CONTRACTS TECHNICAL SPECIFICATION

Contract Title:

Electromagnetic Analyses Support

Technical Specification

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	Name	*Affiliation*
Author	**Giulio SANNAZZARO**	**CIE/TI/SYSA section leader**
Approver	**Stefano CHIOCCHIO**	**CIE/TI division head**

Table of Contents

1 Abstract 3
2 Background and Objectives 3
3 Scope of Work 4
4 Estimated Duration 4
5 Work Description 4
5.1 Definition of the appropriate time stepping for plasma disruptions 4
5.2 Evaluation of IGM excitation (induced by PFV) 5
5.3 Evaluation of excitations to reproduce the HC 6
5.4 Evaluation of IGM excitations to reproduce the TFV 6
5.5 Support to blanket design optimization 6
6 Responsibilities (including customs and other logistics) 7
7 List of deliverables and due dates (proposed or required by ITER) 7
8 Acceptance Criteria (including rules and criteria) 7
9 Specific requirements and conditions 7
10 Work Monitoring / Meeting Schedule 8
11 References / Terminology and Acronyms 8

1 Abstract

This document specifies the requirements for the provision of an Expert in EM field to prepare EM models and carry out EM analyses required to support the design of many out vessel and in vessel components still under development (like blanket and a large number of plasma diagnostics) of the ITER machine.

2 Background and Objectives

The ITER machine consists of many components, instrumentations, assemblies and associated systems. Such systems must withstand the strong EM loads induced by the EM transients occurring during the machine operations and most of the ITER instrumentations must operate in presence of strong EM noise and stray field, whose effects should be reduced in order to not perturb their correct functioning. A huge work of modelling and analyses in the EM field is required to optimize the component design and/or their working conditions in order to fulfil these requirements. Almost all departments rely on the System Analyses (SYSA) section support for EM analyses and the presence, on site, of a very skilled and collaborative EM analyst and Tokomak physics expert is essential to coping with the SYSA present work load.

The objective of present contract is twofold:

i) The EM analyses rely largely on the use of FEM numerical codes. Due the peculiar nature of the EM interactions, to achieve reliable predictions using these tools, beside a correct model of the component under investigation, two main further requirements are needed: a correct reproduction of the EM transient in the ambient in which the component will operate and a good model of its environment. The way to reach these requirements is normally left to the expertise of the analyst. The reliability of approach used is in fact difficult to check and the related uncertainty is often one of the major causes of discrepancies in the results of the EM analyses.

In ITER the effects of the EM transients on the in vessel components are drastically influenced by the Vessel that has a very complex geometric structure. Due to this fact the analysis of any ITER in-Vessel component, even if small and of very simple geometry, leads to a huge work to model the environment or to undue simplifications of the structures that can produce erroneous or largely imprecise results.

To face these difficulties SYSA has pointed out a Guideline for Electromagnetic Analyses where the procedures of reproducing the EM transient as well as the degree of detail of the environment are defined.

One of the main objectives to pursue in the frame of this contract is to make these procedures of ease and general use in order to provide to all Domestic Agency DA a checked methodology to perform fast and reliable EM analyses of ITER components.

ii) The ITER blanket modules are important in vessel components. Much work in the past has been spent in analyzing very different blanket design options, now while the overall structure of all blankets modules is well defined, some details have still to be decided in order to fulfil all the engineering constraints. Some of the most demanding constraints are related to the EM loads that these components undergo during plasma disruptions. Now it has become very urgent reaching the definitive design for all the modules and their design must be optimized to reduce, in particular, the EM loads in each module within the allowable limits at the interface with VV already in procurement phase. This work will require several EM analyses for each module to follow all the possible design variants that can be suggested in order to reach this objective. It is then needed to use a modelling technique that allows very fast and reliable model changes required by the blanket design optimization.

The second main objective of this contract is to support to the Blanket design optimization making easier and faster the EM analyses of these components.

3 Scope of Work

The Expert will work on studying and defining the standardization of the methodologies to interface 2-D MHD codes, used to simulate the plasma disruptions, to the 3-D FEM model used for the EM analyses.
The Expert will develop and qualify procedures, select suitable check of the suggested methodologies and compile data packs for the execution of the procedures.

In support of EM modelling the expert will develop meshing techniques that allow very fast and reliable model changes in order to support the blanket design optimization.
It will also be required to participate in design reviews and document review processes.

4 Estimated Duration

The duration for the contract shall be 12 months with provision for a further 12 months extension. During the 12 months contract is foreseen a total of 180 working days (with a maximum of further 180 working days for the 12 months extension).

5 Work Description

To perform a complete EM analysis of an in vessel component three concomitant phenomena, occurring during a plasma disruption, must be taken into account; the eddy current induced by the Poloidal Field Variation (PFV), the eddy current induced by the Toroidal Field Variation(TFV) and the onset of Halo Currents(HC). For the three phenomena equivalent excitations to be used in the EM analyses can be evaluated staring from the outputs of DINA simulations.

5.1 Definition of the appropriate time stepping for plasma disruptions

The EM transients related to plasma disruptions are normally provided by the outputs of the 2-D DINA code. The time stepping of these outputs ranges from several hundreds to one

thousand, much more than normally needed by the 3-D EM analyses. To avoid too much long run durations of the analyses, the time step number of the EM transient must be reduced by a factor of about ten. An appropriate selection of the time steps of the DINA outputs is then needed. The time step selection is normally left to the analyst and if not appropriate could produce undue modification of EM transient and imprecise results.
To eliminate this uncertainty the expert will produce, for all (about 20) DINA simulations of the ITER reference disruptions, a "reduced DINA output", to be put on IDM at disposal of all EM analysts where the appropriate selection of the time steps is given.

For each event it will be documented that the field behaviour outside the plasma region is not affected by the time steps selection operated by the expert.

5.2 Evaluation of IGM excitation (induced by PFV)

The expert shall be expected to take ownership of the definition of all the interface excitations for the ITER reference disruptions for the ITER General EM Model (IGM) that has been developed in SYSA to ease the EM analyses of the in vessel components.

In particular this work will consist in evaluating the equivalent time behaviour of the currents in the toroidal excitations that will be used in the IGM to reproduce the same poloidal field variations of the plasma in all conducting structures surrounding the plasma. The time stepping used for each event will be that one defined in 5.1.

For each disruption the expert will provide the documentation of the precision achieved, comparing the field behaviour and the field time derivative vs. time in the in vessel region, obtained using the IGM excitations, with the correspondent quantities obtained using directly the full DINA outputs.

5.3 Evaluation of excitations to reproduce the HC

The expert will be expected to collaborate with SYSA personnel to write down, using the Visual C++ programming language, a general procedure to evaluate, starting from the outputs of the DINA simulations, the time evolution of the poloidal distributions of halo current on any surface.

The expert will apply the above procedure to evaluate for each disruption the halo current entering in the plasma facing surface of the IGM.

Following the indications of ITER load specifications document the expert will evaluate for each module and each disruption the total halo current vs. time in each blanket module and on the divertor.

5.4 Evaluation of IGM excitations to reproduce the TFV

The DINA output provides the toroidal field variation occurring inside plasma during a plasma disruption. This transient induces poloidal currents in all conducting structures surrounding the plasma.

The IGM includes a set of poloidal excitations located on the surface of a torus placed inside the plasma region that can reproduce the same toroidal flux variation of the plasma.

The expert, taking the flux variation vs. time coming from the DINA outputs, will evaluate for each plasma disruptions the currents vs. time that must be loaded to the poloidal excitations of IGM to reproduce the same toroidal flux variation occurring in the plasma during disruptions. Provided that the toroidal field variation produced by these excitations is equal to the toroidal field variation due to the plasma, even the eddy currents induced in all the conducting structures surrounding the plasma region will be the same.

All the excitations evaluated in points 5.1 to 5.3, together with the software package needed for their use, will be put on IDM and will be at disposal of IO, the DA and all their collaborators for the EM analyses of the in vessel components.

5.5 Support to blanket design optimization

In support to blanket design optimization, the expert will provide the required number of FEM models.
These models will be obtained modifying the IGM including very detailed meshes of the component under investigations and of the main neighbour conductors.

The expert will provide the IO with the modelling techniques that will allow all the mesh modifications, needed to analyze the main design variants that can be suggested to minimize the EM loads, without perturbing the remaining part of the FEM model.

These mesh modifications will be performed in an automatic way using the software package provided by the expert;

6 Responsibilities (including customs and other logistics)

Contractor:

The Contractor warrants that all personnel supplied under the contract have the necessary qualifications and experience to carry out their work. All short-listed candidates proposed will be interviewed.

The work shall be performed on the ITER site because daily exchanges and periodic meetings are foreseen.

ITER:

The contractor will work under the technical instruction of an ITER nominated engineer.
ITER will provide the required information-access to the respective ITER files for executing the work when needed to follow the implementation plan during execution of the work package.

In particular ITER will make available any technical information needed for the contractor to perform the work. All issued / requested documents containing this information must be returned to ITER on completion of the contract.

ITER shall provide a computer with network access rights, an email account and access to Ansys and Visual C++ software packages.

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

Section 5 details typical deliverables for a selection of task types. Each activity listed in chapter 5 (5.1 to 5.5) will be documented by the expert with a detailed report. The generation of these deliverables shall be monitored by the IO TRO during execution of the contract and reviewed at the end of each work package.

8 Acceptance Criteria (including rules and criteria)

Typical deliverables as described in section 7 shall be regularly reviewed by IO. The contractor shall update his reports in order to take into account any comments.

9 Specific requirements and conditions

The following attributes are required to carry out the typical work packages identified in this specification:

- University degree in physics, or a combination of qualifications and experience acceptable to IO

- Minimum of 20 years' experience in the EM issues related to the project and operations of tokamak machines and in the EM problems related to the design of tokamak components
- Good knowledge of the plasma physics
- Deep familiarity with ANSYS FEM EM code.
- Demonstrated ability to develop innovative solutions to face the complex problems related to use of the FEM codes in the EM analyses of tokamak components.
- Deep knowledge of the main program languages like FORTRAN, C and C++ languages.
- Deep knowledge of Visual C++ language.
- Ability to communicate effectively and to write clear and concise reports in English
- Proficient in the use of Microsoft Office suite of software
- Good interpersonal and communication skills
- Ability to work independently when required

10 Work Monitoring / Meeting Schedule

The official language of the ITER project is English.
Generally, the work shall require the presence of the Contractor's personnel at the site of the ITER Organization.

Each work package shall commence with a kick-off meeting.

- A monthly progress meeting shall take place.
- A short review shall take place at the completion of each work package.
- Other regular meetings will take place on an ad-hoc basis as deemed necessary

The Contractor shall prepare short minutes of each kick-off, monthly and milestone progress meeting

11 References / Terminology and Acronyms

DA	Domestic Agency
IO	ITER Organisation
EM	Electromagnetic
SYSA	System Analyses Section
TRO	Technical Responsible Office
PFV	Poloidal Field Variation
TFV	Toroidal Field Variation
HC	Halo Currents