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Diagnostics Irradiation Testing

of

Electrical Components & Cables

Technical Specifications

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	Name	*Affiliation*
Author	**D. Prieto**	**ITER**
Reviewers	**G. Vayakis**	**ITER**
Approver	**M. Walsh**	**ITER**

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Table of Contents

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1. Abstract

The intent of this document is to define several tests, to be performed, through this one agreement, with a qualified high radiation test facility. Each test will be described in a separate task. The first test is for cabling described in detail; subsequent tasks of similar complexity on cabling + sensor or cabling + connector assemblies are also outlined.

2. Background and Objective

Mineral Insulated Cable (MIC) will be used in ITER system to provide diagnostic data to examine the functionality of the fusion reaction and other investigative information. It is therefore important to determine the performance of these cables under similar conditions in a high radiation test environment.

ITER is considering a series of irradiation tests on MIC and terminations. None of the test cables will be used directly on the ITER, but they will qualify cables and termination techniques.

ITER is also preparing specific sensors (pickup coils, bolometers etc), to be wired using MIC and dedicated connectors in ITER. The performance of these assemblies (connectors and sensors) must also be tested.

At present, ITER Diagnostics Division is interested in performing three separate tests and possibly more in the future concerning the irradiation of MI Cable and small electrical assemblies.

Immediate testing requested by ITER:

a. MI-cable irradiation testing of terminated cables.

Other future irradiation testing:

b. Different configurations for specific terminations and cable assemblies.
c. Tests of magnetic sensor assemblies

3. Scope of Work for Immediate Testing (a)

The company is requested to provide testing on two sets of MI cables. These sets meet the physical criteria and testing parameters that were provided to the supplying company (Appendix 1). Two sets will be supplied. They will be similar, with the exception of slight differences in the termination. The scope of work includes:

1. Review and confirmation of the test configuration and test programme
2. Preparation and pre-characterisation of the samples
3. Irradiation tests (in-situ and post-irradiation examination as appropriate)
4. Documentation of results

3.1 Review and confirmation of the test configuration and test programme

The basic configuration is shown in Figure 1. This configuration can be adapted depending on the facility; the adaptations needed must be agreed before contract signature.

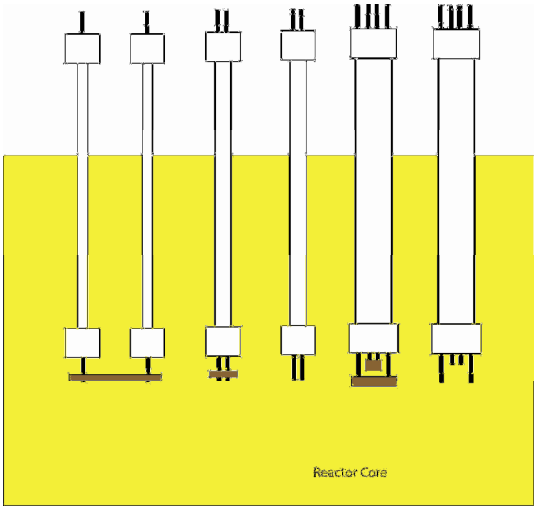

Figure 1: Intended MIC configuration

3.2 Preparation and characterisation of the samples

Shorting and connecting tabs made of Cu are required across the samples (See Figure 1). As thermoelectric testing is required, soldering and brazing are not acceptable. Laser, friction, resistive or ultrasonic welding are acceptable. The company is expected to propose the connection method, and implement it after agreement with ITER.

Basic electrical tests of the cables and joints are required. The company is expected to execute these before and after the irradiation tests. These tests include insulation resistance and bandwidth,

In addition, the company is shall tag and compile a photographic record of samples pre-irradiation for comparison with post-irradiation results. This photographic record should be sufficient to resolve details at the 10 um level at the MIC and other component termination.

3.3 Irradiation tests

The samples terminated by a short in Figure 1 shall be tested for RIC/RIEMF/RITES. The open sets shall be tested for RIC/RIEMF/RIED. RIED testing must be done across all combinations of terminals and sheath.

3.3.1 Objective 1: RIEMF (core/sheath) under irradiation

RIEMF current from core to sheath must be measured in-situ at reasonable intervals for each type of cable. Currents expected in 1 uA range. The company shall make these measurements using certified test equipment of suitable resolution and accuracy.

3.3.2 Objective 2: Thermoelectric performance of cables under irradiation

DC voltage generated in the conductor thermoelectrically shall be monitored to check for RITES. The desired result is null (that is, negligible DC voltage generation at the cable ends). Negligible is <10 nV. Therefore the company must provide and use certified nano-voltmeter instrumentation. Voltages must be monitored at reasonable intervals during the test, to be agreed with ITER.

3.3.3 Objective 3: To confirm in-situ the RIC of cable + termination.

The conductance of the cable assembly insulator shall be monitored to verify its RIC. This can be tested intermittently as the irradiation progresses. The configuration can be done either core to sheath or core-to-core, as appropriate and agreed with ITER.

3.3.4 Objective 4: RIED

Radiation-induced electrical degradation (RIED) should be assessed by monitoring the change in insulation resistance for the worst case environment (open termination). The insulation quality of the cable before and after each exposure should be recorded as often as practicable given the exposure programme.

3.3.5 Objective 5: post irradiation examination

The company shall compile photographic records post irradiation to allow comparison with the pre-irradiation record.

3.3.6 Objective 6: Sealing performance of terminations

The company shall verify and the quality of the seals before and after irradiation. This test should be the first and last test being performed of all tests being performed above. Each termination should be tested, ideally both ends, before irradiation and after last exposure using Helium bath method and steam exposure followed by drying and electrical test. They should be tested a 3rd time during 100 cycles RT -> 350 C.

3.3.7 Irradiation Conditions

Two exposure cycles:

(1) Behind blanket qualification. 150°C/ 20 Gy/s (blanket). RIED samples: 500 V applied for 50 hours (1% of ITER life) at end of exposure. To 0.5 dpa (steel)

(2) 200°C/ 100 Gy/s (divertor). RIED samples: 500 V applied for 15 hours at end of exposure (1% of cassette life). To 3 dpa (steel).

Atmosphere/cooling: He gas.

3.4 Documentation

In addition to the test report for each test, appropriate data processed into physical quantities will also be supplied in electronic form. Acceptable forms are excel sheets and matlab files. Calibration factors appropriate to each dataset must also be supplied with the data.

4. Additional tests (b)

A second round of tests, similar to the first is expected with different MIC assemblies:

- triaxial MIC with open and shorted terminations
- twin MIC terminated with shorted connector assemblies (approximate dimension of each connector assembly: 20 x 20 x 50 mm. materials: ceramic [shapal, alumina], copper and stainless steel)
- quad MIC terminated with shorted connector assemblies

The overall volume of these components excluding cabling will be agreed with ITER. The company shall indicate the volume proposed with their bid. The numbers will be adapted to the agreed volume.

5. Additional tests (c)

A third round of tests, similar to the first is expected with different MIC assemblies:

- twin MIC terminated with LTCC core pickup coils (approximate dimensions: 10 x 40 x 40 mm; 5-10 samples depending on available volume to be agreed with ITER)
- quad MIC terminated with bolometer assemblies

The overall volume of these components excluding cabling will be agreed with ITER. The company shall propose available volumes with the bid.

6. TENDERER Acceptance Criteria

The selection criteria to be used by the IO to evaluate the quotations are listed in Table 6.1.

Table 6.1: Criteria and weighting used by the IO to evaluate the TENDERER's responses.

	Criteria	Weight
1	Quality of response in meeting all the technical specification requirements	15%
2	Ability to demonstrate previous experience (min 5 years) of Irradiation testing within a suitably qualified high radiation test facility.	40%
3	Quality of CV's (suitably qualified expert engineer/professional)	15%
4	Schedule and cost	30%

7. Milestones & Deliverables

Table 7.1: Proposed deliverable and report schedule for each set of tests.

Deliverable	Title	Delivery date
Del. 1	Test quality plan : KOM	February 2012
Del. 2	Intermediate reports: every 3 months	May 2012 August 2012 November 2012
Del. 3	Final Test Report: end of tests	February 2013

8. Estimated Duration

The estimated contract duration will be 12 months.

For the 1st test: Start: ASAP : July 2012
For subsequent tests: dates to be agreed.
The company shall indicate earliest start dates with their bid.

9. Work Description for cable tests (a)

The MI Cable will be manufactured in Japan and shipped to the ITER site for inspection. After inspection, the agreed subset of the cables will be packed and shipped to the testing company. Once the testing is done at the facility, the results will be documented by the company and a final detailed report will issued to ITER Diagnostics. All work will be performed per the **Scope of Work** to determine the cables total performance and efficiency. Additional test parameters will be discussed and established by the testing company and ITER if deemed necessary.

10. Responsibilities (including customs and other logistics)

ITER Diagnostic shall ship to the testing company via the standard shipping and delivery system at ITER. Testing company will confirm shipment and condition of the package.

11. Specific requirements and conditions

Minimum requirements are that the terminations and cables are assembled for testing per the scope of work outlined above. The scope of work will vary for each separate test. The company will provide the entire test infrastructure necessary to set up the cables for testing. (i.e. support structures to mount the cables and terminations for testing)

12. Milestones & Meeting Schedule-

The contract shall span over a period not more than 12 months from kick-off to delivery of the final test results. Key milestones are:

Milestone	**Dates (weeks)**	**Location and Deliverables**
Kick-off meeting	T_0	At start of contract (T_0). This meeting shall be held at the reactor site or other be agreed. Minutes of Meeting.
Progress meetings (Monthly)	T_0 – 1 month	These meetings shall be held at ITER-IO premises or via phone conference. Minutes of Meeting.
Progress reports (Quarterly)	T_0+ 3 months	To be presented at IO site or via video conference. The Contractor shall present any test results, which shall be reviewed and agreed by ITER-IO.
Final Test results & report	T_0+12 months	To be held at ITER-IO premises.

Minutes of meetings and any action item lists shall be written by ITER- IO and drafts shall be sent to the Contractor by e-mail not later than 5 working days after the meeting. Test result reports shall be written by the contractor and sent to IO within 5 days of the tests taking place. After agreement by both parties, the minutes of meeting and test result reports shall be released.

It is expected that the tasks above will be carried out by a minimum of two experts.

13. Payment schedule / Cost and delivery time breakdown

Invoices may be submitted to IO for payment upon completion of each test. Payment will be made upon IO approval of a test report and upon receipt of a valid invoice.

14. Results dissemination

All results obtained in the frame of the work described in this document shall become the property of IO and as such will be available for use either partially or fully in the future development of the project.

15. Quality Assurance (QA) requirement

The organisation conducting these activities should have an ITER approved QA Program or an ISO 9001 accredited quality system.
The general requirements are detailed in ITER document ITER Procurement Quality Requirements (22MFG4)
Prior to commencement of the task, a Quality Plan Quality Plan (22MFMW) must be submitted for IO approval giving evidence of the above and describing the organisation for this task; the skill of workers involved in the study; any anticipated sub-contractors; and giving details of who will be the independent checker of the activities.
Prior to commencement of any manufacturing, a Manufacturing & Inspection Plan Manufacturing and Inspection Plan (22MDZD) must be approved by ITER who will mark up any planned interventions.
Deviations and Non-conformities will follow the procedure detailed in IO document MQP Deviations and Non Conformities (22F53X)
Prior to delivery of any manufactured items to the IO Site, a Release Note must be signed MQP Contractors Release Note (22F52F).
Documentation developed as the result of this task shall be retained by the responding company for a minimum of 5 years and then may be discarded at the direction of the IO.

16. References / Terminology and Acronyms

- MI Cable, or MIC: Mineral Insulated Cable
- RIEMF - Radiation-Induced Electromotive Force
- RIC – Radiation-Induced Conductivity
- RIED – Radiation-Induced Electrical Degradation
- RITES – Radiation-Induced Thermo-electric Sensitivity

Appendix 1: Specification of the MI Cable to be tested under test (a)

a) For Single Core Coaxial Cable:

1. MI Cable Specification

(1.) Sheath Diameter : ϕ 1.9mm

(2.) Core Diameter : Approx. ϕ0.46mm

(3.) Core Number : 1

(4.) Sheath Material : 316SS

(5.) Core Material : Oxygen Free Copper

(6.) Insulation: Alumina (Purity is 99.55%up)

(7.) Sheath Thickness : Approx. ϕ0.3mm

(8.) Withstand Voltage Test : 600VAC, 1 min (in the Atmosphere)

(9.) Insulation Resistance : ≥5MΩ, 500 VDC

2. Hermetic Termination Specification

(1.) Shape made – curved and straight pins.

(2.) Withstand Voltage Test : 1000VDC, 1 min (in the Atmosphere)

(3.) Insulation Resistance : ≥5MΩ, 500VDC (at Room Temperature)

(4.) Airtightness : 1.0 X 10^{-10} Pa m^3/s

3. Available quantities:-

For Set I

Quantity :
5 MI cables × ϕ 1.9 ,10m length
(With both ends hermetic terminations)

For Set II

Quantity :
5 MI cables × ϕ 1.9 ,10m length
(With both ends hermetic terminations)

b) For the Twisted Pair Terminated Cable:

1. MI Cable Specification

(1) Sheath Diameter：φ3.8mm
(2) Core Diameter：Approx. φ0.62mm
(3) Core Number：2（Core Twisted）
(4) Twist pitch ：Approx. 100mm (Target：≦100mm)
(5) Sheath Material：316SS
(6) Core Material：Oxygen Free Copper
(7) Insulation ：Alumina (Purity is 99.55%up)
(8) Sheath thickness：Approx. 0.44mm
(9) Withstand Voltage Test：1000VAC、1min (in the Atmosphere)
(10) Insulation Resistance：≧5MΩ、500VDC

2. **Hermetic Termination Specification**
   (1) Shape made – curved and straight pins
   (2) Withstand Voltage Test：1000VDC、1min (In the Atmosphere)
   (3) Insulation Resistance：≧5MΩ、500VDC (At Room Temperature)
   (4) Airtightness：1.0×10-10 Pa・m3／s
3. **Available quantities**

For Set I

Quantity：
(1) 5 MI cables × ϕ 3.8 ,10m length
(2) 4 MI cables × ϕ 3.8, 10m length (With both ends hermetic terminations)
(3) 2 MI cables × ϕ 3.8, 200mm length (With one end hermetic termination)

For Set II

Quantity：
(1) 4 MI cables × ϕ 3.8, 10m length (With both ends hermetic terminations)
(2) 2 MI cables × ϕ 3.8, 200mm length (With one end hermetic termination)

c) For the Terminated Quad Core MI Cable:

1. **MI Cable Specification**
   (1) Sheath Diameter：φ4.0mm
   (2) Core Diameter: Approx. φ0.45mm
   (3) Core Number：4（Twisted Cable）
   (4) Twist pitch ：Approx. 100mm (Target：≦100mm)
   (5) Sheath Material：316SS
   (6) Core Material: Oxygen Free Copper
   (7) Insulation ：Alumina (Purity is 99.55%up)

(8) Sheath thickness: Approx. 0.44mm
(9) Withstand Voltage Test：1100VAC、1min (In the Atmosphere)
(10) Insulation Resistance：≧5MΩ、500VDC

2. Hermetic Termination Specification

(1) Shape made – curved and straight pins.
(2) Withstand Voltage Test：1000VDC、1min (in the atmosphere)
(3) Insulation Resistance：≧5MΩ、500VDC (at Room Temperature)
(4) Airtightness：1.0×10-10 Pa・m3／s

3. Available quantities:-

For Set I

Quantity：	
(1) 5 MI cables	× ϕ 4.0 ,10m length
(2) 2 MI cables	× ϕ 4.0, 10m length (With both ends hermetic terminations)
(3) 2 MI cables	× ϕ 4.0, 200mm length (With one end hermetic termination)

For Set II

Quantity：	
(1) 2 MI cables	× ϕ 4.0, 10m length (With both ends hermetic terminations)
(2) 2 MI cables	× ϕ 4.0, 200mm length (With one end hermetic termination)

Un-terminated ends to will be sealed against moisture ingress by a suitable method. Each set will be tested using the same equipment to establish a correlation as to performance of the cables. Hysteresis of the equipment and other error factors should be noted and compensated in the calculations and results provided.