



TECHNICAL SPECIFICATION FOR THE ITER quench detection review

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Abstract

This Technical Specification concerns the supply of the expertise to review the quench detection system proposed for the ITER magnet system.

The supply will include:

- 1- Description of the signal compensation method at JET for detection
- 2- Analysis of data collected during JET experiment Px-3.4.3 "Data acquisition for ITER toroidal field coil protection system"

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Terms and Definitions

Term	Definition	Acronym
Acceptance Data Package	Is the documentation package linked with a deliverable to be submitted by the supplier	ADP
Fusion for Energy	The European Joint Undertaking for ITER and the Development of Fusion Energy	F4E
Technical Responsible Officer	F4E's responsible for communicating all technical contractual actions and decisions to the Supplier	TRO
Quality Officer	F4E's responsible for QA for the Contract	QAO
IO	ITER Organisation sometimes referred to as ITER	IO
KOM	Kick-Off Meeting of the Contract	KOM
Subcontractor	All economic operators who supply items to the Supplier under the Contract	---
Supplier	<p>The supplier is either:</p> <ol style="list-style-type: none"> 1. the Contractor as defined in the supply or service Contract, or 2. the Beneficiary as defined in the Grant Agreement. <p>The successful Bidder (Tenderer or Applicant) is referred in the document as the "supplier".</p> <p>The supply-chain follows the scheme below Supplier -> Organization (F4E) -> Customer (e.g. IO)</p>	---

Applicable Documents

Ref number	Doc Number	Doc number and document title..
[A1]	F4E_D_24AU92 v1.0	Selection of a quench detection for the ITER TF system (ref. ITER_D_435VH7)
[A2]	F4E_D_246YNB v1.0	Final report by CREATE on TF quench analysis (ref. ITER_D_48L4B2)
[A3]	F4E_D_24AYTG v1.0	Phenomenology of CREATE studies about QD in TF coil (ref. ITER_D_47TJ7T)
[A4]	F4E_D_24ALTF v1.0	Quench Detection Options for Balanced Bridge and Co-wound Tape Balance in TF coils (ref. ITER_D_69WQZM)
[A5]	F4E_D_24B2DN v1.0	Selection of a detection for the ITER CS system (ref. ITER_D_332E8)
[A6]	F4E_D_23Z7F4 v1.0	Selection of quench detection for the ITER PF system (ref. ITER_D_64MA7Y)
[B1]	F4E_D_24JGUS v1.0	Implementation of quench detection tapes
[B1]	F4E_D_243DQK v1.0	Introduction and Overview of TF coil insulation
[B1]	F4E_D_24KP8E v1.0	Quench detection strategy Functionality

1. INTRODUCTION

1.1. Introduction to ITER & Fusion for Energy

The ITER project aims to build a fusion device, twice the size of the largest current devices, with the goal of demonstrating the scientific and technical feasibility of fusion power. It is a joint project between the European Union, China, India, Japan, South Korea, the Russian Federation and the USA. ITER will be constructed in Europe, at Cadarache in the south of France.

The European Joint Undertaking for ITER and the Development of Fusion Energy or 'Fusion for Energy' is a type of European organisation known as a Joint Undertaking created under the Euratom Treaty by a decision of the Council of the European Union.

'Fusion for Energy' has three main objectives:

- Providing European contributions to the ITER international fusion energy research project being built in Cadarache, France;
- Providing European contributions to a number of joint projects with Japan that aim to accelerate the development of fusion - the "Broader Approach";
- Coordinating a programme of activities to prepare for the first demonstration fusion reactors that can generate electricity (DEMO).

1.2. Subject of this Technical Specification

The detection of a quench for the sake of magnet protection in the ITER Toroidal Field coils is a challenging operation due to the presence of external magnetic fields linking differently the TF conductor. The trigger of the quench protection system is a shocking action for the magnet structure since the forces induced by the fast ramp down of the current are extremely high. Moreover the TF coils were designed to absorb safely a limited number of quenches during their lifetime. Therefore the quench detection system must be designed in order to avoid spurious triggers.

The quench detection system relies on compensated voltage measurement in order to allow inductive voltages to be mutually eliminated. In fact in order to detect a transition of the superconductor to a normal conducting state (resistive voltage is generated) the removal of the inductive component of the voltage along the cables is required.

The electromagnetic quench detection system that is being developed for the ITER machine to decouple purely inductive electromagnetic signals from superconductors' resistive transitions can profit from the experience gained during the operation of the Joint European Torus (JET) in domains like arc detection, short-circuit detection and machine protection in general, where compensation of large inductive signals needs also to be performed. Therefore the operational experience recorded for the European Torus is certainly of relevance for the design of the ITER quench detection system.

This contract concerns the supply of a study of the electromagnetic effects on the coil protection system during JET dry-runs and plasma operation. The objective is to obtain a good prediction of the effect on the coil quench detection system during ITER operational scenarios.

2. SCOPE OF THE TENDER

2.1. Scope of supply

2.1.1. General

The scope of this task is to make available to F4E and IO the expertise acquired with JET operation in relation to the coil protection system (CPS and DMSS). In particular, the electromagnetic effects of JET plasma operation to both systems but more specifically on the DMSS (Direct Magnetic Safety System) which is the most affected. Particularly the induced voltages to the measurement during plasma disruptions, will be assessed.

The following table defines the base Work Breakdown Structure (WBS) of the works, that shall be further developed and detailed by the Bidder.

WBS	Activity
subtask1	Descriptions of the JET Coil protection systems: DMSS (Direct Magnet Safety System) and CPS (Coils Protection System)
subtask 2	Analysis of data collected during JET experiment Px-3.4.3 "Data acquisition for ITER toroidal field coil protection system"

2.1.2. Services

n.a.

2.1.3. Hardware

n.a.

2.1.4. Software

n.a.

2.1.5. Miscellaneous

n.a.

2.2. Boundaries

n.a.

3. TECHNICAL REQUIREMENTS

These tasks will be carried out as part of the EFDA work programme. Reports will therefore be approved by the EFDA Leader as part of the normal monitoring of tasks under EFDA prior to their transmission to F4E for final approval.

3.1.1. Subtask-1: JET COIL PROTECTION SYSTEM DMSS and CPS

The following points have to be considered:

- Description of the magnet protection systems that JET have installed and are used during the tokamak operation;
- Description of the instrumentation (such as voltage taps, Rogowski coils, etc) of the coil protection system;
- Description of the compensation both hardware (e.g. bridges) and algorithms to deduce the resistive component of signals;
- Description of how instrumentation is wired and routed to minimise electro-magnetic perturbations.

3.1.2. Subtask-2: Report on TF coil data collection taken during JET parasitic experiments

In JET a parasitic experimental activity was approved and executed as part of the 2011 work programme in order to assess the influence of magnetic flux changes to the magnet protection system. Acquisition of the relevant signals was performed as follows (see Section 4):

- a. Acquisition during dry run
- b. Acquisition during several plasma events

The Supplier will write a report about the experiment where the information will be collected and reviewed. The details of this report will be addressed in the KoM.

3.2. Components/systems/Mock-ups/Prototype/software/upgrading test facility

N.A.

4. BACKGROUND: TESTS AT JET (SUBTASK 2)

In ITER, the quench detection is based on voltage comparison between subset of coils. During different JET plasma phases the PF coils including vertical stabilization coils have significant current variations which can generate perturbations in the TF coil voltage measurement. In order to quantify such interferences from the coils current variations but also from the plasma in the ITER Quench Detection System an experiment at JET was done and data were collected at different induced voltage on the TF and PF coils.

DMSS (Direct Magnet Safety System) and CPS (Coils Protection System) were used to acquire different voltage and Current data on the coils.

Here is the list of the test activities performed:

The data collection was set up in order to catch the TF sub-coil voltages at different events (i.e. ramp down and up of current, VDE etc). This exercise was done during:

- Dry Run : preferably during the restart (Power Supply commissioning)
- Plasma pulse with VDE (plasma commissioning)

The tests were done parasitically to the commissioning.

a) Test during dry run

DMSS fast trigger time was set to capture potential interference during different coils current variations.

b) Test performed during Plasma Pulse, in particular during

- Break down
- Slow VDE test
- Fast VDE test
- Density limit Disruptions
- Modes lock TBD...

Data from about 35 parasitic pulses were taken, these tests were parasitic to plasma commissioning and more specifically when disruption test were done.

Details can be found in attachment 1: JET_pulse_schedule.xls

5. LOGISTIC SUPPORT REQUIREMENTS

n.a.

6. ASSEMBLY, COMMISSIONING AND TESTS ON SITE

n.a.

7. LONG TERM CONDITIONS

n.a.

8. APPLICABLE DESIGN REFERENCES

8.1. Reference conditions

- n.a.

8.2. Safety and regulatory requirements

- n.a.

8.3. Codes and standards

- n.a.

8.4. Environmental requirements

- n.a.

9. DELIVERABLES AND SCHEDULING

The following Milestones and deliverables shall be included in the Quality Plan (Control Plan).

List of Milestones				
No.	Name	Control Point	Comments	Expected date (month)
1	Approval of document collecting all information corresponding to subtask 1:	NP		Kick-Off Meeting + 2
1a	By the EFDA Leader		Approved by EFDA	
1b	By F4E		Approved by F4E	
2	Approval of the preliminary analysis of the data collected during plasma scenarios and dry runs: end sub-task 2	NP		Kick-Off Meeting + 3
2a	By the EFDA Leader		Approved by EFDA	
2b	By F4E		Approved by F4E	
3	Approval by F4E of the final report: Experiment description and data assessment.	NP		Kick-Off Meeting + 4
3a	By the EFDA Leader		Approved by EFDA	
3b	By F4E		Approved by F4E	

List of Deliverables			
No.	Name / Nature	Description	Delivery date (month)

1	Document (word or pdf)	Document collecting all information corresponding to subtask 1	Kick-Off Meeting + 2
4	Document (excel file + word or pdf)	Preliminary Analysis of the data collected during plasma scenarios and dry runs	Kick-Off Meeting + 3
5	Document (word or pdf)	Final report: Experiment description and data assessment.	Kick-Off Meeting + 4

10. QUALITY CLASS

The quality class of this contract is **class 4**

11. IDENTIFICATION REQUIREMENTS

n.a.