Introduction for ITER Blanket Shield Block

Blanket Technology Team
ITER Korea, NFRI
◆ **ITER Project**

An international collaborative research and development project which Korea and six other technologically advanced countries (EU, Japan, USA, Russia, China, India) have created to jointly construct and operate the ITER fusion research reactor.

◆ **Objective of the ITER**

To demonstrate the scientific, technological and commercial feasibility of fusion power.

◆ **Duration**

- 1988 ~ 2001 (14 years): Conceptual and Engineering Design
- 2007 ~ 2019 (12 years): Device Construction **Current**
- 2017 ~ 2037 (18 years): Device Operation
- 2037 ~ 2042 (5 years): Deactivation
- After 2042: Decommissioning
The main functions of the Blanket System are to:

- Contribute in absorbing radiation and particle heat fluxes from the plasma and Neutral Beam Shine Through.
- Contribute in providing neutronic shielding to the vacuum vessel and external vessel components.
- Provide shielding to in-vessel diagnostics, such as waveguides, bolometers and coils.
- Constitute the primary interface to the plasma in the main chamber providing a plasma-facing surface compatible with the plasma performance requirements (heat loads, impurity influx) and a limiting surface defining the plasma boundary during limiter operation and plasma start-up/ramp-down.
- Provide passage for the plasma diagnostics, viewing systems, microwave antennas or launchers, neutral beam injectors, the gas and pellet fuelling systems and other minor ancillaries.
The Blanket System consists of 440 Blanket Modules (BM) covering ~600 m². A BM comprises two major components: a plasma facing First Wall (FW) panel and a Shield Block (SB). The BMs are segmented into 18 poloidal locations: rows 1 to 6 are the inboard region, rows 7 to 10 are the upper region and rows 11 to 18 are the outboard region. The inboard and upper modules (except BM10) are segmented toroidally into 18 equal modules, and the outboard modules (except BM14 and 15) are segmented into 36 modules. In the upper and equatorial port region (BM10, 14 and 15), the modules are located between ports and therefore segmented into 18 modules. In the NB area, vessel sectors 2, 3 and 4 have a custom segmentation for BM 14 and 15.
Each BM is attached to the Vacuum Vessel through a mechanical attachment system of flexible supports and a system of keys.

Each BM has electrical straps providing electrical connection to the vacuum vessel.

Cooling water (4 MPa and 70°C, inlet pressure and temperature, respectively) is supplied to the BM by manifolds supported off the vacuum vessel. The coolant is routed firstly through the FW, and then through the SB.

Figure 1.2-6 Schematic examples of Inboard and upper SB modules
Introduction – Shield Block

**Blanket Shield Block**
- Material: Stainless Steel 316LN-IG
- Typical modules (SB04) size: 1.4 x 1.0 x 0.4 m
- Typical modules (SB04) weight: 2.6 ton
- Module number: 440 modules

**Procurement Shield Blocks of ITER Korea**
- KODA: 220 modules (Including inserts and pins)
- 15 main variants, 66 minor variants
For a BtP PA, the Manufacturing Design shall be carried out by the DA and its Supplier in the following steps:

1. 3D Models at FDR maturity, together with 2D drawings detailing additional information (e.g. general assembly drawings on the basis of models at final design maturity, interface tolerances, etc), shall be provided by the IO, as part of the BtP Design;

2. The Supplier shall prepare Manufacturing Design 3D Models, based on the Models at FDR maturity provided by the IO;

3. The Manufacturing Design 3D CATIA Models shall be checked and approved by the DA, then accepted by the IO;

4. The Supplier shall prepare general assembly drawings, on the basis of manufacturing design models, (checked and approved by the DA, and accepted by the IO) and manufacturing drawings (checked and approved by the DA, and sent to IO for information) based on the accepted Manufacturing Design Models;

5. The Supplier shall start manufacturing based on these manufacturing drawings, following a Production Readiness Review.
Process Qualification

The process qualification is based on:

◆ The manufacturing and testing of one SB Full Scale Prototypes (FSP), per manufacturing technology and per manufacturer shall be required.
  • SB 6 and/or SB 16 shall be assumed for the FSP. The final number of FSP and their reference geometry has to be agreed with the IO.

◆ The acceptance of:
  • The Welding Data Package.
  • Any critical process technologies (e.g. deep drilling, etc...).
  • Final acceptance tests (hydraulic pressure, hot helium leak and dimensional test).
Prior to the start of production, each Supplier shall identify its most critical operations. The list of critical operations shall be described in the Manufacturing and Inspection Plan, which shall be disclosed to the DA and notified to the IO for acceptance and mark-up interventions.

The DA shall carry out the production of the SBs according to the technical specifications of the Annex B and related Appendices and reference documents.

The DA shall carry out the Factory Acceptance Tests of SBs.
Components shall be delivered to the ITER site.

IO shall carry out the Final Acceptance Tests of SBs.

- Cold helium leak test.
- Geometrical shape and tolerances.
**Extent of the Supply and Spares**

- **One Full-Scale SB prototype** per manufacturing technology and per manufacturer, which is required for the pre-production qualification.

- **SBs** as per table below.

- **Bolt self-locking technology**, accepted by IO (e.g., Spiralock).
  - The LCF shall be applied only on the internal female thread of the FW central bolt insert.

### Table: Poloidal row of SBs procured by KODA

<table>
<thead>
<tr>
<th>Poloidal row of SBs procured by KODA</th>
<th>Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>SB 1</td>
<td>18</td>
</tr>
<tr>
<td>SB 2</td>
<td>18</td>
</tr>
<tr>
<td>SB 6</td>
<td>18</td>
</tr>
<tr>
<td>SB 7</td>
<td>18</td>
</tr>
<tr>
<td>SB 8</td>
<td>18</td>
</tr>
<tr>
<td>SB 12</td>
<td>36</td>
</tr>
<tr>
<td>SB 13</td>
<td>36</td>
</tr>
<tr>
<td>SB 15</td>
<td>22</td>
</tr>
<tr>
<td>SB 16</td>
<td>36</td>
</tr>
<tr>
<td><strong>TOTAL NUMBER OF PROCURED SBs</strong></td>
<td><strong>220</strong></td>
</tr>
</tbody>
</table>

### Table: Included in SB Supply

<table>
<thead>
<tr>
<th></th>
<th>Numbers (*)</th>
<th>Spares</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Bolt Insert and locking pins (2) assembly</td>
<td>220</td>
<td>10%</td>
<td>242</td>
</tr>
<tr>
<td>SB inserts and locking pins (2) for the SB to VV Electrical Strap mounting</td>
<td>1760 (inserts) 3520 (locking pins)</td>
<td>10%</td>
<td>1936 (inserts) 3872 (locking pins)</td>
</tr>
<tr>
<td>Inserts(2) and locking pins(4) assembly for the connection of the FW to SB ES bolts</td>
<td>440 (inserts) 880 (locking pins)</td>
<td>10%</td>
<td>484 (inserts) 968 (locking pins)</td>
</tr>
</tbody>
</table>

(*) Final numbers to be in accordance with the CATIA models.
Further Schedule

<table>
<thead>
<tr>
<th>Name</th>
<th>Baseline Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blanket Shield Signed with IO</td>
<td>30-Nov-2013</td>
</tr>
<tr>
<td>Contract Signature Blanket Shield Prototype (KO)</td>
<td>31-Oct-2014</td>
</tr>
<tr>
<td>Qualification, Prototype Blanket Shield (KO) Complete</td>
<td>31-Mar-2016</td>
</tr>
<tr>
<td>Contract Signature Blanket Shield (KO) (Series Production)</td>
<td>01-Apr-2016</td>
</tr>
<tr>
<td>IPL &gt; Delivery of Blanket Shield Block Rows Last of 1 &amp; 2 by KO-DA to ITER Site</td>
<td>04-Nov-2019</td>
</tr>
<tr>
<td>IPL &gt; Delivery of Blanket Shield Block Rows Last of 7 &amp; 8 &amp; 6 by KO-DA to ITER Site</td>
<td>08-Jan-2020</td>
</tr>
<tr>
<td>IPL &gt; Delivery of Blanket Shield Block rows Last of 15S (incl. Shine) &amp; 12 &amp; 13 by KO-DA to ITER Site</td>
<td>05-Jul-2020</td>
</tr>
<tr>
<td>IPL &gt; Delivery of Blanket Shield Block Rows Last of 16 &amp; 15C by KO-DA to ITER Site</td>
<td>29-Oct-2020</td>
</tr>
</tbody>
</table>

Delivery schedule could be changed in accordance with ITER schedule
Technical Issues – Fabrication of forged block

- Fabricated 316L(N)-IG was certificated by EN10204:2004
- End of Manufacturing Report for 316L(N)-IG
Technical Issues – Machining (Cutting & Milling)

◆ **Cutting**

◆ **Milling**
Technical Issues – Drilling

Front side

Upper side

Lower side
Technical Issues – Welding

Front side

Back side

Lower side

Upper side
Technical Issues – Slitting
Shield Block 08 – Full Scale Prototype

• **References**
  - 3D CATIA model
  - 2D Drawings
  - Technical requirements
  - ITER Vacuum Hand Book (SB07-TypeA_ver-FDR20131108)