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EXTERNAL REFERENCE / VERSION

Technical Specifications (In-Cash Procurement)

Technical specifications for the design and procurement of electric motors and inverters for SMF compatibility tests

The purpose of this technical specification is to specify the system to be designed, manufactured and delivered to ITER organization (IO) in the purpose of performing Static Magnetic Field (SMF) compatibility tests of commercial AC rotating machines (asynchronous motor and permanent magnet motor) and Variable Frequency Drives (VFD). The system to be delivered is expected to be representative of the typical electrical systems that will be installed at IO.

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1 Preamble

This Technical Specification is to be read in combination with the General Management Specification for Service and Supply (GM3S) – Ref [1] that constitutes a full part of the technical requirements.

In case of conflict, the content of the Technical Specification supersedes the content of Ref [1].

2 Purpose

The purpose of this technical specification is to specify the test bench to be designed, manufactured and delivered to ITER organization (IO) with the objective of performing Static Magnet Field (SMF) compatibility tests on one AC rotating machine (asynchronous motor) and one Variable Frequency Drive (VFD).

The scope of the delivery also includes the mechanical load connected to the motor shaft and other equipment in order to obtain a full turnkey system.

3 Acronyms & Definitions

3.1 Acronyms

The following acronyms are the main one relevant to this document.

Abbreviation	Description
SAT	Site Acceptance Test
FAT	Factory Acceptance Test
IO	ITER organization
SSEN	Steady State Electrical Network
SMF	Static Magnet Field
AC	Alternative current

For a complete list of ITER abbreviations see: ITER Abbreviations (ITER_D_2MU6W5).

3.2 Definitions

Supply Contract: shall mean any Contract for the delivery of a defined set of products, goods or items.

Contractor: shall mean an economic operator who have signed the Contract in which this document is referenced.

Supplier: shall mean a legally registered entity, that can provide standard / catalog goods or material, or standard services to a Contractor, or a subcontractor, that will enable the performance of the scope of work to be provided by the Contractor or subcontractor.

Shall: indicates a mandatory requirement.

May: indicates a suggestion or an option.

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4 Applicable Documents & Codes and standards

4.1 Applicable Documents

This is the responsibility of the Contractor to identify and request for any documents that would not have been transmitted by IO, including the below list of reference documents.

This Technical Specification takes precedence over the referenced documents. In case of conflicting information, this is the responsibility of the Contractor to seek clarification from IO.

Upon notification of any revision of the applicable document transmitted officially to the Contractor, the Contractor shall advise within 4 weeks of any impact on the execution of the contract. Without any response after this period, no impact will be considered.

Ref	Title	IDM Doc ID	Version
1	General Management Specification for Service and Supply (GM3S)	82MXQK	0.0
2	ITER abbreviations	ITER_D_2MU6W5	1.18

4.2 Applicable Codes and Standards

This is the responsibility of the Contractor to procure the relevant Codes and Standards applicable to that scope of work.

All the components of the test setup shall be compliant with the France standard and the CE mark.

Ref	Title	Doc Ref.	Version
CS1	NF C-18510 Electrical risk prevention		
CS2	NFC-15100 Low voltage electrical installations		
CS3	ISO 9001		

5 Scope of Work

This section defines the specific scope of work, in addition to the contract execution requirement as defined in Ref [1].

5.1 Scope of Supply #1

5.1.1 Description

IO plans to perform tests using a specific platform to verify the compatibility of different components at SMF. This SMF will simulate the SMF created by the Tokamak.

The scope of this contract includes, but not limited to, the following tasks:

- The conceptual studies required to refine the ratings of the system (voltage, current, operating modes and other parameters to be identified during the contract execution).
- The engineering work required to design and to manufacture the system.
- The procurement and assembly of the components required to build the system and its load, including cubicles, protection systems, motor, load, variable frequency drive, sensors, protection panel, mechanical platform.
- The execution of Factory Acceptance Tests (FAT) aimed to demonstrate the performances of the most critical components that compose the system. The FAT and the test plan shall be proposed by the Contractor and accepted by the IO.
- The shipment of the system to the IO's facility located in Saint Paul Lez Durance in France.
- The support to IO for the installation, commissioning of the system and for SMF effects analysis after testing. The presence of the Contractor at the IO's test facility might be required on demand by IO.
- Changing the configuration of the test setup, after delivery, to perform other tests taking into account the results of previous tests. Some examples of configuration changes are: adding more sensors, changing motor bearings, etc.

In the ITER's facility, different systems are concerned by the SMF constraint. The SMF is produced during the operation of the ITER Tokamak. Several studies/tests have already been performed or are planned to be. Consequently, the tests that will be performed with this system will be focused on the behavior of the asynchronous motor and of the associated Variable Frequency Drive.

The tests of other components will not be performed with this system since these components are already considered in other activities that are in progress at IO.

The system to be tested shall consist of a three-phase asynchronous motor, a motor load, protection, and control system. The objective is to test the motor (with load, without load, at variable speed, at variable power load) and the VFD (separately) under the effect of SMF. To do this, an ad hoc design is required to make the system flexible (see Figure 1 and **Error! Reference source not found.**, chapter 5.1.1).

Additionally, these tests will help defining test procedures, as typical IEC standards do not consider SMFs for immunity requirements and testing.

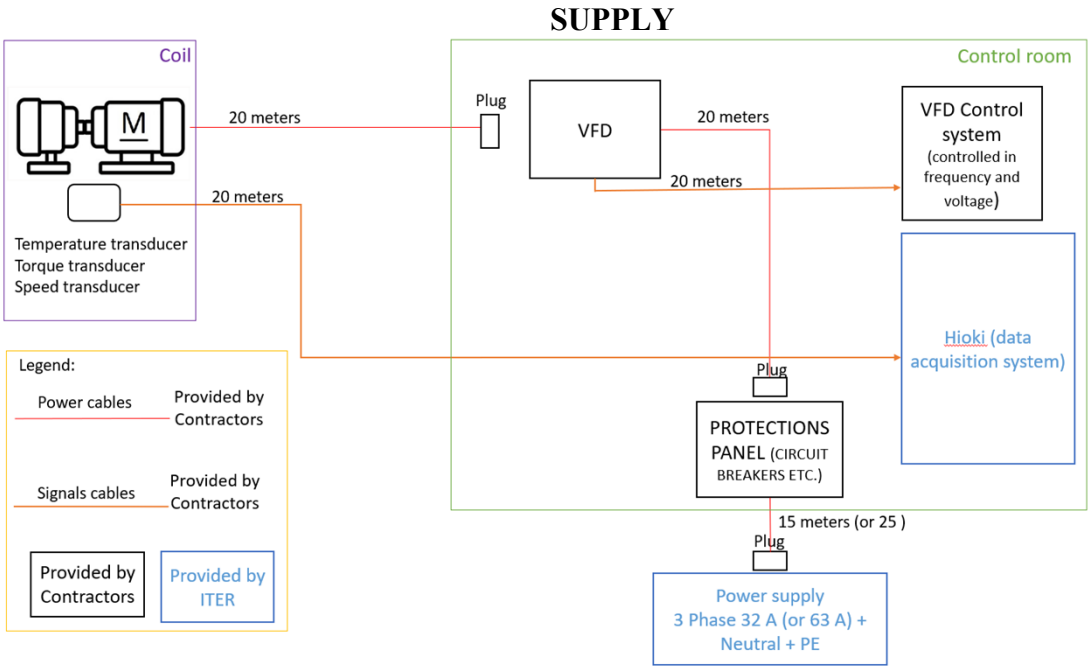

Figure 1 Block Diagram of the motor test setup

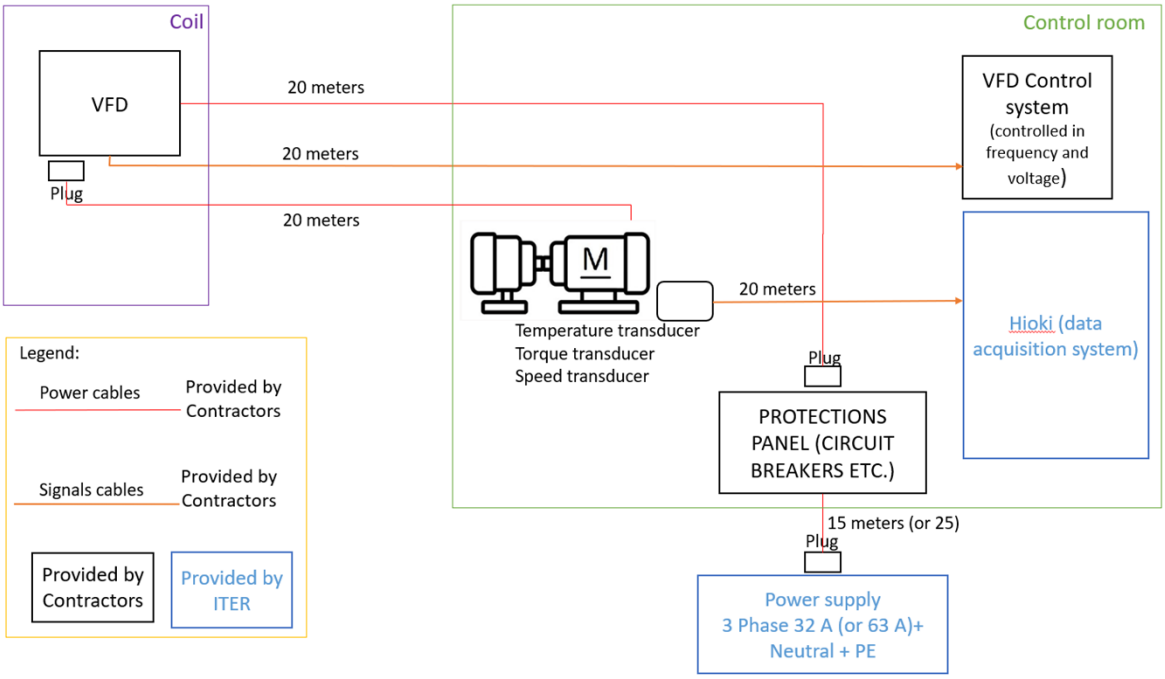

Figure 2 Block Diagram of the VFD test setup

List of the system provided by the ITER Organization:

- Power supply (see chapter 5.1.7)
- Handling tool (see chapter 5.1.6)
- Data acquisition system (“Hioki MR8740T” see chapter 5.1.5)

List of the system provided by the Contractor:

- Asynchronous motor (see chapter 5.1.2)
- Mechanical load connected to the motor shaft. (see chapter 5.1.2)
- Variable Frequency Drive (VFD) (see chapter 5.1.2)
- Interface Motor – VFD (see chapter 5.1.5)

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- VFD control system (see chapter 5.1.2)
- Interface VFD - VFD control system (see chapter 5.1.5)
- Protections panel (see chapter 5.1.2)
- Interface Protections panel – Power supply (see chapter 5.1.5)
- Interface VFD – Protections panel (see chapter 5.1.5)
- Platform to link test setup with handling tool (see chapter 5.1.6)
- Temperature sensors (compatible with our data acquisition system, see chapter 5.1.2)
- Torque sensors (compatible with our data acquisition system, see chapter 5.1.2)
- Speed sensors (compatible with our data acquisition system, see chapter 5.1.2)
- Interface all sensors – Data acquisition system (see chapter 5.1.5)

5.1.2 Design requirements

The test benches shall be modular to perform the tests with several configurations and to allow easier troubleshooting.

The contractor shall define the final electrical parameters (current, voltage, load…) of the system during the contract execution based on the technical requirements, interfaces, and commercial availability of components.

Nevertheless, design and performance requirements are proposed in this section in order to guide the Contractor during the tender process. The schematic and diagrams presented in these sections (chapter 5) are for illustration purposes and do not consider all the components and devices required for this system.

Motor

The motor shall be an air-cooled three-phase asynchronous motor.
The motor will drive a load (see chapter 5.1.2).

The power (kW) of the motor shall be compatibility with the power supply of the system (see chapter 5.1.7) and the dimensions and weight of the handling tool, 1 m^3 and 200 kg maximum payload (see chapter 5.1.6). However, the nameplate power of the motor shall be ≤10kW.

It should be noted that these maximum values compatible with the handling tool shall have to include the engine, the load and the platform that shall be provided to fix the setup to the handling tool (see Figure 12 and 13 chapter 5.1.6).

The motor shall be chosen with temperature sensors inside, to acquire the temperature of the windings and the bearings. The temperature sensors shall be at least two for the windings and one for each bearing. If the motor's manufacturer has a solution with more than the required minimum number thermocouples inside the motor, this shall be proposed and justified in the technical offer.

Further information on the sensors is given below.

The motor (as well as the other components) shall be able to work in several positions, see figure 14 in chapter 5.1.6.

The test setup shall be designed to test the motor with and without cooling (the motor cooling).

Mechanical Load

The mechanical load connected to the motor shaft shall be compatible as much as possible to work under SMF without parameters changes.

The proposed technical solution is outlined hereunder.

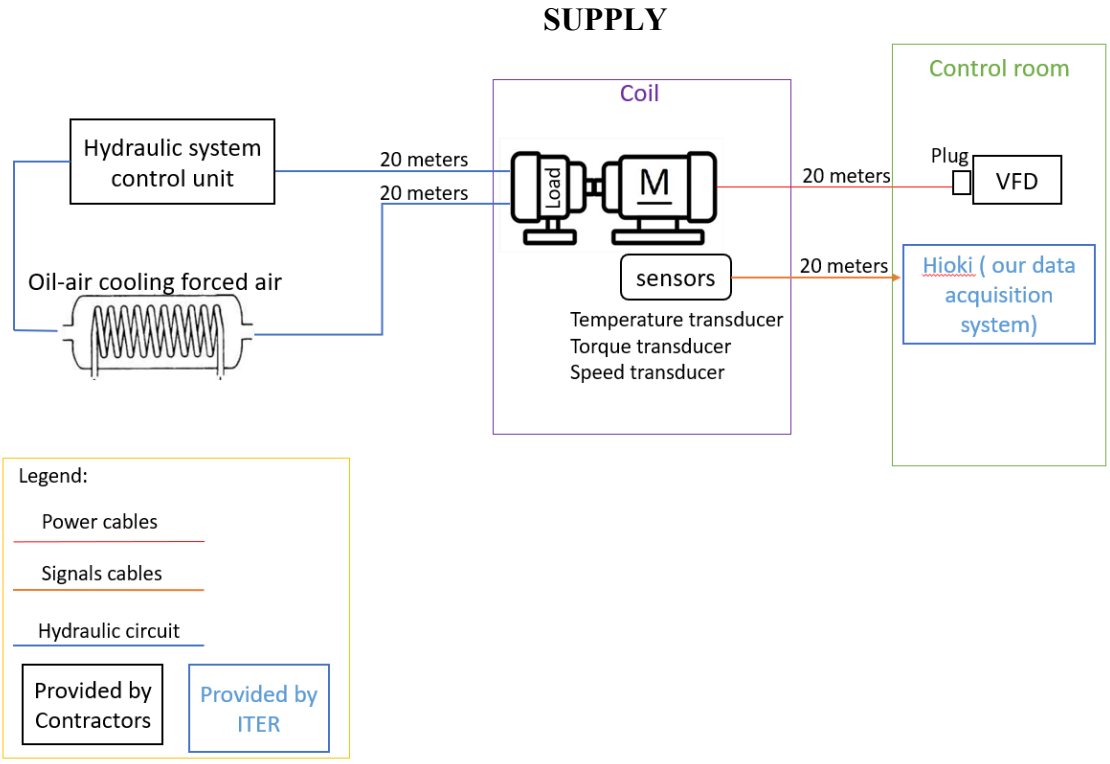

Figure 3 Block Diagram of the proposed technical solution

The proposed technology of the Mechanical Load is based on a hydraulic system and shall meet the following characteristics:

1. Fluid vector shall be oil.
2. The Mechanical Load shall be capable to work in 4 quadrats.
3. Even if the testing of the motor is limited to 1-quadrant operation, for future test set-ups of other rotating components the Mechanical Load shall be suitable for 4-quadrant operation and a rated power of at least 25 kW, continuous duty.
4. The Mechanical Load shall be made non- ferromagnetic material or with electromagnetic shield until 100 mT.
5. The system shall be capable to control the power of the Mechanical Load in all operating conditions from no-load to load.
6. Shall be possible to measurements the speed and the torque (direct or indirect measurements are acceptable).
7. In the system shall be present an oil-air cooling (with forced ventilation) to regulate the oil temperature (to be able to carry out long-term tests without needing to stop the test to let the load cool).
8. The cables of the hydraulic system shall be flexible cables.

The Mechanical Load shall be able to operate compatibly with the motor thermal time constants, to be able to appreciate the motor temperature variations.

The power of the Mechanical Load shall be compatible with the power of the motor, to test the motor in all possible output power range.

The Mechanical Load must be designed for easy manual detachment using tools (i.e. not through an automatic system) from the motor to allow the testing of the motor in no-load conditions.

The Mechanical Load (as well as the other components) shall be able to work in several positions, see figure 14 in chapter 5.1.6.

Contractors shall provide a document indicating the solution with its advantages, disadvantages, Duty Cycle at the maximum power, and costs.

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Variable Frequency Drive (VFD)

The VFD shall be capable to change the input voltage and the frequency of the motor.

The VFD shall be capable to change the input voltage up to the maximum voltage value compatible with the insulation of the motor chosen by the contractor.

The VFD shall be capable to change the frequency up to the maximum frequency value compatible with the mechanical characteristics of the motor chosen by the contractor.

The VFD shall be able to control the motor.

The VFD shall be able to invert the current's direction (to invert the torque of the motor).

The electrical parameters of the VFD shall be defined by the Contractor.

VFD Control system

The control system shall be equipped with a manual stop button to stop the supply of the test setup.

The control system will be positioned at 20 meters from the VFD. The Contractor's responsibility is to select, procure and install that system.

Sensors

Sensors and probes shall be integrated in the system.

The sensors and the connecting cables shall be compatible with the interface connecters of the data acquisition system, provided by the IO (see chapter 5.1.5).

The sensors will be connected to the data acquisition system (provided by the IO) for controlling and testing the system. The selection, the procurement, the implementation and installation of these sensors are included in the scope of this Contract.

The system shall include at least the following sensors:

1) temperature of the motor.
2) Torque and speed of the rotor.

All sensors shall be compatibility with the data acquisition system provided by IO. To do this all sensors shall be chosen from the document in Appendices (chapter 12).

Temperatures sensors

There shall be the temperature sensors mentioned in the "motor" section.

The temperature sensors shall be thermocouple, 20 meters long.

The temperature sensors shall be compatible with the temperature board model "8967" of our data acquisition system (see chapter 5.1.5 and Appendices, chapter 12, for more information about our data acquisition system).

The sensors shall be easy to install and uninstall them from the motor.

Torque and speed sensors

There shall be one torque sensor and one speed sensor for each motor.

The sensors shall be easy to install and uninstall them from the motor.

The Contractor shall choose and install embarked sensors suitable to operate in the presence of Static Magneti Field. If this is not possible, the Contractor shall underline it to IO.

The sensors shall be compatible with the Voltage board model "U8975" of our data acquisition system (see chapter 5.1.5 and Appendices, chapter 12, for more information about our data acquisition system).

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Protection panel

An electrical protection panel shall be realized, in which there shall be the circuit breakers to protect the motor and the VFD by overcurrent and short-circuit, and then the switches to protect people from electrical risks.

The protection panel shall protect the system and the people but is not mandatory to have an upstream selectivity with the power supply shown in chapter 5.1.7.

The contractor shall provide the cable to connect the protection panel with the power supply (see chapter 5.1.5).

The contractor's responsibility for the protections is to select, procure and install them.

The contractor's responsibility shall be to design and verify compliance with the NF-C-15100 standard.

5.1.3 Operating requirements

NA

5.1.4 Performance requirements

NA

5.1.5 Interface requirements

Interface all sensors – Data acquisition system

The sensors and the connecting cables shall be compatible with the interface connecters of the data acquisition system, "Hioki" MR8740T, provided by the IO (see figure 1 and figure 2, chapter 5.1.1). The "Hioki" will be positioned at 20 meters from the motor.

Figure 4 "Hioki" MR8740T

Web site: https://www."Hioki".com/in-en/products/data-acquisition/daq-testing/id_6715

The MR8740T is rack-mountable data acquisition system that delivers high-speed, multichannel measurements up to 108 channels. All details on this data acquisition system and its measurement boards are show in Appendices (chapter 12).

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If the sensors cannot be directly connected with our data acquisition system, an interface shall be defined, according to the characteristic of data acquisition system (show in this chapter and Appendices, chapter 12).

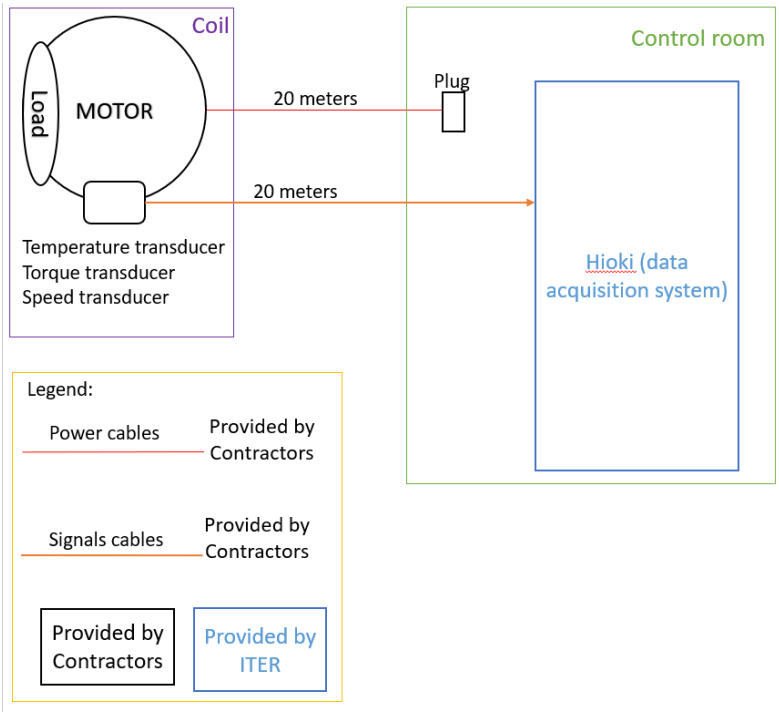

Figure 5 Interface all sensors – Data acquisition system

For the connection between temperature sensors and our data acquisition system, the temperature sensors shall be thermocouples. Contractor will be able to find this information on document in Appendices (chapter 12).
The contractor shall define the connection between torque and speed sensors and our data acquisition system.

Interface Motor – VFD

A cable and a plug (if it's necessary) shall be defined to connect the motor with the VFD.
The cable and the plug shall be adequately sized for the power of the system.

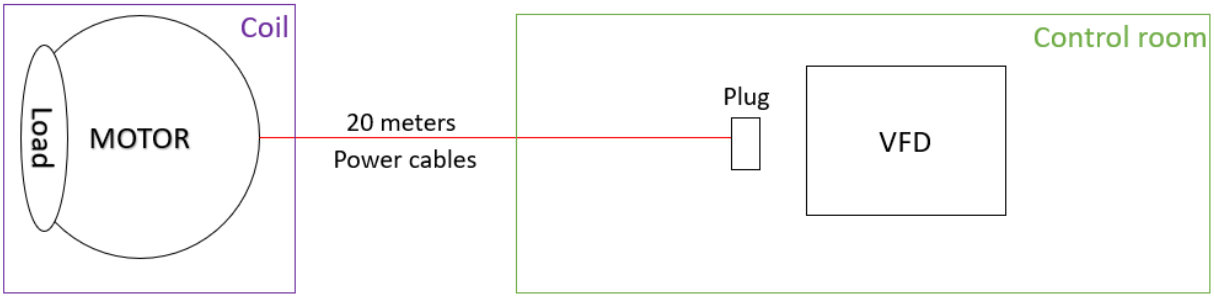

Figure 6 Interface Motor – VFD

Interface VFD – Protections Panel

A cable and a plug shall be defined to connect the VFD with Protection Panel.

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The cable and the plug shall be adequately sized for the power of the system.

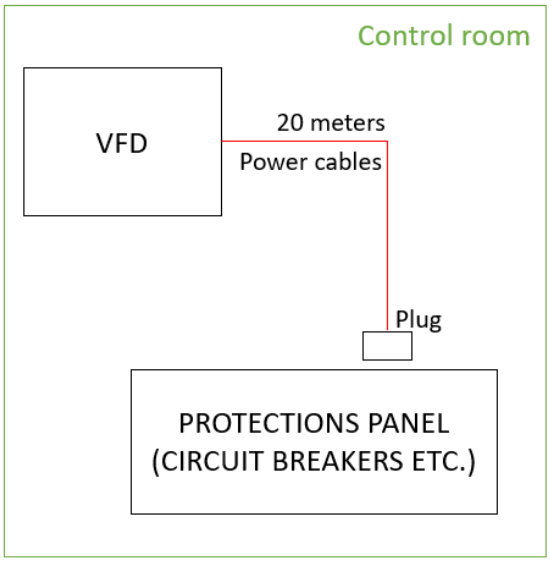

Figure 7 Interface VFD - Protections panel

Interface Protection panel – Power supply

A cable and a plug shall be defined to connect the Protection Panel with the power supply (show in chapter 5.1.7), according to the characteristic of power supply show in chapter 5.1.7.

The cable and the plug shall be adequately sized for the power of the system.

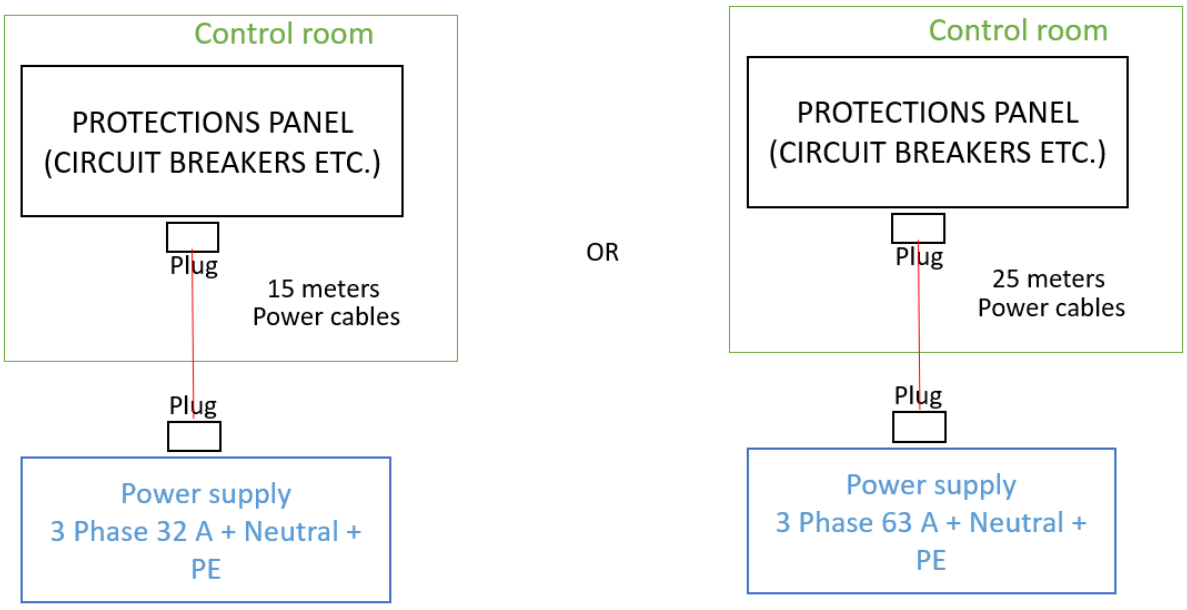

Figure 8 Interface Protection panel – Power supply

It should be noted that the power supply 63 A is more distant than power supply 32 A.

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Interface VFD – VFD control panel

A control system and its interface shall be defined to control the VFD and so the motor.

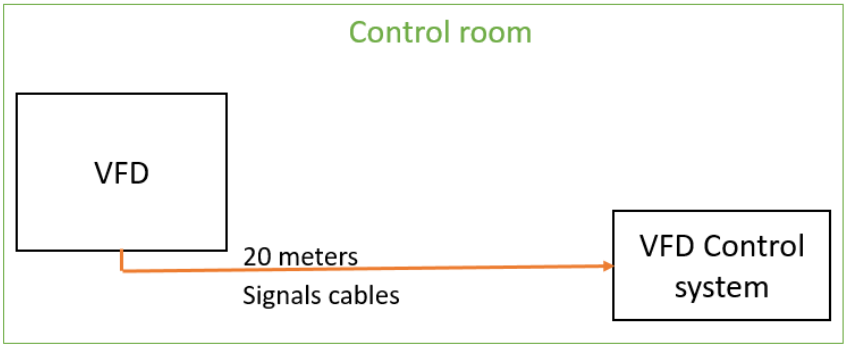

Figure 9 Interface VFD – VFD control panel

5.1.6 Mechanical Requirements

A simplified sketch presenting the plant of the SMF test facility is shown in Figure 10 chapter 5.1.6.

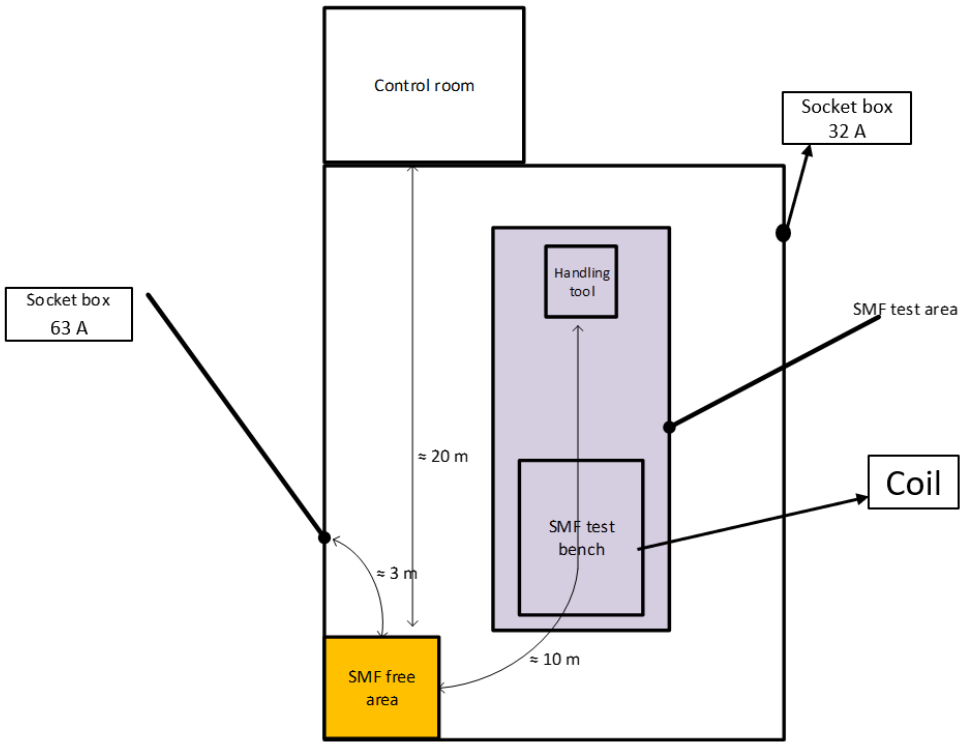

Figure 10. Simplified implantation sketch of the SMF test facility

The maximum value of SMF is 275 mT (milliTesla).

Two areas are planned to be used for placing the test setup:

- SMF test area: On the handling tool, that will be then moving part in the SMF test bench, for the system(s) that will be tested under SMF conditions. During the test, the cabling will be disconnected in the handling tool before to move the system(s) in the SMF test bench.
- Control room: Where the protection panels, control system and VFD will be placed.

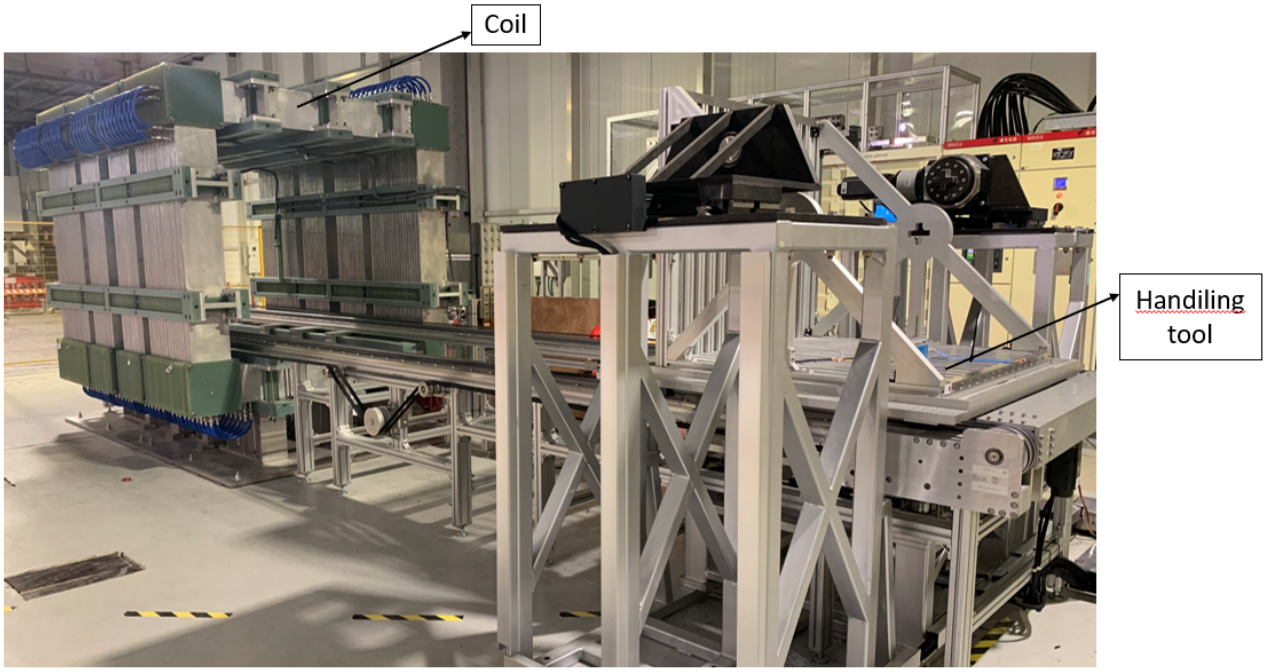

Figure 11 SMF test facility

During the SMF tests, each test setup will have to be fixed on the handling tool, shown in Figure 12 chapter 5.1.6, in order to perform the tests in several directions.

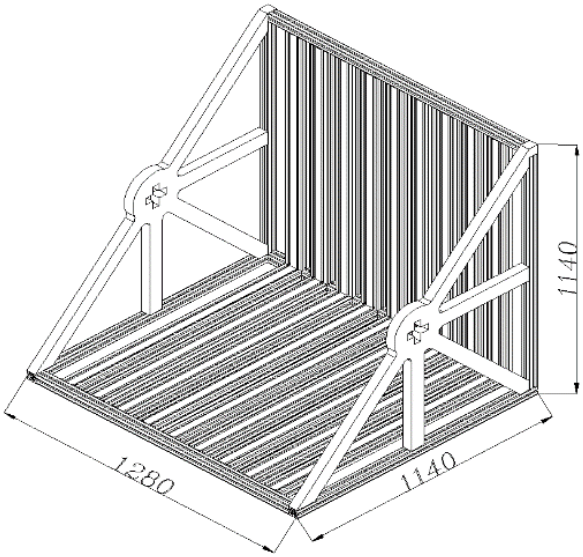

Figure 12. Schematic of the handling tool

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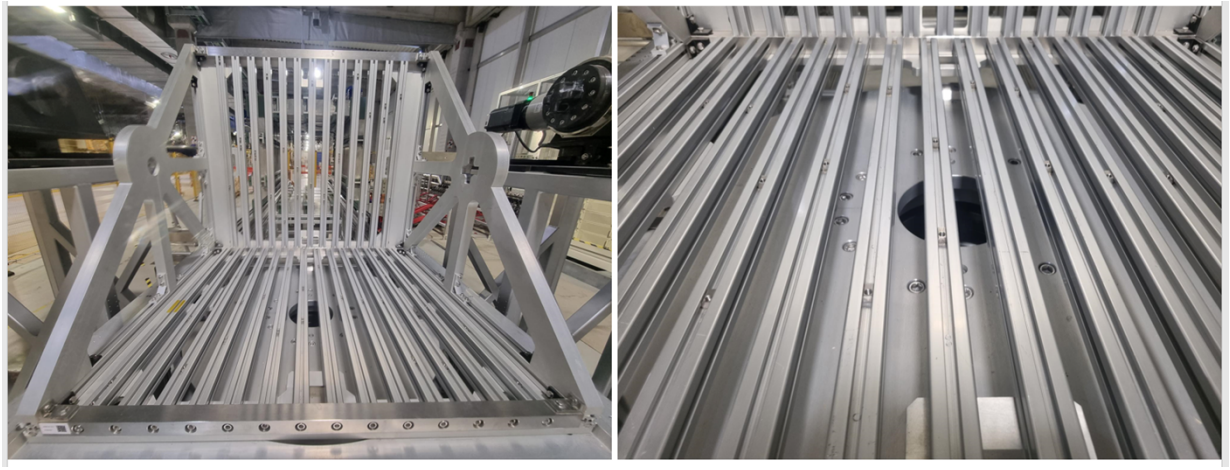

Figure 13 Pictures of the handling tool

IO will provide the handling tool show in figure 12 and 13 (chapter 5.1.6).

The maximum volume that can be handled by the tool is 1 m^3 (1 x 1 x 1 m).

The maximum payload (dead load) is 200 kg.

The fixations have to support the system in the three planes (X, Y and Z), the handling tool and so the test setup will rotate in several position (show in figure 14, chapter 5.1.6).

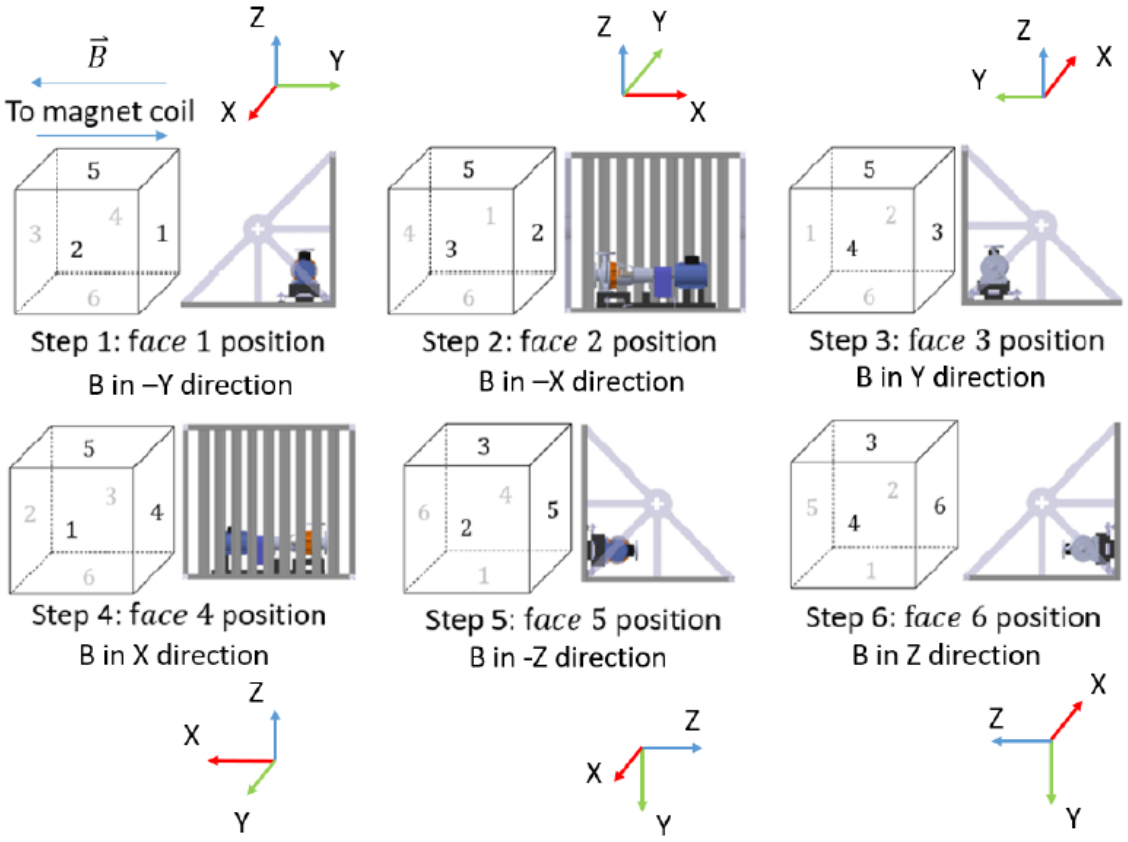

Figure 14 Possible rotation and face positions of the handling tool

The test setup shall be able to work in all the six-position show in figure 14 (chapter 5.1.6).

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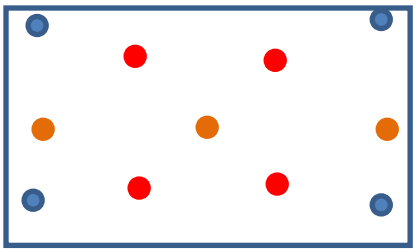
Platform to link test setup with handling tool

In order to handle the system correctly, the contractor shall design a platform (made of non-ferromagnetic material) that will be fixed in the handling tool. The contractor shall provide the screws or other fixing tools (made of non-ferromagnetic material) to fix the platform in the handling tool.

Example of the platform:



Blue holes, for example, to fix platform with the handling tool.

Orange or red holes for example, to fix the test setup with the platform (and so with the handling tool).

Figure 15 Example of mechanic fixing tools used for other test.

Figure 16 Example of a test setup fixed to the holder.

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5.1.7 Electrical Requirements

The system will be connected on the IO's Steady-State-Electrical-Network (SSEN).

For the power circuit the characteristics and the requirements to be considered are given in table 1 chapter 5.1.7.

Voltage	230/400 V ± 10 %
Frequency	50 Hz ± 1 %
Grounding system	TN-S in accordance with NF C15-100 (corresponding to IEC 60364)
Total harmonic distortion	< 5 %
Max current	4 x 63 A
Min power factor	0.85
Max current harmonics rejection	5%
Socket(s) type	3-L (32 A) + Neutral + PE or 3-L (63 A) + Neutral + PE

Table 1 Requirements for the power supply of the test bench

If the power factor and harmonics limits are not respected, filters shall be included in the scope of this Contract.

The control system will be supplied through another typical 2L+T socket, supplied from a different feeder.

Below are shown the pictures of the power supply.

Figure 17 Power supply 32 A – 16 A

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Figure 18 Zoom of the protections in the power supply 32 A – 16 A

Figure 19 Zoom of the protections in the power supply 32 A – 16 A

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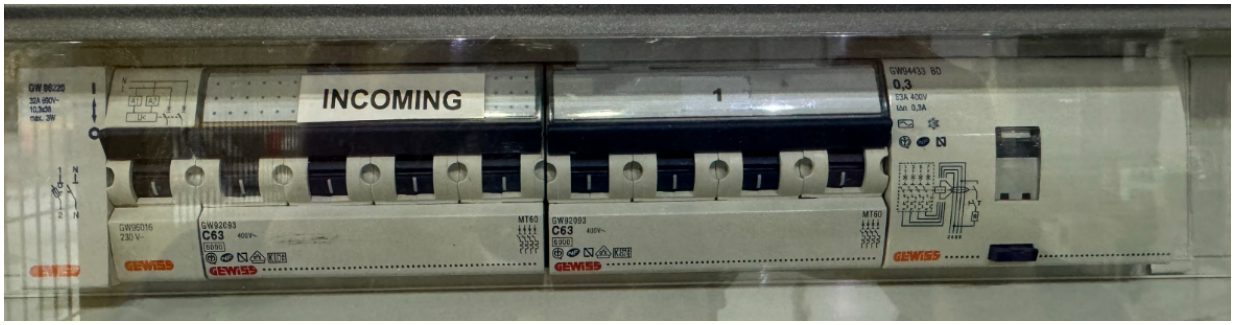

Figure 20 Zoom of the protections in the power supply 63 A - 16 A

Figure 21 Socket power supply 63 A

5.1.8 Software requirements

The control system shall be able to control the VFD**.**

The Contractor's responsibility is to develop and install that control system.

The VFD control system shall be capable to control the VFD, in Voltage and frequency.

The VFD control system shall be capable to invert the direction of the current (to invert the torque of the motor).

The control functions shall be mature enough to be implemented for real system. The sample times and data types shall be defined according to the requirements and the final implementation of the control system.

The control system shall be able to start and stop the motor (at any operational stage) and turn off the VFD.

5.1.9 Material, welding and fabrication requirements

Everything has already been detailed in the previous chapters.

5.1.10 Quality Control Provisions

Company certification ISO9001 and ISO 14001

5.1.11 Spare Parts

The contractor shall provide a list of spare parts considering five years of operation of the test setup.

This list will be considered an optional.

IO will choose to purchase or not as optional action.

5.1.12 Packing, preservation & shipping

See chapter 8.

5.1.13 Delivery Time

See chapter 8.

5.2 Scope of Supply #2

5.2.1 Description

The IO want to predict the possibility to do a test with different kind of bearings. The cost estimate of these following cases shall be included in the scope of this Contract.

- Option 1
  Motor with steel bearing shall be provided.
  The possibility to replace the steel bearing with ceramic bearings shall be included in the scope of the Contract. That possibility shall be carried out sending the motor to the Contractor's technical office or, in alternative, by the presence of the contractor in the IO's facility to replace the bearings.

- Option 2
  The Contractor shall provide two different types of motor. Motor with steel bearing and motor with ceramic bearings.

IO will choose to accept 'Option 1' or 'Option 2'.

5.2.2 Service Duration

NA

6 Location for Scope of Work Execution

NA

7 IO Documents & IO Free issue items

Validation of the deliverables (show in chapters 8).

8 List of deliverables

The Supplier shall provide IO with the documents and data required in the application of this technical specification, the GM3S Ref [1] and any other requirement derived from the application of the contract.

You can find here below a minimum list of documents, but not limited to, that are required within the expected timing.

The Work Plan is split into GTD (see table below). Such GTD may correspond in the contract to milestone of payment.

Technical Design Family (TDF)	Generic Document Title (GTD)	Further Description	Expected Timing (T0+x) *
Delivery Family	Detail design engineering	In order to validate the design of the system before its manufacturing, the technical offer (which the contractor shall have to provide for the tender) shall be considered like a preliminary version. The design review will not be considered completed until the major comments have not been addressed by the contractor and the related deliverables have not been accepted. These activities correspond to the initial phase in which the contractor shall provide the detail documents engineering (in accordance with what was said before). Deliverables to be provided by the Contractor are: - Calculations and motivations that justify the choice of components and so the design of the test setup, like electrical ratings, operating range, sizing of the system (output current, output voltage, frequency…) and yet a document indicating the solution with its advantages, disadvantages, continuative time of work at the maximum power (to be intended as “duty cycle of the load”).	T0 + 2
Delivery Family	Materials supply	These activities correspond to the approval of materials by the supplier. Deliverables to be provided by the Contractor are: - Certification of all components and sub-components. - Data sheets of all components and sub-components.	T0 + 3

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Delivery Family	Factory assembly and FAT (*1)	These activities correspond to the supplier's factory assembly of the system and FAT. Deliverables to be provided by the Contractor are: - Declaration of Phase completion (FAT)	T0 + 5
Delivery Family	On-site transport, installation, SAT (*2)	These activities correspond to the transport to the IO site of the system, the installation at the IO site, and the SAT. Deliverables to be provided by the Contractor are: - List of the software and source codes - Operation and maintenance manual - As built diagrams. - Training for IO personnel - One year warranty - Declaration of Phase completion (SAT)	T0 + 6

(*) T0 = Signature Date of the contract; X in months.

(*1) FAT = The objective of the Factory Acceptance Tests (FAT) is to verify the correct design and manufacturing of the system and specific components and their compliance with the technical requirements before shipment to IO. In the case of non-conformities, the contractor is expected to take all necessary actions to address them or to request deviations requests.

IO reserves the right to ask FAT with the presence of IO personnel in contractor's factory.

(*2) SAT = The presence of the Contractor at the IO's site is mandatory to install the system and verify the correct design and manufacturing of the system and specific components and their compliance with the technical requirements.

Supplier shall prepare their document schedule based on the above and using the template available in the GM3S Ref [1] appendix II (click here to download).

After Sale Services

The contractor shall provide the labor and subsistence cost for the technical supports (for working days) in their offer. The IO will issue the Instruction to Proceed (indicating the start and finish date) to request the support (at least in advance of 1 month). The contactor shall ensure the required senior engineer with sufficient technical competence be ready to provide the support at the requested time.

9 Quality Assurance requirements

The organization 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). This system is classified as quality class 4. Quality class 4 does not have specific requirements excepts the ones which are presented in this technical specifications

Documentation developed as the result of this task shall be retained by the performer of the task 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.

SUPPLY

shall be reviewed and approved by the IO prior to its use, in accordance with Quality Assurance for ITER Safety Codes (ITER_D_258LKL).

10 Safety requirements

The scope under this contract does not covers for PIC and/or PIA and/or PE/NPE components, [Ref 1] GM3S section 5.3 applies.

Personnel Safety

Regarding personnel safety, the system shall be compliant with NF-C-15 00 standard. The most important requirements are listed hereafter:

- The grounding scheme selected for this system is TN-S. The supply of the system shall be automatically disconnected after the occurrence of the first fault.
- Live parts shall be protected against direct contacts considering a minimum IP 2X protection degree.

10.1 Nuclear class Safety

NA

10.2 Seismic class

No specific safety requirement related to PIC and/or PIA and/or PE/NPE components apply

11 Specific General Management requirements

Requirement for [Ref 1] GM3S section 6 applies whereas applicable.

12 Appendices

Hioki MR8740T Data Sheet

MR8740T_E4-23E_0.pdf