Summary of the Project

Investigation of Distributed Sensing Techniques Based on Fibre Optic Technology and Their Applicability to ITER Leak Localisation

1 Introduction

ITER will be the largest and most complex vacuum system yet to be built. Situated in Southern France, adjacent to the French CEA Cadarache site, the ITER facility covers approximately 190 hectares and is designed to study the fusion reaction between the hydrogen isotopes tritium and deuterium.

It is expected that water leaks from the Tokamak Cooling Water System (TCWS) Primary Heat Transfer Systems (PHTS) into the main vacuum vessel (VV) and helium leaks into the cryostat from the thermal shield and magnet systems will result in a reduction of the availability of the ITER machine and hence method(s) of leak localisation and repair must be developed to minimise machine down time caused by leaks.

Methods of leak localisation can be characterized by two groups – invasive and non-invasive. Invasive techniques require a vessel vent and hence a longer intervention to localise and subsequently repair a leak is required it therefore preferable to utilise non-invasive techniques. It has been proposed that fiber optic cables have the potential to perform as a distributed continuum of sensors along the length of one cable.

2 Scope

Under the scope of the envisaged service contract the Contractor shall perform studies into the feasibility of operating a sensor based on fiber optical technology in the ITER VV and Cryostat. The Contractor shall define and execute a test plan to validate the concept is viable. Based on the results of the studies the Contractor shall propose a concept design of leak localisation system based on the method and study the feasibility of integration of the system with the current ITER design. The Contractor shall develop an R&D plan which when executed will practically demonstrate the applicability of the method to ITER should the method proven viable through the studies. The execution of the R&D plan is outside of the scope of this contract.

3 Planned Approach

The following indicatively describes how the work in executing the contract is planned:

3.1 Collection of Data

The Contractor and ITER shall agree the leak type (helium, water) and leak magnitude to be studied the position of the leak shall also be agreed.

The Contractor shall collect and agree the conditions (geometries, radiation, temperature etc.) under which the technique will operate and will collect all the necessary (CATIA) models from ITER required to perform the task. From this data the Contractor shall compile a requirements document detailing requirements (spatial resolution, response time etc.) provide a detailed description of how the task is to be performed.

3.2 Sensing Phenomenon

There are, in the main, two ways in which the distributed sensor based on fibre optic technology may operate. Firstly by direct interaction between the leak and the fibre optic which causes a deformation of the crystal lattice or secondly by indirect interaction where by the leak is detected utilising another means which, in turn, induces some measurable effect in the fibre optic cable.

Distributed sensors based on fibre optic technology have traditionally utilised temperature, strain or stress to deform the crystal structure of the fibre optic in such a way that the deformation may be sensed using a (for e.g.) a laser scattering / dynamic grating method. The focus of this task is to define the proper transfer mechanism which will convert the effect of leakage into a quantity which may be measurable in the fibre.

Examples of the first direct case to be studied under the scope of the contract include:

- Temperature change of fibre optic caused by leak
- Strain/stress change in fibre caused by temperature change

Examples of the second indirect case which shall be studied under the scope of the contract include:

- Applied coating interaction with the leaking species to induce a measurable change in the cable
- Physical sensors (micro penning,) distributed along the length of the cable. On detection of a leak the discrete sensors cause a deformation in the fibre optic cable which can be measured and the position of the discrete sensor inferred. In this was one fibre optic cable can readout many sensors thus illuminating the requirement for much in vacuum cabling and complicate feeds crossing vacuum boundaries.

3.3 Validation of Concept

The Contractor shall propose, for approval by ITER, a test plan which when executed will demonstrate that the concept has the potential to meet the requirements of the Technical Specification. On approval of the test plan the Contractor shall prepare the necessary test equipment and execute the test plan. Should tests show the concept does not have the potential to meet the requirements of the technical specification the contract shall be terminated. If tests confirm that the concept has the potential to meet the requirements of the technical specification the Contractor shall proceed to concept design phase of the contract. Should the results of test prove negative the contract shall be terminated.

3.4 Concept Design Phase

The Contractor shall make a concept design of leak localisation system based on the concentration map technique. The Contractor shall describe in the design the number, location, sensitivity and response time of the sensors required to realise the technique. The Contractor shall study the feasibility of integration of the concept with existing ITER systems and propose enhancements to the ITER design where necessary to accommodate the system.

3.5 Plan to Demonstration

The Contractor shall develop a resource loaded plan which if executed will practically demonstrate technique and it's applicability to ITER. The execution of the plan is outside of the scope of the contract.

4 Schedule

Action	Tentative date(s)
Call for Pre-qualification	End August 2011
Call for tender	October 2011
Tender submission	November 2011
Contract Award	December 2011
Start of contract	December 2011
End of contract	December 2012

5 Experience

The potential tenderers should have proven experience in the following areas:

1) The Contractor shall have adequate experience in modelling of complex systems.

2) The Contractor shall have adequate experience in vacuum technology.

6 Candidature

Participation is open to all legal persons participating either individually or in a grouping (consortium) which is established in an ITER Member State. A consortium may be a permanent, legally-established grouping or a grouping, which has been constituted informally for a specific tender procedure. All members of a consortium (i.e. the leader and all other members) are jointly and severally liable to the ITER Organization.

The consortium groupings shall be presented at the pre-qualification stage. The tenderer's composition cannot be modified without the prior approval of the ITER Organization after the pre-qualification.

Legal entities belonging to the same legal grouping are allowed to participate separately if they are able to demonstrate independent technical and financial capacities. Candidates (individual or consortium) must comply with the selection criteria. The IO reserves the right to disregard duplicated references and may exclude such legal entities from the pre-qualification procedure.