Changes versus previous version:

- Section 5 on Professional profiles for candidates added;
- Deliverables have been replaced by work description and documentation (reports);
- Contract is for 1 year with two additional extensions of one year each as options.

Technical Specifications

Technical Support for Instrumentation High-Voltage Tests

This technical specification describes work related to High Voltage (HV) tests to be conducted under special conditions (vacuum, cryogenic) for the SS&A section of the IO Magnet Division. The tasks to be performed include checks carried out at facilities belonging to both CERN and the IO, and also organizational, preparation, execution and documentation work.

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1 Purpose

The purpose of this contract is to cover the need for technical work related to the High Voltage tests of the Instrumentation for the Coils and Feeders of the ITER Magnet System. The final objective is to guarantee the instrumentation performance according to technical specification, quality and schedule requirements. To this end, there is a need to ensure the testing of components first at CERN then at the IO.

1.1 Background

Instrumentation and Control (I & C) components are required in the Magnet Systems (coils, feeders, structures, electronics cubicles) for safety, investment protection, control actions and system monitoring in order to contribute to the reliable operation of the ITER machine.

All sensors, instrumentation cables, conventional control systems, quench detection systems, etc. are procured directly by the ITER Organization.

Part of the Instrumentation items shall be delivered to the DAs for integration according to the signed PAs in compliance with the official schedules. The remaining part will be used during the assembly phase on the ITER site.

The Magnet Division of the Tokamak Department has launched contracts for the series production of elements belonging to the cryogenic circuits of the superconducting magnets as well as their instrumentation system, namely:

- Insulating Breaks,
- HV instrumentation wires and cables,
- HV instrumentation feedthroughs,
- Co-wound tapes for TF coil quench detection.

The series production phase follows the prototype phase, where Instrumentation items were qualified. The next four years starting from January 2014 will be a very active period where the series production of those elements will be carried out. While the manufacturers are requested to supply the instrumentation items which have successfully gone through the routine tests, the IO intends to validate and confirm the design and the manufacturing processes by performing the quality control tests on the firsts of series, and on a statistical basis during production (screening).

Indeed, for qualification, for the confirmation tests on the series production and in preparation for the assembly work, ITER is going to organize its own internal laboratory suited to all necessary tests (including HV tests) on instrumentation components operating at temperatures from 4.5 K to 300 K. In a first stage (2014) the IO will use the HV Reference Laboratory installed at the European Laboratory for Nuclear Research, CERN. After 2014, a Laboratory in the vicinity of the IO site will be provided.

2 Scope of work

The work will correspond to the following domains of competence:

a) Preparation or review of convenient test protocols for the different phases of the Instrumentation item manufacture (pre-series and series production);

b) Preparation and follow-up of technical purchasing documents for tooling or materials related to tests to be performed;
c) Set-up and maintenance responsibility (including calibration) for all the necessary testing devices;
d) Performing electric tests of different nature, including High Voltage tests, and in certain cases mechanical cycling at cryogenic temperatures, on series production units, according to relevant standards;
e) Writing up of test reports;
f) Interfacing with third-party companies when radiation doses are applied to components;
g) Participation to review processes within the IO and companies;
h) General consultancy on High Voltage engineering matters.

The work is to be performed at two locations:

- For the year 2014 at the European Laboratory for Nuclear Research (CERN) based in Geneva (Switzerland)
- For two subsequent years, on the IO's premises close to the ITER site. These two years are optional on a 1+1 basis.

To accomplish the above scope, two professional profiles are needed. The first one corresponds to a more experienced engineer with PhD, the second to a more junior engineer. See Chapter 5.

3 Definitions

BDV: Break Down Voltage

CERN: European Laboratory for Nuclear Research

CWT: Co-Wound Tape

DA: Domestic Agency

DWS: Detailed Work Schedules

FTE: Full-time equivalent

HV: High Voltage

IB: Insulating break

IDM: ITER Document Management system

IO: ITER Organization

MAG: Magnet Division

PI: Polyimide

QA: Quality Assurance

RT: Room Temperature

SSA: Superconductor Systems and Auxiliaries Section

TKM: Tokamak Directorate

TRO: Technical Responsible Officer

4 References

[1] ITER_D_KLEXW6 - Summary of the technical specification on axial insulating breaks for the ITER magnets
[2] ITER_D_KR7J6E - Summary of Technical Specification: High Voltage Wires for the Instrumentation of the ITER Superconducting Magnet Systems
[3] ITER_D_KS6DS8 - Summary of the Technical specifications for the Supply of the instrumentation cables for the ITER magnets
[4] ITER_D_KS8BZF - Summary of the Technical specifications for the Supply of the high-voltage instrumentation feedthroughs for the ITER magnets
[5] ITER_D_KR598A - Summary of the Technical specifications for the Supply of the co-wound tape for the TF coils, CS and Feeders
[6] ITER_D_HPRBWY - Non-Destructive Qualification Tests for ITER Cryogenic Axial Insulating Breaks
[7] ITER_D_L3QJW2 - Non-Destructive Qualification Tests for ITER Cryogenic Axial Insulating Breaks: Slides corresponding to paper [6].

5 Professional profiles for candidates

The following two profiles are required. Companies can present offers for either the two profiles or only one profile.

5.1 Profile 1

The first profile should have the following skills and expertise:

- PhD (controls, cryogenics, HV engineering);
- Three to five years of professional experience in instrumentation, process control, sensor reading and related software applications;
- Three to five years' experience in the high voltage testing of components working in a cryogenic and vacuum environment;
- Ability to operate high voltage (up to 60 kV) equipment, e.g. DC and AC power supplies and power amplifiers;
- Having obtained recently (less than five years old) an electrical certification is compulsory;
- Training experience in Inspection, Maintenance and Repair of power machines above 50kW;
- Good analysis capabilities in the domain of electrical engineering;
- Knowledge in Labview and automatic regulation would be an advantage;
- Able to prepare a test programme and adhere to its schedule;
- Able to work in an international environment like IO and CERN;
- Good level of English (read, written, spoken).

5.2 Profile 2

The second profile should have the following skills and expertise:

- MSc in Electrical Engineering;
- Recent experience (within the last three years) in design of electrical equipment;

- Recent experience (within the last three years) in instrumentation and measurements for electrical systems working at high voltage in the kV range (e.g. transmitters, monitoring systems, in-field instruments, etc.);
- Experience in preparing comprehensive documentation and reports including P&IDs, wiring diagrams, instrument data sheets and test results;
- Good analysis capabilities in the domain of electrical engineering;
- Able to work in an international environment like IO and CERN;
- Good level of English (read, written, spoken).

6 Estimated Duration and Workload

The contract duration shall be one year, starting in January 2014. The IO may extend these services for two additional periods of one year each (total of three years).

The workload over that estimated duration corresponds to the following:

- 2 FTE for year 2014 (Profiles 1 and 2)
- 1 FTE for the following year(s) (if the offer is presented with the two profiles for the first year, Profile 1 should be considered for the optional second and third years).

7 Work Description

7.1 Description of the instrumentation items to be tested

7.1.1 Insulating break

IBs are required to provide isolation between the electrical potential of the superconducting coils and the cryogenic supply lines (ground). The break consists essentially of a length of composite insulating tube, (produced from epoxy-glass) that is bonded at both ends to stainless steel fittings. The insulating tube must be of sufficient length to prevent electrical breakdown through the fluid between the two steel tubes at the high voltages that may occur in a 'fault condition' during machine operation. The IBs are manufactured by ASIPP in two different sizes for 4 kV and 30 kV as represented in Figure 1 and Figure 2.

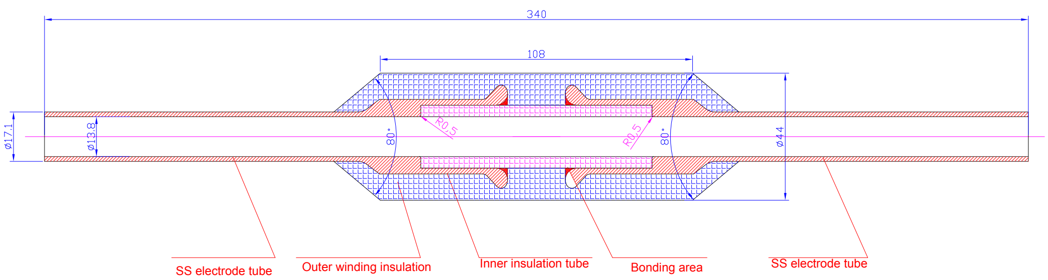

Figure 1. Design of the ASIPP 4 kV HV IB

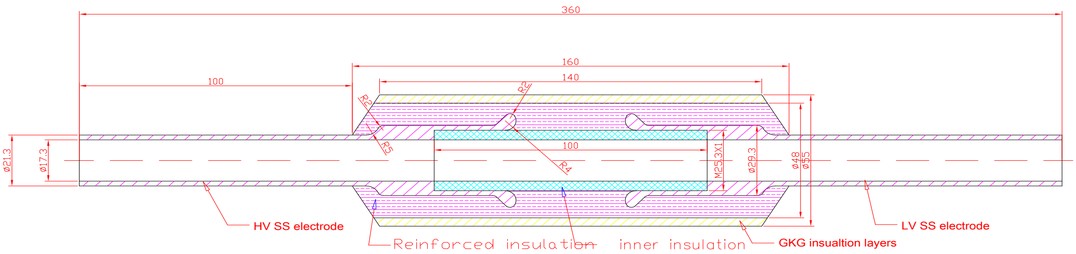

Figure 2. Design of the ASIPP 30 kV HV IB

7.1.2 HV instrumentation wires

HV individual wires are needed to connect the sensors installed in the ITER Superconducting magnet system at a temperature level of around 4.5 K, to the HV cables connected with the feedthroughs located in the cryostat wall.

The HV instrumentation wires are designed and manufactured to operate under vacuum at 4.5 K in an ionizing radiation and magnetic field environment.

The HV wire consists of a PI-insulated silver-coated copper-filament conductor of type AWG 20, 22 or 28.

Various types of individual HV wire are needed for rated voltages of 1, 2 or 30 kV, with outer diameters from 0.5 to 3 mm, depending on the operation and environmental conditions.

7.1.3 HV instrumentation cables

The HV cables are connected from the sensors installed in the ITER Superconducting magnet systems at a temperature level of around 4.5 K to the HV feedthroughs located in the cryostat wall at room temperature.

The HV instrumentation cables are designed and manufactured to operate under vacuum at 4.5 K in an ionizing radiation and magnetic field environment.

The signal to be transported by the cables from the sensors is on the order of 100 mA with a frequency of 0.1 to 1 kHz.

Various types of cable are required with different rated voltages (4 or 30 kV), different numbers of wires (2, 6, or 9) and grouping (in twisted pairs or triplets).

The HV wires are made of copper filament conductors (between AWG22 and AWG26) with silver coating.

The shields are braided screens, with a maximum transfer impedance of 20 mΩ/m + 1 nH/m (from DC to at least 100 MHz), made of a silver-coated copper mesh covering at least 85% of the total cable surface.

The insulation is in PI.

The Outer Diameter of the cable is in the ranges reported below:

- ID = 7 to 9 mm in case of 2 wires;
- ID = 11 to 12.5 mm in case of 6 wires;

- ID = 12 to 13.5 mm in case of 9 wires.

The example of HV cable, schematically represented in Figure 3, consists essentially of a combination of 9 wires twisted in three triplets, two shields and the electrical insulations.

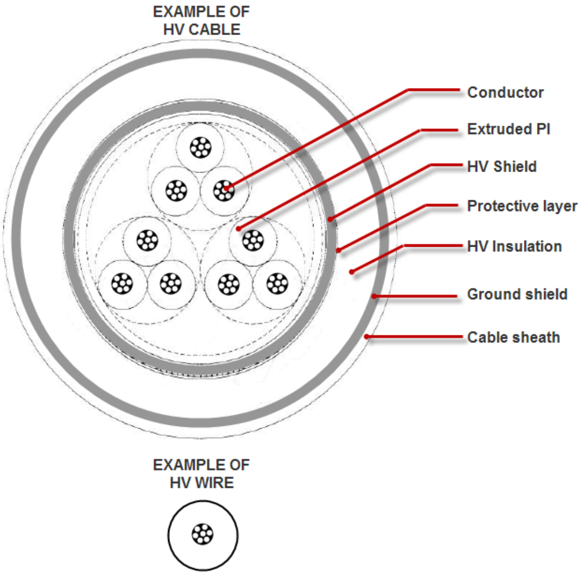

Figure 3. Cross-section of an example of a HV wire & cable

7.1.4 HV instrumentation feedthroughs

The HV Instrumentation feedthroughs are needed in the Superconducting systems for the transition of the HV instrumentation cables from the vacuum vessel to atmospheric pressure at room temperature.

They carry the signals from the voltage taps and co-wound tapes located in the coils and feeders (in the conductor jacket or in the He pipes) out of the satellites.

The feedthrough is divided into two parts:

- The plug which is the male (or female) part to be connected with the RT cable;
- The socket which is the female (or male) part to be connected with the vacuum-cable. It includes the flange for the assembly to the satellite from outside.

The final potting operation of the assembly ensures the leak tightness of the feedthrough.

Various types of HV instrumentation feedthroughs design are required:

- 2-pin 4 kV (type A) and 2-pin 30 kV (type B);
- 6-pin 4 kV (type C) and 6-pin 30 kV (type D);
- 9-pin 30 kV (type E).

Figure 4 depicts a generic example of feedthrough.

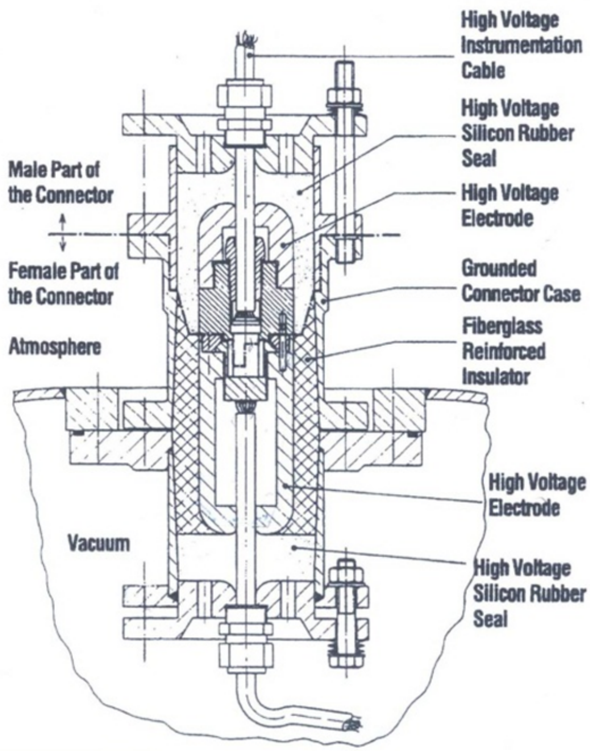

Figure 4: Example of a HV Instrumentation feedthrough used for the POLO model

7.1.5 Co-wound tapes

The Co-wound tapes (CWT) are needed by the ITER Superconducting magnet system for quench detection in the TF coils, CS coils and Feeders. The CWT, embedded in the superconductor turn insulation and twisted around the conductors, is used to measure the inductive voltage pick-up in the coil winding. The signal is then used to balance the inductive noise and remove it from the quench signal, which improves the sensitivity when measuring the resistive quench voltage.

Two types of CWT are required:

- Type 1: One metal strip and S-glass for the TF coils and the Feeder busbars;
- Type 2: Two metal strips and E-glass for the CS coils.

The CWT has one (or two) stainless steel tape(s) in AISI 316L with a cross-section of 0.05 × 2.8 mm, embedded in an S-glass tape having 36 (or 72) warps, a weft density of 8×2 yarns/cm (or 12×2), a thickness of 0.14 mm (or 0.18) and a width of 15 mm (or 50 mm).

7.2 Description of the tests

The lists of electrical, mechanical, leak and thermal tests to be performed under this Technical Specification are reported in Annex 1 in Table 1 to Table 12. Some changes during the development of the activities are allowed with the IO's agreement.

Irradiation and any other tests which are not executable at CERN or at the IO's laboratory will be requested to other Institutes. The IO wishes that the follow-up of those tests be performed by the Contractor as they are part of more global test programmes for which the Contractor shall be responsible.

The different tasks can be sub-divided according to the different development programmes of the components, namely:

- Task 1: Tests on Insulating breaks [1]
  The required tests are listed in Table 3.
- Task 2: Tests on HV instrumentation wires [2]
  The required tests are listed in Table 4.
- Task 3: Tests on HV instrumentation cables [3]
  The required tests are listed in Table 6.
- Task 4: Tests on HV instrumentation Feedthroughs [4]
  The required tests are listed in Table 8.
- Task 5: tests on co-wound tapes for TF coils quench detection [5]
  The required tests are listed in Table 11.

Specimens from companies participating in series production programmes will be tested according to the specifications. The Contractor shall be in charge of the following activities:

a) Preparation or review of convenient test protocols;
b) Set up of the facility;
c) Realisation of the tests according to agreed plans;
d) Writing-up of test reports for each test.

NOTE 1: The IO also expects that those test reports include recommendations for quality recovery or improvement if needed.

NOTE 2: Aspects related to costs, quality assurance, commissioning, operation, maintenance and safety shall also be addressed.

Each test shall be performed by the Contractor according to the relevant standards, with similar modalities as those used during the prototype phase, where applicable.

The Contractor shall prepare a test programme (protocol) for each Task, to be submitted to the IO's approval before implementation. All the protocols already have a so-called prototype version (prepared by CERN in the past) that can be easily modified to meet the requirements of these specifications.

7.3 Description of test devices

The basic test device set-ups to be used for the instrumentation items are described below. The lists are not exhaustive and additional instruments may be required during the development of work.

All the test facilities shall be conforming to all standard and law requirements.

7.3.1 Insulating break

- DC HV test devices up to 56 kV;
- DC HV test devices up to 40 kV;
- Switch impulse test device of about 56 kV peek, Tp 232 µs, T2 2380 µs;

- Lighting impulse test device of about 56 kV peek, T1 1.2 μs, T2 41 μs;
- Leak test device with 40 bar pressure in a vacuum chamber;
- Facility for thermal cycles 300 – 77 K;
- Facility for mechanical static tests at 300 K and 77 K: traction, compression, bending and torsion;
- Facility for fatigue tests (60.000 cycles) at 300 K and 77 K: traction, compression, bending and torsion;
- Endoscope for internal visual inspection;
- Instruments for dimensional inspection.

7.3.2 HV wire

- DC and AC HV test devices up to 56 kV;
- DC HV test devices up to 20 kV;
- Paschen test device system;
- Facility for mechanical cryo test;
- Facility for outgassing test.

7.3.3 HV cable

- DC and AC HV test devices up to 56 kV;
- DC HV test devices up to 20 kV;
- Paschen test device system;
- PD test device system;
- Facility for mechanical cryo test;
- Facility for outgassing test.

7.3.4 HV feedthrough

- DC and AC HV test devices up to 56 kV;
- DC HV test devices up to 20 kV;
- Paschen test device system;
- Leak test device.

7.3.5 Co-wound tape

- Electrical resistance measuring devices at RT;
- Electrical resistance measuring devices at 4.5 K;
- Mechanical resistance measuring system at 77 K;
- Thermal cycle facility 77 K - 300 K.

7.4 Test facility

Details on the test facility at CERN can be seen in [6] and [7].

8 List of tests and due dates

8.1 Delivery plan

The preliminary plan for the delivery of samples to be tested and the related reports are summarized below:

- **19 HV Insulating Breaks** as detailed in Annex 1:

  Table 1– Estimated number of HV IBs to be tested

  Table 2– Time distribution of the HV IBs to be tested (per quarter of a year)

  Table 3– List of tests for the axial IBs of ITER magnets

- **77 tests of HV Wires**, (3 different types) as detailed in Annex 1:

  Table 4– Estimation of HV wire samples to be tested

  Table 5– Time distribution of HV wire samples to be tested

- **263 tests of HV Cables**, (3 different types) as detailed in Annex 1:

  Table 6– Estimation of HV cable samples to be tested

  Table 7– Time distribution of HV cable samples to be tested

- **23 HV Feedthroughs** units, (3 different types) as detailed in Annex 1:

  Table 8– Estimated number of HV Feedthroughs to be tested

  Table 9– Time distribution of the HV Feedthroughs to be tested (per quarter of a year)

  Table 10– Preliminary list of tests for the HV Feedthroughs

- **68 tests of Co-wound tape**, (3 different types) as detailed in Annex 1:

  Table 11– Estimation of Co-wound tape samples to be tested

  Table 12– Time distribution of Co-wound tape samples to be tested

These numbers are to be considered as today's estimations, minor changes are expected. Tests are carried out at the CERN HV Reference Laboratory under coordination and supervision of the CERN staff.

The CERN Staff will deliver the adequate training to run the installations and the make compulsory safety briefings.

8.2 Documentation to be produced

For each one of the specimens described in section 8.1 and according to section 7 (Work Description), a comprehensive test report shall be prepared. The reports should include at least the following information:

- Date and site of the test;

- Name of operator and detail of his/her qualification;
- Description of the tested component;
- Technique used;
- Values measured;
- Test conditions (e.g. temperature, pressure, humidity);
- Sketch showing the technical setup;
- Electronic copy of the multichannel recorder;
- Description of employed apparatus and auxiliary equipment;
- Equipment calibration report;
- Statement of sensing device type, measuring range, uncertainty and resolution;
- Standards applied.

Every test plan and report templates shall be submitted to the TKM/MAG/SSA TRO for approval prior to the start of any testing operations.

To ensure the uniformity of tests, the understanding of the performances and the continuity of satisfactory operations, all proposed or existing procedures or practices to implement the equipment and calibration systems shall be documented. This documentation shall provide a complete detailed plan for controlling the accuracy of all measurement and test equipment, and shall mention every measurement standard utilized. The method, intervals and targeted accuracy shall be compliant with the standards.

9 Acceptance Criteria

After delivery, the IO shall have two calendar weeks to accept the documents/reports mentioned in Sections 2 and 7. After this delay, and in the absence of any comment from the IO, these documents shall be deemed accepted by the IO.

10 Specific requirements and conditions

In terms of qualification and experience, the Contractor shall deploy personnel who:

- have at least 5 years' post graduate experience in electrical testing related to problems associated with superconductivity, cryogenics and vacuum systems;
- are familiar with magnet design manufacturing, testing and superconductivity;
- are proficient in English to communicate and write technical reports and specifications in English.

Other requirements:

- A work plan shall be established and agreed by the IO every two months. Travelling and missions shall be only upon agreement with the IO;
- This contract shall be executed by a maximum of two persons. Splitting it into parts and sharing those between more parties or individuals is not permitted;
- The staff working on this contract shall be available full time and deployed by CERN to the IO site in St Paul-lez-Durance, France.
- The Contractor may be required to be certified in performing specific tests according to relevant standards; in this case the IO will bear the relative costs.

11 Work Monitoring/Meeting Schedule

Regular meetings will take place to make sure that all the information required for the development of the activities is available; the frequency of those meetings should be at least once a week.

12 Payment schedule

The tests should be performed according to the protocols (see Section 7.2 Description of the tests) and documents shall be delivered to the IO as specified in Section 8 (List of tests and due dates). Monthly payments are foreseen after delivery of the corresponding reports.

For travel, subsistence and other expenditure incurred in the mission done by the Contractor personnel to accomplish the work entrusted by the IO, a budget is fixed. Cost will be sustained by the Contractor, and then invoiced to the IO.

13 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 Procurement Quality Requirements (ITER_D_22MFG4).

Prior to commencement of the task, a Quality Plan 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 (see Procurement Requirements for Producing a Quality Plan (ITER_D_22MFMW)).

Prior to commencement of any manufacturing, a Manufacturing and Inspection Plan must be approved by ITER who will mark up any planned interventions (see Requirements for Preparing and Implementing a Manufacturing and Inspection Plan (ITER_D_22MDZD).

Deviations and Non-conformities will follow the procedure detailed in ITER Requirements Regarding Contractors Deviations and Non Conformities (ITER_D_22F53X).

Prior to delivery of any manufactured items to the IO Site, a Release Note must be signed in accordance with ITER Requirements Regarding Contractors Release Notes (ITER_D_22F52F).

Documentation developed as the result of this task shall be retained by the performer of the task or the DA organization for a minimum of 5 years and then may be discarded at the direction of the IO. The use of computer software to perform a safety basis task activity such as analysis and/or modelling, etc. shall be reviewed and approved by the IO prior to its use, in accordance with Quality Assurance for ITER Safety Codes (ITER_D_258LKL).

Annex 1. Plan of the instrumentation items to be tested

Table 1– Estimated number of HV IBs to be tested

Phase	Amount of units for Type Test (according to Table 3 of the Technical Specification)	Hypothesis of Production Rate [Units / month]	Manufacturing Schedule
Series	1/25 up to 100th = **1**	20	Jan 2014
	1/50 from 100th to 300th = **4**	30	Feb 2014 - Aug 2014
	1/100 from 300th to 1000th = **6**	42	Sep 2014 - Dec 2015
	(Total 11 IBs)		

Table 2– Time distribution of the HV IBs to be tested (per quarter of a year)

	2014				**2015**			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
	1							
	1	2	1					
			1	1	1	1	1	1
Total	**2**	**2**	**2**	**1**	**1**	**1**	**1**	**1**

Table 3– List of tests for the axial IBs of ITER magnets

Type Tests		Conditions
1	Visual Inspection	
2	Initial Leak Test	Leak Test at 39 bar, 300K
3	High voltage DC (Design)	56kV in dry air (in bulk)
4	Switch Impulse test	56kV in dry air (in bulk)
5	Lighting impulse test	56kV in dry air (in bulk)
6	High voltage DC (Design)	56kV in dry air (side – to – side)
7	Switch Impulse test	56kV in dry air (side – to – side)
8	Lighting impulse test	56kV in dry air (side – to – side)
9	30 Thermal cycles to 77K	30 cycles cooling rate ≥20K/min
10	10 Pressure cycles	10 cycles 39 bar at 77K
11	10 Pressure cycles	10 cycles 39 bar at RT
12	Tension/Compression Test	5 cycles in tension and compression (2kN) at RT and 77K
13	Tension/Compression Fatigue	60K cycles ±1kN at 77K
14	Torsion Test	5 cycles in torsion (100Nm) at RT & 77K
15	Torsion Fatigue	60K cycles 50Nm at 77K
16	Bending Test	5 cycles in bending (100Nm) at RT & 77K
17	Bending Fatigue	60K cycles 50Nm at 77K
18	High voltage DC (Design)	56kV in dry air (in bulk)
19	Switch Impulse test	56kV in dry air (in bulk)
20	Lighting impulse test	56kV in dry air (in bulk)
21	High voltage DC (Design)	56kV in dry air (side – to – side)
22	Switch Impulse test	56kV in dry air (side – to – side)
23	Lighting impulse test	56kV in dry air (side – to – side)
24	Final Leak Test	Leak Test at 39 bar, RT
25	Destructive tests (NA)	

Table 4– Estimation of HV wire samples to be tested

ESTIMATED Tests HV Wires	Series production (total estimated: 27 km) (tests 10 m every 3000 m). Number of tests:
AC and DC voltage test in air	9
Paschen tightness	9
Fatigue bending at RT and 77 K	9
Radiation resistance (300 kGy) Perform fatigue and HV tests after irradiation	x
Outgassing tests at RT	x
BDV up to 80kV	9

Table 5– Time distribution of HV wire samples to be tested

2014 Jan-Apr (SP)	2014 May-Aug (SP)	2014 Sep-Dec (SP)	2015 Jan-Apr	2015 May-Aug	2015 Sep-Dec	2016 Jan-Apr	2016 May-Aug	2016 Sep-Dec	Total number of tests (check)
3	3	3	0	0	0	0	0	0	9
3	3	3	0	0	0	0	0	0	9
3	3	3	0	0	0	0	0	0	9
X	x	x	0	0	0	0	0	0	x
x	x	x	0	0	0	0	0	0	X
3	3	3	0	0	0	0	0	0	9
								Total	**36**

Table 6– Estimation of HV cable samples to be tested

ESTIMATED Tests HV CABLES	First series production (FSP) 100 m single length. Test every 20 m. Number of tests:	Series production. (SP) Total estimated: 24 km. Tests 10 m every 500 m. Number of tests:
AC and DC voltage test in air (between shields, between wires and between wires and shields)	5	48
Paschen tightness	5	48
Fatigue bending at RT and 77 K	5	48
Outgassing tests at RT	5	0
Radiation resistance (300 kGy) Perform fatigue and HV tests after irradiation	x	x
Partial discharge	5	48
BDV up to 80kV	5	48

Table 7– Time distribution of HV cable samples to be tested

2014 Jan-Apr (FSP)	2014 May-Aug (SP)	2014 Sep-Dec (SP)	2015 Jan-Apr (SP)	2015 May-Aug (SP)	2015 Sep-Dec (SP)	2016 Jan-Apr (SP)	2016 May-Aug (SP)	2016 Sep-Dec (SP)	Total number of tests (check)
5	6	6	6	6	6	6	6	6	53
5	6	6	6	6	6	6	6	6	53
5	6	6	6	6	6	6	6	6	53
5	6	6	6	6	6	6	6	6	53
5	0	0	0	0	0	0	0	0	5
x	x	x	0	0	0	0	0	0	x
5	6	6	6	6	6	6	6	6	53
5	6	6	6	6	6	6	6	6	53
								Total	**323**

Table 8– Estimated number of HV Feedthroughs to be tested

Phase	Amount of units for Type Test	Hypothesis of Production Rate [Units / month]	Manufacturing Schedule
Series	1/25 up to 100th = **4** 1/50 from 100th to 300th = **4** 1/100 from 300th to 1000th = **7** **(Total 15 FTs)**	20 30 42	Apr 2014 - Aug 2014 Sep 2014 - Mar 2015 Apr 2015 - Jul 2016

Table 9– Time distribution of the HV Feedthroughs to be tested (per quarter of a year)

	Estimation number of FTs to be tested (per quarter of a year)							
	2014				**2015**			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
		2	2					
			1	1	2			
						2	2	3
Total	**0**	**2**	**3**	**1**	**2**	**2**	**2**	**3**

Table 10– Preliminary list of tests for the HV Feedthroughs

	Test	Galvanic separation	Parameters	Acceptance
A - Electrical				
1	Leak test		Vacuum on the vacuum side and atmospheric pressure on the other side - 3 min.	< 10^{-9} mbar l/s
2	Electrical resistance of each contact		Ω	< 10 Ω
3	HVT DC/AC	Σ individual pin + HV guiding electrode Vs. Ground Shield	56/40 kV in dry air, 1kV/s, 10 min of stay	Leakage < 0.2µA -DC < 0.1mA - AC
4	HVT DC/AC	Σ individual pin Vs. HV guiding electrode	5/3.5 kV in dry air, 1kV/s, 10 min of stay	Leakage < 0.2µA -DC < 0.1mA -AC
5	HVT DC/AC	Pin to pin (2,6 or 9)	5/3.5 kV in dry air, 1kV/s, 10 min of stay	Leakage < 0.2µA -DC < 0.1mA -AC
6	Paschen test in DC	Σ individual pin + HV guiding electrode Vs. Ground Shield	35 kV with low pressure air on main vacuum side decreased in step values: 100 0 - 100 - 10 - 1 - 0.1 - 0.01 mbar. Air at atm. pressure on the other side. 10 min hold at each step	Leakage < 0.2µA
7	Paschen test in DC	Pin to pin (2,6 or 9)	35 kV with low pressure air on main vacuum side decreased in step values: 100 0 - 100 - 10 - 1 - 0.1 - 0.01 mbar. Air at atm. pressure on the other side. 10 min hold at each step	Leakage < 0.2µA
8	Paschen test in AC	Pin to pin (2,6 or 9)	35 kV with low pressure air on main vacuum side decreased in step values: 100 0 - 100 - 10 - 1 - 0.1 - 0.01 mbar. Air at atm. pressure on the other side. 10 min hold at each step	Leakage < 0.1mA
9	Irradiation		From 2 to 10 kGy performed by IO	
10	Thermal cycles		5 cycles from RT to 77 K (10 min in liquid nitrogen vapours followed by 5 min in liquid nitrogen)	
11	Leak test		Vacuum on the vacuum side and atmospheric pressure on the other side - 3 min.	< 10^{-9} mbar l/s
B - Non electrical (made on the sample cut from the original UL)				
6	Visual inspection			Absence of defects
7	Dimensional			All values inside the tolerances

	Test	Galvanic separation	Parameters	Acceptance
8	Check of correspondence colour wire/pin			According to the agreed colour map

Table 11– Estimation of Co-wound tape samples to be tested

ESTIMATED Tests Co wound tape At least two different types	Series production (SP) 600 km. 10 m every 10000 m Number of tests:	Total Number of tests
Mechanical & cryo tests	56	56
Resistance test	56	56

Table 12– Time distribution of Co-wound tape samples to be tested

2014 Jan-Apr (SP)	2014 May-Aug (SP)	2014 Sep-Dec (SP)	2015 Jan-Apr (SP)	2015 May-Aug (SP)	2015 Sep-Dec (SP)	2016 Jan-Apr (SP)	2016 May-Aug (SP)	2016 Sep-Dec	Total number of tests (check)
8	8	8	8	8	8	4	4	0	56
8	8	8	8	8	8	4	4	0	56