenance manually assisted

Port Cell
- Low activation level (~ 10 micro Si/h during maintenance)
- Less controlled in-situ hands-on maintenance
Maintenance for port plug components
- Remove PP by RH cask and transfer to the Hot Cell
- For RH cask docking, all components in IS/PC should be removed.
- ISS/PCSS will facilitate the modular removal of the diagnostics.

Figure 47 – Cask Docking Station Systems passive guidance
UPP Installation by RH cask
- Gripping point
- Space reservation for rails and skids
Design status in UP18

**Diagnostic systems in UP18**

<table>
<thead>
<tr>
<th>Systems</th>
<th>Tenant DA</th>
<th>Design Level</th>
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</thead>
<tbody>
<tr>
<td>VUV</td>
<td>KO</td>
<td>CDR</td>
</tr>
<tr>
<td>NAS</td>
<td>KO</td>
<td>CDR</td>
</tr>
<tr>
<td>UVNC</td>
<td>RF</td>
<td>Pre-CDR</td>
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</table>

**PA signature:** May 2013

**PDR schedule**

- **SIR of UP18 PI** (July 2015)
- **CDR of UVNC** (Mid 2014)
- **PDR of NAS** (Oct. 2014)
- **PA of UVNC** (End 2014)
- **PDR of UP18 PI** (June 2015)
Design status in UP18

**Port Plug**

**Assembly sequence**
1. VUV and NAS is mounted on DSM from the back side, while UVNC is mounted from the plasma side.
2. DFW is mounted to DSM assembly.
3. DFW/DSM assembly is inserted to the UPP structure from the plasma side.
Design status in UP18

**DSM design**
- Material cost
- Structural stiffness for DFW mounting
- ESPN exemption

**Supporting frame behind DSM**

<table>
<thead>
<tr>
<th>Option 1. machining from one big forged block</th>
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</thead>
<tbody>
<tr>
<td>- Simple and robust</td>
</tr>
<tr>
<td>- Expensive material: big forging block</td>
</tr>
<tr>
<td>- Large machining</td>
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<tr>
<th>Option 2. shell structure with shielding block</th>
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<tbody>
<tr>
<td>- Relatively low material cost (still ESR)</td>
</tr>
<tr>
<td>- simple water channel for outer shell, but a bit complicated water connection between shell and shielding blocks</td>
</tr>
<tr>
<td>- More components</td>
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<tr>
<th>Option 3. welding and machining of small forged block</th>
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<tbody>
<tr>
<td>- compromise of the other two options</td>
</tr>
<tr>
<td>- Welding between blocks requires more study.</td>
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</tbody>
</table>
In UP18, the main diagnostic components in IS/PC is VUV Edge system. The others (VUV and NAS) have pipes only.
**Design status in UP18**

**Shut-down dose rate in UP18 (Preliminary evaluation)**

- **Current SDDR 108 $\mu$Sv/hr in the interspace**

<table>
<thead>
<tr>
<th>Parameter of UPP Stricture / Environment</th>
<th>Influence to SDDR inside the UPP interspace</th>
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</thead>
<tbody>
<tr>
<td>Single labyrinth at the UPP bottom gap</td>
<td>-20</td>
</tr>
<tr>
<td>Inconel-718 bolts at UPP back-flange</td>
<td>+19</td>
</tr>
<tr>
<td>Increased top/bottom gap around UPP from 25 mm to 45 mm</td>
<td>+13</td>
</tr>
<tr>
<td>Void in blanket manifolds</td>
<td>+12</td>
</tr>
<tr>
<td>Diagnostics apertures of the UPP18</td>
<td>+9</td>
</tr>
<tr>
<td>Void around in-vessel coil manifolds and ELM feeders on the lateral sides of UPP</td>
<td>+8</td>
</tr>
</tbody>
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- **SDDR increase due to diagnostic apertures in UP18: 9 microSi/h**
  
  (A. Serikov, et al., “effect of diagnostic apertures on shut-down dose rate in ITER upper port plug #18, 45th Annual meeting on nuclear technology, 2014)
FDR of the Generic UPP structure has passed in June 2013. It means that the common platform is provided for diagnostics in ITER.

Major issues in the port integration
- Harsh environment in the port plug
- Shut-down dose rate in IS/PC (ALARA)
- Maintenance
- Interface management between IO and DAs
- Feedthroughs: SIC, RCC-MR

Status in UP18 PI
- PA signature: May 2013
- PDR is planned in June 2015.
- Interfaces in the port plug is settled down, even though it still needs minor update.
- On-going activities :
  - design of DSM and supporting frame
  - Piping in IS/PC
  - The Shut-down dose rate in IS is expected to be < 100 microSi/h.