Summary Technical Specification

Mechanical handling equipment for In-Vessel Assembly

1. Purpose

The ITER project is based in St Paul Lez Durance in the south of France. It has entered the construction phase and the assembly of the Machine is scheduled at the end of 2015. Further information can be found on the ITER website (http://www.iter.org) and also at the web pages of the ITER Parties that can be accessed via the ITER website.

This document outlines the mechanical handling equipment that has to be designed, manufactured and tested to allow the transfer of new components and systems from the on-site pre-assembly area through the Vacuum Vessel (VV) ports and manipulate them into their final installed position.

2. Background

The VV is a doughnut-shaped chamber equipped with ports at 3 levels to enable the access inside the vessel for component installation and maintenance.

Due to the size and weight of the equipment to be handled and the shape of the VV, dedicated tooling has to be designed to perform the in-vessel installation. Dedicated access platforms will also be designed to support the installation process inside the VV.

Typical component to be installed are up to 4 tons and up to 13x0.5x5m.

The ITER Organisation (IO) has completed a design scheme for the installation of the in-vessel components and produced concepts of the associated tooling. This tender process concerns the design and manufacture of these tools.
3. Scope of Supply:

1. Design, manufacture and testing of the tools required for the in-vessel installation (see summary below and annex for more details),
2. The design and manufacture of mock-up components to demonstrate equipment functionality,
3. A trial and test facility to allow assembly and testing of the equipment, as well as training of personnel,
4. The preliminary and final design review (the IO will conduct the conceptual design review during 2013) at IO site in France,
5. Delivery of all equipment, including the test facility, to the IO site in France.

Example of the main equipment to be supplied:

a. Through Port Transfer System

This equipment will be used to enter equipment in the vessel.

b. In-Vessel Tower Crane

The In-vessel crane will be used to lift component inside the vessel. Similar equipment will be supplied to lift workers inside the vessel.
c. In-Vessel Floor:

Its function is to allow a large number of people working at the same time in a dedicated area of the vessel.

![In-Vessel Floor Diagram]

\[\text{In vessel staging used to perform manual assembly operations inside the VV. 5 levels of staging provide access from diverter to upper levels of the VV.}\]

![Test and Training Facility Diagram]

\[\text{To allow the equipment produced to be commissioned, tested and IO personnel trained in its use, a test facility will require designing and building. This is anticipated to equate to three sectors worth of the VV interior with a simplified layout. The estimated layout is shown below.}\]
4. Supplier Capability

a. Experience

The supplier and its personnel shall have suitable experience. This includes but is not limited to:

- Extensive experience in the design of mechanical handling equipment,
- Extensive experience in the manufacture of mechanical handling equipment,
- Experience in fabrication, machining and assembly of complex machinery,
- Experience in large volume metrology suitable to complete required tasks,
- Experience of producing equipment suitable for clean-room conditions,
- Experience in training external personnel in the safe operation of equipment,
- Experience of working to the relevant standards and codes suitable for the type of equipment to be supplied and operated in France.

b. Technical Capacity

- The candidate, which may be a single company or a consortium with/without sub-contractors, shall possess the full range of professional competences and experience at a level commensurate with the work to be carried out on this contract,
- The candidate shall demonstrate his experience of producing similar machinery and tooling,
- The candidate shall demonstrate his experience of designing equipment to meet safety regulations,
- The qualified personnel shall include design engineers (mechanical, electrical and systems specialists) CATIA CAD operators, stress engineers, project managers, planners, manufacturing engineers and skilled trades personnel for manufacture, inspection and assembly.

c. Facilities

The supplier shall have or have access to suitable facilities for design, manufacture, assembly and testing of the equipment to be supplied. The design and manufacture of mock-up components will also be required to demonstrate equipment functionality.

Refer to section 3 to have the size of the test and training facility.
d. Quality Assurance

The candidate shall have an accredited Quality Assurance system.

The IO is currently conducting a study to finalise the regulatory requirements and this will be issued with the call for tender.

5. Tentative schedule:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Milestone date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kick off meeting</td>
<td>February 2014</td>
</tr>
<tr>
<td>Preliminary Design review</td>
<td>September 2014</td>
</tr>
<tr>
<td>Final Design review</td>
<td>December 2014</td>
</tr>
<tr>
<td>Manufacture</td>
<td>August 2015</td>
</tr>
<tr>
<td>Assembly and commissioning</td>
<td>October 2015</td>
</tr>
<tr>
<td>Trials and training</td>
<td>January 2016</td>
</tr>
<tr>
<td>Delivery to IO site</td>
<td>February 2016</td>
</tr>
</tbody>
</table>

6. Candidature

Participation is open to all legal persons, which are established in an ITER Member States. Candidates are allowed to form consortia or subcontract other companies. In this case, ITER Organization shall only have one single executive contact. All members of a consortium (i.e. the leader and all other members) are jointly and severally liable to the ITER Organization for the implementation of the contract. The Candidate’s composition (i.e. an individual legal entity or a consortium) shall be presented at the pre-qualification stage, following this Call For Nomination. The candidate’s/tenderer’s composition cannot be modified without a prior approval of the ITER Organization after the pre-qualification.

No more than one application can be submitted by a legal person whatever the form of participation (as an individual legal entity or as a member of a consortium submitting an application). In the event that a legal person participates in more than one application, all applications in which that person has participated may be excluded.

Legal entities belonging to the same legal grouping are allowed to participate separately if they are able to demonstrate independent technical and financial capacities. IO reserves the right to disregard duplicated references and may exclude such legal entities from the tender procedure.

Any subcontractor(s) shall not be considered to be members of a consortium and the experience and capacity of subcontractors will not be taken into account during the pre-qualification procedure.

In considering the formation of consortia, candidates should consider carefully the need to select appropriate partners to ensure financially competitive offers.
ANNEX 1:

1. Introduction

The components to be installed are:

2. Edge Localised Mode (ELM) Coils.
3. In-board and Out-board Blanket Manifold.
4. Diagnostic equipment and wiring looms.
5. Shield Blocks.
6. First Wall Panels.

Other assembly tasks that require a mechanical handling capability.

1. Personnel carrying for manual operations at height.
2. Assembly equipment movements (e.g. Welding machines)
3. In-vessel survey work.

Other equipment to be supplied include:

1. The design and manufacture of a Staging system that provides four levels inside the VV for personnel access to allow manual work such as welding, leak testing and wiring of diagnostics to take place.
2. The design and manufacture of mock-up components to demonstrate equipment functionality
3. The design and build of a trial/test facility will also be required to validate the equipment produced.

The (IO) study of the assembly below is to illustrate an acceptable method that could be used to complete the tasks. It is the IO intention that the chosen supplier will either develop the IO’s proposal or develop his own solutions or a combination of both. It will be the supplier’s responsibility to ensure the mechanical integrity, functionality and completeness of the equipment supplied to meet the assembly task requirements.

Two key pieces of mechanical handling equipment and a Staging system have been identified by the IO as essential to the assembly operation. These are briefly described below.

2. In-Vessel Tower Crane (IVTC) and Through Port Transfer System (TPTS)

The IVTC has been conceived as a device to aid first assembly and will be used in conjunction with a TPTS to manipulate components into their final installed position in the ITER VV. The TPTS is a mechanism that transports components through the equatorial ports and presents them in the required orientation for the IVTC to lift and place them safely and quickly in the required location. The concept for the IVTC is to manipulate components, secured to a rigid support structure safely and under complete control.

The IVTC is mounted on rails that are manually installed in the lower vessel area. The remainder of the IVTC is installed using the TPTS. The wheel assemblies are lowered onto the rails, and then the carriage containing the slewing ring and control equipment are connected to the wheels. The column which is approximately 5m high is then attached to the slewing ring on the carriage after being transferred thorough the equatorial port. The final part of the assembly is to attach the pantograph mechanism to the column. The
IVTC can then be commissioned ready for use. Alternative concepts have been considered and one such concept with a tower appears in some of the illustrations.

Initial studies have shown the IVTC is a vital tool to install all the components required for phase one assembly - VS coil, ELM coils, In-Board / Out Board Manifolds, a large number of diagnostic systems plus ancillary equipment for manual installation work, such as brazing equipment. It is anticipated that two IVTCs will operate in the vacuum vessel, one specifically for load carrying duties and the other for personnel e.g. for metrology surveys where a clear uninterrupted view of the vessel walls is essential.

Prior to the In-vessel assembly work the IVTC will be employed for the build of the VV itself, lifting components such as diagnostic systems when sub-assembly work commences on the sectors as soon as they are delivered. The sub-assembly time in the assembly hall is short and critical to the machine assembly schedule. Moving people and components around the inside of the sector quickly, safely and efficiently will be vital to maintain the program. During VV welding, the IVTC will be employed to move welding equipment quickly and safely around the work site.

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View of proposed IVTC inside VV

Through Port Transfer System (TPTS)
3. In-vessel Staging

The purpose of the staging is to provide personnel access to all surfaces within the VV. Due to the size and shape of the VV each level of staging is unique, it is envisaged that the stage will be comprised of five levels, which are identified.

![In-vessel staging](image)

The naming of the Staging levels follows the format of the VV which has three main levels, the Upper, Equatorial and Lower/Diverter level.

The flooring is of a modular configuration that shall enable the flooring to occupy any of the one to nine sectors, and this shall be achievable without the need for staging in the adjacent sector.

The concept of the design is that brackets are attached to the VV wall onto which radial beams are fitted onto which are mounted floor panels. A key feature of the design is the ability to install and remove the Staging quickly. Other items required are steps, safety barriers, platforms, lighting, power supplies and assembly tooling, transfer and storage equipment.

![Sectional view of Staging and VV](image)

Sectional view of Staging and VV to illustrate the scope of supply required

4. VS Coil installation
The VS Coils when installed are two water cooled coils in the upper and lower part of the vessel. To enable the installation each coil is manufactured in three sections which allow the coil to pass through the main Equatorial Port into the VV.

![Diagram showing the VS Coil installation process](image)

The VS coil is to be introduced into the ITER VV through the Equatorial Port in 120 degree segments using the proposed equipment shown below. The coil section will not fit easily through the Equatorial Port; however by careful manipulation it is possible for the coil to enter the VV by this route. It is proposed that the coil section is guided down two dedicated tracks fabricated to give the precise route through the port. The coil section is supported on its centre of gravity and at the rear of the coil which allows the coil to be manipulated and ensure it maintains clearance from the port and VV walls. Once inside the VV, with the utilisation of some winches, tooling and the IVTC the coil section can be manoeuvred into an assembly position suitable for the joining of the coil sections. Joining of the coils is by a brazing method and welding that is still being developed and is not part of this mechanical handling equipment call. After the joining process has been approved and tested the coils are raised or lowered to their final installed position for final fixing.

![Diagram of proposed equipment](image)

Proposed layout of VS Coil transfer equipment (VV removed for clarity)
The table below indicates the size, weight and quantity of VS Coils, and tooling to be moved.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Size (M)</th>
<th>Weight (Kg)</th>
<th>Qty.</th>
<th>Number of IVTC Lifts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Upper VS Coil</td>
<td>13x0.5x5</td>
<td>1000</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Lower VS Coil</td>
<td>13x0.5x5</td>
<td>1000</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Personnel work platform</td>
<td>1.5x1.5x2</td>
<td>400</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>Coil Joining equipment (not part of this supply)</td>
<td>?</td>
<td>250</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>5</td>
<td>Support fixtures</td>
<td>?</td>
<td>150</td>
<td>18</td>
<td>36</td>
</tr>
</tbody>
</table>

5. ELM Coil installation

The ELM coils and its Feeders are transferred into the VV using the TPTS on support stands with their own dedicated lifting frame attached. Once inside the VV the TPTS has the facility to rotate the ELM coils and Feeders so that they are presented in the correct orientation for the IVTC to transfer them to the required position. The IVTC will then off-load the coils and Feeders onto pre-installed tooling that receives the components at the stand-off position (approximately 400mm from the final installed position). Once the IVTC has placed the ELM coil or Feeder onto the tooling it moves away to allow the second IVTC to position personnel adjacent to the tooling so that they can make the final positioning of the ELM coil or Feeder by hand operation using bespoke tooling.
The table below indicates the size, weight and quantity of ELM Coils, Feeders, tooling and personnel to be moved.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Size (M)</th>
<th>Weight (Kg)</th>
<th>Qty</th>
<th>Number of IVTC Lifts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Upper ELM Coil</td>
<td>4.3x1.5x0.4</td>
<td>1500</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>Equatorial ELM Coil</td>
<td>3.8x2.7x0.3</td>
<td>1500</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>Lower ELM Coil</td>
<td>4.4x2.3x0.4</td>
<td>1500</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>Lower ELM Coil Feeder</td>
<td>4.5x2.4x0.2</td>
<td>750</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>5</td>
<td>Equatorial ELM Coil Feeder</td>
<td>2.3x0.9x0.2</td>
<td>750</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>6</td>
<td>Upper ELM Coil Location tooling</td>
<td>?</td>
<td>250</td>
<td>1</td>
<td>18</td>
</tr>
<tr>
<td>7</td>
<td>Equatorial ELM Coil Location tooling</td>
<td>?</td>
<td>250</td>
<td>1</td>
<td>18</td>
</tr>
<tr>
<td>8</td>
<td>Lower ELM Coil Location tooling</td>
<td>?</td>
<td>250</td>
<td>1</td>
<td>18</td>
</tr>
<tr>
<td>9</td>
<td>Lower ELM Coil Feeder Location tooling</td>
<td>?</td>
<td>250</td>
<td>1</td>
<td>18</td>
</tr>
<tr>
<td>10</td>
<td>Equatorial ELM Coil Feeder Location tooling</td>
<td>?</td>
<td>250</td>
<td>1</td>
<td>18</td>
</tr>
<tr>
<td>11</td>
<td>Personnel work platform</td>
<td>1.5x1.5x2</td>
<td>400</td>
<td>1</td>
<td>180</td>
</tr>
</tbody>
</table>

6. In-board and out-board manifold installation

The In-board and Out Board Manifolds are installed in a similar way. The Manifold is attached to a lifting frame and positioned onto the TPTS and is then driven into the VV. At the edge of the port there are rollers that allow the Manifold and lifting frame assembly to rotate and be lowered to the lower section of the VV. Once the assembly reaches the lower area of the VV it mates with a location feature that allows the assembly to be turned into the upright position. Once the Manifold and lifting frame are in the correct orientation the IVTC is able to lift and transfer it to the required In-vessel position where it is deposited onto pre-installed tooling. The second IVTC with personnel is then utilised to make the final positioning and connections to the VV wall.
The table below indicates the size, weight and quantity of Manifolds, tooling and personnel to be moved

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Size (M)</th>
<th>Weight (Kg)</th>
<th>Qty.</th>
<th>Number of IVTC Lifts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>In-board Manifold</td>
<td>7.5x2.8x1.25</td>
<td>250</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td>2</td>
<td>Out-board Manifold</td>
<td>7.4x2.0x0.7</td>
<td>325</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td>3</td>
<td>In-board Manifold location tooling</td>
<td>?</td>
<td>250</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td>4</td>
<td>Out-board Manifold location tooling</td>
<td>?</td>
<td>250</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td>5</td>
<td>Personnel work platform</td>
<td>1.5x1.5x2</td>
<td>400</td>
<td>1</td>
<td>144</td>
</tr>
</tbody>
</table>

7. Diagnostic equipment and wiring looms.

Wiring looms are installed with a similar method to the In-board and Out-board manifold. There are 108 to be installed with a weight of approximately 400Kg.
8. Shield Blocks and First Wall Panel

The installation of Shield Blocks and First Wall Panel is carried out in phase 2 of the machine assembly after the ITER machine has been commissioned. The connection of the Shield Block and First Wall Panel to the VV is made using Remote Handling equipment (not part of the equipment supply), however the IVTC and TPTS will be utilised as a mechanism to deliver the components to the In-vessel assembly position. For this less demanding task the IVTC can be reconfigured as shown below.

There are 440 Shield Blocks and 440 First Wall Panels which vary in weight up to 4000kg.