Assessment of disruption heat fluxes in JET and ITER

Technical Specifications

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1 Background

Heat fluxes during the thermal and the current quench phase of a disruption in ITER are expected to cause surface melting on the first wall and the divertor above certain thresholds in thermal energy and plasma current. Besides a possible degradation of the heat load capabilities of these plasma facing components (PFCs), melting of tungsten or beryllium can contribute to dust production if material is lost while in the liquid phase. It is therefore essential to quantify the amount of melted material in major disruptions and vertical displacement events at different thermal and magnetic energies. The conversion factor, describing how much of the melted material is transformed into dust, is not easily determined and such an analysis is not part of the work described here.

Especially during the thermal quench, the energy loss and deposition on the wall and in the divertor is driven by macroscopic MHD. Models covering these are time consuming and not yet mature enough for a quantitative analysis. Therefore, the alternative approach usually taken is to prescribe heat flux profiles in the scrape-off layer that are mapped onto the surfaces of PFCs using field line tracing. The impact of MHD on the profiles is taken into account by an effective increase of the e-folding length.

2 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.

Denomination	Definition	Acronym
ITER Organization	For this Contract the ITER Organization	IO-
ITER Organization Responsible Officer	Person appointed by the ITER Organization with responsibility to manage all the technical aspects of this contract	IO-RO
Contractor	Firm or group of firms organized in a legal entity to provide the scope of supply.	C-
Contractor Responsible	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	C-R
ITER Organization Task Responsible Officer	Person delegated by the IO-RO for all technical matters, but limited to one specific task order	IO-TRO
Contractor Task Responsible Officer	Equivalent to the IO-TRO in the Contractors team.	C-TRO

3 Scope of the work

The aim of the first part of this work is to perform heat flux calculation based on field line tracing with the code PFCFLUX for various disruption scenarios in ITER. Together with the code RACLETTE, the heat flux footprint will be converted into surface temperatures and mass of melted and evaporated material.

The second part will be to validate the calculation of heat flux footprints using the same technique as for the ITER calculations applied to JET data. This will be done using existing JET IR camera data from VDEs and major disruptions that has been recorded during disruption experiments in campaigns with the ITER-like wall.

An optional extension will extend the work to divertor heat loads and more detailed parameter scans.

4 Task description

The work is split into two parts: I) Heat flux assessment for ITER VDEs and major disruptions and II) validation of the applied heat flux calculations using JET data.

Part I

This part is on assessing ITER heat loads using field line mapping to determine the heat fluxes at the PFCs of the first wall. The amount of melted material is to be calculated from the energy deposition using the code RACLETTE. Equilibria based on DINA runs and complementary information will be provided by IO.

The following cases are to be performed:

a) Thermal quench of upward and downward VDE for thermal energies from 10 to 350 MJ and e-folding length from 10 to 100 mm at outer mid-plane
b) Thermal quench of a major disruption for thermal energies from 10 to 350 MJ and e-folding length from 10 to 100 mm at outer mid-plane
c) Current quench of upward and downward VDE for plasma currents from 1 to 15 MA and e-folding length of 10, 20 and 30 mm at outer mid-plane

Optional (extension):

The following additional calculations are to be addressed:

d) Assess the impact of the findings from part II on the cases described above. This includes assessing the possible impact of different types of major disruptions and plasma parameter
e) Study the impact of different TQ times during upward and downward VDEs
f) Study the energy deposition in the divertor for major disruptions and downward VDEs

Part II

This part includes the analysis of JET data from the wide-angle IR camera and calculation of heat flux distribution on the first wall using the code THEODOR. This analysis should cover thermal quenches of upward VDEs and major disruptions as well as magnetic energy deposition during an upward vertical displacement in the current quench. A description of the distribution in poloidal and radial direction depending on the disruption parameters is expected for both phases, thermal and current quench. Where possible, an assessment of the toroidal asymmetry should be undertaken, which can involve also other diagnostics.

Once, the heat flux distribution on the PFCs is obtained, radial profiles at the outer mid-plane or other appropriate locations will be prescribed and mapped by PFCFLUX in order to fit the heat deposition on the first wall.

Optional (extension):
This work extends the analysis described above to divertor heat fluxes using divertor IR camera data and field line mapping. The ratio of divertor to first wall energy deposition is to be determined for various disruption types that are available in the JET database.

5 Deliverables and Schedule

The duration is 6 months with a possible extension of 6 months (see options in § 4). The work is expected to commence beginning in September 2014.

The Contractor shall submit all the relevant numerical data necessary to promote this task to the ITER Organization upon request by IO-RO anytime during the course of this task.

The Contractor shall submit all deliverables to the ITER Organization as described below:

Deliverable	**Content**	**Due date**
Intermediate report	Results from the ITER heat flux assessment as described in part I a)-c); initial survey of available JET data and first analysis	3 month after signature
Final report	Work as defined for part I a)-c) and II	6 months after signature
Intermediate report (extension)	Assessment of JET divertor heat fluxes as described in part II (extension);	3 month after start of extension
Final report (extension)	Work as described in Part I d)-e) and II (extension)	6 month after start of extension

The 6 months extension is optional and will be decided when initial results on the JET data analysis are available.

6 Responsibilities

ITER:

ITER will provide the necessary information and access to the adequate ITER files for executing this work when needed following the implementation plan.

Contractor:

The contractor will provide results according to the scope of the work outlined above and agreed between IO-TRO and the contractor as the work proceeds, and will fulfil the implementation plan and conditions of present contract.

7 Quality Assurance Program

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.

8 Specific Skills and Competencies

The contractor is expected to fulfil the following requirements:

- At least 5 years of experience in plasma physics R&D
- Experience in JET data analysis
- Experience in the analysis and interpretation of IR camera data, including the derivation of heat fluxes
- Good understanding of the disruption processes, experience in disruption experiments is desirable
- Experience with the codes required to fulfil this task (PFCFLUX, THEODOR, RACLETTE)

9 Specific Requirements and Conditions

The ITER Organization will pay per each deliverable as described in § 5 of these Technical Specifications.

Payments are subject to proper approval of the deliverables by the ITER Organization.

The contractor will include the cost for each deliverable in their proposal.

The official language of the ITER project is English. Therefore all input and output documentation relevant for this Contract shall be in English.

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 will be to a large extent performed remotely.

The work will require the presence of the contractor at the site of the ITER Organization, Route de Vinon, CS 90 046, 13067 St Paul-lez-Durance, France for 1-2 stays of about one week each.

The work will also require the presence of the contractor at JET, Culham Science Centre, Abingdon, OX14 3DB, United Kingdom, for 1-2 stays of about one week each.

The contractor will include the travelling costs in their proposal.

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 Acceptance criteria

The Contractor shall submit a draft of the deliverables defined in § 5 at completion of the work.

The IO-TRO 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.

The contract will be considered completed after ITER has accepted the last deliverable.

11 Meeting schedule

The Contractor shall also propose a list of meetings with ITER for progress monitoring in agreement with schedule proposed in § 5. At least the following meetings should be foreseen.

Scope of meeting	**Point of check progress or final report**	**Place of meeting**
Kick-off contract	Work program	ITER site or video conference
Progress meetings	Checking progress about every 4 weeks	ITER site or video conference
Closing contract meeting Contract completion	Checking final report	ITER site or video conference