Compeled ITER Task Agreements (ITAs, for information and expression of interest)

ONGOING CALLS

Ref F4E-CITA-010:

“Effects of ELM Control Coils on Energetic Particle Confinement in ITER”

Fusion for Energy has received the ITA below (sent for competition to all DAs) on the subject “Effects of ELM Control Coils on Energetic Particle Confinement in ITER”. EU associations and other competent institution are invited to take note of this call.

F4E may respond to the IO call (partially or in full) and, in case F4E is awarded the ITA, F4E will publish a call (grant or procurement, open or negotiated/single beneficiary, as appropriate).

Interested parties are invited to provide their expression of interest (EOI) complete with contact information (i.e. company name, full address (no post box, please), contact person, telephone and fax number, e-mail address and web-page) by e-mail quoting the reference number of this call for interest.

Expressions of interest are acceptable from entities that are established in the territory of a Member of Fusion for Energy (EU Member States + Switzerland).

Closing date for EOI: 28 September 2011

Email for EOI: ITER-ITAs-Competed@f4e.europa.eu
Task on Effects of ELM Control Coils on Energetic Particle Confinement in ITER

Technical Specifications

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IDM Number: ITER_D_6FVU29
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1 Abstract

This Tender specification is for the supply of support to the ITER Organization in the fields of Plasma Operations and Energetic Particle Confinement.

2 Background and Objectives

2.1 The present specification is for the provision of support to the ITER Organization in the fields of Plasma Operations and Energetic Particle Confinement.

2.2 General information on the background and objectives of the effects of ELM Control Coils on energetic particle confinement is described as follows. The ELM control coil is expected to mitigate large ELMs by means of ergodization of edge magnetic field structures. It has been reported [1, 2] that the confinement of NB fast ions is degraded in edge stochastic magnetic field region, leading to a significant increase of the first wall (FW) heat load as high as the allowable limit, while alpha particles do not suffer such the confinement deterioration. These simulations were done only for a 9MA steady-state plasma. Inductive and hybrid scenarios have wider alpha particle profiles and then can suffer more alpha particle losses than in the steady-state scenario. Density profile variation also should be investigated since the source profiles of the alpha particle and NBI fast ion are changed. As a sensitivity study, effects of the edge safety factor profile on the resonant / anti-resonant conditions among energetic ions and magnetic fields also should be done. The purpose of this task is to have more calculations, using the most recent optimized ELM control coil operations and Test Blanket Modules (TBMs) magnetic fields, of energetic particle losses in various H-mode operation scenarios to determine if the associated high energy particles can lead to concentrated power fluxes beyond the present design values of the in-vessel components at some particular locations.

2.3 The Tenderer, awarded and having signed the Contract shall be denominated as the Contractor.

3 Scope of Work

This task is to provide results of orbit following Monte-Carlo calculations of energetic particle losses in the present ITER geometries including the effects of ELM control coils on energetic particle losses. ELM control coil magnetic perturbations are far higher than those generated by TBMs and the toroidally acyclic distribution of ferritic inserts (FI) such as HNB tangential ports and dummy modules at TBM ports. Thus, the calculations shall be done for toroidally cyclic magnetic perturbations by toroidal field (TF) ripple and FI that shall be provided by the IO. These calculations must first calculate 3D maps of the magnetic perturbation generated by the ELM control coils for the conditions listed below, so as to better understand the radial extent of the perturbations which are influencing the fast particles. For each condition, the α-particle and NBI particle losses will be provided as a percentage of the input α-particle and NBI power and the resulting additional heat flux to the first wall due to these energetic particle
losses will be calculated in MW/m², where for non-DT plasmas only NBI particle loss shall be provided. The poloidal and toroidal distribution of energetic particle heat flux onto a close approximation of the present first wall design will be provided for each condition within a reasonable statistical uncertainty. This work consists of the three steps;

(1st step)
In order to find operations that can cause high FW heat load, the total loss of energetic ion species shall be evaluated for the combinations of the 4 ITER H-mode plasmas (15MA DT inductive, hybrid, 9MA DT steady-state and He plasma with hydrogen NBIs) and the 6 sets of the ELM control coil operation parameters (no excitation, n=3 and 4 cosine/sine waveform at two coil currents and n=4 square waveform). The NBI fast ion and alpha particle shall be studied in the three DT plasmas, and the NBI ion shall be studied in the He-plasma case. The ELM coil parameters considered here are the ones optimized for ELM suppression, and they shall be provided by the IO.

1) 15 MA, 5.3 T, Q=10, DT, 500 MW scenario,
  1-1) without ELM coil field,
  1-2) with ELM coil field : n=3 cosine(or sine) waveform,
  1-3) with ELM coil field : n=4 cosine(or sine) waveform,
  1-4) with ELM coil field : n=3 cosine(or sine) waveform at a different coil current,
  1-5) with ELM coil field : n=4 cosine(or sine) waveform at a different coil current,
  1-6) with ELM coil field : n=4 square waveform,
where only the NBI fast ion shall be calculated for the 1-4) case.

Then, 6 and 5 simulation cases for the NBI ion and the alpha particle, respectively.
In total 11 simulation cases.

2) Hybrid DT scenario,
  2-1) without ELM coil field,
  2-2) with ELM coil field : n=3 cosine(or sine) waveform,
  2-3) with ELM coil field : n=4 cosine(or sine) waveform,
  2-4) with ELM coil field : n=3 cosine(or sine) waveform at a different coil current,
  2-5) with ELM coil field : n=4 cosine(or sine) waveform at a different coil current,
  2-6) with ELM coil field : n=4 square waveform,
where only the NBI fast ion shall be calculated for the 2-4) case.

Then, 6 and 5 simulation cases for the NBI ion and the alpha particle, respectively.
In total 11 simulation cases.

3) 9 MA, 5.3 T, Q=5, DT, 350 MW scenario,
  3-1) without ELM coil field,
  3-2) with ELM coil field : n=3 cosine(or sine) waveform,
  3-3) with ELM coil field : n=4 cosine(or sine) waveform,
  3-4) with ELM coil field : n=3 cosine(or sine) waveform at a different coil current,
  3-5) with ELM coil field : n=4 cosine(or sine) waveform at a different coil current,
  3-6) with ELM coil field : n=4 square waveform,
where only the NBI fast ion shall be calculated for the 3-4) case.

Then, 6 and 5 simulation cases for the NBI ion and the alpha particle, respectively.
In total 11 simulation cases.

4) He-plasma + Hydrogen NBI,
  4-1) without ELM coil field,
  4-2) with ELM coil field : n=3 cosine(or sine) waveform,
  4-3) with ELM coil field : n=4 cosine(or sine) waveform,
  4-4) with ELM coil field : n=3 cosine(or sine) waveform at a different coil current,
4-5) with ELM coil field : n=4 cosine(or sine) waveform at a different coil current,
4-6) with ELM coil field : n=4 square waveform,
In total 6 simulation cases for the NBI ion.

(2nd step)
Based on the results of the 1st step, the 2D FW heat load pattern shall be evaluated for 6 cases that have non-negligible fast ion losses. Effects of the toroidal rotation of the ELM coil field shall be evaluated, by rotating the ELM coil current distribution for the above 1) scenario, and by utilizing the toroidal periodicities of the FW and ELM coil geometries and the magnetic fields by TF ripple and FI for the other scenarios. The considered 6 simulation cases shall be determined upon consultation between the IO and the DA.

(3rd step)
Based on the results of the 1st and 2nd steps, sensitivity studies by scanning the electron density and edge safety factor (q) shall be investigated.

(3-a) electron density scan
This scan study shall be done to examine how energetic ion source in the edge region, where ELM coil field induced losses of energetic ions can occur, affect the FW heat load. The total loss fractions of the NBI fast ion and alpha particle shall be evaluated for each of the 1), 2) and 3) scenarios with one higher and one lower electron density profiles against the reference one, where the ELM coil operation is fixed to the cosine(or sine) waveform at the most dangerous toroidal mode number n=4. The 2D FW heat load pattern shall be evaluated for 3 cases. Choice of the density values and the 3 simulation cases for 2D heat load assessment shall be determined upon consultation between the IO and the DA.

(3-b) edge q scan
This scan study shall be done to examine how the edge equilibrium magnetic field structure affect the FW heat load through changes of the resonant and non-resonant conditions between energetic ions and ELM coil fields. The edge magnetic field structure can vary on assumptions of the pedestal structure through the bootstrap current. The total loss fractions of the NBI fast ion and alpha particle shall be evaluated for the 3) scenario with two different edge q profiles made by pedestal structure scan, where the ELM coil operation is fixed to the cosine(or sine) waveform at the most dangerous toroidal mode number n=4. The 2D FW heat load pattern shall be evaluated for 2 cases. Choice of the edge q profile and the 2 simulation cases for 2D heat load assessment shall be determined upon consultation between the IO and the DA.

4 Estimated Duration
The duration of the Service Contract will be 6 months from the date of the signature by the last of the contracting parties, with the option of extensions to be agreed and defined by both parties. The ITER Organization explicitly reserves the right to decide whether or not to extend the Contract.
5 Work Description

The present task description defines only the framework of the Task – General Task Description. Details of each subtask will be developed through communications between the corresponding Contact Persons. Priorities of the subtasks will be agreed between the IO-TO and the C-TO considering IO needs and availability of human resources on the C-Team.

Depending on the preliminary results and on the current needs for the ITER detailed design, some variation in the specification of detailed calculations may be required during the course of the task. Frequent communications between the IO-TO and the C-TO are therefore envisaged to discuss and agree on details of the calculations and priorities.

6 Responsibilities (including customs and other logistics)

ITER:
The IO shall be responsible for providing the needed information, data and access to the adequate ITER files for executing this work when needed following the implementation plan.

Contractor:
The Contractor appoints a responsible person, the Contractor’s Task Officer (C-TO), who shall represent the Contractor for all matters related to the implementation of this Contract.

The Contractor will provide results according to the scope of the work outlined above and will fulfil the implementation plan and conditions of the present contract.

7 List of deliverables and due dates (proposed or required by ITER)

In each subtask, the deliverable is the final report describing the statement of each problem, modelling, input data and approximations used in the studies and the results obtained e.g. formulas, figures and EXCEL tables with the data shown in the figures.

Further details on deliverables and priorities of the subtasks will be agreed between the IO-TO and the C-TO.

Starting date: Signing of contract
Completion date: 6 months from the date of signature

One progress meetings will be organized as required to exchange information and to review the intermediate results of the task.
8 Acceptance Criteria (including rules and criteria)

Quality plan shall provide work breakdown and list of check points at which the IO should review status of the work and make a decision for its continuation. The IO will also participate in reviewing the results of test and analysis.

The Contractor shall submit a draft of the deliverables foreseen in the Scope at completion of the work.

The IO-TO shall review the deliverables and reply, within the time specified in the 15 following days, a commented version of the deliverables.

The Contractor shall perform all the necessary modifications or iterations to the deliverables and submit a revised version.

Contract will be considered completed after the IO has accepted the last deliverable.

9 Specific requirements and conditions

In response to this call for tender the following shall be provided:

- Schedule of deliverables
- Cost breakdown
- Payment schedule
- Profile of key personnel involved in execution of the work activity
- Implementation Plan for execution of the contract to demonstrate how the work will comply with the requirements of this specification. The Implementation Plan shall include list of points which need IO check and/or approval for continuation of the work
The official language of the ITER project is English. Therefore all input and output documentation relevant for this Contract shall be in English. The Contractor shall ensure that all the professionals in charge of the Contract have an adequate knowledge of English, to allow easy communication and adequate drafting of technical documentation. This requirement also applies to the Contractor’s staff working at the ITER site or participating to meetings with the ITER Organization.

Documentation developed shall be retained by the contractor for a minimum of 5 years and then may be discarded at the direction of the IO.

The work may require the presence of the Contractor’s personnel at the site of the ITER Organization, Route de Vinon sur Verdon, 13115 Saint Paul Lez Durance, France, for short time, for the purpose of meetings and data gathering.

For all deliverables submitted in electronic format the Contractor shall ensure that the release of the software used to produce the deliverable shall be the same as that adopted by the ITER Organization.

10 Work Monitoring / Meeting Schedule

Contractor shall also propose a list of meetings with ITER for progress monitoring in agreement with schedule proposed in § 7. At least the following meetings should be foreseen.

<table>
<thead>
<tr>
<th>Scope of meeting</th>
<th>Point of check/Deliverable</th>
<th>Place of meeting</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kick-off</td>
<td>Confirm scope and schedule of the work</td>
<td>ITER site or video conference</td>
<td>Upon entry into force of the Task Agreement</td>
</tr>
<tr>
<td>Progress meeting</td>
<td>Review progress</td>
<td>ITER site or video conference</td>
<td>3 months after the entry into force of the Task Agreement</td>
</tr>
<tr>
<td>Closing contract meeting</td>
<td>Review deliverables</td>
<td>ITER site</td>
<td>6 months after the entry into force of the Task Agreement</td>
</tr>
</tbody>
</table>

11 Payment schedule / Cost and delivery time breakdown

Payment shall be made by the IO upon entry into force of the contract and the acceptances of the progress reports and the final report, as shown in the following table.
<table>
<thead>
<tr>
<th>Payment Allocation</th>
<th>Deliverables</th>
<th>Date</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Payment</td>
<td>None</td>
<td>Upon entry into force of the Task Agreement</td>
<td>50 % of the total payment</td>
</tr>
<tr>
<td>Final Settlement</td>
<td>Final report</td>
<td>12 months after the entry into force of the Task Agreement</td>
<td>50 % of the total payment</td>
</tr>
</tbody>
</table>

12 **Quality Assurance (QA) requirement**

Prior to commencement of any work, a Quality Plan must be provided to IO for approval. This is a separate document which comprises:

1) a workplan with proposed time schedule and agreed preliminary dates for progress meetings,

2) a statement of those involved in the activity and their approximate role and contribution in time,

3) a statement of what work will be subcontracted and who will responsible for checking this.
13 References / Terminology and Acronyms

In the following table denominations and definitions are given of all the actors, entities and documents referred to in this Specification, together with the acronyms used in this document.

<table>
<thead>
<tr>
<th>Denomination</th>
<th>Definition</th>
<th>Acronym</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITER Organization</td>
<td>For this Contract the ITER Organization</td>
<td>IO</td>
</tr>
<tr>
<td>ITER Organization Task Officer</td>
<td>Person appointed by the ITER Organization with responsibility to manage all the technical aspects of this contract</td>
<td>IO-TO</td>
</tr>
<tr>
<td>Contractor</td>
<td>Firm or group of firms organized in a legal entity to provide the scope of supply.</td>
<td>C</td>
</tr>
<tr>
<td>Contractor’s Team</td>
<td>The Contractor plus all the sub-contractors/consultants working under its responsibility and coordination for the performance of the contract</td>
<td>C-Team</td>
</tr>
<tr>
<td>Contractor Task Officer</td>
<td>The person appointed (in writing) by the legally authorised representative of the Contractor, empowered to act on behalf of the Contractor for all technical, administrative legal and financial matters relative to the performance of this contract</td>
<td>C-TO</td>
</tr>
</tbody>
</table>

References
