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Technical Specifications (In-Cash Procurement)

ICH RF Sources Market Survey Technical Specification

This technical Specification is issued in the frame of the implementation of a Market Survey dedicated to the Ion Cyclotron Radio Frequency Sources

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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 addition the Ion Cyclotron Radio Frequency Sources requirements are defined in the SRD 51 [20].

In case of conflict, the content of the Technical Specification supersedes the content of Ref [1] and [20].

2 Purpose

ITER is a multinational R&D project, which aims to demonstrate scientific & technical feasibility of fusion power. The ITER project is being jointly constructed at St. Paul lez Durance Cedex, France by the 7 Countries (European Union, Japan, China, India, Korea, Russia and USA). The ITER Ion Cyclotron Heating & Current Drive (ICH) system is required to perform wall conditioning and plasma scenarios

The ITER ICH system requires **4 RF sources**, each providing 3 MW output power in CW mode (2000s) at VSWR= 1.5 (for any phase of reflection coefficient) in the frequency range 40 – 55 MHz

Each RF source shall be made of identical components and shall be tunable for the frequency range of 38 to 57 MHz.

The typical RFS sources components are:

- low power RF sources
- Solid state power amplifier
- high power tube-based amplifiers
- their related grids power supplies and protection circuits
- Tunning system for the cavities
- I&C for remote operation and protection
- Water and air cooling
- Transmission lines (3”, 6”, 9” or 12”)
- A mis matched transmission line to perform acceptance test.

The HPA2 and HPA3 anode High Voltage Power Supplies (HVPS) are excluded from the supply.

The 3 MW dummy load to perform the RF testing of the source is excluded as well.

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The 4 sources are fed by one master synthesizer. The 3 MW output power is connected to a 12”TL.

In some of the applicable or reference documents, an RF source design/layout may be mentioned/detailed/indicated. This shall not be considered as an input and **the supplier shall remain free to propose any RF source design compliant** with the requirements defined in the present technical specification.

The scope of work will cover the supply, installation and commissioning on ITER site of the 4 RF sources, and mainly comprises the following activities:

- Engineering activities for producing the Final Design of the RF sources
- Manufacturing of the 4 RF sources
- Production of engineering document for the IO Design review processes
- Final design adjustments as required during the manufacturing process
- Supervision and reporting of the manufacturing process
- Inspections and quality records, as specified in the [4]
- Activities for certification/qualification of procedures and processes
- Factory testing of each RF sources
- Delivery to ITER site
- Assembly and installation on ITER site
- Commissioning and Site Acceptance Tests on ITER site
- Cleaning and packaging
- Preservation and storage
- Contract management as required by IO
- Documentation (not inclusive list: design reports, diagrams, drawings, quality assurance

documents, installation and test procedures, manual of operation)

- Training.

The transfer of ownership from the contractor to IO shall be effective at the IO acceptance of the SAT report.

The installation and commissioning of the RF sources will be performed in the Building 20 at ITER site.

An overview of the ICRH system and its RFS source is shown in the following Figure 2-1.

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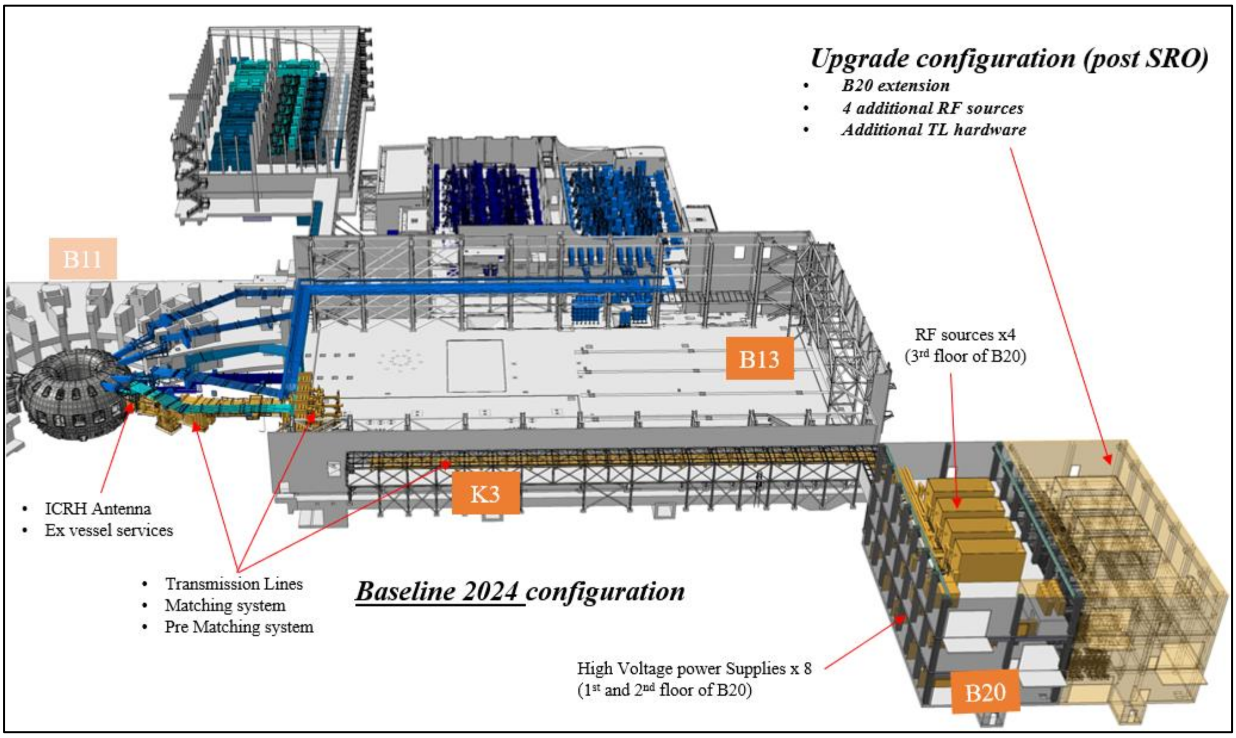

Figure 2-1: Overview of the ICRH system in ITER site

3 Acronyms & Definitions

3.1 Acronyms

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

CRO	Contract Responsible Officer
GM3S	General Management Specification for Service and Supply
IO	ITER Organization
PRO	Procurement Responsible Officer
ATP	Authorization to Proceed
CODAC	Control, Data Access and Communication (ITER subsystem)
COTS	Commercial of The Self
FDR	Final Design Review
FAT	Factory Acceptance Test
GIP	Generated Intellectual Property
HVPS	High Voltage Power Supply
HP	Hold Point
HPA	High Power Amplifier
ICH&CD	Ion Cyclotron Heating & Current Drive
IDP	Input Data Package
IO	ITER Organization
LCU	Local Control Unit

LPM	Litre per minute
MMTL	Mismatch Transmission Line
MIP	Manufacturing & Inspection Plan
MRR	Manufacturing Readiness Review
NP	Notification Point
PCS	Plasma Control System
P&ID	Piping & Instrumentation Diagram
PFD	Process Flow Diagram
PDR	Preliminary Design Review
PSC	Plant System Controller
PS	Power Supply (Unit)
RAMI	Reliability, Availability and Maintainability Inspection
RF	Radio Frequency
R&D	Research & Development
SAT	Site Acceptance Test
TL	Transmission Line
VSWR	Voltage Standing Wave Ratio

3.2 Definitions

Terms used in this specification are covered under Section 2.1 of the GM3S that is requiring a definition to ensure proper understanding of the document. Please note definition of the Contractor, although defined in Ref [4] 2.1 is duplicated here as the term is largely used within this document.

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

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.

During execution of the contract the latest version of documents at the time of contract signature shall be applicable. Future application of these referenced documents will be addressed case by case mutually. 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.

These reference documents shall be implemented for the components supplied by the contractor, wherever applicable. The list of reference document is given in the Table 4-1. For a better understanding, they are grouped with some explanations. Further details could be exchanged during the kick-off meeting.

Ref.	Title	No.
These documents describe the quality management in ITER Organization. They are helpful to understand the general context of ITER organization but as well the detailed requirements linked to the quality classification of the IC RF sources. Specific documents on the delivery processes or the ITER numbering system are provided.		
[1]	Order dated 7 February 2012 relating to the general technical regulations applicable to BNI - FR (7GJHSE) translated for guidance in: Order dated 7 February 2012 relating to the general technical regulations applicable to BNI - EN (7M2YKF) and the subsequent ASN decisions linked to this Order	ITER_D_7GJHSE & ITER_D_7M2YKF
[2]	ITER Procurement Quality Requirements & ITER Quality Assurance Program (QAP)	ITER_D_22MFG4 & ITER_D_22K4QX
[3]	Quality Classification Determination	ITER_D_24VQES
[4]	General Management Specification for Service and Supply (GM3S)	ITER_D_82MXQK
[5]	Procedure for Management of Deviations & Nonconformities	ITER_D_2LZJHB ITER_D_22F53X
[6]	Manufacturing Inspection Plan (MIP) Template	ITER_D_QV7GQF
[7]	ITER function category and type for ITER numbering system	ITER_D_2FJMPY
[8]	ITER numbering system (for parts/components)	ITER_D_28QDBS
[9]	Specification for Labelling of Equipment on ITER Project	ITER_D_VYJ7U2
[10]	Procedure for the CAD management plan	ITER_D_2DWU2M
[11]	ITER Document Breakdown Structure Overview	ITER_D_43327Q
[12]	Risk and Opportunity Management Procedure	ITER_D_22F4LE
[13]	#00 - PGC Volume 1 Internal Regulations Environmental requirements	ITER_D_T6V4RP ITER_D_27WDZW ITER_D_97WRFP

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Ref.	Title	No.
	Contractor Safety Management Procedure Procedure for Occupational Health and Safety Hazard Identification and Assessment Vehicle Access and Traffic Circulation and Parking on the ITER Site ITER Site access Procedure General Management Specification for Executing Entities at the ITER Site	ITER_D_Q2GBJF ITER_D_AJLQRF ITER_D_N3MG3V ITER_D_S3893D ITER_D_YX55YY
[14]	Working Instruction for the Delivery Readiness Review (DRR)	ITER_D_X3NEGB
[15]	Procedure for Transportation of Components to ITER Site	ITER_D_RY5C6Q
[16]	Design Review Procedure	ITER_D_2832CF
[17]	Working Instruction for Manufacturing Readiness Review	ITER_D_44SZYP
[18]	Order dated 29 September 2017 approving Nuclear Safety Authority Decision 2017-DC-0591 of 13 June 2017 on the minimum technical design requirements to be met by workplaces in which electrical equipment that emit X-rays is used.	ITER_D_VH8MYG
[19]	Assessment of French Order of 29 September 2017 on technical requirements to be met by workplaces in which electrical equipment emit X-rays.	ITER_D_WDYTR6
The following documents provide technical information on applicable standards/rules at IO. Some of them are quite general as the ITER Plant Control Design Handbook. The list of applicable standards shall be adapted as per the proposed design component characteristics. Some other documents specify the interface/operation requirements.		
[20]	SRD-51-IC (Ion Cyclotron Heating and Current Drive System (ICH&CD))	28B33K
[21]	SRD-51-HV (Ion Cyclotron Heating & Current Drive Power Supplies (ICH&CD PS))	2MHS2W
[22]	Plant Control Design Handbook	ITER_D_27LH2V
[23]	Electrical Design Handbook Part 3: Codes and standards	ITER_D_2E8DLM
[24]	Electrical Design Handbook Guide A: Electrical Installations for SSEN Client Systems	ITER_D_2EB9VT
[25]	IO cabling rules	ITER_D_335VF9
[26]	EDH Part 4: Electromagnetic Compatibility (EMC)	ITER_D_4B523E
[27]	IO Cable catalogue	ITER_D_355QX2

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Ref.	Title	No.
[28]	Codes and Standards for ITER Mechanical Components	ITER_D_25EW4K
[29]	3 1/8 inch EIA Transmission line flange	ITER_D_4FHCF3
[30]	6 1/8 inch EIA Transmission line flange	ITER_D_4FHGF2
[31]	12 inch Transmission line flange: fix and swivel	ITER_D_4FJGBX ITER_D_3QT2B6
[32]	ICH System Concept of Operation	ITER_D_3MBC4P
The floor response spectrum needed to carry out the seismic simulation will be provided by ITER. The following documents provide guidelines for seismic analysis.		
[33]	Instructions for Seismic Analyses	ITER_D_VT29D6
[34]	EU-DA Report – PA 6.2.P2.EU.02 - Methodology to be Used to Generate the Seismic Floor Response Spectra for Ancillary Buildings at ITER	ITER_D_PN36V6
[35]	IO Building 20 FRS Data	ITER_D_EALT5G

Table 4-1: list of reference documents

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 in addition to the ones mentioned in this section.

The following standards are applicable for the execution of this project. These codes and standards shall be implemented for the components supplied by the contractor, wherever applicable.

4.2.1 Codes and Standards for high power RF Equipment

- IEEE C 95-1-1991 OR European directive 2013/35/UE standard defines the limit of exposure for peoples to the RF electromagnetic fields.
- EN 55011: 2007 OR EN 55011:2011 at system level.
- Décret 2016-1074 du 3 août 2016 relatif à la protection des travailleurs contre les risques dus aux champs électromagnétiques (Decree 2016-1074 of 3 August 2016 relating to the protection of workers against the risks due to electromagnetic fields): www.legifrance.gouv.fr/jo_pdf.do?id=JORFTEXT000032974358
  (This decree is taken for transposition of Directive 2013/35/EU of 26 June 2013 into French law) In particular, the radio-frequency exposure for personnel working in areas adjacent to sources of hazard should comply with the limits recommended by the International Non-Ionizing Radiation Committee (INIRC), part of the ICNIRP statement (Guidelines for limiting exposure to time-varying electric, magnetic and electromagnetic fields (up to 300 GHz)). The exposure limit for workers expressed as Equivalent Power

density for plane waves is: < 1.0 mW/cm². Requires the application of European directive 2013/35/EU, which refers to directive 1999/519/EC regarding workers exposed to risk

OR updated standards as:

Applicable Standards and directives:

- Electromagnetic Compatibility (EMC): European directive 2014/30/EU
- Machinery: European directive 2006/42/EC
- Pressure equipment: European directive 2014/68/EU
- Restriction of hazardous substances in electrical and electronic equipment (RoHS 2) 2011/65/EU
- Ionizing radiation: European directive 2013/59/EURATOM
- REACH.

4.2.2 Codes and Standards for RF Transmission lines.

High power RF transmission line flanges are the interface between ICRF source system & main transmission line system. No specific standards are indicated in ITER standards. Therefore, flanges [29] [30] [31] shall be used.

Pressure equipment: Directive 2014/68/EU:

- NF EN 13480-1 V1 (December 2017 + A1 April 2019 + AC1 July 2020) Industrial metal piping - Part 1: general.
- NF EN 13480-2 V1 (December 2017 + A1/A2/A3 October 2018 + A7 April 2020+ AC1 July 2020 + A8 October 2021) Metallic industrial piping - Part 2: materials.

4.2.3 Codes and Standards for mechanical components

Commercial material shall conform to the applicable standard (ASTM, JIS, DIN, etc.) for the definition of their grade, physical, chemical, and electrical properties and related testing. All materials for which a suitable certification from the contractor is not available shall be tested to determine the relevant properties, as part of the procurement. A complete traceability of all the materials, including welding materials, shall be provided. RF Source system will be built using Cu/SS/Brass/Al/Be-Cu/Teflon etc.

Corrosion-free materials shall be used in the water-cooling pipes. Especially, mild steel, Aluminium and brass fittings & connections are forbidden for DMDI water circuits.

Mechanically welded structures and cooling circuits:

- NF EN 1993-1-1 + NA (black steels), NF EN 1993-1-4 + NA (stainless steels).

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The use of any chemical compound or product shall comply with the REACH regulation and shall be approved on the basis of its material safety datasheet

All fasteners shall be ISO metric thread type.

Codes and standards for IC H&CD mechanical components shall follow the General ITER specifications: Codes and Standards for ITER Mechanical Components [28].

In addition, the following codes and standards shall be applied:

- ASME B31.3, process piping
- ASME ANSI B16.25 - pipe, valve, fitting and flange butt weld ends
- ANSI-ASME B16.34 - valves - flanged, threaded, and welding end
- ASME B36.19 - stainless steel pipe
- ASME Section IX - welding and brazing qualification
- Pressure Equipment Directive (PED).

For bought-out components (OEM), design limits shall be set according to manufacturer's recommendations.

Machinery: directive 2006/42/EC:

- NF EN ISO 12100 (31/12/2010) general principles for design, risk assessment and risk reduction
- NF EN ISO 13849-1 (03/03/2016) safety of machinery-parts of control systems related to safety- part 1: general principles for design
- NF EN ISO 13849-2 (14/10/2012) Safety of machinery - safety-related parts of control systems
- NF EN 60204-1 (14/09/2018) safety of machinery - electrical equipment of machines - part 1: general requirements
- NF EN IEC 60204-11 (January 2019) safety of machinery-electrical equipment of machines - Part 11: requirements for equipment operating at voltages above 1 000 V a.c. or 1 500 V d.c. and not exceeding 36 kV
- NF EN ISO 13857 (October 2019) safety of machinery-Safety distances preventing upper and lower limbs from reaching hazardous areas
- NF EN ISO 14122-1 (01/03/2017) safety of machinery-permanent means of access to machinery-Part 1: selection of a means of access and general access requirements
- NF EN ISO 14122-2 (01/03/2017) safety of machinery-permanent means of access to machinery-part 2: working platforms and gangways

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- NF EN ISO 14122-3 (01/03/2017) safety of machinery-permanent means of access to machinery-part 3: stairs, step ladders and guard rails
- NF EN ISO 14122-4 (01/03/2017) safety of machinery-permanent means of access to machinery- part 4: fixed ladders
- NF EN 619+A1 (24 December 2010) safety and EMC requirements for equipment for mechanical handling of insulated loads
- NF EN ISO 13850 (18/12/2015) safety of machinery - emergency stop function - design principle
- NF EN ISO 14120 (16/01/2016) safety of machinery-guards-general requirements for the design and construction of fixed and movable guards.
- NF EN ISO 14119 (06/12/2013) safety of machinery-interlocking devices associated with guards-principles for design and selection
- NF EN ISO 12198-1 (November 2008) safety of machinery-estimation and reduction of risks arising from radiation emitted by machines
- NF EN ISO 12198-2 (November 2008) safety of machinery - estimation and reduction of risks arising from radiation emitted by machines - Part 2: Procedures for measuring radiation emissions
- NF EN ISO 12198-3 (November 2008) safety of machinery - estimation and reduction of risks arising from radiation emitted by machines - part 3 : Reduction of radiation by attenuation or shielding
- NF EN 61010-1 (January 2011+A1 February 2019) Safety requirements for electrical equipment for measurement, control and laboratory use - Part 1: General requirements
- NF EN 50664 (November 2017) Generic standard for demonstrating compliance of equipment, used by workers, with the limits for human exposure to electromagnetic fields (0 Hz - 300 GHz), at the time of commissioning or on site
- NF EN IEC 62311 (January 2020) Assessment of electronic and electrical equipment in relation to human exposure restrictions to electromagnetic fields (0 Hz - 300 GHz)
- NF EN IEC 61439-1 (May 2021) Low-voltage switchgear and control gear assemblies - Part 1: General rules
- NF EN IEC 61439-2 (May 2021) Low-voltage switchgear and control gear assemblies - Part 2: power switchgear and control gear assemblies
- Decree of December 16, 2011 relating to the special provisions applicable to certain laboratories and test platforms
- NF EN 50191 (February 2011) Installation and operation of electrical test equipment.

4.2.4 Codes and Standards for electrical components:

All the system components shall be designed, manufactured and tested in compliance with the latest issues of the standards published by IO (Electrical Design Handbook Part 3: Codes and Standards [23], EDH Guide A: Electrical Installations for SSEN Client Systems [24], EDH Part 4: Electromagnetic Compatibility (EMC) [26], Plant Control Design Handbook [22]), the International Electro Technical Commission (IEC) and NFC 15-100 & NFC 13-200. Applicable standards shall be listed by the contractor. They shall be submitted to IO for review and approval/acceptance.

All applicable French local and national rules, regulations and decrees shall be strictly followed. There is a requirement in France to have a legal inspection (NFC 15-100 & NFC 13-200) of any electrical equipment before it is energized for the first time. The contractor shall implement all the requirements of such legal inspection during production of items in factory and conduct legal inspection at factory before shipment to ITER. The contractor is also responsible for the clearance for Legal inspection of their supplied components at ITER, France.

4.2.5 CE Marking

CE Markings shall be implemented in accordance with European directives requirements. The list of European directives concerning CE marking is available on the following web site https://ec.europa.eu/growth/single-market/ce-marking/manufacturers_en. Other useful information can be found in the "Guide of implementation of directives based on the New Approach and the Global Approach": http://ec.europa.eu/enterprise/policies/single-market-goods/files/blue-guide/guidepublic_en.pdf.

Applicability of CE marking on Components/sub-systems etc. shall be listed by the Contractor They shall be submitted to IO for review and approval/acceptance.

If delivery will be a "partly completed machine" then CE marking may not be applicable according to the EU Machine Directive. However, contractor shall issue a certificate of incorporation of RF source components along with regulatory technical documentation to substantiate the demonstration of conformity to regulation. COTS integrated in contractor's delivery shall have CE marking.

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5 Scope of Work

This section defines the specific scope of work, in addition to the contract execution requirement as defined in [4].

The scope of work is broken down as follow :

Scope of Supply#1:

- Design definition with an associated design review and acceptance of the design by IO
- Manufacturing of the 4 RF sources including the FAT of the main components.

Scope of Service#1:

- Installation of the 4 RF sources at IO site.

Scope of Service#2:

- Commissioning of the 4 RF sources at ITER site assessed by A Site Acceptance Test (SAT).

The supplier shall be responsible of the full scope. The transfer of ownership will be done after the successful completion of the SAT at IO.

5.1 Scope of Supply #1 Four ICH Radio Frequency Sources Design

5.1.1 Description

The RF source technical specifications, requirements and interface requirements are defined in the following sections. The design shall be developed in accordance with these requirements their validation through SAT process. The initial requirement propagation shall be demonstrated at the design review. The contractor shall produce the RFS source design and shall integrate within the B20 environment in accordance with the interface requirements. Once the design is ready for being submitted to IO for acceptance, IO will organize a final design review, in order to accept the design for manufacturing.

5.1.2 Design requirements

The following requirements shall be followed:

- The RF sources components shall use technology that is currently available, and for which reliability level can be determined before being installed in ITER. This reliability shall be defined during the design phase and compatible with the overall the ICH minimal inherent availability target (from 88 % to 97 % depending on the system operation functions)

- The RF sources shall be capable of an efficient, continuous operation under high variation of VSWR up to a maximum value of 1.5, for any phase of reflection coefficient.
- The IC system shall be designed to operate at discrete bands of 2 MHz fully covering the desired frequency range.
- In-band electronic modulation shall be provided from each mid band frequency, up to ±1 MHz deviation, with a frequency resolution of 1 kHz.
- RF power control: The amplitude and phase of each RF source output power shall controlled in a closed control loop and compared with a time variable suitable reference, provided by the associated subsystem controller. All equipments of the IC system shall comply with the RF power control requirements.

The ramping up of all RF sources output power shall be synchronized with a maximum delay of 10µs. the output power specification is given in the Table 5-1.

Forward power control range (MW)	0.005 to 3.5
Power modulation accuracy (%)	5.0
Power modulation frequency (3dB break) (kHz)	1.0
Max RF power rise time (full modulation range) (ms)	200
Response to a trip request (µs)	< 10
Overshoot	< 5%
Max residual power with RF power source ready (power reference at 0) (kW)	2.0

Table 5-1: Output power control specification (per RF source)

The frequency modulation specification is given in the following Table 5-2.

Output frequency range (MHz)	n1*
Frequency step (kHz)	1. 0
Offset frequency (kHz)	0.1
Frequency modulation (MHz)	±1.0
Closed loop response to a frequency step (Δf<±1.0 MHz) (µs)	100
Frequency overshoot (kHz)	< 20

Table 5-2: Frequency modulation requirements

Note * n1: value has to be compatible with Frequency Range and Modulation Bandwidth described in Table 5-4.

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The phase modulation specification is given in the following Table 5-3.

Phase control range (°)	360
Minimum output power level allowing phase control (kW)	5
Absolute phase accuracy, including offset and noise (°)	3
Closed loop response to a phase step (Δϕ<± 90°) (µs)	20
Phase overshoot (°)	< 20
Max time interval to lock (any frequency and phase) (ms)	10

Table 5-3: Phase modulation requirements

- The maximum output harmonic level shall not be higher than –20 dBc at any power level and frequency with matched load.
- For the 4 operating modes, the RF power sources will have to be operated at any fixed frequency between 40 and 55 MHz.
- The RF power sources shall accept a high level of transient reflected power up to VSWR=2 (for any phase of reflection coefficient) duration 1s, 10% duty cycle.
- The change from one frequency to other shall be performed without RF power in ≤ 6 minutes.
- RF sources shall be located in electro-magnetic enclosures, individual or common ones (including, if needed X-ray protection shield for the tube), as required to operate RF source within the EMI limit. It shall be also used to provide personnel protection against RF and DC high voltages.
- The power dissipated in air inside the RF buildings by the RF sources shall not exceed 25 kW per RF source.
- The RF power sources shall be designed to optimise the system efficiency during steady state working conditions.

5.1.3 Operating requirements

5.1.3.1 General operation requirements

The RF source system is a key actors for the implementation of ICH operation and protection functions

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The RF source shall fulfil the operation requirement parts of ICH System concept of Operation [32].

The RF source shall be operated remotely through its Local Control Unit. The RF power sources shall comply with the operation modes:

- Plasma heating and current drive
- Wall conditioning
- Antenna conditioning
- RF source test on dummy load

The system shall be equipped with instrumentation for the automatic control of RF power, frequency, phase and protection against Voltage Standing Wave Ratio (VSWR).

Inputs for automatic protection against arcing in antennas, dummy loads, transmission lines, matching systems and power sources shall be included in the design.

In normal operation the RF source shall be remotely operated via the Plant System Controller (PSC).

The RF source shall be locally or remotely monitored and controlled by the Local Control Unit (LCU) for debugging/commissioning operation and data acquisition.

All the RF measurement equipments integrated in the RF source shall be designed to allow calibration for relevant parameters.

For any internal parameter exceeding pre-established thresholds, set at nominal values (e.g. electronic tubes grid current, anode power dissipation …), the output RF power shall be limited to a safe value, within a timeframe compatible with components technical limits. Safety thresholds shall be set at nominal working parameters.

If some limiting condition will appear at antenna and transmission lines, it shall be communicated to the PSC and in response PSC will modify the set point of requested power; the source shall respond accordingly.

The limitation thresholds shall vary accordingly to the duration of the overrun (fast and slow overload detection).

The RF power sources shall automatically and safely recover from a power trip to normal operation.

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Each RF power source shall insure its own protection first of all by reducing the RF output power level or switch off the RF power/anode and grids voltage, and shall be protected against:

- o VSWR variations beyond the specified level on the RF output, for any phase of reflection coefficient
- o All internal malfunctioning (over current, over voltage, over temperature, breakdowns …)
- o All abnormal commands (over range signals, non-consistent commands)
- o Water/air cooling interruption
- o Pressurized air interruption
- o PSC or CODAC failure
- o Electrical power supply interruption.

5.1.3.2 I&C requirements

The Local Control Unit shall be design as per ITER PCDH [22].

The documentation, software codes and tool for computing process, allowing equipment maintenance and calibration shall be part of the procurement.

5.1.3.2.1 Local Data Acquisition System

Several status (single bit), data (multiple bits) and signals shall be generated during the operation of RF Sources. Alarm signals shall be matrixed and handled in priority groups. Circular memories capable of few minutes of data storage shall be operated in trigger mode so as to maintain / available to the IC Plant System Control (PSC) request of the record of unforeseen events. Minimum event duration will be defined by IO in consultation with the supplier during design phase.

Signal list and its characteristics required for the PSC and CODAC will be provided by IO.

Signal interfacing topology for hard wire interlock for intra plant system will be finalized and provided by IO.

Communication and interfacing protocol between LCU and PSC shall be as per PCDH.

5.1.3.2.2 Sequence control system

The description below, summarized in Figure 5-1, refers to a basic operating conditions (level of readiness) in which each of the 4 RF source system can be in use.

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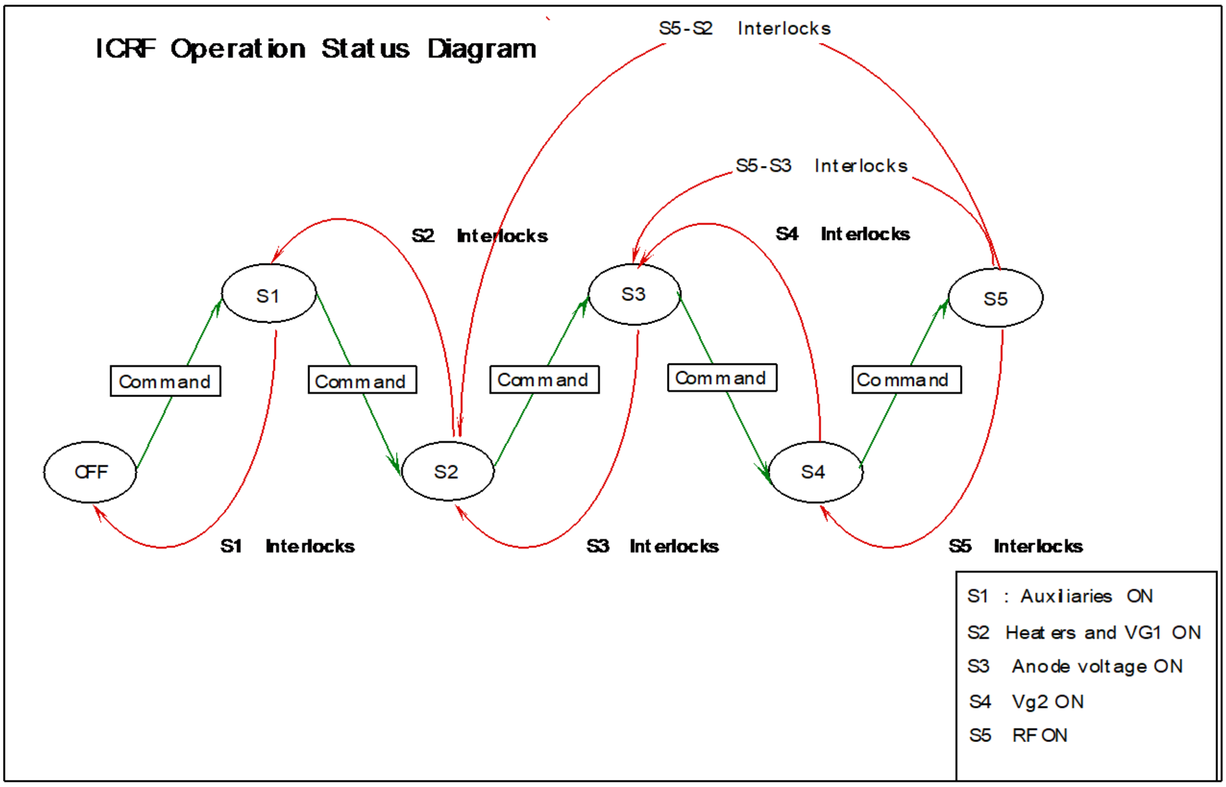

Figure 5-1: Basic state diagram of RF power source

The supplier may refine the required states, but the ones mentioned in Figure 5-1 are the minimum ones. Transitions from one state to another shall be requested by a manual or automatic command, acknowledged, executed if the plant and environment conditions are compatible with that state and aborted if these conditions are not met within a pre-set time lag from the request.

System parameters (such as frequency, power, etc.) can be adjusted independently of the status of readiness. This is defined in the interface with Plasma Control System (Cf. Table 5-5,) and in the System Concept of Operation [32].

Each Subsystem interfacing with RF sources is set into (and out of) operation under the supervision of a dedicated programmable logic controller, through a sequence of levels of readiness from the “OFF” to the “RF ON” state. In normal mode of operation, the RF power can be safely applied to the plasma in the amount and with the time profile requested by the PSC.

The 4 RF source systems are driven independently through the start-up/down sequence and can rest for an indefinite time at each level, unless:

- An operator command requests a higher or lower level of the sequence and/or
- An alarm incompatible with the actual level of readiness occurs.

In the first case, the level of readiness is modified according to the request. In the second case, it is switched down to a level in which the alarm is either reset or can be ignored. Both up- and down- transitions may require several steps and involve time delays. They are executed in sequence and the execution of each step shall be monitored and logged.

Any external command request is acknowledged by a status signal which remains true until the command is executed. Specific alarm signals are flagged if the execution is prevented by one or more fault conditions and remains true until reset by automatic or operator action.

5.1.3.2.3 Real time Control system

There are three parameters- Frequency, Phase and Amplitude that shall be regulated for proper operation and as per experimental requirement and as per the interface with PCS (Cf. Table 5-5).

5.1.3.2.4 Protection and Health & Safety system

Protection may be fast or slow, managed through I&C components or hard wired. The fast protection shall act within 10 μs to insure the protection of the source and associated system. If the operating parameter crosses the maximum level specified by system designer, RF shall be withdrawn. In order to maintain operation, all these signals are connected to fault handling system which shall have intelligence to decide the action i.e. if the fault is external arcing, only RF shall be withdrawn and end stage control grid shall be set to blocking negative level and again reapplied with particular timing characteristics and if the fault is internal arcing then RF as well as HVPS shall be withdrawn and again reapplied with predefined timing characteristics. Timing characteristics will be defined during design phase.

5.1.3.2.5 Position Control Unit

RF source can be made of tube based amplifiers. The position Control System controls the positioning of the corresponding tuning element offline according to the operational frequency requested by Plant Control System. A set of positional data for each operational frequency shall be generated and saved as reference. Control motor shall be operated remotely under supervision of LCU and tuning element shall be positioned at particular position defined by the operational frequency. The interfaces between the RF sources and the I&C system are:

- Control signals for adjacent components (status of different Auxiliary power supply,….)
- Remote controls
- Measurements on auxiliary systems and services when required, such as flow, pressure, temperature, position…
- Status sharing in real time related to RF sources
- Data acquisition of RF measurements, control and safety signals
- Output for inner diagnostics of the generators

SUPPLY

- Real time control system (amplitude & phase waveforms, frequency, status…)
- Interlock and safety signals.

All Instrumentation and Control components shall be conformed to standards, specifications and interfaces as documented in the Plant Control Design Handbook [22].

5.1.4 Performance requirements

The RF power source main performance requirements are defined in the following Table 5-4

Sr. no.	Specification	Level & Units	Remarks
1	Operating Central Frequency Range	40-55 MHz	The system performance shall be checked for full power, duration & bandwidth requirement.
2	System tuning	within 360s	Any lower frequency to any higher frequency or vice versa
3	Frequency deviation over any central frequency (1dB bandwidth point)	±1MHz	1dB bandwidth point shall be demonstrated at four central frequencies i.e. 40 MHz, 42 MHz, 53MHz & 55 MHz, with 3.0 MW output power without changing tube biasing or input RF power.
4	Nominal output power	3.0MW	– Matched load condition: RF Power shall be demonstrated at 40 MHz, 42MHz, 53MHz & 55 MHz for 2000s. – Mismatched load condition: RF Power shall be demonstrated at 40 MHz, 42 MHz, 53MHz & 55 MHz for 2000s with VSWR 1.5:1 at 5 different phase angles.
5	Maximum VSWR	1.5	With any phase of reflection coefficient
6	Transient VSWR	2.0 (1s max)	Output power may be reduced
7	Electrical efficiency	65% to 45%	Depending upon load conditions
8	Pulse duration: ON time	2000s	System shall be tested for 2000 s operation for acceptance at 40 MHz, 42 MHz, 53MHz & 55 MHz.
9	Duty cycle	25%	
10	Input and Output impedance	50 Ω	
11	Emergency RF power cut-off response	<10 µs	
12	RF radiation limit	<1mW/cm^2	It shall be within the limits recommended by the

SUPPLY

Sr. no.	Specification	Level & Units	Remarks
			International Non-Ionizing Radiation Committee (INIRC).
13	Max frequency modulation frequency (Response time)	1 kHz	
14	Power modulation range at the load	2kW-3.0MW	
15	Max amplitude modulation frequency (Close-loop response time)	100Hz	
16	Max phase modulation frequency (Close-loop response time)	10 kHz (at fixed reference/any frequency)	

Table 5-4: RF source main performance requirements

The supplier is free to choose any configuration that will allow these specification achievements.

5.1.5 Interface requirements

The design of the RF source shall be compliant with the physical and functional interfaces.

The RF sources have interfaces with other PBS51 sub systems and with other ITER PBS (external interfaces). They are specified in the Table 5-5.

Interface	Name	IDM reference
Cooling water	IS-26.CC-51-001	334USK
Low voltage Power supply	IS-43-51-001 Interface between SSEN-LV-Class-II-IP and IC H&CD System	3NST27
	IS-43-51-003 Interface between SSEN-LV-Class-IV-OL and IC H&CD System	3P2RD4

SUPPLY

	IS-43-51-006 I&C Interface between SSEN and Ion Cyclotron H&CD System	UNLL5W
Cable tray	IS-44-51-001 Interface between Cable Tray System (PBS 44) and Ion Cyclotron H&CD System(PBS 51) for all types of cables	MV39SP
CODAC	IS-45-51-002 Interface between CODAC and IC.CI.ICH1	UP7QEQ
Central Interlock	IS-46-51-001 Interface Sheet (IS) between Ion Cyclotron Heating and Current Drive system and Central Interlock System	BEUS9H
Plasma Control System	IS-47-51-001 Architecture	KFZA76
Plasma Control System	IS-47-51-002 - List of signals and variables	KGQQMV
Central Safety System	IS-48.02-51-001 Interface Sheet between ICH&CD System PBS51 and Central Safety System (Occupational Safety) PBS48.02	MVHGRK
ICH High Voltage Power Supply	IS-51.HV-51.RS-001 High voltage interface between IC HVPS and IC RFS Systems	62JL2R
	IS-51.HV-51.RS-002 I&C interface between IC HVPS and IC RFS Systems	62HQH2

SUPPLY

	IS-51.HV-51.RS-003 Key protection interface between IC HVPS and IC RFS Systems	62J8YX
ICH Transmission Lines	IS-51.RS-51.TL-001	F7NZY7
ICH Plant Control System	IS-51.RS-51.CI-001	
Building 20	IS-51-63.20-001 Interface Sheet between Ion Cyclotron Heating & CD System (PBS 51) and Building 20 (PBS 63.20)	BGM2DM
REMS	IS-51-64-001 Interface between Ion Cyclotron H&CD & REMS	UX5SQ2
Liquid And Gas	Interface Sheet (IS) between Liquid & Gas Distribution (PBS 65) and Ion Cyclotron H&CD System (PBS 51)	33G8CG
ICH Configuration Management Model in Building 20	AB-CMAF CMM for PBS 51 in Building 20 (SRO, DT1 and DT2)	EJMPD2

Table 5-5: List of RFS interfaces

As part of these interfaces are design dependent like the one dedicated to the Anode Power Supply (HVPS), the applicability of each of them will be defined in the next phase.

Anyway, the main dimensioning parameters are recalled in the following sections.

5.1.5.1 Interface with the Building 20

The maximum dimension of one RF source shall not exceed 3.4 m x 9 m x 5 m (W x L x H). The maximum weight of one RF source shall be 18 t.

SUPPLY

The maximum heat exhaust shall not exceed 1 % of the output power per source. The B20 crane available for installation and maintenance has 5 t capacity.

The building 20 is a three-floor building. The RF sources are located at the 3rd floor (Level 3).

The total space allocated for 4 RFS in Building 20 is 18.1 m x 9 m x 5 m as shown in the following Figure 5-2 and Figure 5-3.

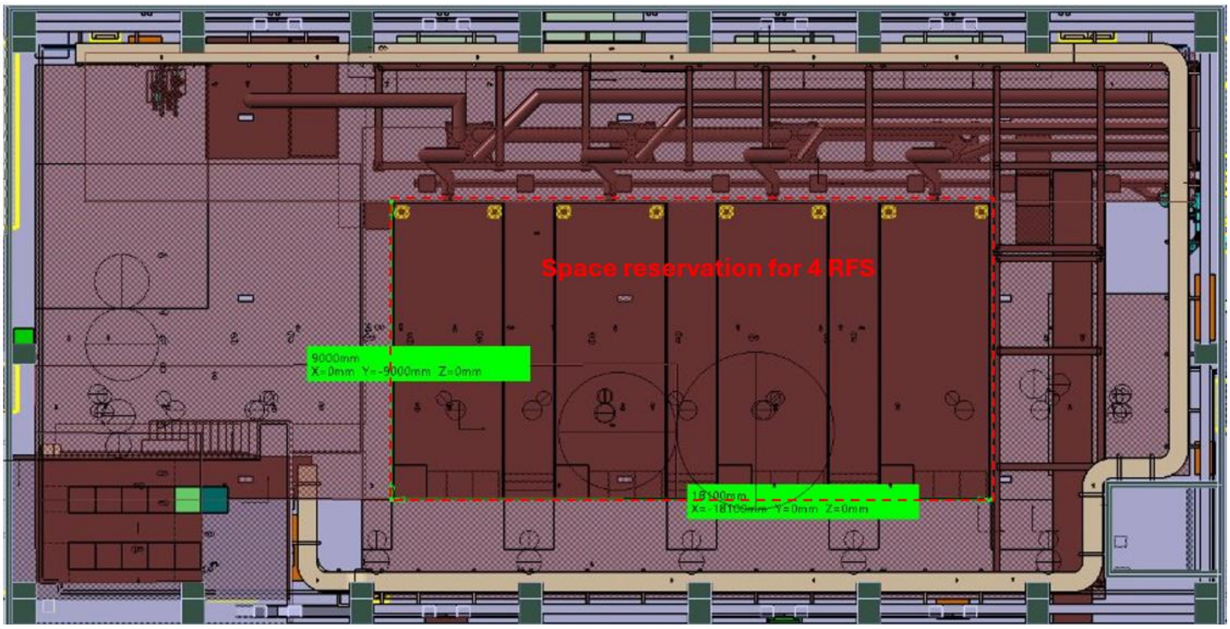

Figure 5-2: RFS space reservation at B20 L3 (view from top)

Figure 5-3: RFS space reservation at B20 L3 (side view)

RF enclosure, service platform along with ladder shall be compliant with the building interface requirements in particular for what concerned the pointed load (cf. Interface with Building in Table 5-5).

Outside temperature range at ITER is from -10 to 40°C with relative humidity (RH) range of 65-95%. However, inside temperature range in Building 20 Level 3 is [18°C-30"C] and RH ≤ 85%.

5.1.5.2 Interface with Transmission Lines

The interfaces with transmission lines are mechanical, electrical (RF) and functional (3 MW dummy load and protections). The RF flanges design for different transmission line dimensions are fixed and defined in [29][30][31]. It concerns in particular the interface with the PBS51 12" transmission lines. The interface at the outlet of the RF sources is done through a 12" Transmission line [31] part of a gas barrier. One volume of the gas barriers is shared with RFS; the resulting technical constraints are detailed in the interface document (cf. Table 5-5).

During test of the RF sources on Dummy Load at ITER site, the MMTL shall be installed before the dummy load, in between two transmission lines, which implies additional interfaces requirement associated with cooling circuit.

RFS I&C shall have a direct connection in between Transmission line protection system (for RF arcs for instance) for an RF switch off in less than 10 µs. As the transmission lines are as well contributing to the fast protection of the antenna, the RF switch off shall be implemented as well on the Master synthesizer to allow a simultaneous RF switch off of the 4 RF sources.

5.1.5.3 Interface with High Voltage Power Supplies

The interface with HVPS is highly dependent on the layout chosen by the supplier. The details given in the IS on the HVPS topology **are indicative only**. Attention is given on the main efficiency required on the RFS that is driven by the PPEN power available and the HVPS target efficiency. 5.9 MW of DC power is available per RF source. The penetration of HVPS cables is fixed in building 20 as the HVPS will be installed at level 1 and level 2 of the building.
The interface comprises:

- High voltage terminal/transmission hardware
- Grounding /earthing point
- Control & Interlocks.

5.1.5.4 Interface with water cooling, Compressed Air and Nitrogen

The fluid systems provided by ITER for interfacing the RF sources are described below:

- Water loops (CCWS) with requirement on the inlet/outlet temperature (max inlet temperature 31°C, max outlet 60°C), inlet pressure (7.3 bars) and maximum pressure drop of 5.5 bars. The operation average heat load for 4 RF sources is 7.6 MW.

SUPPLY

- Compressed air for valves actuators or pressurized transmission components, air cooled components,… (max flow and pressure defined; cf. Specific interface sheet in Table 5-5).
- Compressed dry nitrogen for pressurized TL and fluid drainage in RFS water cooling circuits (max flow and pressure defined; cf. Specific interface sheet in Table 5-5).
- Demineralized water for filling the circuits before connecting to the main loop.
- Draining and drying circuits (max flow rate will be defined in the next version).
- Air cooling/recycling in the surrounding environment of the RF sources, if needed.
- Moisture drain off.

5.1.5.5 Electrical Interface

The RF sources electrical interfaces with class II (Uninterrupted) supply are:

- Terminal block
- Grounding/earthing point
- Interlocks.

The RF sources electrical interfaces with class IV supply are:

- Line Terminal block
- Grounding /earthing point
- Interlocks.

5.1.6 Mechanical Requirements

Additional mechanical interfaces are within:

- The Key management system for HV Lock Out
- The Cable Trays for laying power cables and control/monitoring cables.

5.1.7 Electrical Requirements

The following requirements shall be considered:

- Electrical power for components/sub-systems as per layout: The utility power (~250 kW per RF source) at IO site are 400V±10% / 3 phase / 50 Hz and 230V±10% / single phase / 50 Hz.
- The contractor shall proceed to the connection of the RFS component's grounding to the global Earthing/Grounding network [26].

SUPPLY

- Any required Auxiliary power supplies supplied by the contractor shall interface with grids tubes.

5.1.8 RF source design assessment

The contractor shall deliver the RF source design package once the design is mature for being assess through an IO design review process [16]. At this stage, the data package provided in the appendix II shall be completed and shall be made available to the IO panel and experts at least 2 months prior to the design review. The deliverables produced during the final design phase are integral part of the FDR input data package. All documents shall be in approved state prior to the final design review.

According to the design review results, the contractor shall implement the necessary corrective action to update the design, as required by the design review panel. All the corrective action shall be implemented within a 6 month period, in order to close the design review. The manufacturing of the component shall not start until the formal closure of the final design review (unless agreed otherwise on long lead item procurement)

5.1.9 RF source design deliverables

The deliverable definition shall be in line with the IDP required for the Final Design Review. Typical IDP is provided in Annexure II.

Additional Preliminary design reports shall be provided by the supplier; their content level of maturity will be detailed in the next version of this specification.

The Table 5-6 specifies the different deliverables to be produced by the contractor during the design phase. All deliverables shall be submitted for IO review and acceptance.

DL#	Description	Type	Due dates
1	Quality plan (full scope)	Document	T0+1
2	RFS Preliminary Design Description report	Document	T0+6
3	RFS Preliminary structural analysis package	Document & analyses model	T0+12
4	RFS Preliminary LCU description	Document	T0+12
5	RFS Preliminary Layout drawings	Document + native CAD file + ENOVIA	T0+8
6	RFS Preliminary Interface Compliance Matrix	Document	T0+6

7	RFS Preliminary 2D drawings	Native CAD file + ENOVIA	T0+8
8	RFS Preliminary 3D model	Native CAD file + ENOVIA	T0+8
9	RFS Preliminary PFDs	Native CAD file	T0+14
10	RFS Preliminary P&IDs	Native CAD file	T0+14
11	RFS Preliminary Wiring & cabling & single line diagram package	Native CAD file	T0+14
12	RFS Preliminary Bill of material	Document	T0+6
13	RFS Preliminary validation plan	Document	T0+6
14	FDR IDP (Cf. 13.2)	Design Review Input Package	T0+20

Table 5-6: List of design deliverables

5.2 Scope of Supply #1 – Four ICH Radio Frequency Source Manufacturing

Upon completion of the final design review and its closure, the contractor may proceed to the manufacturing of the RF sources. To be noted that due to time constraint, some procurement of long lead item might be anticipated during the design phase, following a written agreement of IO.

5.2.1 Manufacturing requirements

The RF Source are non-PIC components. Therefore, manufacturing requirement shall be established during engineering design phase to comply the specifications listed in this document and shall be implemented during the manufacturing processes.

Detailed Quality Plans, Manufacturing Inspection Plans (MIP) as per template [6], work plans and procedures shall be developed by the contractor and Subcontractors for each step of fabrication. They shall be submitted to IO for review and approval/acceptance.

In order to simplify and reduce the cost of integrating, operating and maintaining the systems, the contractor shall use as much COTS components as possible.

Recommendations for spare parts provisioning shall be provided following the RAMI analysis of the IC H&CD subsystems, both for scheduled and unscheduled maintenance. These recommendations shall take into account the operating conditions, the benefits of using as many standard parts as possible, and the risk of components obsolescence over the lifetime of ITER.

The manufacturing tolerances shall be consistent with achieving the overall installation tolerances, taking into account inaccuracies that result from installation and tolerances of mating components.

However, the manufacturing requirement will follow the general rules described in SRD51 [20]:

All critical items and components shall be identified. These critical components shall be identified in each specific design description.

Spares can be reasonably expected to be needed within 12 months of full-time operation of the system and shall be procured no later than the system commissioning phase.

The source of material property information for design analysis shall be either the applicable structural code or the ITER Material Properties Handbook. In the case of conflict, the ITER Material Properties Handbook shall take precedence.

Commercial material shall be conformed to the applicable standard (ASTM, JIS, DIN) for the definition of their grade, physical, chemical, and electrical properties and related testing. All materials, for which a suitable certification from the supplier is not available, shall be tested to determine the relevant properties, as part of the procurement. A complete traceability of all the materials including welding material shall be provided.

Corrosion free material will be used in the water cooling pipes.

For a list of materials that will be defined during the design phase, part of the following shall be provided:

- Brief description of the material and of its manufacturing process
- Applicable standards
- Delivery conditions (e.g. required heat treatments, cold work, …)
- Chemical composition
- Required minimum, average thermal and mechanical properties at various temperatures, including the testing protocol and standards. It shall be mentioned whether the properties refer to the “as delivered” material or to the “as manufactured” material or both.
- Specific requirement on the maximum scatter band of the material properties
- Required certificates and characterisation reports

5.2.2 Quality Control Provisions during manufacturing

The “Manufacturing and Inspection Plan” (MIP) [6] produced by the contractor and Subcontractors will mark up any intended intervention point. MIPs are used to monitor Quality Control and acceptance tests during the execution of the Contract. It should be noted that interventions additional to those required in this Technical Specification may be included on the MIP by IO. The right IO listed above shall apply in relation to any Subcontractor and in this case the IO will operate through the contractor. The overseeing of the quality control operation by the IO shall not release the contractor from his responsibility in meeting any aspect of this Technical Specification.

5.2.3 Spare Parts

The contractor shall provide within this procurement a basic set of (essential) spare parts covering 1 year of equipment operational life. These spare parts can be used during commissioning and warranty period to ensure a high availability by a faster repair of the equipment, in such case the contractor shall replace at the earliest convenience the used parts at his own charge.

A list of essential spare parts is to be submitted with the tender proposal and the final list is to be agreed at the FDR, based on the results of the RAMI analysis, with the appropriate specifications of storage space and conditions.

The risk of obsolescence of the components shall be considered.

In addition to the above, the contractor shall propose a detailed list of spare parts that will cover 5 years of equipment operational life beyond the warranty period.

5.2.4 RFS assembly and Factory Acceptance Test

Factory Acceptance Test shall be part of the design validation plan, each RFS shall undergo the FAT campaign to validate its performances prior to delivery at IO.

The test description, purpose and justification shall be defined by the contractor and part of the offer with a dedicated quotation.

The detailed procedure shall be part of FDR input package, the FAT report shall be produced by the contractor. The approved FAT procedure shall be followed to perform the testing of each RFS. IO will witness the FAT at the contractor or its sub-contractor premises. On need basis, adjustment of the approved FAT procedure might be required, in such case, Deviation Request shall be submitted to IO review and approval prior to implementation.

After the FAT, any required retrofit on the RF source design shall be submitted through deviation request procedure to IO and taken in charge by the supplier after IO acceptance.

The FAT duration shall be defined in the schedule proposed by the supplier; it shall be compatible with the delivery schedule mentioned in Section 8 and with the overall contract schedule.

5.2.5 Packing, preservation & shipping

Once the FAT of a single source is completed, the contractor shall proceed to its disassembly and packing. Depending on the timeline, the contractor may have to store and preserve the components before delivery

The following generic requirements apply for the shipment of equipment from the manufacture/assembly site to the ITER Site. Suitable precautions shall be taken to avoid damage to the equipment. The components shall be fitted with the required accelerometers or other sensors and shall be packed as defined in 5.2.5.3**.** The equipment shall be controlled and inspected after packing, and during preservation phase.

5.2.5.1 Labelling and Traceability

All components and the main subcomponents shall be clearly marked in a permanent way and in a visible place with the IO official numbering system according to the document “ITER Numbering System for Components and Parts” [7] and [8]. A detailed ‘IO component identification standard’ together with printed label templates and tagging standards will be provided by IO [9].

The equipment included in the scope of supply shall be fitted with a rating plate in accordance with the applicable standards. The rating plate shall bear the identification of the corresponding equipment in the project.

In addition, identification of the equipment and components shall comply with the labelling requirements defined in EDH Guide A [24].

5.2.5.2 Cleaning

During cleaning, particular attention shall be given to the removal of weld spatter, debris and other foreign matter. The contractor shall ensure effective cleaning without damage to the surface finish, material properties or metallurgical structure of the materials.

5.2.5.3 Packaging and Handling

Any special IO or regulatory transportation requirements shall be documented and provided to the contractor prior to shipment.

Subsequent to the Factory Acceptance Test, the components shall be partially disassembled to the optimum size that can be shipped. All components requiring re-assembly at ITER Site shall be clearly labelled and tagged.

The contractor shall design and supply appropriate packaging, adequate to prevent damage during shipping lifting and handling operations. Where appropriate, accelerometers or other sensors shall be fitted to ensure that limits have not been exceeded. Accelerometers shall be fixed onto each box and shall be capable of recording the acceleration along three perpendicular directions [15].

Shock absorbing material shall be used.

Each shipment shall be accompanied by a Delivery Report shall be prepared by the contractor, stating as a minimum [14]:

- The packing date
- The full address of the place of delivery and the name of the person responsible to receive the package, as well as of 's name and full address
- Bill of Material
- Security Measures
- Release Note
- Packing List
- Material Safety Sheet
- The declaration of integrity of the package
- The declaration of integrity of the components
- Any additional relevant information on the status of the components.

The Delivery Report shall be signed by a representative of the IO and the contractor. The signature by the IO of the Delivery Report prior to shipment represents a Hold Point (HP).

5.2.5.4 Shipment, Transportation and Delivery

Before the shipment, a Release Note shall be prepared in accordance with the "Contractor Release Note" [14] and approved by IO.

Upon receipt of the package, IO shall prepare an Inspection Report.

The following points will be checked:

- The integrity of the package, including identifying visible damage
- The reading of the accelerometers or other sensors
- The enclosed documentation

- The number and type of components contained in the shipment from the documentation.

In the case of anomalies, the IO shall make any additional relevant remark on the inspection report.

IO will inspect the accelerometers or other sensors mounted on the boxes. If these accelerometers record shocks above 5g, a thorough inspection of the components shall be performed. A decision on acceptance of the delivery of the components will be made by the IO.

- The boxes will be opened in presence of the contractor's representative, once moved to the final assembly place. The integrity of the components, including identifying visible damage will be checked by IO.

If the components are in an acceptable condition, the IO will sign the Inspection Report. The signature of the Inspection Reports is an IO Hold Point.

The original of the Inspection Report shall be kept by the IO and a copy of it shall be kept by the contractor.

Optional Hardware delivery

Additional hardware components (assembly tools etc…) required for the services described in this technical specification shall be defined and provided by the contractor.

Their compatibility with ITER applicable standards and handbooks such as EDH and PCDH shall be assessed during this contract execution and their implementation required IO approval.

5.2.6 RFS manufacturing & FAT deliverables

The Table 5-7 specify the deliverables required during the manufacturing and testing phase, and associated due dates.

DL#	Description	Type	Due dates
15	End of RFS #1 manufacturing report	Document	T0+34
16	End of RFS #2 manufacturing report	Document	T0+52
17	End of RFS #3 manufacturing report	Document	T0+62
18	End of RFS #4 manufacturing report	Document	T0+66
19	FAT report of RFS#1	Document	T0+34
20	FAT report of RFS#2	Document	T0+54
21	FAT report of RFS#3	Document	T0+64
22	FAT report of RFS#4	Document	T0+68
23	RFS #1 *And associated documentation as per 5.2.5* (Delivered at ITER site)	Hardware	T0+36
24	RFS #2 *And associated documentation as per 5.2.5* (Delivered at ITER site)	Hardware	T0+56

25	RFS #3 *And associated documentation as per 5.2.5* (Delivered at ITER site)	Hardware	T0+66
26	RFS #4 *And associated documentation as per 5.2.5* (Delivered at ITER site)	Hardware	T0+70
27	TBD (MMTL, lift tools, test tools, etc)	Hardware	All along the project

Table 5-7: List of deliverables during manufacturing and testing phase

5.3 Scope or Service #1 – Assembly at ITER site

5.3.1 Service Description

The contractor shall be responsible of the Assembly at IO premises. The assembly comprises all activities required within the space reservation (RFS enclosure (s)) specified in the B20 L3, as shown in the Figure 5-4 & Figure 5-5

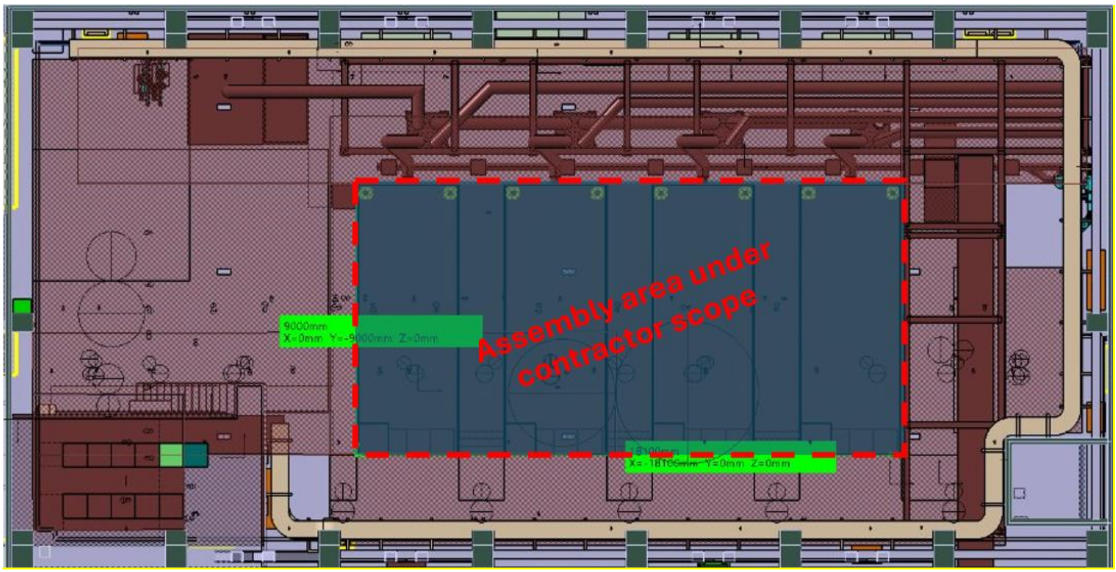

Figure 5-4: Assembly area for the 4 RFS in B20 at L3

The contractor shall provide the necessary qualified resources to perform the assembly activities. The activities shall be based on the assembly procedure approved during manufacturing phase. IO will be responsible for the activities outside the RFS enclosure(s), defined as “installation” in the rest of this specification, as specified in the following Figure 5-5. It consists in making available all services required to operate the source, like water cooling, CODAC, compressed air and nitrogen, as well as the transmission line up to the dummy load; the installation work will be performed by IO up to the connection point with RFS components.

SUPPLY

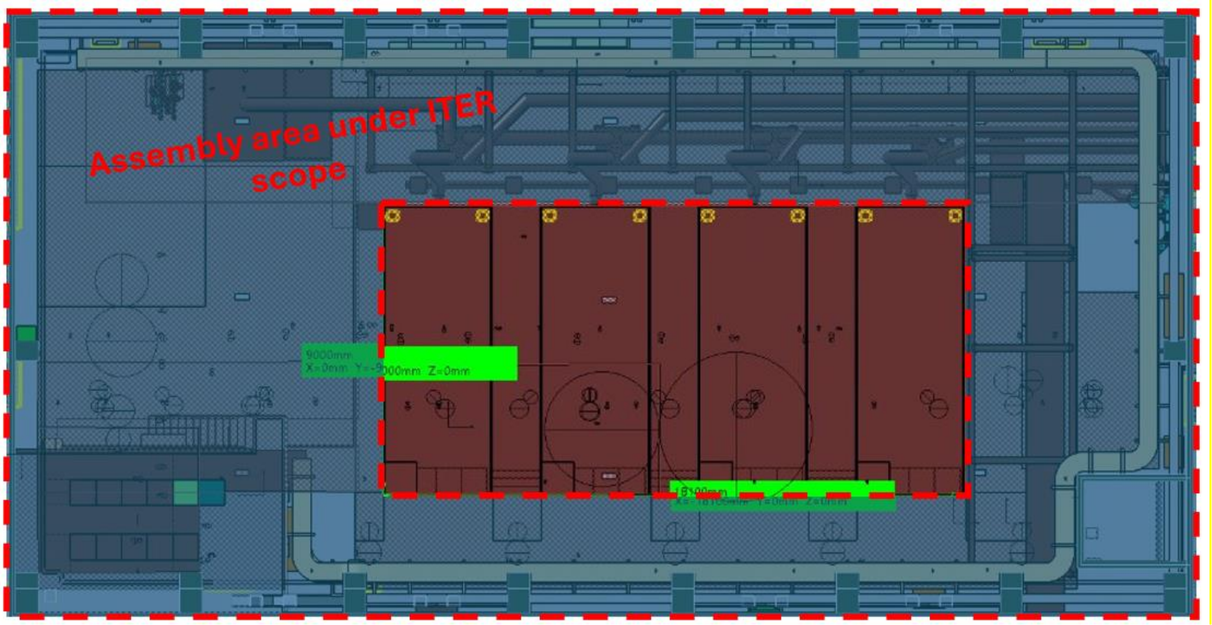

Figure 5-5: area under IO responsibility for assembly task

After completion of each of the RFS assembly & installation, a conformity report issued by the contractor and approved by IO stating that the assembly has been correctly completed and that the system is ready for being commissioned on the dummy load.

Note: Intermediate testing activities may be required during the assembly and installation phase; this shall be clearly identified in the assembly procedure and shall not be considered as commissioning activity describe in the scope of Service #2.

5.3.2 Site conditions

The equipment shall be installed at ITER Site, France, in the Building 20.

The outdoor environmental conditions of the site are summarized below:

- Elevation (above sea level) 315 m
- Outdoor temperature range -10 to 40 °C
- Average outdoor temperature over 24-hour period -10 to 35 °C
- Wind speed ≤ 140 km/h
- Outdoor relative humidity (24-hour average) ≤ 95 %
- Pollution Level (according to IEC Standard 60071-2) Level 1

5.3.3 Ambient conditions

The HVAC system for the Building 20 keeps the environmental conditions summarized below:

- Indoor temperature range 10 to 35 °C
- Indoor temperature range tolerance ±2 °C
- Room relative humidity 15 to 85 %

- Minimum air change rate 30 m³/hr/person
- Room pressure relative to outside environment Positive
- Minimum filtration efficiency: filter class (EN 779) G4/F7\

5.3.4 Facilities in the Building 20

The RF Buildings structure will provide to the contractor the following systems and services to ensure the necessary conditions and a suitable environment both for the staff and the equipment:

- Lighting and service power.
- Fire detection, alarm and suppression.
- Drainage systems.
- Earthing system and lightning protection.
- Heating, Ventilation and Air Conditioning system, including associated hot and chilled water distribution systems.
- Overhead cranes (rated for 5 tons – to be confirmed) and elevator.
- Potable water and drainage for personnel requirements where necessary.
- Access control system.
- Communication network system.
- Compressed air (dry) system.
- Temporary power supplies during installation for tooling etc
- Local support.
- Office space.
- Use of workshop.
- Telephone lines/ internet access etc.

Details on the facilities will be provided by IO during the design phase. It shall be assumed that the consumables (electricity and water) needed during the on-site assembly, on-site installation, on-site commissioning and on-site acceptance will be provided by IO free of charge to the contractor.

5.3.5 Assembly completion in B20

The Table 5-8 specifies the deliverables required during the ITER site assembly activities, and associated due dates.

SUPPLY

DL#	Description	Type	Due dates
28	End of RFS #1 Assembly completion report	Document	T0+45*
29	End of RFS #2 Assembly completion report	Document	T0+62*
30	End of RFS #3 Assembly completion report	Document	T0+72*
31	End of RFS #4 Assembly completion report	Document	T0+76*

Table 5-8: List of deliverables during assembly at ITER site

* the due dates are indicative and shall be optimized as per compatible with coactivity limit and dummy load availability

5.4 Scope of Service #2 – Commissioning and Site Acceptance Test

5.4.1 Service Description

The contractor shall perform the commissioning of the RFS. IO staff will coordinate the commissioning work.

The commissioning plan and associated procedures shall be defined by the contractor and validated through a Commissioning Readiness Review.

IO will provide the services as per the interfaces described in Section 5.1.5; it will be detailed and updated in the next version of this technical specification. Each RFS shall be commissioned up to its SAT readiness. SAT will be performed in the presence of ITER Staff. A typical Site Acceptance Tests description is given in Section 13.1.

After successful completion of the SAT, the contractor shall produce the SAT report; it shall be submitted to the IO review and acceptance. Approval by IO of a SAT report officialise the RFS unit ownership transfer to IO. The warranty period shall start at the SAT approval date.

5.4.2 Service Duration

The Commissioning and SAT duration shall be specified in the schedule proposed by the supplier; it shall be compatible with the schedule mentioned in Section 8.

5.4.3 End of Commissioning & SAT

The Table 5-9 specifies the deliverables required during the ITER site commissioning & SAT activities and associated due dates.

DL#	Description	Type	Due dates
32	RFS #1 CRR package	Document	T0+46*
33	RFS #2 CRR package	Document	T0+63*
34	RFS #3 CRR package	Document	T0+73*
35	RFS #4 CRR package	Document	T0+77*
36	RFS #1 SAT report	Document	T0+48
37	RFS #2 SAT report	Document	T0+68
38	RFS #3 SAT report	Document	T0+78
39	RFS #4 SAT report	Document	T0+82

Table 5-9: List of deliverables during assembly at ITER site

6 Location for Scope of Work Execution

For the manufacturing, assembly, factory testing and packaging the Contractor will perform the work at their own location.

Assembly, installation, commissioning and final acceptance tests will be performed on ITER site.

7 IO Documents & IO Free issue items

7.1 IO Documents

See Section 4.

7.2 Free issue items

N/A

8 Schedule Milestones & Deliverables

The maximum expected duration from the contract signature to the completion of the scope of work is 7 years. The global timeline is constraint with the ITER project needs.

8.1 Contract schedule and associated Milestones

The overall timeline is specified in this section. The Figure 8-1 defines the maximum timeline for the **Scope of Supply #1 – design and manufacturing of 4 RFS** (as described in the Section 5.1).

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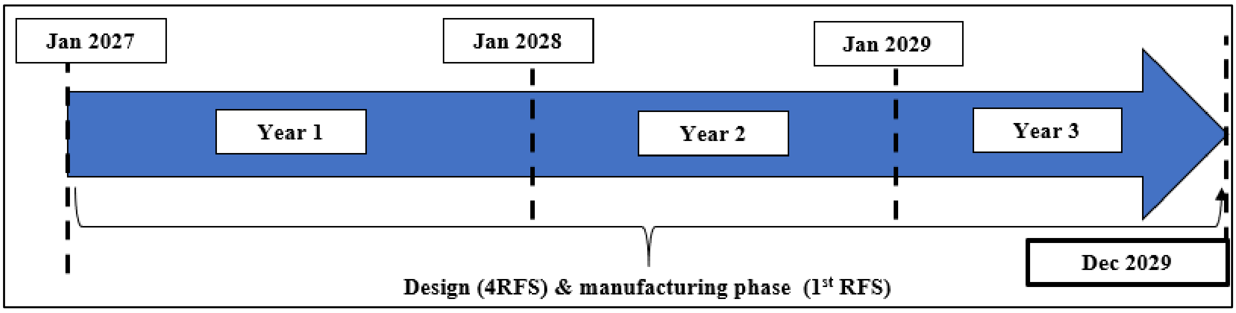

Figure 8-1: Design and manufacturing of RFS

The Figure 8-2 gives the global timeline for **Scope of Service#1 & scope of Service #2**, and the need dates for each individual RFS. To be noted that the most constrained RFS is the RFS#1, for which the installation shall start in January 2030, when the building 20 will be available.

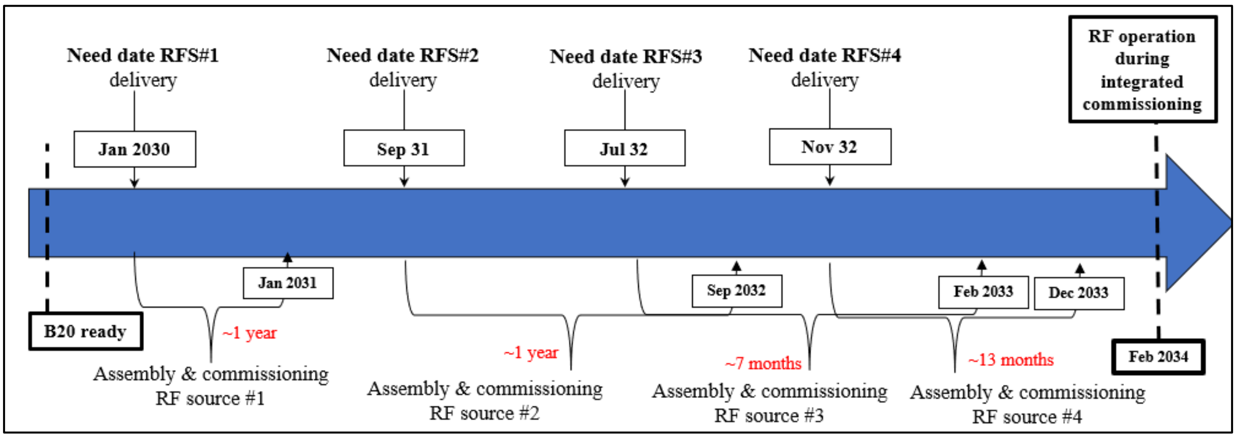

Figure 8-2: key Milestones (Need dates) for RFS delivery

The contractor shall produce the overall project schedule, considering the global timeline, and the need dates. In addition, the following ITER top level milestones (L1 milestones) shall be integrated in the execution schedule:

- L1 - End of IC RF Sources Procurement, Manufacturing and FAT → 24th December 2032
- L1 - End of IC RF Sources Installation and SAT → 23rd December 2033

The contractor shall issue the initial schedule for the whole project, and shall maintain the schedule forecast up to date throughout the overall work execution. The contractor is free to optimize the schedule according to its manufacturing capabilities, and shall demonstrate that need dates are achievable, in accordance with the Figure 8-2. The Final design review date is therefore not scheduled yet, since it is based on the contractor capacity to execute the **Scope of Supply #1 – design and manufacturing of 4 RFS.** the contractor shall provide the Final design review milestone, and it shall be not later than end of the second year (as shown in the Figure 8-1).

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8.2 Deliverable summary

The contractor shall produce the deliverable as specified in the Table 5-6, Table 5-7, and Table 5-8. The following Table 8-1 summarizes the deliverables and dues dates to be provided by the contractor.

DL#	Description	Type	Due dates
Scope of Supply #1 – Design of 4 RFS			
1	Quality plan (full scope)	Document	T0+1
2	RFS Preliminary Design Description report	Document	T0+6
3	RFS Preliminary structural analysis package	Document & analyses model	T0+12
4	RFS Preliminary LCU description	Document	T0+12
5	RFS Preliminary Layout drawings	Document + native CAD file + ENOVIA	T0+8
6	RFS Preliminary Interface Compliance Matrix	Document	T0+6
7	RFS Preliminary 2D drawings	Native CAD file + ENOVIA	T0+8
8	RFS Preliminary 3D model	Native CAD file + ENOVIA	T0+8
9	RFS Preliminary PFDs	Native CAD file	T0+14
10	RFS Preliminary P&IDs	Native CAD file	T0+14
11	RFS Preliminary Wiring & cabling & single line diagram package	Native CAD file	T0+14
12	RFS Preliminary Bill of material	Document	T0+6
13	RFS Preliminary validation plan	Document	T0+6
14	FDR IDP (Cf.13.2)	Design Review Input Package	T0+20
Scope of Supply #1 – Manufacturing of 4 RFS			
1	End of RFS #1 manufacturing report	Document	T0+34
2	End of RFS #2 manufacturing report	Document	T0+52
3	End of RFS #3 manufacturing report	Document	T0+62
4	End of RFS #4 manufacturing report	Document	T0+66
5	FAT report of RFS#1	Document	T0+34
6	FAT report of RFS#2	Document	T0+54
7	FAT report of RFS#3	Document	T0+64
8	FAT report of RFS#4	Document	T0+68
9	RFS #1 *And associated documentation as per 5.2.5* (Delivered at ITER site)	Hardware	T0+36
10	RFS #2 *And associated documentation as per 5.2.5* (Delivered at ITER site)	Hardware	T0+56

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11	RFS #3 *And associated documentation as per 5.2.5* (Delivered at ITER site)	Hardware	T0+66
12	RFS #4 *And associated documentation as per 5.2.5* (Delivered at ITER site)	Hardware	T0+70
13	TBD (MMTL, lift tools, test tools, etc)	Hardware	All along the project
Scope of Service #1 – Assembly at ITER site			
14	End of RFS #1 Assembly completion report	Document	T0+45*
15	End of RFS #2 Assembly completion report	Document	T0+62*
16	End of RFS #3 Assembly completion report	Document	T0+72*
17	End of RFS #4 Assembly completion report	Document	T0+76*
Scope of Service #2 - Site Acceptance Test and commissioning of the RFS			
18	RFS #1 CRR package	Document	T0+46*
19	RFS #2 CRR package	Document	T0+63*
20	RFS #3 CRR package	Document	T0+73*
21	RFS #4 CRR package	Document	T0+77*
22	RFS #1 SAT report	Document	T0+48
23	RFS #2 SAT report	Document	T0+68
24	RFS #3 SAT report	Document	T0+78
25	RFS #4 SAT report	Document	T0+82

Table 8-1: Deliverable summary table

9 Quality Assurance requirements

The Quality class under this contract is QC2, [4] GM3S Section 8 applies in line with the defined Quality Class.

In particular, The ITER Quality Assurance Program shall be applied to the full contract scope t and the contractor shall comply with the procedure **Quality Requirements for IO Performers (22MFG4 v64)**.

The contractor quality plan shall be provided at the beginning of the task.

All requirements of this Technical Specification and subsequent changes proposed by the Supplier during the course of execution of this Contract are subject to the Deviation Request process described in Procedure for the management of Deviation Request (ITER_D_2LZJHB) and Procedure for management of Nonconformities (ITER_D_22F53X).

10 Safety requirements

The scope under this contract doesn't cover neither PIC nor PE/NPE components.

Nevertheless, the following Defined requirement shall be considered in the design of the RFS. Therefore associated Protection Important Activity shall be identified and their monitoring shall be ensured during the execution of the work [20]:

- **[51ICs642-R;Defined Requirement]** The use of high power electronic tubes in RF sources can produce Xray radiation. Protective measures shall be defined and implemented to lower X-ray emission to a level such that the effective dose likely to be received by a worker, as a result of the use in that room of equipment emitting X-rays under normal conditions of use, remains below 0.080 mSv per month
- **[51ICs788-R;Defined Requirement]** The operation of the RF sources' high power electronic tubes generates X-rays. The tubes shall be shielded to make their X-ray radiation ALARA and to avert their classification as generators of ionizing radiation

Resulting requirements are defined in the following sections.

For Protection Important Components and in particular Safety Important Class components (PIC/SIC), the French Nuclear Regulation shall be observed, in application of the Article 14 of the ITER Agreement the Contractors and Subcontractors (if any) are informed that:

- ITER is a nuclear facility (an "INB", for Installation nucléaire de base, "Basic nuclear installation" in French regulation) identified in France by the number "INB no. 174".
- The ITER Policy on Safety Security and Environment Protection Management (ITER_D_43UJN7) must be circulated, known, understood and applied by all staff of the and cascaded down in the managerial lines of the contractors and sub-contractors.

In application of the ITER agreement, article 14, ITER follows the French Regulation for Nuclear safety. Because of its inventory in nuclear materials, ITER has been classified in France as a nuclear facility "*Installation Nucléaire de Base*" and in particular numbered as INB no.174 per the French Decree No. 2012-1248 dated 9 November 2012 authorizing IO to create a basic nuclear facility called "ITER" (ITER_D_CZK7M5) and the associated ASN Decision 2013-DC-0379 dated 12 November 2013 establishing the prescriptions applicable to ITER Organization for the design and construction of the licensed nuclear facility INB No. 174 called ITER (ITER_D_MU6PP3).

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10.1 Safety design criteria

The IC H&CD RF sources shall comply with the technical requirements of the French Order dated 29 September 2017 [9] and summarized in [18] setting the minimum technical design rules applicable to premises in which electrical equipment emitting X-Ray radiation is installed.

X-ray radiation and RF radiation near the vicinity of the equipment will follow the ITER standards (EN 55011, IEEE C 95-1991), and radiation protection directive 2013/59/EURATOM (transposed by French Decrees 2018-434 and 218-437) & shall be monitored by IO at IO site.

During operation of the ICRF source, RF leakage may be observed at certain locations, which needs to be prevented to avoid hazardous RF exposure to the staff.

Electronic tubes are high vacuum devices. The insulating parts are made of ceramics; they can break and implode violently, projecting dangerous debris. The RF cavities shall be fabricated to confine such debris.

High power electronic tubes dissipate very large amounts of heat. The cooling liquid can be at very high temperature. The untimely opening or break in a cooling circuit can release very hot water or steam. Sufficient protection shall be ensured for workers.

Access to the RF cavities during operation shall be forbidden by proper enclosures with key management system.

Equipment shall be designed to limit the propagation of fire to adjacent components. The inventory for all solid, liquid and gaseous toxic products for the HP components shall be limited to the maximum extent possible in the design, and their impact maintained As Low As Reasonable Achievable (ALARA) during operation.

The French Labour Code art. R.4226-1 is applicable to any design activity of components to be delivered to ITER site. This relates to the control of a new electrical installation (NFC 15-100, NFC 13-200 Standard, Decrees 2018-434 (codifying French Public Health Code) and Decree 2018-437, [11]& [12]).

10.2 Safety limits

The dose rate of X-ray should be less than or equal to 0.5 μSv/hr measured at 0.1 m of any point that can be reached by operator in normal operating conditions [Decrees 2018-434 (codifying French Public Health Code) and Decree 2018-437 (codifying French Labour Code)].

The RF exposure for workers expressed as Equivalent Power density for plane waves shall be: < 1.0 mW/cm^2 measured at 10 cm from the RF source enclosure. European directive 2013/35/UE referring to 1999/519/CE relating to workers' exposure to electromagnetic risks are applicable.

10.3 Safety monitoring requirements

Safety monitoring requirements shall be generated & submitted by the contractor for the approval of IO. Contractor shall monitor the same during factory acceptance test.

Monitoring shall be provided by IO during site acceptance tests to indicate the status in all operational states and accident conditions to indicate whether the above safety functions and requirements are being met.

X-ray emission will be checked during assembly, integration & commissioning and periodic measurement will be required, which is under IO safety division responsibility.

11 Seismic classification

The IC RFS is classified as Non-Seismic Components but the RFS design shall comply with the specified in this section.

The seismic analyses process for ITER components and the corresponding spectrum to be used for the analysis are defined in the [33], [34] & [35].

The purpose of the analysis is to check the behaviour of the components under the loads corresponding to 3 types of earthquake: SL 1, SL 2 and EC8-ULS (defined in Eurocode 8)

Depending on the seismic classification, the IO has to demonstrate different or common conditions under the different earthquake events:

For SL 2:

The RF sources shall not jeopardize the building stability. In particular, the contractor shall provide the RFS design assessment against SL-2 loading condition. It is part of IO tasks to check for compliance as regard to building stability.

For SL 1:

In compliance with the requirements for Investment Protection, the RF sources shall be designed to be reasonably expected to restart and operate in normal situation after an SL-1 event, without special maintenance or tests. Only analytical calculation for SL1 shall be conducted without testing the system on the shake table.

For EC8-ULS

The RF source stability shall be maintained. This guaranties that occupational safety is ensured as per Eurocode 8 criteria. This applies to the area occupied by workers.

12 Special Management requirements

Requirement of GM3S [4] Section 6 applies in full.

12.1 CAD design requirements

This contract requires CAD activities, GM3S [4] Section 6.2.2.2 applies.

13 Appendices

13.1 Appendice I – SAT description

13.1.1 Test general conditions

All components used in the tests will be submitted to a specific validation: dummy load, transmission lines, etc. to make sure that no default on them will affect tests results nor test conditions.

All measurement tools will be calibrated, and the certificate will be available. Measuring equipment calibrations will be done every year.

All measurement errors bars will be defined and discussed within the design phase.

13.1.2 Test description

13.1.2.1 Functional and interfaces tests

Geometry:

- Check sources overall dimensions
- Check location of connections (water, electrical, etc…)
- Check source weight (before packaging, estimation by summing the different components weight)

Electrical:

- Electrical connections, grounding and protection circuits are OK (connector standards, cables sizes, etc….).

Control and instrumentation:

- Interlock and safety chains OK (logic, threshold and time response). It contains specific wire burn test for limitation of arc energy dissipation in tubes.
- Measurements are available in local and remote way.
- Local operation of the source via its controller is OK.
- Remote operation of the source via IC plant controller is OK.

Cooling

- Water cooling circuits are tested under real conditions; measurement of pressure drop at nominal flow.

- Air cooling circuits are tested under real conditions; measurement of pressure drop at nominal flow.

Assembly

- Source components assembly in terms of RF contact should meet full power tests on matched and unmatched load conditions. These tests are common with performance tests.

Mechanical test

- Check cavity movement (range and speed)
- Vacuum leak if applicable.
- Gas pressure test if applicable

13.1.2.2 Performance test

They have to ensure that all the specification requirements are met. They will be made in two types of operation mode: on matched mode and on unmatched mode.

All requirements will be verified.

Tests on matched load (VSWR ≤ 1.1)

It consists in full power 2000 s test at 4 frequencies 44 MHz, 55 MHz +2 frequencies in between.

For each frequency, measurement of:

- Output power calorimetric measurement (dummy load cooling circuits) and RF measurements.
- Reflective power amplitude and phase.
- Vacuum inside the end stage tube, if available.
- Tube operational parameters to ensure the stability of the working point, both electrical parameters and dissipation measurements (anode, screen grid voltages and currents, temperature, water flows,…). The complete list will be defined during the design phase.
- Bandwidth measurement
- Detection and suppression of parasitic oscillation measurements, if any.

Run tests: 5 successive pulses of 2000 sec demonstration pulses at full power with a duty cycle of 1/4.

Tests on unmatched load (VSWR =1.5)

It consists in full power 2000 s test at 4 frequencies 40 MHz, 55 MHz +2 frequencies in between.

For each frequency, output power and tube internal parameters will be checked at different reflection phase angles:

- For the two first sources: (0; 45°; 90°; 135°; 180°, 225°; 270°;315°)
- For the 2 balance sources: φ_{min}, minimum power phase angle (as defined in the previous test), φ_{min} +90°, φ_{min} +180°

Measurement of:

- Output power calorimetric measurement (dummy load cooling circuits) and RF measurements.
- Reflective power amplitude and phase.
- Vacuum inside the end stage tube, if available.
- Tube operational parameters to ensure the stability of the working point, both electrical parameters and dissipation measurements (anode, screen grid voltages and currents, temperature, water flows,…).

Detection and suppression of parasitic oscillation measurements, if any

The complete list will be defined during the design phase.

13.2 Appendice II – Typical FDR Input Data Package (IDP)

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.

The following list is an example of the documentation required for the Final Design Review. The list is provided for indicative purpose and might not be exhaustive.

Category	Document Type	Further Description
DOC	RF Source design description document	
CAD	General arrangement of components inside the RFS enclosure	CATIA files
CAD	51RSWD_PFD_001	Process flow diagram – water distribution
CAD	51RSWD_PFD_002	Process flow diagram – water distribution
CAD	51RSWD_PFD_003	Process flow diagram – water distribution
CAD	51RSWD_PFD_004	Process flow diagram – water distribution
CAD	51RSGD_PFD_001	Process flow diagram – gas distribution
CAD	51RSGD_PFD_002	Process flow diagram – gas distribution
CAD	51RSGD_PFD_003	Process flow diagram – gas distribution
CAD	51RSGD_PFD_004	Process flow diagram – gas distribution
CAD	51RSWD_PID_001	Process & Instrumentation diagram (cooling water)
CAD	51RSWD_PID_002	Process & Instrumentation diagram (cooling water)
CAD	51RSWD_PID_003	Process & Instrumentation diagram (cooling water)
CAD	51RSWD_PID_004	Process & Instrumentation diagram (cooling water)
CAD	51RSGD_PID_001	Process & Instrumentation diagram (gas)
CAD	51RSGD_PID_002	Process & Instrumentation diagram (gas)
CAD	51RSGD_PID_003	Process & Instrumentation diagram (gas)

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CAD	51RSGD_PID_004	Process & Instrumentation diagram (gas)
CAD	51RSA1-SLD-001	Single line diagram
CAD	51RSA2-SLD-001	Single line diagram
CAD	51RSA3-SLD-001	Single line diagram
CAD	51RSA4-SLD-001	Single line diagram
CAD	51RSA1-CBD-001	Cabling diagram
CAD	51RSA2-CBD-001	Cabling diagram
CAD	51RSA3-CBD-001	Cabling diagram
CAD	51RSA4-CBD-001	Cabling diagram
CAD	Local Control cubicle wiring diagram	
CAD	Auxiliary power supply wiring diagram	
CAD	Motor control cubicle wiring diagram	
CAD	Distribution board wiring diagram	
CAD	SSPA wiring diagram	
DOC	Plant System Instrumentation and Control Specification	
DOC	List of signals for the RF Source	
DOC	List of data	
CAD	Cubicle Hardware Configuration Diagram	
DOC	Description of Plant System State Machines	
DOC	Instrumentation and Control - Physical and Functional Architecture	
DOC	Equipment List	
BOM	Bill of material	
DOC	Technical Requirements Specification	
CAD	51RS assembly drawing	
CAD	51RSWD Isometric drawing	
CAD	Support structure drawing	
CAD	51RS Detailed Model	
DOC	Design Justification Plan	
DOC	Design Compliance Matrix - DCM	
DOC	Interface Compliance Matrix	
DOC	Functional Analysis Report-FAR	
DOC	Structural Integrity Report	
DOC	Seismic and dead weight calculation	
DOC	Thermomechanical calculation	
DOC	CANECO calculation	
DOC	CFD calculation	

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DOC	Any engineering analysis which is additional to the RAMI, HIRA, HOF which are listed hereafter	
DOC	REACH compliance justification	
DOC	RAMI analysis of the RFS	
DOC	HOF analysis of the RFS	
DOC	FAT & SAT Plan and Procedure	
DOC	Requirement Validation Matrix	
DOC	ROX and Research and Development Report	
DOC	Commissioning Plan	
DOC	Commissioning Test Procedure	
CAD	Part Drawing	
CAD	Installation Drawing	
DOC	Installation Execution Document	
DOC	RF Source concept of operation	
DOC	Operation procedure	
DOC	Maintenance procedure	
DOC	RF Source disassembly procedure	
DOC	RF Source maintenance and inspection plan	
DOC	Schedule and procurement plan	
DOC	Issue or Risk or Opportunity Analysis Report	
DOC	Change Request or Record, Deviation Request, Non-Conformance Report - NCR	
DOC	Contractor Quality Plan	
DOC	Sub Contractor quality plan	