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EXTERNAL REFERENCE

Annex B

Annex B for the supply of Electron Cyclotron Emission (ECE) Diagnostic Front End and Receiver (55F1.0A and 55F1.0D)

ANNEX B To Procurement Arrangement 5.5.P04.US.01 between ITER International Fusion Energy Organization for the Joint Implementation of the ITER Project and The United States ITER Project Office For the supply of Electron Cyclotron Emission (ECE) Diagnostic Front End and Receiver (55F1.0A and 55F1.0D)

Approval Process			
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Annex B for the supply of Electron Cyclotron Emission (ECE) Diagnostic Front End and Receiver (55F1.0A and 55F1.0D) (AQ8KZG_v1_9)	v1.9	Approved	25 Oct 2012	Now, coherent with IN-DA Annex B and PI Annexes B.
Annex B for the supply of Electron Cyclotron Emission (ECE) Diagnostic Front End and Receiver (55F1.0A and 55F1.0D) (AQ8KZG_v1_8)	v1.8	Signed	08 Oct 2012	Important typos in Specification table corrected.
Annex B for the supply of Electron Cyclotron Emission (ECE) Diagnostic Front End and Receiver (55F1.0A and 55F1.0D) (AQ8KZG_v1_7)	v1.7	Approved	05 Oct 2012	A typo in Table 16 corrected.
Annex B for the supply of Electron Cyclotron Emission (ECE) Diagnostic Front End and Receiver (55F1.0A and 55F1.0D) (AQ8KZG_v1_6)	v1.6	Signed	04 Oct 2012	Following comments from Robert Pearce, sections 4.3 and 5.3.1 were modified.
Annex B for the supply of Electron Cyclotron Emission (ECE) Diagnostic Front End and Receiver (55F1.0A and 55F1.0D) (AQ8KZG_v1_5)	v1.5	Signed	03 Oct 2012	A few typos corrected.
Annex B for the supply of Electron Cyclotron Emission (ECE) Diagnostic Front End and Receiver (55F1.0A and 55F1.0D) (AQ8KZG_v1_4)	v1.4	Signed	03 Oct 2012	Highlighted items cleaned.
Annex B for the supply of Electron Cyclotron Emission (ECE) Diagnostic Front End and Receiver (55F1.0A and 55F1.0D)	v1.3	Signed	02 Oct 2012	Several typos corrected below Table 16.

(AQ8KZG_v1_3)				

Annex B for the supply of Electron Cyclotron Emission (ECE) Diagnostic Front End and Receiver (55F1.0A and 55F1.0D) (AQ8KZG_v1_2)	v1.2	Signed	02 Oct 2012	Comments from Reviewers to v1.1 are included and highlighted in yellow throughout the text.
				
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Annex B for the supply of Electron Cyclotron Emission (ECE) Diagnostic Front End and Receiver (55F1.0A and 55F1.0D) (AQ8KZG_v1_1)	v1.1	Signed	24 Sep 2012	Comments from Reviewers to v1.0 are included and highlighted in yellow throughout the text.
Annex B for the supply of Electron Cyclotron Emission (ECE) Diagnostic Front End and Receiver (55F1.0A and 55F1.0D) (AQ8KZG_v1_0)	v1.0	Signed	05 Aug 2012	

Diagnostic Annex B

ANNEX B

To

Procurement Arrangement

5.5.P04.US.01

between

ITER International Fusion Energy Organization for the Joint Implementation of the ITER Project

and

The United States ITER Project Office

For the supply of Electron Cyclotron Emission (ECE) Diagnostic Front End and Receiver (55F1.0A and 55F1.0D)

Abstract:

This document is an integral part of the Procurement Arrangement (PA) 5.5.P04.US.01. It specifies the technical requirements for ECE front end/ receiver while complying with ITER's technical practices, safety and quality assurance requirements.

Version Record

IDM version#	***Tracking Version#***	***Date***	***Description***
1.0	1.0	05/08/2012	First draft
1.1	1.1	24/09/2012	Second draft
1.2	1.2	02/10/2012	Third draft
1.3	1.3	02/10/2012	Fourth draft
1.4	1.4	03/10/2012	Fifth draft
1.5	1.5	03/10/2012	Sixth draft
1.6	1.6	04/10/2012	Seventh draft
1.7	1.7	05/10/2012	Eigth draft
1.8	1.8	07/10/2012	Nineth draft
1.9	1.9	25/10/2012	Tenth draft

List of TBD & TBC

Description	***Section***
Comments from Reviewers to v1.0 are included	Highlighted in yellow throughout the text
Comments from Reviewers to v1.1 are included	Highlighted in yellow throughout the text
Several typos corrected	Below table 16.
Clean version; highlighted items cleared	Throughout the text
Minor typos corrected; comments from Robert Pearce included	Vacuum-related sections

Contents

Abbreviations, Acronyms and Definitions

Acronyms used in this Technical Annex are as given in ITER Abbreviations (2MU6W5) & https://portal.iter.org/Pages/abbreviations.aspx.

Some acronyms specific to the Diagnostic components under this Annex B are defined below. To be completed according to the Diagnostic.

ATPP	Authorization-To-Proceed Point
ECE	Electron Cyclotron Emission
ESP	Equipement Sous Pression
ESPN	Pressurised Nuclear Equipement (From French "Equipements Sous Pression Nucléaire")
HP	Hold Point
HV	High Voltage
MRR	Manufacturing Readiness Review
NA	Not Applicable
NP	Notification Point
PED	Pressure Equipment Directive
PQR	Procedure Qualification Records
PSH	Plant System Host
SS	Stainless Steel
TIP	Toroidal Interferometer/Polarimeter
WAV	Wide Angle Viewing (Visible IR TV)
WPQ	Welding Procedure Qualification
WPS	Welding Procedure Specification
WQ	Welder or Operator Qualification

Port Plug Test Facility (PPTF) is The Facility of Port Plug Test Stands used to Test Upper and Equatorial Port Plugs and their associated equipment.
Diagnostic Port Plug Test Facility Equipment: equipment provided by PBS 55 to achieve the Diagnostic functional tests (different from the engineering tests) on the PPTF.

Environmental Tests means Engineering Tests which include:

- Hydraulic Flow Test & Setting
- Hydraulic Pressure Test
- Thermal Cycling
- Global He Leak Testing - Hot & Cold
- Dimensional Control Test & Visual Inspection
- Reduced Overall Dimensional Control
- Electrical Compliance Test
- Magnetic field immunity test

1 Subject

This document is an integral part of the Procurement Arrangement (PA) 5.5.P04.US.01between the Domestic Agency of the United States of America (USDA) and the ITER Organization. It specifies the technical requirements for the **ECE (Front End and Receiver; 55F1.0A and 55F1.0D)** while complying with ITER's technical practices, safety and quality assurance requirements. In this document the designation of this diagnostic is the following:

55.F1.0A and 55.F1.0D Electron Cyclotron Emission Front End and Receiver

The applicable documents mentioned directly or indirectly in this document, and required as having to be absolutely applied in order to respect the rules of IO are listed in section 9.1. The reference documents, which can be usefully consulted for exercising the activities related to the project, are also listed in section 9.2.

1.1 Description of the Procurement

The Electron Cyclotron Emission diagnostic (PBS 55F1) provides essential information for plasma operation and for establishing performance characteristics. It measures the electron temperature profile (edge/core), electron temperature fluctuations and radiated power in cyclotron frequency range from the plasma providing information on the following parameters as reported in the PR (Project Requirements (PR) (27ZRW8)) v4.6: Edge Electron Temperature Profile, Core Electron Temperature Profile, ELM temperature transient, NTM and TAE δT/Te, as well as contributes to the measurement of βp and runaway electron indicator. The roles of the measurements and contribution of the ECE diagnostic are summarized in Table 1.

Table 1: Role of the 55F1 ECE diagnostic in the ITER program.

Title	Parameter	Contribution	Operation Role
04. Plasma energy	006: βp	Supplementary	1a.1 MP
05. Radiated power	008: Main plasma Prad	Supplementary	1a.2 BC
14. H-mode, ELMs and L-H mode transition indicator	032: ELM temperature transient	Backup	2. PHY
15. Runaway electrons	034: Emax	Supplementary	2. PHY
15. Runaway electrons	035: I runaway	Supplementary	2. PHY
23. Electron temperature profile	**052: Core Te**	**Primary**	**1b. AC**
23. Electron temperature profile	053: Edge Te	Supplementary	2. PHY
27. High frequency instabilities (MHD, NTMs, AEs, turbulence)	**061: NTM δT / Te. (complex; 100ms integration time)**	**Primary**	**1b. AC**
27. High frequency instabilities (MHD, NTMs, AEs, turbulence)	063: TAE δN / n, δT/T	Supplementary	2. PHY

The main challenges for the implementation of the **integrated ECE system** on ITER are as follows:

- Front-end optics designs should be optimised for required spatial resolution and to accommodate plasma height variation to fulfil measurement requirements;
- Design of the vacuum- and radiation-compatible hot calibration source and shutter mechanism;
- Integration of the front-end optics, the hot calibration sources and shutter mechanism into the Equatorial port plug;
- Design and integration of the of the primary confinement barrier and alignment system with front waveguide holder;
- Design of the ex-vessel quasi-optical polarizer splitter box, supports for waveguides which would be able to withstands the stresses induced by electromagnetic forces, thermal expansion and mechanical loads;
- Protection of transmission line, quasi-optics and microwave solid state components from ECH and other stray radiation;
- Design of instrumentation able to perform fluctuation and profile measurements with sufficient resolution simultaneously to meet measurement requirements;
- Provide a capability to perform real-time analysis for feedback control;
- Design and integration of optics arrangement for Michelson interferometer.

Further in this Annex B, only the items related to the scope of **ECE 55F1 (Front-End and Receiver)** will be discussed and addressed.

1.2 Function of the Procurement

The present Annex B is at Functional Specification level. IO provides functional specifications, a viable conceptual design, and accompanying explanatory drawings and analyses as they were presented at the Conceptual Design Review.

Standard Requirements:

In this case of Functional Specification type PA, the IO is responsible for carrying out the Conceptual Design and providing the functional requirements and related documents, e.g. SRD, ICDs, PFDs, and CMMs, when available, as detailed in the ITER_D_2832CF - Design Review Procedure v1.12 and SDP document ITER_D_3VTBNK - System Design Process Working Instruction Update v1.2. Thereafter the responsibility for the Preliminary Design and Final Design is taken over by the DA. The DA is responsible to provide a system which fulfills the functional requirements and to demonstrate that such requirements and the derived acceptance criteria are met.

The Conceptual Design Phase for this procurement has been completed before signature of the present PA. Approval and Closure of the Conceptual Design Review (CDR), and Authorization to proceed to Preliminary Design activities have been recorded in **https://user.iter.org/?uid=A6GZ66 v1.0**. 45 chits were written by the Review Panel members and by the other participants. Chits have

been reviewed by CDR Review Panel members and approved by the CDR Chairman (list of all chits see folder https://user.iter.org/?uid=73MTBM). Of these, there were 7 category 1 chits. These have all been satisfactorily answered and closed: **https://user.iter.org/?uid=4FDYWE (folder)**.

The complete technical description for the ECE system (at the CDR level) can be found in the IDM (folder): **https://user.iter.org/?uid=4ENXC4**.

2 Scope of PA

2.1 General

This Annex B describes the scope of supply of all equipment as required to Electron Cyclotron Emission Diagnostic (ECE) – front end and receiver. As specified in Table 2, this includes all Diagnostic components installed in the port plug (including those installed on the closure plate), some components in the port interspace, and their ancillaries (software, cooling connections and manifolds, supports, mirrors, couplings, local controllers, safety and interlocks devices, etc), calibration sources and any required installation tooling, the associated operating manuals and any specialized tooling as outlined in Section 2.1.1.2. The boundary interfaces of this Annex B are outlined in Section 4 Technical Interfaces.

This Annex B includes the design development, starting after the conclusion of the conceptual design developed for the Conceptual Design Review. The DA shall use this conceptual design as input and shall continue to develop the ECE Diagnostic (front end and receiver) to a final stage, and subsequent procurement, manufacturing, testing and shipping to the delivery site, as well as the commissioning without plasma after installation at ITER Site. The installation at ITER site is carried out by IO with the technical assistance of the DA. Accompanied with the development is a series of deliverables used to document either the R&D development or the progress in procurement.

In the following sections, IO provides functional specifications and accompanying explanatory drawings of the components based on the concept design (**https://user.iter.org/?uid=4ENXC4 (folder)**). These solutions are indicatory for the detailed design of the PDR. As the design and performances responsibility lie with the DA, the DA may suggest other technical solutions which will be subject to IO agreement, provided that they meet all the requirements of the present PA.

2.1.1 Scope of the supply

The DA shall deliver to the IO the components of Procurement Package No. 5.5.P04.US.01 listed in Table 2, and in the quantities set out in Table 2.

It must be noted that this list is based on the conceptual design, which shall be considered as a starting point. Therefore this list is preliminary and will be refined as the design matures. A revised list of deliverables will be prepared by DA and approved by IO during the Preliminary and Final Design Reviews, and shall apply accordingly.

The PBS reference (level 2) of components is: **55F1 (front end and receiver)**.

2.1.1.1 List of Deliverables

List of deliverables	Details	Quantity
In-port plug elements of the quasi-optical transmission lines (mirrors, shutters, feedthroughs etc) with supports	Includes quasi-optical components, casing and supports (perpendicular and oblique lines-of-sight)	2 sets
Hot source assemblies with supports and alignment features	Calibration sources for ECE lines-of-sight	2
Primary confinement assemblies (under the assumption of one assembly per transmission line)	Primary waveguide windows provided by IO under the PBS 55.NW.	2
Compliant gas seal between the port plug and the splitter box	To provide a gas seal complant enough to handle relative motion of the box and the port plug	2
A set of instruments with electronics for: - X-mode radiometer (244 – 355 GHz)	Full-time instrument with ECH protection circuit	1
Controllers. A set of specialised signal processing electronics (including control, digitizing and pre-processing)	With real-time data processing capability	1
ECH protection system	For measures implemented in the port plug and for measures local to protection of X-mode radiometer	2
Analysis and system control software	The ECE is meant to operate as a single diagnostic. To this end the software for monitoring hot source functions (US) and to run the X-mode radiometer (US) must be interoperable with the (IN) contribution.	1 set
Diagnostic local control Cubicle with its contents (in the diagnostic area)		1 set
Tools for testing of installed equipment	Including hot calibration source system for the diagnostic stability checks/ calibrations, mm-wave sources and detectors.	1 set
In-port plug Transmission installation manual	A method of alignment shall be compatible with IO metrology techniques.	1 (one) set
Electronics and analysis hardware operation manual		1 (one) set
Analysis and system control software operation manual		1 (one) set
System operational manuals		1 (one) set
Spares for critical components	Spares for quasi-optical elements in the port plug (DSM)	1 (one) set for each category
Other spares	Detailed list of spares to be agreed at the PDR; also those components required for test pieces required for training or weld qualification purposes.	Detailed number of spares to be agreed at the PDR (also to evaluate spares for possible damage during installation)

** The definition of other spares will be defined by IO at the end of the RAMI study in agreement with the DA.*
*** The quantity of spares will be defined by IO at the end of the RAMI study in agreement with the DA.*

Table 2 : DA Scope of Procurement

Prototypes or components to be developed for R&D activities or design validation are not included in this list, since they do not formed part of the deliverables.
The components of the diagnostic (ECE front end and receiver) will be installed in the places as given by Table 3.

Item	Place
Front-end quasi-optics with supports and shutters; primary confinement barrier	In the middle DSM in the Eq. Port #9; primary confinement barrier of the Port Plug closure plate
Ex-vessel components: calibration sources and their supports	Equatorial Port #9 interspace, attached to the PP closure plate
RF/IF cubicles of X-mode radiometer and signal processing electronics	Diagnostic building, B74 L1
Analysis and system control software.	Local Control Cubicle
Local Control Cubicle (in the Diagnostic Building)	Diagnostic Building 74

Table 3: Location of the diagnostic sub-systems or components

The DA shall take into account the distinctive features of each installation place for the design, the manufacture and the testing of each component included in this PA.

2.1.1.2 Related tools

Within frame of the execution of this Annex B, the DA shall supply the following components or materials for acceptance testing at DA-Site, integration on the port plug (if any) and testing at the US DA-site, and integration and testing at ITER Site, as given in Table 4.

Additional Items to be delivered	Destination
Stand-alone data acquisition hardware and software required for diagnostic testing prior and after to installation on ITER, by means of local control cubicles.	ITER Site
Special pieces of equipment or tools needed for packaging, handling, storage and transportation of Items for integration on EQ09 port plug.	US
Special pieces of equipment or tools needed for installation on EQ09 port plug.	US
Special pieces of equipment or tools needed for packaging, handling, storage and transportation of Items at ITER site.	ITER Site
Any special equipment, which would be additional to Items delivered such as installation means, test and commissioning means, service connection means.	ITER Site

Additional Items to be delivered	Destination
Any special tool and test equipment needed for maintenance, alignment and calibration of the diagnostic at ITER site, including hardware, cabling and software.	ITER Site
Others as agreed by IO and DA	ITER Site

Table 4: Additional Items to be delivered by DA.

Within the context of this PA, the DA commits to maintain the specific tools especially developed for the manufacture, control, inspection of any parts of this PA, including the spare parts, during the period of technical obligation as defined in Annex-A or until a date agreed by IO and the DA. After that period, if the DA or its subcontractors are no longer able to maintain the Items, the DA shall notify the IO before the DA will delete them. IO shall respond within 30 days.

2.1.2 Extent of the supply

Within the framework of this PA, DA is responsible for main following tasks given in Table 5.

Main activities to meet the requirements of this PA
[DA1] DA quality plan submission for IO acceptance prior to the Annex B implementation, Execution of engineering design for the Preliminary and Final Design Phase, including analyses and calculations according to ITER_D_22MAL7 - Analysis and Calculations v4.0 and reporting according to Guideline for Structural Analyses (35BVV3) v1.1. Organisation of the PDR and FDR according to the DA design review procedure approved by IO (see ITER_D_2832CF - Design Review Procedure v1.12).
[DA2] Research and development activities needed for development of the design. Fabrication and testing of trial components or prototypes.
[DA3] Assistance to the IO in identification, definition, and resolution of all interfaces involving this Annex B (see Section 4).
[DA4] Other activities identified in the Design Development Plan which involve achieving prototype, specific testing or anything else (see Section 5.5)
[DA5] Assessment of the Remote Handling Compatibility in accordance with ITER_D_2NRTWR - RH Compatibility Procedure v2.3.
[DA6] Preparation of tender documents & execution of tendering phase. Manufacture qualification process.
[DA7] Production of manufacturing design, schemes and drawings. Production of the metrology plan.
[DA8] Preparation and implementation of a Manufacturing and Inspection Plan according to ITER_D_22MDZD - Manufacturing and Inspection Plan v2.1.
[DA9] Procurement of all the required materials (hardware and software) according to ITER Handbooks (see section 7.2)
[DA10] Development of acceptance criteria and test procedures for Prototype testing and Factory Acceptance, according to Section 6.

Main activities to meet the requirements of this PA
[DA11] Development of Software required for operation of the diagnostic instrumentation during calibration, off-line testing and plasma operation. Development of Software required for deriving the desired measurement quantities from the diagnostic signals. Software for assessing the validity of provided measurement and parameters.
[DA12] Development of all the tools required to support the manufacture, the assembly, the calibration, the alignment, the testing, the handling, the storage and the installation at ITER-site.
[DA13] Manufacturing, Inspection, Testing at DA site, Technical Assistance for the installation at ITER site, Commissioning without plasma as defined in Main PA and technical assistance for the technical obligation after Annex B completion.
[DA14] Documentation, including the assembly, operating and maintenance instructions for the system and each type of component.
[DA15] Disassembly in modular form, Cleaning, Packaging and Delivery of the Diagnostic components and related tools, to the delivery destination (at the ITER Site).
[DA16] All labor and services necessary to the management, performance, and supervision of the design and integration work at DA and IO, while following all ITER's procedures in force.
[DA17] Quality assurance and the qualification procedures required to set the manufacturing process, including all the necessary equipment and experienced personnel for the examinations.
[DA18] Development of the RAMI analysis with IO oversight

Table 5: Main activities in the scope of the DA, within the Annex B context

This list only presents the main tasks and shall not be considered as exhaustive.

2.1.2.1 Component provided by IO

Table 6 lists the items provided by IO.

ITEM	Comment
Diagnostic First Wall	With appropriate aperture(s) for quasi-optical receivers
Ex-vessel cables	Cabling between Diagnostic hall and Port Cell/Interspace as required for system alignment. Cabling between the Diagnostic Hall and the data acquisition cubicle(s) for data transmission.
Window assemblies	IO provides primary confined standard window assemblies (part of PBS55.NW).
The PSH hardware, CODAC core system software and the state machine for the Common Operating States (COS) will be provided by IO, but all configuration data shall be provided by DA.	
TOOLS	**Comment**
Portable CODAC Front End	Software package provided for I&C development work and factory acceptance test. It "simulates" the CODAC system later used for operation of ITER.

Table 6 IO Scope of Supply.

The complete interface definition of these items shall be finalized by IO for the PDR (see Section 4).

The Items supplied by IO to the DA for integration on the diagnostic will undergo an acceptance procedure upon delivery at the DA site. This procedure will be prepared by IO and agreed by DA before the manufacture readiness review.

2.2 Design and related activities

As defined in Table 5, the DA shall perform the engineering activities requested in this Annex B, at least consisting of:

- any required preparatory study;
- the preparation of tender specifications and execution of the tender phase;
- the preparation of the manufacturing drawings;
- the preparation of the technical specifications for tests and inspections;
- the preparation of the delivery specification;
- the quality assurance and the qualification procedures required to set the manufacturing process, including all the necessary equipment and required personnel qualifications for the examinations;
- any other document in the scope of Table 5 activities mutually agreed by the DA and IO.

2.3 *Manufacture of the Equipment (or Material or Component)*

A common manufacturing strategy is being explored by IO for the Port Plug Drawer modules. The DA may choose to take advantage of this, or may choose a separate approach. This structure will need to be manufactured to the requirements of the RCC-MR (Edition 2007) French nuclear code Section 1 Subsection H (“supports”).

2.4 *On Site Test, Installation and Integration*

The On-site services responsibilities are defined in the Main Part of the present Procurement Arrangement. An Agreement (ITER_D_4HCXYP - On site work by the U.S. Domestic Agency V1.0) has been signed between U.S. Department of Energy and ITER Organization. Technical Support and Commissioning responsibilities are defined in the Main part of this Procurement Arrangement.

On-Site testing is detailed in section 6.1.2.

On-site responsibilities for the DA are including:

- Appropriate technical assistance for the installation at ITER site of each component and tool included in the scope of this Annex B. For this purpose, an appropriate team shall be made available and be managed throughout the integration at ITER site.
- Initial training for operating, installing and maintaining the assemblies and their related tools and ancillaries. A session of training shall be held at ITER Site, regarding the operating, the calibration and maintenance of the diagnostic.

The technical assistance for the installation of the procured system at ITER site shall consist of the following work:

- Visit of an ECE technical expert to ITER Site for installation oversight during the installation period
- Consulting on the technical aspects of installation

- Operation support of the Plant I&C and CODAC
- Visit of a technical expert for initial alignment of the entire transmission line.

2.5 Documentation

Standard Requirements:

Any document from the DA, produced during the execution of the PA, can be sent to the IO for Approval, Acceptance or Information purpose.

The general rule is as follows:

a. The IO has responsibility for approving documents related to safety, interfaces, integration and ITER performance.
b. The DA has responsibility for the documents requested by the PA, therefore the DA is responsible for getting any such document approved internally, before sending it to the IO;
c. The IO returns the documents requested by the PA, such as shown with accepted or approved;
d. Documents sent for information require no further decision (neither acceptance nor approval). Comments can be sent where there is a serious, major issue on the content of the document.

Unless specifically specified otherwise, the standard documentation review cycle shall include:

· The IO shall have ten (10) calendar days from the receipt of the DA's documents to review, comment and/or approve them, as the case may be;

· The DA shall have eight (8) calendar days from the receipt of commented documents to update and resubmit them to the IO; and

· The IO shall have five (5) calendar days from the receipt of the DA's submission to review and return the documents

· On submission of documents for acceptance: if no comments are made within the defined time frame, the document is deemed to be accepted by the IO.

The DA shall provide IO with the documents and data defined in the Annex B1 of this Annex B. In case the DA revise the documents and data submitted to the IO, the DA shall immediately submit them to the IO for the same submittal purposes as the originals until the documents and data become "As-Built" status.

The deliverable documents and their contents are defined through the general ITER Project Procedures and derive from the activities that are necessary to achieve this PA.

I&C deliverables for all life-cycle phases are defined in the following document: I&C deliverables for Diagnostics Annex B (3MQKJS) v2.0.

2.5.1 During execution of the PA

2.5.1.1 Management deliverable document

The requirements for the management and quality documents are set in the Annex A of the Procurement Arrangement.

2.5.1.2 Design deliverable document

The Preliminary Design and Final Design deliverables shall include all documents and drawings to describe the design as expected in the design review procedure Design Review Procedure (2832CF) v1.12.

2.5.1.3 Manufacturing deliverable document

The Manufacturing Deliverable documents will be a set of reports documenting the activities associated with the tendering and manufacturing phase. These reports include:

- Procurement description: review of the tender process with reference to the Expression of interest document, evaluation of tenders and selection. This report is to be provided prior to the final selection of supplier. IO shall be invited to review report and may participate in the final supplier selection as per Annex A,
- Readiness Review Report: A summary of the production readiness review meeting to be held prior to initiation of manufacturing,
- Manufacturing reports: Regular reports submitted on a two months basis of the manufacturing status. Any delays, manufacturing problems, alternative manufacturing methods deviating from that presented at the readiness review shall be included,
- Final Manufacturing report: Summary report covering the given manufacturing deliverable and the above reports,
- Test reports.

The IO will review the Manufacturing Phase Deliverable and provide its comments within twenty working days after having received the report. DA is required to send the final Manufacturing Phase Deliverable taking into consideration IO's comments.

2.5.1.4 Factory acceptance test deliverable documents

The Factory Acceptance test Deliverable document shall include:

- Test program
- Summary of results
- Any non-compliance listed and actions to be taken to resolve non-compliance
- Final deliverable list including as built drawings of manufactured components
- Packaging report listing number of crates, crate identification and contents

The IO will review the Factory Acceptance Test Deliverable and provide its comments within twenty working days after having received the report. A final Deliverable document will then be submitted by the DA to IO approval.

2.5.1.5 ITER site acceptance test phase deliverable documents

The ITER site acceptance test deliverable documents are provided by the IO and include:

- Report summarizing the inspection of equipment upon delivery at the ITER site.
- Report on installation and commissioning without plasma procedures, including any non-conformances or overlooked design limitations.
- Report on the Final Acceptance Tests performed by the IO.

The DA is required to review the ITER-site Acceptance Test Deliverable and provide its comments within twenty working days of receiving the report. A final Deliverable will then be circulated taking into consideration the DA's comments

2.5.1.6 Specific deliverables documents

In principle the documents to be provided are defined through the general ITER Procedures. If needed this section requires specific documents if they are not required by ITER procedures.

On site reports are provided by the IO during the period of technical obligation and include:

- Report on installation and commissioning without plasma procedures, including any non-conformances or overlooked design limitations,
- Metrology Requirements / Plan.

2.5.2 "As Built" Documentation

This includes documentation on the quasi-optical mm-wave elements (mirrors etc) installed in the port plug drawer, including actual achieved manufacturing tolerances (mirror flatness, alignment, etc.)

2.5.3 Documentation for Operation and Maintenance of the System

- In-port plug transmission elements installation manual,
- Electronics and analysis hardware operation manual,
- Analysis and system control software operation manual,
- System and SSCs operational manuals.

3 Management of the Procurement

The main phases of the overall procurement cycle are listed below:

- Preliminary Design
- Final Design
- Manufacturing Design
- Qualification
- Procurement
- Manufacture
- Assembly
- Factory Acceptance Testing
- Delivery to the Port Integrator and to ITER Site (depending on parts of the system)
- Installation and Integration at the Port integrator and at ITER Site (depending on parts of the system)
- Acceptance Testing at the Port integrator and at ITER Site
- Commissioning, when applicable
- Final Acceptance at the ITER Site.

The content and requirements of each phase is detailed in the following sections.

The scope of this Annex B encompasses 8 phases:

- Preliminary Design of the Items,
- Final Design of the Items,
- Fabrication and Manufacture of the Items, inclusive of Factory Acceptance Testing,
- Delivery of the Items to delivery destinations,
- Site acceptance inspection at the US Port Integration facility
- Technical Support during Assembly and Installation of the Items as defined in in ITER_D_4HCXYP - On site work by the U.S. Domestic Agency V1.0,
- Commissioning of the System as defined in ITER_D_4HCXYP - On site work by the U.S. Domestic Agency V1.0,Technical Support during the period of Technical Obligation,
- Provision of all Technical and Quality Documentation.

3.1 Share of Responsibilities between the IO and the DA

The sharing of responsibilities between the Parties is summarized in Table 7 and is further detailed in the following sections.

Activity	*IO*	*DA*
Tendering	*A*	*R*
Phase 1 Preliminary Design		
Preliminary Design	*A*	*R*
Preliminary Design Review	*A*	*R*
Phase 2 Final Design		
Final Design	*A*	*R*
Final Design Review	*A*	*R*
Phase 3 Manufacture, Assembly, FAT and Delivery		
Manufacturing Readiness Review	*A*	*R*
Manufacturing and Assembly	*A*	*R*
Factory Acceptance Testing	*A*	*R*
Packing and delivery to the ITER Site	*A*	*R*
Phase 4 Integration & Acceptance		
Integrate with ITER infrastructure	*R*	*S*
Testing Readiness Review	*A*	*R*
Integrated Commissioning Testing	*A*	*R*
Final Acceptance	*A*	*R*

R = Responsible for organizing, performing and for the content;
A = Review/Comment/Accept but with no responsibility for the content;
S= Support.

Table 7. Summary of the Sharing of Responsibilities between the IO and the DA.

3.1.1 Responsibilities of shared activities

The sharing of responsibilities between the Parties is detailed in Table 6 for the IO activities and in Table 5 for the DA activities. The summary is given in Table 7.

3.1.2 IO activities

Within framework of the execution of this Annex B, IO will exercise design approval and oversight through interface management and through the process of Preliminary and Final design reviews. This includes working with the DA to predefine the criteria for successful design reviews.

IO will also exercise a close oversight of the DA manufacture and testing activities through the reviews and control points.

The main activities in the scope of the IO within the frame of this Annex B are listed in Table 8.

Principal activities in the scope of the IO within the frame of this Annex B.
[IO1] IO will provide the existing designs, design studies, and CAD models of the Diagnostic at the Annex B signature.
[IO2] IO will manage all interfaces between the components under this Annex B and components directly provided by IO. IO will monitor[1] all interfaces between the components under this Annex B and the components provided by other involved DAs. IO will coordinate the parallel developments in the involved DA(s) and will manage disputes related to boundaries of responsibility. IO will work with the involved DA(s) to clearly define, schedule, and enforce linked milestones in the appropriate PAs. Examples of such milestones include: • Regular meetings where updates to the spatial envelopes are evaluated. • Schedule coordination meetings. • Work with the DA to organize and execute Preliminary and Final Design Reviews. • Provide timely indication of proposed changes in requirements or loads that may impact the design. Such changes may require PCR. • Assistance in PDR and FDR preparation for components included in the present PA. • PDR(s) and FDR(s) for subsystems provided by other DAs or IO. • Milestones for delivery of qualified subsystems provided by other DAs or IO. • Milestones for completion of functional testing of subsystems at the DA site.
[IO3] Implementation and maintenance of the interface control documents (ICD) system and related interface sheets, with the assistance of DA.
[IO4] Timely review of Preliminary and Final Design packages for Items under this PA. Following each Design Review, a report summarizing the findings of the Review will be prepared by the IO and transmitted to the DA.
[IO5] Definition of remote-handling requirements as input into design of Items, if remote handling is needed.
[IO6] IO is in charge of the Licensing Activities regarding the components under this PA, while relying on the technical files prepared by the DA.
[IO7] Ex-vessel electrical, vacuum and hydraulic connections of the diagnostic at ITER site will be defined and provided by IO.
[IO8] Installation of the components, with the technical assistance of the DA.
[IO9] Acceptance tests at IO site with the technical assistance of the DA and post commissioning tests.

Table 8 IO activities.

3.2 Procurement follow-up

3.2.1 Phasing of the project

The design progress logic and the work plan for the next design phases have been determined according to the conclusions of the following section of the Design Description Document of 55F1 Electron Cyclotron Emission (ECE) diagnostic, https://user.iter.org/?uid=679HW9 v1.1

Section 6.2 of the DDD: “Description of design development and optimization”
Section 6.5 of the DDD: “Summary of risk analysis and proposed mitigation plans”
Section 15 of the DDD: “Status of R&D”.
and according to the Integrated Project Schedule.

1 IO shall be kept informed of all technical exchanges between the DA and the other Domestic Agencies, which take place within the context of the present Annex B.

This section aims at describing the project activities, the progress logic and the work plan for the next phases. Detailed work for R&D prototype and qualification is defined in section 5.5.

The conditions of delivery are described in main PA section I.4.

The approach is summarized in the chart in Fig. 1.

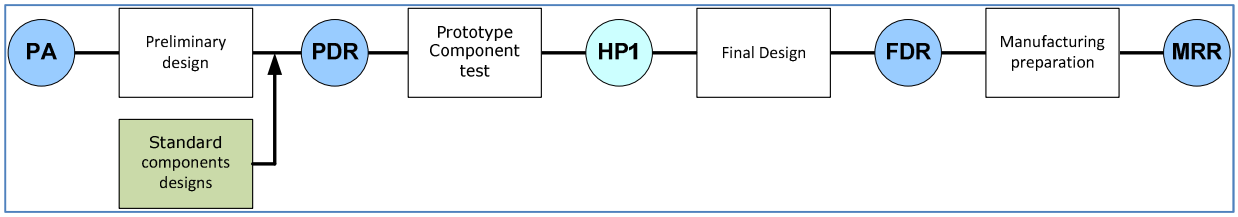

Figure 1 : Indicative Design Development Plan.

The main phases for the design after the Conceptual Design Review are:

- 55.F1 Preliminary Design
- 55.F1 Final Design of the components located in the port plug and port interspace,
- 55.F1 Final Design of the components located in the diagnostic area,
- 55.F1 Manufacturing Readiness of the components located in the port plug and port interspace,
- 55.F1 Manufacturing Readiness of the components located in the diagnostic area

The design milestones are summarized in Table 9.

Milestone	Name
HP1-PDR	Preliminary Design approved
HP2	ECE in-port plug TL components and Receiver Prototype test and approval for components identified at PDR as requiring prototyping
HP3-FDR	Final Design of the components located in the port plug and port interspace approved
HP4-FDR	Final Design of the components located in the diagnostic area approved
HP5-MRR	Manufacturing Readiness of the components located in the port plug and port interspace approved
HP6-MRR	Manufacturing Readiness of the components located in the diagnostic area approved

Table 9 Milestones of the 55F1 ECE diagnostic (front end and receiver).

Design changes or severe issues found during the studies may lead to adaptation of the Design Development Plan given in Fig.1.

3.2.2 Notification Points, Authorizations-to-Proceed Points, Hold Points, Witness Points and Surveillance Points

Standard Requirements:

The DA shall ensure a close oversight of the production of its main Suppliers in accordance with an approved Manufacturing and Inspection Plan (MIP) (see Manufacturing and Inspection Plan (22MDZD) v2.1). This monitoring shall include Notification Points, Authorization-To-Proceed Points, Hold Points, Witness Points and Surveillance Points at critical steps in the Suppliers' plans. The Control Points shall be integrated into the agreed schedule and MIPs, as defined in Section 5 of Annex A.
A Notification Point (NP) is a milestone where the Supplier is required to notify the DA, who informs the IO, that it has completed a specific task or a specific deliverable and is proceeding to the next task or to the next action on the specific deliverable. A NP is meant to enable DA and IO personnel to follow the progress of the contract and possibly to witness a critical manufacturing step at the Supplier's premises. The Notification shall be sent by the Supplier to the DA at least 14 calendar days prior to the scheduled manufacturing step. The DA shall inform the IO of the Suppliers' Notification within 2 calendar days and the DA and the IO shall decide whether or not they want to attend within the following 2 calendar days. A NP shall not affect the production flow of the Supplier that shall continue the work even without a reply from the DA and/or IO.

An Authorization-To-Proceed Point (ATPP) is a milestone where the Supplier is required to notify the DA, who informs the IO, that it has completed a specific task or a specific deliverable and must wait for an authorization from the DA before proceeding to the next task or to the next action on the specific deliverable. The DA shall grant the Authorization To Proceed on the basis of clearly identified Quality Control data and Acceptance test results to be provided by the Suppliers. The DA shall have 4 calendar days to review the Supplier's data and to notify the IO of its decision. The IO shall have 3 calendar days to review the DA decision. Beyond these 7 calendar days and if there is no IO reaction, the DA shall notify the Supplier of its decision. In case of authorization, the Supplier shall proceed to the next task or to the next action on the specific deliverable. In case of rejection, the Supplier shall develop with the DA a recovery plan that shall be submitted and reviewed by the IO within 7 calendar days of submission. In case of IO objection, the IO shall detail its motives in writing and the DA shall have 7 calendar days to answer the IO objection and, whenever suitable, develop a recovery plan with the Supplier. An ATPP shall only affect the specific task or the specific deliverable it is associated with and shall not interfere with the execution of other tasks of the production or other deliverables of the same kind.

A Hold Point (HP) is a milestone where the Supplier is required to notify the DA, who informs the IO, that it has completed a specific task or a specific deliverable and must stop the associated processes until a HP Clearance is issued. The HP Clearance shall be issued on the basis of clearly identified Quality Control and data and acceptance test results to be provided to the DA and the IO at the time of the request. The DA shall have a maximum of 7 calendar days to review the Suppliers data and to notify the IO of its decision and the IO shall have a maximum of 7 calendar days to review the DA assessment and to confirm or reject it. In case of clearance, the Supplier shall resume its activity. In case of rejection, the Supplier shall develop with the DA a recovery plan that shall be submitted and reviewed by the IO within 14 calendar days of submission. In case of IO objection, the IO shall detail its

reasons in writing and the DA shall have 14 calendar days to answer the IO objection and, whenever suitable, develop a recovery plan with the Supplier.

A Witness Point (W) is a milestone which identifies an operation to be witnessed. The Supplier is required to notify the DA, who informs the IO. A Witness Point indicates a mandatory inspection to witness a critical manufacturing operation at the Supplier's premises. Adequate notice shall be given to the IO, in order to allow the IO to participate to the operation. (Notification shall be sent by the Supplier to the DA at least 14 calendar days prior to the scheduled manufacturing operation).

A Surveillance Point (S1) identifies an operation that requires 100% inspection.

A Surveillance Point (S2) identifies an operation that requires random inspection or spot checks.
Review (R) identifies a document or report to be reviewed. IO/DA shall have 14 calendar days to review the document or report.

The list of NPs, ATPPs, HPs, W and S to be implemented during the various phases of this PA will be defined mutually between the IO and the DA, during the design process, as regards to project phasing.

The control points will be defined mutually between IO & DA, during the Preliminary Design Phase in accordance with the project phasing described in section 3.2.1. Additional Control Points may be identified following review of the MIPs.

Table 10 lists the control points already demanded by IO, within the frame of this PA.

Review / Inspection / Event	Objective	Control Point
Quality Plan submission	IO acceptance; refer to Annex A section 5	HP
Physics risks mitigation review	IO approval	HP
Preliminary Design Review (PDR)	IO approval regarding the preliminary design	HP
R & D findings	Clear a show stopper	R
End of testing program performed on prototype	Validate the design by experiment	HP
Final Design Review (FDR)	IO approval regarding the final design	HP
Tender Process	IO approval regarding the selection criteria and intellectual property provisions [see AnnexA-3.2 e/f and 3.3]	HP
Manufacturing Readiness Review (MRR)	IO approval regarding the procedures and technical specifications prepared for the manufacture, before the start of the manufacture.	HP

Review / Inspection / Event	Objective	Control Point
Change control	[See AnnexA-3.2 d and 3.3]	R
Inspection during manufacturing	See equipment during manufacturing	NP
Inspection during manufacturing	Approve the operations done up to the inspection, before carrying on.	HP
Final Manufacture Review	IO technical approval regarding manufactured components, before starting the integration and/or the tests.	R
Factory Acceptance Test Review	IO approval before shipment of the Diagnostic components to the next destination.	HP
PP Integration Test Review	IO approval regarding the integration and associated testing.	HP
Inspection at ITER site on delivery, preliminary acceptance tests.	Identification of any damage during transportation	HP
Final Acceptance Testing	Any tests by the IO at ITER Site to allow final acceptance.	HP

Table 10 : Main Reviews and Inspections.

3.2.3 Data Management

Standard Requirements:

The data generated during the execution of the PA shall be entered into the ITER IDM. Exchange of documentation between the Supplier, the DA and the IO shall comply with the Procedure on procurement documentation exchange between IO, DAs and contractors (35BVQR) v2.1

These engineering data shall be organized according to the ITER Document Breakdown Structure Overview (43327Q) v1.1 and to the document ITER Plant Breakdown Structure (28WB2P) v2.0.

IO shall manage these data in accordance with the Intellectual Property Rights as defined in the Main part of this Procurement Arrangement.

The data generated by the DA's Supplier may be handled electronically and entered into a database similar to the ITER IDM, if the type of Items requires so. The structure of this database should be defined by the DA in agreement with IO. The Supplier and the DA should use this database to store information related to the PA. All data entered in the database will be kept strictly confidential by IO and DA and, under no circumstances, shall be communicated or made accessible to other suppliers or DAs. Data consistency checks shall be implemented to facilitate DA and IO oversight. Data flow shall be consistent with the following protocol:

- Data flow from the Supplier to the DA, when applicable: Relevant data shall be made available by the Supplier to the DA through the database each time a control point is requested, or a deviation

request, a non-conformance report, or any other document which is part of the PA deliverables is issued by the Supplier.

- Data flow from the DA to the IO: Relevant data shall be made available by the DA to the IO through IDM each time a control point is requested, or a deviation request, a non-conformance report, or any other document which is part of the PA deliverables is issued by the DA, in accordance with the document "ITER_D_2DKFR2 - Procurement Arrangement related Documentation Exchange, Access and Storage Conventions " v2.6.

CAD data files that are managed through specialized CAD software (e.g. CATIA, See System Design and others) undergo other requirements which are specified in the Add link to DCIF for this PA, as detailed in Section 10 of Annex A. Metrology data exchange should conform to the ITER Dimensional Metrology Handbook, https://user.iter.org/?uid=46FN9B v2.1.

3.2.4 IO Reviews

The Design Reviews shall be performed in accordance with the DA Design Review Procedure, which is in line with the IO "Design Review Procedure".

The IO and DA will organize Status Reviews (SRs) and Quality Control Reviews (QCRs) by mutual agreement. These may be focused on particular areas of production and will be organized by IO as required by the progress and performance. The present schedule for these reviews is as follows:

- Preliminary Design Review;
- Final Design Review;
- Manufacturing Readiness Review, before starting manufacturing;
- Status and Product Quality Review, when needed;
- Installation Readiness Review, before starting installation at the ITER Site;
- Testing Readiness Review, before starting acceptance testing at the ITER Site;
- Operation Readiness Review, before starting operation at the ITER Site.

The DA shall organize Design Reviews according to the IO-approved design review procedure ITER_D_2832CF - Design Review Procedure V1.12. Status / Quality Control reviews shall be organized by mutual agreement between IO and the DA. They may be focused on the different design stages and particular areas of production. The membership of the Review Group and its terms of reference need to be approved by IO.

The main Reviews and Inspections are given in Table 10.

4 Technical Interfaces

Diagnostics (PBS 55) have interfaces with a large of number of systems. At a high level these are summarized in the Interface Control Table [2FA7AQ] (folder). The important ones from the point of view of the Electron Cyclotron Emission (ECE) are summarized in Table 11. The schematic layout of the ECE diagnostic is given in Fig. 2. All of these interfaces have Interface Control Documents (ICDs). For some of them, Interface Sheets (ISs) have already been written, describing with more details the interfaces (Table 11) as they are applicable to **ECE front-end and receiver**.

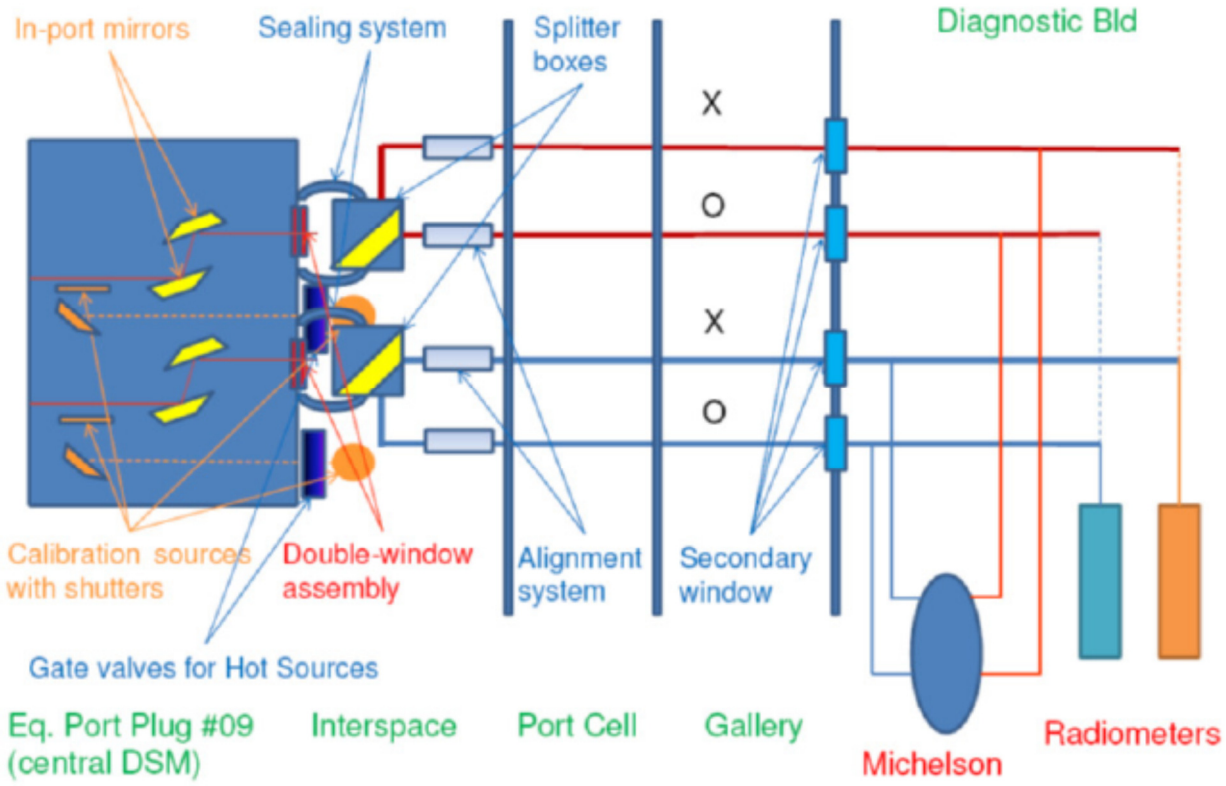

Figure 2 Schematic layout of the ECE diagnostic.

System	PBS	Interface Control Document	Interface Sheet
Machine Assembly & Tooling	22	ICD 22-55 Machine Assembly&Tooling [3V8YX9] v1.0	IS-22-55-035. Not written yet
Remote Handling	23	ICD 23-55 Remote Handling System [33MTMU] v1.6	IS-23-55-009 [64PKDH]: Not written yet
Vacuum	31	ICD 31-55 Vacuum [33SHV8] v1.4	IS-31-55-014 [7A4VDQ] v1.0
SSEN	43	ICD 43-55 SSEN [2KSJ68] v1.1	IS-43-55-001 [3VUL6D] v2.1

			IS-43-55-002 [3VV3JT] v2.0 IS-43-55-003 [3XZRQM] v1.2
Cable Trays System	44	ICD 44-55 Cable Trays System [2WH9UJ] v1.2	IS (PBS43, PBS44) - (PBS55) [4ESYDV] v1.0
CODAC	45	ICD 45-55 Codac [33TAMZ] v1.5	IS 45-55.F2-P. Not written yet IS 45-55.F2-L. Not written yet
Plasma Control System	47	ICD 47-55 Plasma Control System [34KGXG] v1.0	IS 47-55-037. Not written yet.
Port Plug Test Facility	58	ICD 55-58 Port Plug Test Facility [34M96J] v1.1	IS 55.EQP10-58, 55.UP1-58. In progress.
Reinforced Concrete Buildings : 11-Tokamak Building 14-Tritium Building 74 Diagnostic Building 21 Hot Cell Facility 13-Assembly Building	62	ICD (PBS 62-11, 62-14, 92-74) - (PBS 55) [2EPQ2V] v1.5 ICD (PBS 62-21) - (PBS 55) [2EPR54] v1.3 ICD (PBS 62-13) - (PBS 55) [3QG3LN] v1.2	IS (PBS 62-11, 62-14, 62-74) – (PBS 55) [34GS5D] v4.1 IS (PBS 62.21) - (PBS 55) [357AB7] v1.2 IS (PBS 62.13) - (PBS 55) [3Y6WHW] v1.2
Radwaste Treatment and Storage Systems	66	Interface Control Document (ICD) between Diagnostics (PBS 55) and Radwaste Treatment and Storage System (PBS 66) (ITER_D_35XUDM v1.0)	IS-55-66-001 (ITER_D_35ZMWC v1.0)

TABLE 11. Current status of Interface Control Documents for **ECE (Front End and Receiver)**.

The systems listed below (Table 12) have no direct interfaces with the ECE but should be considered respectively for the following reason: ECH has an interface as it is included as a load specification. The signal from ECH protection circuit (as given in Table 2) integrated in the ECE diagnostic may be used by CIS, as well as by any other user which may want it. The applicability of this interface for ECE system will be decided before the PDR of 55F1 (Front End and Receiver) ECE diagnostic. CSS (PBS 48) may have an interface because of occupation safety for maintenance and operation of the diagnostic system. The applicability of this interface for ECE system will be decided before the PDR of 55F1 (Front End and Receiver) ECE diagnostic.

EC H&CD System	52	ICD to be prepared	
Central Interlock System	46	ICD 46-55 Central Interlock System [2LPSQY] v1.2; new	IS-55-46-001. Not written yet

		version to be prepared	IS-55-46-002. Not written yet IS-55-46-003. Not written yet
Central Safety System	48	ICD 48-55 Central Safety System [2LPZ6G] v1.2; to be updated	Not written yet

TABLE 12. Indirect interfaces for ECE Diagnostic.

The outstanding features of some of these interfaces with the **ECE (Front End and Receiver)** are discussed below.

4.1 Machine assembly and tooling (PBS 22)

The attachment of the ex-vessel transmission line components require interface with Machine assembly and tooling. At the earliest opportunity, the DA will provide an assembly concept, and an alignment and metrology strategy.

4.2 Remote Handling (PBS 23)

The **ECE (Front End and Receiver)** requires the maintenance, calibration and refurbishment of the system by Remote Handling (RH).

4.3 Vacuum (PBS 31)

The **ECE (Front End and Receiver)** requires a rough pumping capability to evacuate the interspace between the port flange (windows assembly) and the polarization splitter box. The vacuum interfaces need to be further developed in agreement with the IO PBS 31 and reviewed prior the PDR.

4.4 SSEN and Cable Trays (PBS 43 and 44)

The supply of the back-end of the system in the diagnostic areas with electrical power is due to the interface with SSEN (PBS 43) and, via 55NE, with Cable Trays System (PBS 44).

4.5 CODAC and Plasma Control System (PBS 45 and 47)

There is an interface with CODAC (PBS 45) and PCS (PBS 47) for instrumentation and control.

4.6 Port Plug Test Facility (PBS 58)

Because parts of the front end of the system are located inside the Equatorial Port Plug 10 and Upper Port Plug 1, there is an interface with PBS 58 for functional and environmental tests in the Port Plug Test Facility.

4.7 Radwaste treatments and storage systems (PBS 66)

Because the in-port plug parts of the diagnostic may produce some amount of the operational radwaste type “B”, there is an interface with PBS 66.

The 3D and 2D CAD Model Approval Inrefacing System Control Sheet for 55F1 ECE diagnostic can be found here: ITER_D_A6UBTX - The 3D and 2D CAD Model Approval Interfacing System Control Sheet (PC-CMAF ECE-CMM-L1-level) v1.0.

5 Technical Requirements

The “Project Requirements Document” ITER_D_27ZRW8 - Project Requirements (PR) v4.6, the “Project Specification document” ITER_D_2DY7NG - IC-2/ 7.1 Project Specification v2.0 and the “System Requirement Document” ITER_D_28B39L - SRD-55 (Diagnostics) from DOORS v3.1 specify the general technical requirements, which have to be fulfilled by the sub-systems included in this Annex B.

The compliance matrix (https://user.iter.org/?uid=734AZL&version=v1.0) attached to the present document, **identifies all the requirements coming from the SRD-55 which are applicabl**e for the sub-systems of the diagnostic under this Annex B.

The following sections provide Technical Requirements particular of this Diagnostic.

5.1 Classification

This sub-section stipulates the ITER classifications that are applicable to the Items to be supplied. The main ITER classifications for the System are listed in the following Table 13.
Other applicable classification shall be also defined, e.g. tritium, cryogenic and remote handling classification.
Changes in the classifications must be in agreement with and approved by IO.

The following table gives the complete classifications of main Items to be supplied with respects to Quality, Seismic Class, Safety and Vacuum, Tritium. PED and ESPN classification are defined in in section 5.3.1.
Remote Handling maintenance is foreseen for the ECE in-port plug components.
This table is an extract of ITER_D_3G2T8J - Diagnostic System Classifications v2.9.

PBS	System Name	Subsystem Description	Diagnostic Component	Safety Class	Seismic Class	Quality Class	Vacuum Class	Tritium Class	RH Class
55.F1.00	ECE	Diagnostic System							
55.F1.0A	ECE - collection and calibration optics	ECE – in-port plug quasi-optical components, shutters and supports	Part of the Port Plug (DSM) transmission line	Non-SIC	SC1 (S)	QC-1	VQC-1B	No-TC	RHC3
55.F1.0A	ECE – collection and calibration optics	Vacuum feedthroughs mounted on closure plate of E9 (mechanical, electrical, hydraulic)		SIC-1	SC1 (S)	QC-1	VQC-1A	TC-1A	RHC2
55.F1.0B	ECE – collection and calibration optics	Transmission Line system and components	Port Plug Penetration and its extension (between the closure plate and the primary window assembly)	SIC-1	SC1 (S)	QC-1	VQC-1A	TC-1A: 1st Confin. Sys, Fixed, flammable conc. H (+T) 1st barrier, vac. jacket, isol. valve	Unclassified*
55.F1.0B	ECE – collection and calibration optics	Primary Window assembly	Primary Vac. Double Window Assembly	SIC-1	SC1 (SF)	QC-1	VQC-1A	TC-1A	RHC2
55.F1.0A or 55.F1.0B	ECE –collection and calibration optics	Calibration Source assembly	Hot source assembly	SIC-1	SC1 (SF)	QC-1	VQC-1A	TC-1A	RHC2

PBS	System Name	Subsystem Description	Diagnostic Component	Safety Class	Seismic Class	Quality Class	Vacuum Class	Tritium Class	RH Class
55.F1.00	ECE	Diagnostic System							
55.F1.0B	ECE – collection and calibration optics	Transmission Line system and components	Compliant gas seal between the port plug and the splitter box (to provide a gas seal complant enough to handle relative motion of the box and the port plug)	Non-SIC	NSC No seismic requirements for safety.	QC-1	VQC-N/A (if purged) VQC-3A (if evacuated)	No-TC	Unclassified*
55.F1.0D	ECE - Receiver	Microwave instruments and electronics	Mm-wave receiver RF/IF (X-mode radiometer) system and electronics	Non-SIC	NSC No seismic requirements for safety.	QC-3	VQC-N/A	No-TC	No RH Maintenance
55.F1.0D	ECE - Receiver	Diagnostic Signal Processing	Diagnostic cubicle content	Non-SIC	NSC	QC-3	VQC-N/A	No-TC	No RH Maintenance
55.F1.0D	ECE - Receiver	Diagnostic Data Acquisition	Cubicle content	Non-SIC	NSC	QC-3	VQC-N/A	No-TC	No RH Maintenance

Table 13: Complete Classification of the components of ECE Diagnostic

**Note: Some components and sub-systems will not be RH Classified, thus there is no requirement to design equipment and operation sequences before machine operation. Several sub-systems are defined to be hands-on maintained and therefore are not RH-classified in the baseline. These systems and components are designated as ALARA driven. This table shall be updated by the DA throughout the design phase, and shall apply accordingly.*

5.1.1 Seismic classification

The ITER Seismic Nuclear Safety Approach is given in ITER_D_2DRVPE - ITER Seismic Nuclear Safety Approach v1.6. In particular this document gives the way to define the seismic classification of each component or sub-system, according to their functional safety requirements. A Seismic Classification is given in Table 13 for the sub-systems under this Annex B. As the design may change, this classification shall be updated by the DA, during the design phase.

Safety Important Components are classified Seismic Class one-SF, SC1 (SF). These components must maintain their confinement function and assure no significant leakage during and following the event of an SL-2 seismic event (Category IV – Extremely unlikely event).

The design of the **55F1 ECE Front End and Receiver** shall take into consideration loading values resulting from seismic events categorized in the ITER_D_6XRG6J - Load Specifications (LS) v3.0). The design process shall include an assessment of the potential damage and system failures that could result during seismic events. Where practical, the **55F1 ECE Front End and Receiver** shall be design to prevent any damages to high value components (investment protection) during seismic events.

5.2 Licensing requirements

Table 14 gives a first classification assessment for the different components of the diagnostic, regarding ESP and ESPN Category and level. This table may change as the design matures and shall apply accordingly.

In accordance with Table 14, in this PA there is no equipment with maximum allowable pressure greater than 0.5 bar In this case the equipment are outside of scope of French Decree 99 -1046 dated December 13th 1999 and subsequent Order and amendments which introduce in force in France the Pressure Equipment Directive (PED) 97/23/EC (abbreviation ESP is used for this regulation) and outside of scope French Order on Nuclear Pressure Equipment, December 2005, (ESPN).

5.3 Applicable Codes & Standards

5.3.1 Mechanical Codes and Standards:

Codes and Standards for ITER Mechanical Components (25EW4K) v4.0 specifies the global ITER approach regarding the Codes and Standards, which are applicable for designing, manufacturing, inspecting and testing mechanical components. This approach takes into account the requirements of the above mentioned regulations.

Applicable Codes and Standards will be different according to the location of the mechanical component in the machine depending on:

- the irradiation level,
- the expected temperature,
- the pressure differential,
- whether it ensures a structural function with respect to the pressure, or not,
- whether it ensures a confinement boundary with respect to the radioactive products, or not,
- whether the component is located inside or outside the vacuum vessel.

The welding of vacuum boundaries must conform to the ITER_D_2EZ9UM - ITER Vacuum Handbook v2.3 (attachment 1).
Table 14 gives Codes and Standards for the different components of the diagnostic.

For the **ECE Front-End and Receiver**, the classification is as follows:

ITEMs	ESP Classification	ESPN Classification	Selected Codes and Standards
Diagnostic Sub-systems located inside the port plug. - Mirrors, - Shutters, - Supports.	Not Under ESP	Not Under ESPN	Design: SDC-IC* and Vacuum Handbook requirements Manufacturing, Inspection: ▪ Conventional parts: RCC-MR edition 2007 or EN Standards and Vacuum Handbook requirements ▪ Non-conventional parts: Technical Specifications. Testing: According to manufacturer and Code.
Interspace systems - Primary confinement barrier elements (window assemblies, hot source assemblies, their supports) - Compliant gas seal between the port plug and the splitter box	Not Under ESP	Not Under ESPN	Design: RCC-MR edition 2007** Manufacturing, Inspection: ▪ Conventional parts: RCC-MR edition 2007** or EN Standards ▪ Non-conventional parts: Technical Specifications. Testing: According to manufacturer and Code.
Diagnostic Enclosure systems	Not Under ESP	Not Under ESPN	Design: RCC-MR edition 2007** Manufacturing, Inspection: ▪ Conventional parts: latest editions of ASME or EN Standards ▪ Non-conventional parts: Technical Specifications. Testing: According to manufacturer and Code.

***SDC-IC: Structural Design Criteria for In-Vessel Components. *ITER_D_222RHC v2.0 - In-vessel Components, SDC-IC*

**Demonstrably equivalent design code may be used, e.g. latest editions of ASME and appropriate ITER load specifications

Table 14. Applicable Mechanical Codes and Standards depending on the ITEM features.

5.3.2 Electrical Codes and Standards

The electrical design of the diagnostic sub-systems shall meet the requirements of all parts of the ITER Electrical Design Handbook (EDH) (folder), in which the Applicable Codes and Standards are also specified in ITER_D_2E8DLM - EDH Part 3: Codes & Standards v1.3.

5.3.3 Codes and Standards for Instrumentation and Control

All Instrumentation and Control components part of this Annex B shall conform to standards, specifications and interfaces as documented in the ITER_D_27LH2V - Plant Control Design Handbook v6.1.

5.4 Design requirements

The functional requirements to be met by the System are defined in the SRD document.
The SRD is complemented by a series of specific applicable documents which contain detailed requirements to be met during the design of the system and the execution of the procurement, i.e. the following ones:

- DCIF;
- Management of CAD Work and CAD Data;
- System Load Specification;
- Electrical Design Handbook;
- ITER Vacuum Handbook;
- CODAC Plant Control Design Handbook;
- ITER Seismic Nuclear Safety Approach ;
- Radiation Hardness Manual (RAD), Volume II Gamma Radiation;
- Remote Handling Control System Design Handbook;
- Tritium Handbook;
- Cryogenic Handbook;
- Preliminary Safety Report (RPrS).

The IDM links to the above-mentioned documents are given in Section 9 of this Annex B.

5.4.1 Functional requirement

The functional requirements are described in detail in the system level DDD (Design Description Document of 55F1 Electron Cyclotron Emission (ECE) Diagnostic, https://user.iter.org/?uid=679HW9 v1.1) which should be referred to as the primary source of the ECE system specifications.

A measurement prioritization for ECE diagnostic is given below:

1. Core electron temperature profile measurement and contribution to the plasma energy measurement;

2. NTM temperature perturbation (δT/Te) measurement;

2. ELM temperature transient measurement;

3. Radiated power measurement in cyclotron frequency range;

4. Edge electron temperature profile and TAE temperature perturbation (δT/Te) measurements;

5. Contribution to the runaway electron parameters study (E_max, I_runaway).

As can be seen, the overall highest priority in a variety of ITER operating phases was identified as the **Core electron temperature profile measurement** and **NTM temperature perturbation (δT/Te) measurement.**

The design of the front end and the X-mode radiometer shall enable the measurements as they are described in this section. The measurement requirements (as stated in the PR/SRD) are given in the Table 15. In addition to the primary roles, the system is also required to provide “Back-up” measurement

capability (when possible) for the ***L-H transition indicator/ELM temperature transient***, and "Supplementary" capability for the following measurement parameters: ***plasma energy/poloidal beta***, ***main plasma Prad/Pece***, some ***runaway electron parameters*** such as ***runaway current after thermal quench*** and ***during failed breakdown***, ***edge electron temperature profile*** and some ***high-frequency instabilities such as turbulence***.

The proposed set of specifications for ECE 55F1 diagnostic is given in Table 16. The ECE diagnostic shall meet these requirements as indicated in Table 16. As the primary diagnostic for core electron temperature profile measurement and for NTM temperature perturbation measurement, the diagnostic must meet the measurement requirements with the specified time resolution and accuracy, as specified in the Table 16, in real-time.

Title	Parameter	Role	Highest Operation Role	Range Value Coverage	Condition	Required Time Resolution	Required Spatial Resolution	Accuracy
04. Plasma energy	*006: βp*	*Supplementary*	*1a.1 MP*	*.01 - 5*	*Ip > 3 MA*	*100 us*	*Integral*	*5% @ βp=1*
05. Radiated power	*008: Main plasma Prad*	*Supplementary*	*1a.2 BC*	*0.1 MW - 1 GW*	*Default*	*1 ms*	*Integral*	*10%*
14. H-mode, ELMs and L-H mode transition indicator	032: ELM temperature transient	Backup	2. PHY	0.05 - 10kev	r/a > 0.85	0.1 ms	5 mm	10%
15. Runaway electrons	*034: Emax*	*Supplementary*	*2. PHY*	*1 - 100 MeV*	*(blank)*	*10 ms*	-	*20%*
15. Runaway electrons	*035: I runaway*	*Supplementary*	*2. PHY*	*(0.05 - 0.7) x Ip*	*After thermal quench*	*10 ms*	-	*30 % rel.*
15. Runaway electrons	*035: I runaway*	*Supplementary*	*2. PHY*	*0 - 1 MA*	*Failed breakdown*	*10 ms*	-	*50 kA*
23. Electron temperature profile	**052: Core Te**	**Primary**	**1b. AC**	**0.5 - 40 keV**	**r/a < 0.85**	**10 ms**	**a/30**	**0.1**
23. Electron temperature profile	*053: Edge Te*	*Supplementary*	*2. PHY*	*0.05 - 10 keV*	*r/a > 0.85*	*10 ms*	*5 mm*	*0.1*
27. High frequency instabilities (MHD, NTMs, AEs, turbulence)	**061: NTM δT / Te. (complex; 100ms integration time)**	**Primary**	**1b. AC**	**(0.1 - 5) x 1E-2**	**Te > 1 keV,**	**100Hz - 10kHz**	**(m,n) < (2,1),(3,2). dr=50mm**	**1 x 10-3**
27. High frequency instabilities (MHD, NTMs, AEs, turbulence)	*063: TAE δN / n, δT/T*	*Supplementary*	*2. PHY*	*5E-6 - 5E-4*	*(blank)*	*30 kHz - 2 MHz*	*n = 10 - 50*	*0.3*

Table 15. Overview of the system requirements for 55F1 ECE Diagnostic from PR/SRD.

MEASUREM.	PARAMETER	CONDITION	RANGE or COVERAGE	Time or Freq. Res.	Spatial or Wave No. Res.	ABS. ACCURACY	STAB. Of MEAS. **
04. Plasma energy	Beta_p	Ip > 3 MA	0.01 - 5	0.1 ms	Integral	5% for beta_p =1	1%
23. Te profile	Core T_e	r/a < 0.9	0.5 – 15 keV	10 ms for profile/ target 1 μs for modes structure	2 – 5 cm increasing with T_e	5%	1%
			15 – 40 keV	10 ms for profile/ target 1 μs for modes structure	5 – 13 cm increasing with T_e	5%	1%
	Edge T_e	r/a > 0.9	0.05 – 8 keV	10 ms for profile/ target 1 μs for modes structure	1 – 5 cm increasing with T_e	5%	1%
			8 – 10 keV	10 ms for profile/ target 1 μs for modes structure	5 – 6 cm increasing with T_e	5%	1%
14. H-mode, ELMs and L-H mode transition indicator	ELM T_e transient & L-H pedestal formation	r/a > 0.9	0.03 – 10 keV	1 μs	1 – 6 cm; limited by physics	5%	1%
15. Runaway electron*	Maximum electron energy	-	up to 100 keV	10 ms	no spatial resolution	20%	20%
	Runaway current	Post thermal quench	(0.05-0.7) x I_p	10 ms	no spatial resolution	-	30% rel.
		Failed breakdown	0 – 1 MA	10 ms	no spatial resolution	50 kA	-
27. High frequency instabilities (MHD, NTMs, AEs, turbulence)	$\Delta T_e/T_e$	r/a < 0.9	$\Delta T/T \geq 1\%$ sensitivity decreasing with bandwidth	0.1 – 1000 kHz	Radial resolution 10 – 20 cm depending on temperature; (m,n) < (2,1),(3,2) for NTM	20%	1% (depends on thermal noise, thus on Bv and Bif)
		r/a > 0.9	$\Delta T/T > 1\%$ sensitivity decreasing with bandwidth	0.1 – 1000 kHz	Radial resolution 4 – 10 cm depending on temperature	20%	1% (depends on thermal noise, thus on Bv and Bif)
05. Radiated power*	Radiated power in ECE band	Default	Freq. range to cover: 70 – 1000 GHz	20 ms/ 5 ms depending on the FTS instrument assessment	Normal and oblique to outer flux surface	20%	10%
	Radiation temperature vs frequency	-	Freq. range to cover: 70 – 1000 GHz	20 ms/ 5 ms depending on the FTS instrument assessment	Normal and oblique to outer flux surface	5%	1%

*The front-end design shall enable the ability to measure these parameters, even though the instrumentation is not necessarily in the list of deliverables for this Annex B. Refer to Section 5.4.3.2 for the target attenuation of the transmission line.

** The stability of the measurement in this table is understood in terms of stability of a measurement over the time period of a discharge, high linearity of the instrument response, and low noise.

Table 16. The proposed set of specifications for ECE diagnostic (Front-End and Receiver).

The ECE is required to provide **Core electron temperature profile measurement** and **NTM temperature perturbation (δT/Te) measurement** for Advanced Control. The original measurement requirements reported in Table 15 specify only time resolution of 10 ms, but not the system latency with which data is delivered to the Plasma Control System (PCS) (see also ITER_D_ 7M2S7Q (folder) for a set of Memorandums on the Measurement Requirements applicable to ECE diagnostic). In order to effectively control the plasma, PCS requires data representing the core temperature profile to be delivered with latency (delay) no greater than 2.5 ms (this defines a latency cycle), from the detection of the signal and the delivery of the required auxiliary data from PCS, assuming that a control cycle time is about 10 ms. PCS will provide necessary auxiliary data arising from other diagnostics and or modelling, mapped to the diagnostic sightline as reported by the diagnostic in its self-description. At present auxiliary data include: electron density profile, magnetic field profile and their errors. Any additional details or requirements for this data exchange will be agreed between IO and DA during the detailed design phase and recorded in the interface sheets with PCS.

For core electron temperature profile measurement by ECE, the high temperatures foreseen in ITER (30 – 40 keV) will affect the spatial resolution, due to the large relativistic and Doppler broadening, which will lead to a widening of the radial extension from which a given frequency in the ECE spectrum is emitted. The target of a/30 would be possible only in regions with a low enough value of Te (typically r/a > 0.5 for Te(0) = 30 keV on ITER). The relativistic downshift at the high temperatures in ITER is substantial and will strongly limit the access to the plasma. It is important to remark that the high temperature scenarios considered for ITER (Te(0) up to 40 keV) would degrade the spatial resolution of Te due to a further widening of the emission layer.

Note that, for the measurement of the core and edge temperature profile, 10 ms temporal resolution as specified in the PR is adequate, whereas for the MHD/ TAE mode structure reconstruction, faster sampling is required. ECE radiometers can achieve much faster sampling than specified in the PR, so the target is set to 1 μs. For ELM evolution study, one has to sample at < 10 μs to follow up the crash and the recovery of the temperature after the event, so 1 μs sampling target is justified.

ECE will play a key role in the targeting of ECH heating to control neoclassical tearing modes (NTMs). The ECH deposition widths for the NTM stabilization are in the range of 30 – 70 mm. The island with the width of w > 20 mm is detectable by ITER ECE. Thus, assumption for ECE channel separation of 20 mm or smaller at NTM radii is adequate for the mode detection and localization. The response time of the feedback system once the mode is tracked is in the order of tens of ms. It is anticipated that it will take about 20 ms to begin moving the ECH steering mirror and then some time to lock onto the mode. The total response time might be 30 – 50 ms or even longer to lock onto the mode and begin suppressing it with ECCD, depending on how far the mode rational surface is away from where the mirror is pointing at the time. The growth time of the NTM is in order of 100 ms, and the target resolution of the diagnostic expressed in terms of sampling rate could be in the range of 0.1 – 1000 kHz. Response to the NTM in ECE measurements is limited by the intrinsic resolution of the instrument which includes the relativistic broadening and the antenna pattern. Also, the signal-to-noise ratio limits the minimum island size to about 2 cm for a dT_e/T_e ~1%. The latency needed for the NTM feedback is estimated to be 1 ms which is sufficient to match the response time of the feedback system. To improve the NTM detection and make the ECH feedback more effective, correlation with another ECE line-of-sight or with magnetic diagnostics will be used to increase the sensitivity of the measurements. For islands as small as 10 mm and located closer to the core, the measurement of ΔTe will be more challenging, but FFT techniques can most likely be employed to enhance signals relative to noise.

For TAE measurements, the measurements do not need to go up to 2 MHz, as stated in the PR. It is unlikely that there will be significant AE activity above 0.5 MHz.

For the maximum electron energy of non-thermal (runaway) electrons, it is obvious that the ECE system will never measure up to 100 MeV. The anticipated upper energy limit is up to a few hundreds of keV, probably less. The exact number will be evaluated for the PDR of the diagnostic, and the front-end design must enable the measurement up to the limits set up by physic constraints.

The DA shall provide the ECE Front End and Receivers with the measurement functions capability reported for two levels (Level A: general, Level B: detailed). They are summarized in Figure 3, which is the functional breakdown for 55F1 ECE Diagnostic. This RAMI Functional breakdown is given in Figure 4, and addresses the potential risks which may stop the ITER machine operation. The RAMI functional breakdown follows the RAMI analysis of the ECE system is reported in ECE RAMI Report (**ITER_D_ 4DASEP**).

Measurements of the **Core electron temperature profile measurement** and **NTM temperature perturbation (δT/Te) measurement** require an interaction with the Plasma Control System (PCS; PBS 47) for the real-time control. Section 8.1.5 of the DDD describes the CODAC and PCS requirements for the ECE diagnostic in order to demonstrate the data flow required to fulfil the specifications indicated in Table 16.

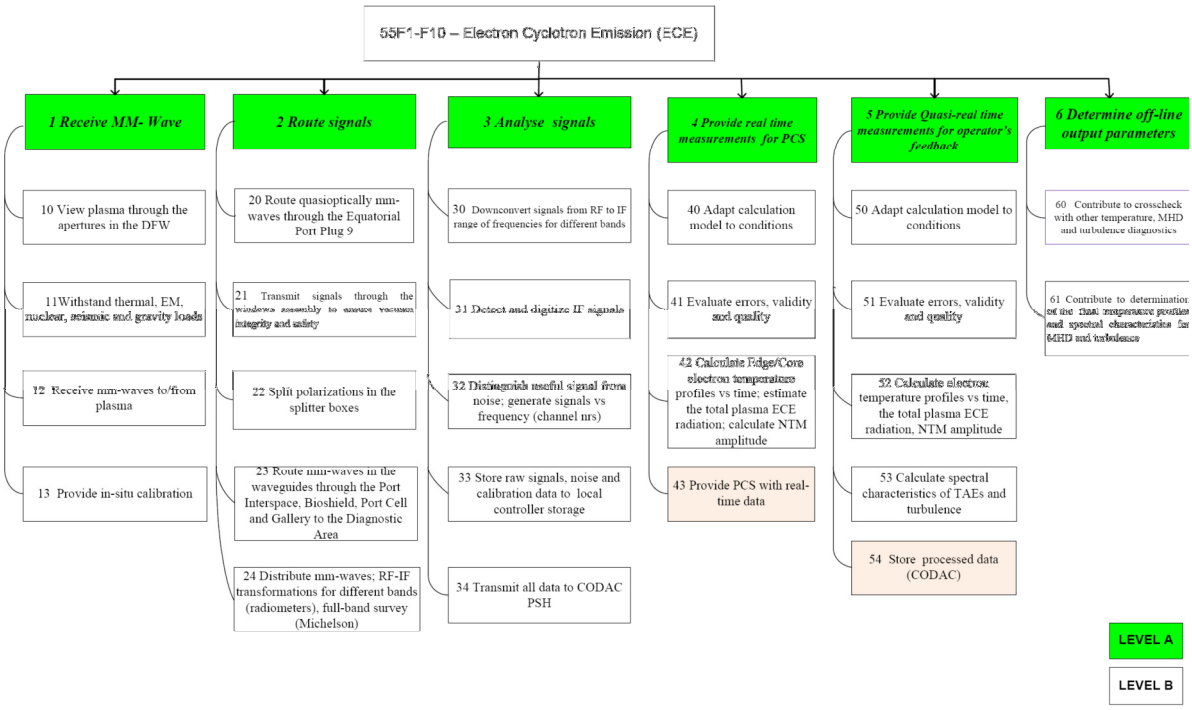

Figure 3. Functional breakdown of the ECE.

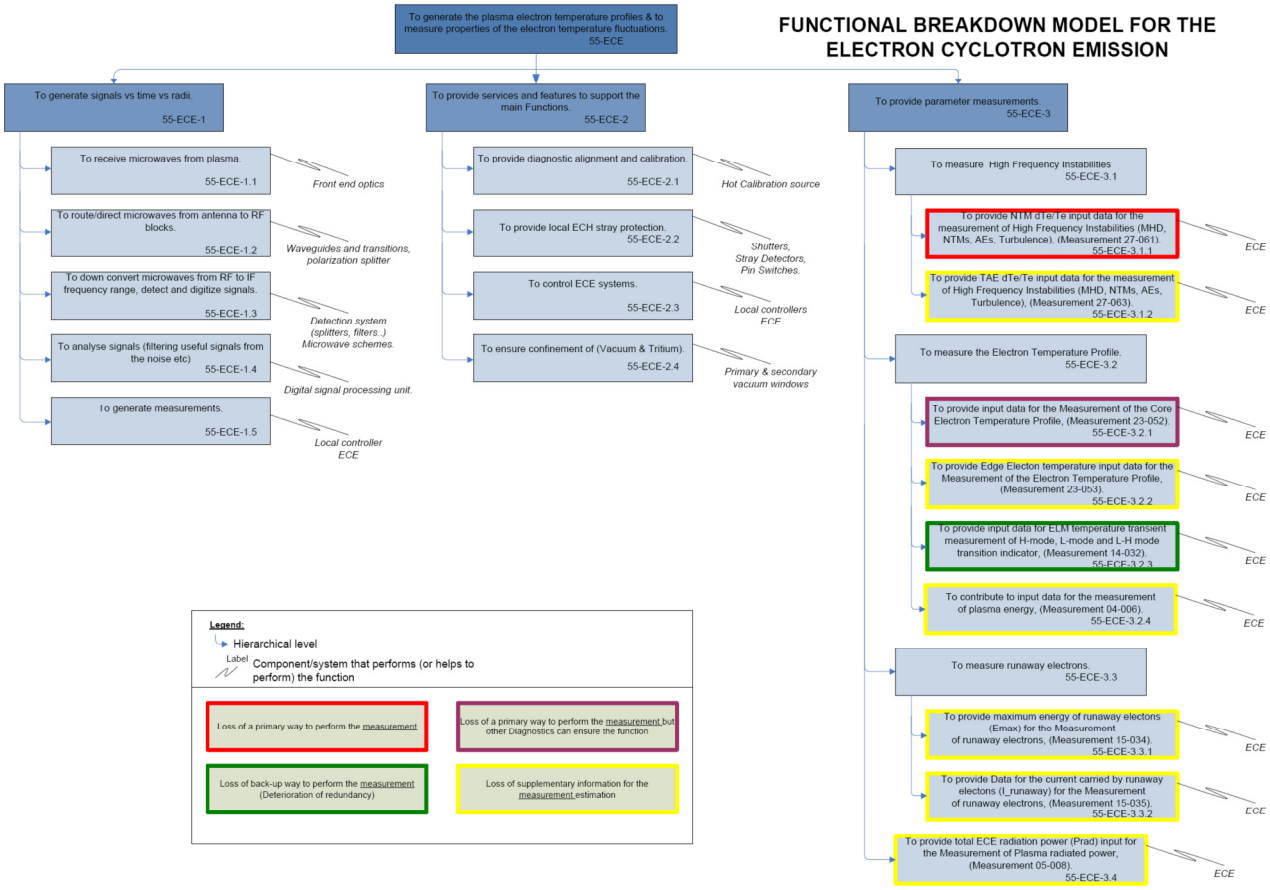

Figure 4. RAMI functional breakdown of the ECE.

5.4.2 Process flow diagram

The Process Flow Diagram is defined for the ECE diagnostic. The DA shall provide for the PDR a detailed design, shown at the conceptual level in Figure 5. The conceptual layout of ECE Engineering Plant breakdown is shown in Figure 6. Details can be found in ITER_D_6KV3XY - 55.F1.00- Process Flow Diagram for ECE v1.0.

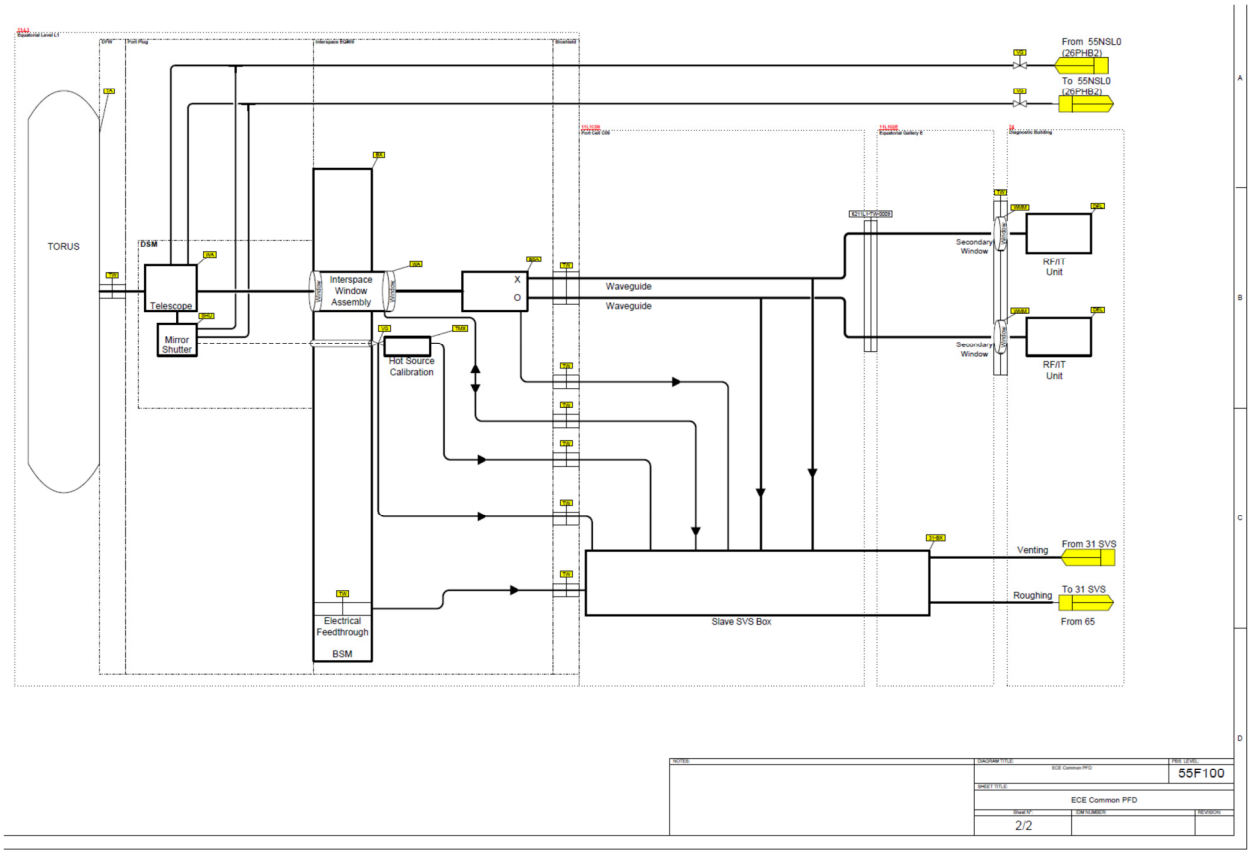

Figure 5. 55F1 ECE Conceptual process flow diagram.

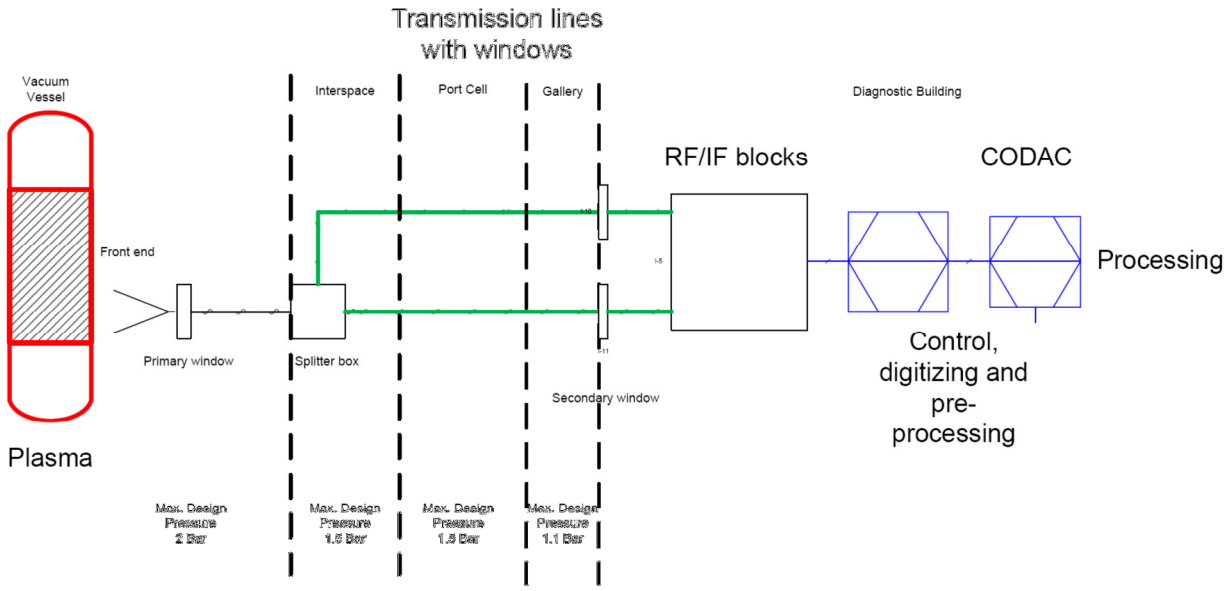

Figure 6. 55F1 ECE Engineering Plant breakdown.

5.4.3 Sub-system requirements

5.4.3.1 Overall Current Design

The baseline system design consists of two lines-of-sight, one looking perpendicular to the plasma and the second one oblique with the toroidal angle of 10 degrees. Each line-of-sight consists of: 1) front-end optics (focusing mirrors, hot source assembly with a shutter), 2) double-windows assembly, 3) quasioptical beam

splitter, 4) transmission lines (TLs), and 5) instrumentation in the diagnostic building. Each sub-system is designed to enable the system to meet or exceed the measurement requirements where possible. The system requirements can be summarized as requiring the following measurement capability in the plasma:

- O-mode core temperature profile measurement (O-mode radiometer, full Bt, provided by IN DA):
    - 122 – 230 GHz
- X-mode core temperature profile measurement (X-mode radiometer, full Bt, provided by US DA) :
    - 244 – 355 GHz
- One X- and one O-mode survey FTS/Michelson interferometer, total two (provided by IN DA):
    - 70 - 1000 GHz
- X-mode core temperature profile measurement in half-Bt operation (O-mode radiometer switched to the X-mode line)
    - 122 – 230 GHz.

5.4.3.2 Front End design

In the port plug there are two quasi-optical front end assemblies based on Gaussian beam optics. The primary reason for having two lines is redundancy, so that if something happens to one line, the second line can be used for the all-important ECE measurements. A secondary reason is so that one line can view the plasma at a slight oblique angle to give additional information about the electron distribution function. Both views will have a heated blackbody source to allow absolute calibration of the ECE instruments including the front end optics and transmission line. The front-end feature a single focussing ellipsoidal mirror as the first element, with a simple turning mirror as the second element to create the required labyrinthian design that prevents streaming of neutrons directly through the port plug. The ellipsoidal mirror focuses an aperture or beam waist at the back of the port plug to a beam waist near the low-field side edge of the plasma. Proper selection of the ellipsoidal mirror focal length yields an optimum spot size in the plasma for both O and X-mode measurements. A Gaussian telescope configuration was considered, but abandoned in favour of the simpler, single focussing mirror design. A Gaussian telescope has the desirable characteristic of beam waists that are independent of wavelength; however, properly executed, this would require a large distance between the mirrors which would have to be taken up by multiple 90-degree bends in the limited port plug space. The motivation in the design is for simplicity to minimize the risk of failure in operation. ECE radiation is collected by front-end optics arrangement in the port plug and a radiation beam is put out from the tokamak vessel through the vacuum double-window assembly. This beam contains both modes (i.e. O-mode and X-mode) of radiation.

The front-end design shall enable all the measurements as they are given in Table 16, without degrading the diagnostic performance, and to comply with the engineering design constraints given by the CMM (ITER_D_A6UBTX - The 3D and 2D CAD Model Approval Interfacing System Control Sheet (PC-CMAF ECE-CMM-L1-level) v1.0) for the integration in the Equatorial Port 9, DSM (drawer) 2. The updated CMM will be

delivered to the port integrator (US DA) after the Port Integration PA signature. The front-end is an integral part of the transmission line; the overall design desire for achieving the good calibration is to have the total TL losses < 15 dB for the Te-profile range of frequencies.

5.4.3.3 Hot Source assembly

The calibration source is needed for in-situ absolute intensity calibration of the front-end components of the diagnostic. The source is a blackbody emitter, and will be needed for a two-temperature calibration of the system sensitivity. It is placed so that emission can be diverted into the optics using a mirror/shutter arrangement. The in-situ calibration allows the diagnostic to provide a fully independent measure of electron temperature despite expected degradation of the front end components between rare opportunities for access. The hot calibration source must operates at ~ 700° - 800°C, must not interfere with nearby diagnostics (as given by the CMM at ITER_D_A6UBTX - The 3D and 2D CAD Model Approval Interfacing System Control Sheet (PC-CMAF ECE-CMM-L1-level) v1.0), and must meet the requirements for the highest quality ITER vacuum albeit during periods when plasma is not being produced.

The Hot Source shall meet the following requirements:

- To be suitable for high vacuum and high radiation environment,
- Allow for high emissivity, *>.95* for *100-500 GHz*, *>.75 500-1000 GHz*, useable up to *1500 GHz*
- To operate at *~700° - 800°C* (*>400°-500°C* above ambient temperature),
- To have uniformity *±10°C,*
- To reach equilibrium temperature in less than 1 hour,
- To have short term stability (*24Hrs*) *~±2°C* and long term stability (*>3yrs*) *±10°C* in the ITER environment.

5.4.3.4 Back-end instrumentation

ITER ECE system has two radiometers (O-mode and X-mode) and two FTS/ Michelson interferometers for O-mode and for X-mode. Thus, there are four measuring instruments that can operate simultaneously.

There are two types of measurement operations:

(1) Full magnetic field (B_{t0} = 5.3 T), and

(2) Half magnetic field (B_{t0} = 2.65 T).

The ITER Research Plan **ITER Research Plan (IRP) (2FB8AC v2.2)** specifies that the half-current/ half-field scenario is a necessary element of the development plan.

There are two front-ends radiation collectors proposed for ECE measurements. One is for perpendicular (radial) measurement and other is for oblique (10^o angle to perpendicular) measurement. By using two polarizer splitter units, the X and O-modes are selected from both the frontend radiation lines. Therefore, there are four transmission lines set up from the port interspace to the ECE room in the diagnostic hall. These four waveguide transmission lines (TL) are laid out at a ceiling of the ECE room. Among these, two TL are for oblique O-mode and X-mode measurement sightline (i.e. OO and OX). Other two TLs are for radial X-mode and O-mode measurement sightline (i.e. RX and RO).

For this Annex B, the back-end delivery contains only X-mode radiometer. The frequency range to be covered is in-between 244 – 355 GHz, as stated in section 5.4.3.1. The anticipated channel coverage set for core and edge measurements at 5.0 T for 2X-harmonic for the X-mode radiometer is given as follows:

- 32 channel core set:

– Frequency range: 234-306 GHz,

– Channel spacing: 2.25 GHz,

– B_{IF} = 2 GHz,

- 16 channel high resolution set:

– Channel spacing: 375 MHz,

– B_{IF} = 250 MHz,

– Switchable to other mixers.

The final channel separations and the final frequency range coverage will be agreed between DA and IO by the PDR.

The ECE is meant to operate as a single diagnostic. To this end the software to run the Hot Sources (US DA) and to run the X-mode radiometer (US DA) must be interoperable with the (IN DA) contribution.

5.4.3.5 Data Delivery Requirements

The ECE is required to provide **Core electron temperature profile measurement** and **NTM temperature perturbation (δT/Te) measurement** for Advanced Control. The original measurement requirements reported in Table 16 specify only time resolution of 10 ms, but not the system latency with which data is delivered to the Plasma Control System (PCS). In order to effectively control the plasma, PCS requires data representing the core temperature profile to be delivered with latency (delay) no greater than 2.5 ms (this defines a latency cycle), from the detection of the signal and the delivery of the required auxiliary data from PCS, assuming that a control cycle time is about 10 ms. PCS will provide necessary auxiliary data arising from other diagnostics and or modelling, mapped to the diagnostic sightline as reported by the diagnostic in its self-description. At present auxiliary data include: electron density profile, magnetic field profile and their errors. Any additional details or requirements for this data exchange will be agreed between IO and DA during the detailed design phase and recorded in the interface sheets with PCS.

For the NTM feedback, the estimated latency is 1 ms.

Any data, which is required by ECE to perform its function and is agreed to be delivered by PCS via CODAC networks shall be assumed as being available when needed, e.g. shall not influence the latency budget.

5.4.4 Specific requirements

All sub-systems of the Diagnostic included in this Annex B shall be provided with fiducial and alignment features. These sub-systems shall avoid adjustment operations after repositioning. This means when these components are removed the alignment shall be recovered after moving and repositioning the sub-system.

Following ALARA principle, the activation dose rate produced by neutron and gamma radiation streaming through the apertures in the ECE system shall target 15 microSv/hr in the Port Interspace and 1.6 microSv/hr in the Port Cell.

The geometrical shape and tolerances shall be measured according to a testing protocol agreed with IO, who may also witness the geometrical measurements. IO shall have access to the measurement data (including raw data if there has been some post-processing) as part of the QA file for the component. This information shall be sent upon each measure.

The DA shall design the integration of the window according to the ITER_D_76ZBR5 - Technical Specifications for Window Assembly Integration v1.0. This document defines physical interfaces for the integration of the window assemblies on the PP closure plates, and also defines the responsibility sharing between IO, the diagnostic owner and the port integrator for the window assemblies, during all the life cycle (design, validation, manufacture, installation) whatever the location of the window assemblies.
This document covers the non-metallic windows and the beryllium windows as well.

5.4.5 Remote handling requirement

The part of the ECE diagnostic reported in this Annex B (ECE front end and receiver) requires RH maintenance for the components located in the Port Plug #9. Hence, there is a need to define the RH compatibility features before further design development or manufacture. The initial (CDR) RH assessment is given in the folder: https://user.iter.org/?uid=4E8SWC. The DA shall, with assistance from IO, update the RH assessment documents throughout the design evolution.

5.4.6 Environmental conditions

The load specifications *(Load Specification for Electron Cyclotron Emission (ECE) Diagnostic, PBS 55F1 (ITER_D_6XRG6J) v3.0* gives the environmental conditions (pressure, temperature and radiation) to be taken into account for the design of the components of the diagnostic that are installed in the vacuum vessel, the port , the port plug, the port inter-space and the port cell.

The environmental conditions for equipment of this diagnostic which are located in the diagnostic building shall be extracted from the ITER_D_2UUZ23-Rooms_Hazards_and_Environmental_Conditions v2.1. Table 17 gives the value of some parameters.

Parameter	Value
Pressure (*)	~ 0,1 MPa
Temperature	16 °C to 32 °C
Max Relative Humidity	≤ 85%
Radiation zone	“white”
Magnetic field	5 to 10 mT

Table 17. Environmental conditions for the equipment in the diagnostic building.

The pressure differential which form parts of the secondary confinement boundary between the Tokamak Building and the Diagnostic Building shall be taken into account for the design.

5.4.7 Geometrical interfaces

The geometrical interfaces and related tolerances will be defined during PDR preparation and approved by IO.

For the ECE front end and receiver there is 1 critical geometrical interface:

1) Interface of the ECE with other diagnostics collocated in EP#9 port plug and interspace.

There is also a geometrical interface with the diagnostic building, in that the ECE equipment described in this Annex B must fit in the available space in the room with other ECE equipment.

ECE front end integration design shall be performed by the US DA taking into account the VV displacement during ITER life cycle. An assessment of the relative displacement of the VV with regard to the buildings is given in Movement of VV Ports Relative to Buildings (22FEB4) v3.1 as a reference document.

5.4.8 Material requirements

5.4.8.1 General requirements for mechanical components

Suitable procedures must be established and maintained for identifying the material making up the components of the equipment which contribute to pressure resistance by suitable means from receipt, through production, up to the final test of the manufactured pressure equipment.

The source of material property information for design analysis shall be either the applicable structural code (see Table 14) or the ITER Material Properties Handbook (folder) (MPH Material Properties), which shall take precedence in case of conflict.

Commercial material shall conform to the applicable standard (ISO, EN, ASTM, JIS, or 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.

A preliminary materials list shall be provided prior to the FDR and a final list by the Readiness Review preceding manufacturing.

5.4.8.2 General requirements regarding material specifications

A material specification shall be prepared by the DA or its suppliers in the following cases:
- The component is located inside the Tokamak,
- The component forms part of the VV and cryostat Vacuum Boundary,
- The component is SIC,
- The component is Quality Class 1 classified,
- Some properties of the material foreseen for a part are critical for any other reasons,
- The component is foreseen to be welded during integration or on-site assembly.

The specification shall include the following issues:
1. Brief description of the material and of its manufacturing process
2. Applicable standards
3. Delivery conditions (e.g. required heat treatments, cold work, …)
4. Chemical composition
5. Specific requirements on the grain orientation and size

6. Required minimum, average thermal and mechanical properties, maximum or minimum physical 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.
7. Specific requirement on the maximum scatter band of the material properties
8. Required certificates and characterisation reports
9. Other requirements depending on the selected codes appropriate to the component classifications.

The materials procured according to these specifications shall be delivered with a material inspection 3.1 or 3.2 according to EN 10204, providing the proof that the material meets the requirements of the material specification.

Material specifications shall be prepared for the Manufacture Readiness Review, and approved by IO before launching the material procurement.

5.4.8.3 Specific requirement for material

Not applicable unless specific requirements for material are known before the Annex B signature. Material for the secondary windows shall be selected in accordance to the Vacuum Handbook.

5.4.9 Safety requirements

Safety Activities concerned by Quality shall respect Safety rules, in particular for the Safety Important Components (SIC). Where there is a conflict between the safety rules and the quality program, the safety rules shall govern and in particular where safety important components are involved.

The safety requirements for this Diagnostic are derived from the Project Requirements Document ITER_D_27ZRW8 - Project Requirements (PR) v4.6, the Project Specification document ITER_D_2DY7NG - IC-2/ 7.1 Project Specification v2.0, the System Requirement Document ITER_D_28B39L - SRD-55 (Diagnostics) from DOORS v3.1.

The method for classifying the component of the present Annex B regarding safety requirements is given in ITER_D_347SF3 - Safety Important Functions and Components Classification Criteria and Methodology v1.8.

Safety important components (SIC-1, SIC-2) and safety related components are defined in section 5.1 and summarized in Table 13.

5.4.10 Design Criteria

The design basis will be based on the role of the component in the ITER Project, the application of the defined Code and Standard and its safety/quality classifications.

5.4.10.1 Load cases

Load Specification for Electron Cyclotron Emission (ECE) Diagnostic, PBS 55F1 (ITER_D_6XRG6J) v3.0 gives a preliminary assessment of the individual loads and combinations to be applied in the structural analysis of the ECE.

This specification shall be updated by the DA following ITER_D_222QGL - Load Specifications (LS) v6.0 throughout the design phase, and apply accordingly.

5.4.10.2 Structural criteria

For mechanical components refer to ITER_D_27ZRY9 - Codes and Standards for ITER Components (STAC 2007) v1.0.

All components of each subsystem included in this Annex B shall be designed to withstand and operate in and under loads as specified in ITER_D_222QGL - Load Specifications (LS) v6.0.

For off-the-shelf components design limits shall be set according to manufacturer's recommendations.

5.4.11 Design Deliverables

The design documents to be delivered by DA for PDR are defined in the Deliverable document list in Annex B1 – List of Appendices. In accordance with the Procedure on procurement documentation exchange ITER_D_35BVQR v2.1, it shall be updated by the DA TRO for the next phases prior to PDR and approved by IO TRO.

Standard Requirements:
For Functional Spec Annex Bs and Detailed Design Annex Bs, the responsibility for completing and finalizing the design lies with the DA. In developing the Preliminary Design and Final Design, the DA is in charge for updating the Design Baseline Documents, such as DDD, ICDs, ISs, Detailed Models and Schematics for DA package part. The IO shall help to generate all these documents. The IO has approval authority on the ICDs, ISs and CMMs, the IO being responsible for interfaces and integration, but not for the detailed design itself. On the other hand the DA is responsible for the detailed design and performance of the system; hence the DA has approval authority on the DDD, except the subject impact to safety and ITER performance, detailed Models and Schematics, while the IO only accepts them. Any changes of the safety content must be approved by the IO. The DA shall submit a Deviation Request or a Non-Conformity Request for any change to the Preliminary Safety Report Preliminary Safety Report (RPrS) (3ZR2NC) v3.0 or to other Regulatory Files.

5.5 Pre-Manufacturing and/or Qualification requirements

This section is defining the R&D and the prototyping needed for the Diagnostic prior to PDR (or FDR) while the general progress logic has been defined in 3.2.1 Phasing of the project.
This section aims at describing the work plan for the next design phases. Several tasks have to be performed for the preliminary design (PDR) and its related load and performance analyses. These tasks will aim at mitigating the risks, optimization of the name of diagnostic system and its implementation in ITER.

5.5.1 R&D

The following activities (steps indicated) until the PDR (which is foreseen to be executed together with the ECE transmission lines) are given below:

A. Development of the shutter concept to protect the front-end optics and the hot source,
B. Calibration source qualification and development,

C. ECH protection development.

5.5.2 Prototype test program

A component prototype test plan including the acceptance criteria will be developed by the DA and delivered to the IO for the Preliminary Design Review. The IO will have one month to review the test plan and send comments back to DA. The review process may include a panel of IO, DA and external experts that will review and comment on the test plan. The panel will provide recommendations to the test plan that shall be incorporated into the test plan by the DA. A final prototype test plan shall be produced by the DA within one month subject to IO approval.

For this step, the following tests shall be performed as a minimum:

- Prototyping of the Hot Source,
- Prototyping of the Shutter concept.

For prototype testing and factory testing, the DA shall prepare a testing plan in collaboration with IO including acceptance criteria. These plans shall be approved by IO before execution. IO reserves the right to witness all or a portion of these tests.

5.6 Manufacturing requirements

This Annex B is defined under functional specification. Therefore detailed manufacturing requirements shall be prepared by the DA during the design phase to comply with the Technical Requirements of the present Annex B.

The general quality requirements are specified in Annex A section 5.

Both manufacturing requirements and Quality Assurance Program implemented during the manufacture shall fit to the various classifications of each component, with respect to Quality, Seismic Class, Tritium Class, ESP Category, ESPN Category and Level, and Vacuum Class, by relying on the ITER Applicable Documents and Applicable Codes and Standards.

Manufacture procedures and specifications shall be prepared by the manufacturer for approval by DA before their implementation. Procedures and specifications will be required for the following operations: material procurement, welding, folding, marking, picking, cleaning, non-destructive inspections, storage and shipping, depending on the Quality Assurance Program.

Throughout the manufacturing process, documentary records will ensure the traceability of all operations.

The manufacturers must ensure the competent execution of the provisions set out at the design stage by applying the appropriate techniques and relevant procedures.

Manufacturing tolerances shall be consistent with achieving the overall installation, taking into account inaccuracies resulting from installation and tolerances of mating components and co-located systems.

For successful integration and installation of all systems, extensive metrology of components is critical. The DA shall supply their metrology data (measured to an appropriate standard), as well as permitting access by IO or other DAs to survey components in production where necessary.

Specific requirements:

Design, manufacturing, testing, assembly, handling and operation shall follow the vacuum handbook ITER_D_2EZ9UM v2.3. This includes: a) selection of materials, b) development of test criteria and acceptance test procedures, c) vacuum acceptance tests witnessed by IO Vacuum Group, d) welding or material non-conformity and e) cleaning and packing. All vacuum welds, inspection and testing shall be carried out by experienced qualified personnel using approved techniques.

5.6.1 Fabricability and Standardization requirements

Standard Requirements:

In order to simplify and reduce the cost of designing, integrating, operating and maintaining the plant systems, the DA shall ensure that the Suppliers use as much components defined as project standards as possible.

Those project standard components and the studies that defined them shall be listed in the ITER Baseline document ITER_D_35UVAQ - ITER Standard Component Register v4.0.

Standard components are described in specific baseline documents as detailed technical specifications aiming at ensuring interchangeability of spares amongst components procured by different Suppliers. In those documents, specific components from specific Suppliers are recommended as examples of components readily available on the market that fulfill the technical specifications. The DA has the choice of either selecting those recommended components or proposing other components under the condition that Suppliers demonstrate that they fulfill the technical specifications and interchangeability requirement.

The components of the sub-systems under this annex B shall be preferably chosen in accordance with the standard solutions given by **Standardized interfaces for all ITER plant system instrumentation and control (I&C): ITER_D_27LH2V - Plant Control Design Handbook v6.1.** The solutions for components for which Remote Handling is envisaged, is given in ITER_D_2E7BC5 - ITER Remote Handling Code of Practice v1.2.

5.6.2 Special Processes

At present, there is no special process required for manufacturing foreseen for the ECE.

Processes that affect the quality of items or services will be controlled by the development and use of specific procedures and by trained personnel in these procedures. Procedures for performing processes must be followed to ensure the consistency of the process. Processes such as those used in welding, heat treating and non-destructive examination shall be performed by qualified personnel using qualified procedures in accordance with specified requirements.

5.6.2.1 Welding Procedure requirements

The welding procedure requirements to be described in this sub-section include the following:

- Outline of the procedures to be adopted and documents to be submitted to, and accepted by the IO
- Definition of the requirements of applicable codes and standards

The Supplier shall prepare welding plan, welding design, Welding Procedure Specification, Welding Procedure Qualification, Welder Certificate, etc.

- Welding Procedure Specification (WPS): defines the requirements of a WPS, a document providing the welder or operator specific instructions on how to complete a welded joint
- Welding Procedure Qualification and Procedure Qualification Record:
  - Welding Procedure Qualification (WPQ): intended to provide proof of weldability of a metal with a particular process, using the parameters stated in the WPS
  - Procedure Qualification Report (PQR): a record of the parameters used during the WPQ defining the requirements of applicable codes and standards
- Welder Qualification: defines requirements relating to the Welder Qualification (WQ) which is intended to prove welder/welding operator's ability to deposit sound welded metal when using a qualified WPS.

As a general rule all the welding activities carried out by the manufacturer shall be supported by:

- A weld plan that specifies the location of each welds that identifies each type of welds, and cross-references the supported Welding Procedure Specification (WPS).

- The Welding Procedure Specifications that provide the welder or operator specific instructions and conditions for achieving the welding operation.

- The Welding Procedure Qualifications (WPQ) providing the proof of the assembly quality.

- The Procedure Qualification Records (PQR) which record the results of the test and the parameters used during the Welding Procedure Qualification.

- The Welder or Operator Qualification (WQ), which provides the proof of the welder or operator’s ability to execute a particular Welding Procedure Specification.

The requirements regarding the weld plan, the WPS, the WPQ, the PQR and the WQ depend on the codes and standards appropriate to the classification classes of the components. These documents will require IO/DA approval prior to the start of any welding activity. Subsequent to the submission and approval by IO/DA of these documents, the supplier shall establish and maintain a list of qualified welders and procedures.

5.6.2.2 Coating requirements

N/A

5.6.2.3 Others

For vacuum items the acceptance tests and procedures shall meet the requirements of ITER_D_2EZ9UM - ITER Vacuum Handbook v2.3.

5.7 Installation and Integration requirements

Attention should be drawn to the fact that ITER has specific rules concerning e.g. safety regulations applicable to works of third parties at ITER, access to and activities on the site, occupational health and safety on the site and special health and safety matters to be taken into account.

5.7.1 Description of the Installation Work at ITER Site

The On-site services responsibilities are defined in the Main Part of the present Procurement Arrangement. On-site services technical scope is:

- Appropriate technical assistance for the installation at ITER site of each component and tool included in the scope of this Annex B. For this purpose, an appropriate team shall be made available and be managed throughout the integration at ITER site.
- Initial training for operating, installing and maintaining the Diagnostic and its related tools and ancillaries. A session of training shall be held at ITER Site, regarding the operating, the calibration and maintenance of the diagnostic.

The technical assistance for the installation of the procured system at ITER site shall consist of the following work:

- Visit of a ECE technical expert to ITER Site for installation oversight during the installation period;
- Consulting on the technical aspects of installation;
- Operation support of the Plant I&C and CODAC.

The detailed workscope for technical assistance will be mutually agreed by the IO and DA during final design before FDR approval.

5.7.2 Boundary Conditions and general requirements

The ECE system will require persons in the port interspace/cell during the initial system alignment. IO will make such accommodations as required.

5.7.3 Integration

The ECE front end will share the space with other systems in EP#9. It shall be integrated with other diagnostics collocated in these areas. In the diagnostic area, the X-mode radiometer is placed in the same room as the O-mode radiometer and FTS (Michelson) instruments supplied by IN DA.

5.7.4 Environment, Safety and Health additional requirements

No additional requirement to those in section Environment, Safety and Health of Annex A.

5.8 Instrumentation and Control requirements

Plant System Instrumentation & Control (I&C) shall conform to standards, specifications and interfaces as specified in the document ”CODAC Plant Control Design Handbook”.

I&C software design, development, delivery and maintenance shall follow the requirements and guidelines described in the Plant Control Design Handbook and its satellite documents (ITER_D_27LH2V - Plant Control Design Handbook v6.1).

The I&C software for a plant system shall be based on a software framework provided by ITER CODAC (“CODAC Core System”) and developed using its prescribed development patterns.

For all I&C software the following actors shall be defined and known at any given moment:

- Author of the software;
- Owner of the software;
- Integrator of the software;
- Maintainer of the software.

All I&C software shall be subject of configuration control. A central ITER CODAC software repository shall be used to keep versions of the software developed and delivered to IO.

All I&C software shall satisfy prescribed QA requirements. Additional requirements may be imposed on the software which is part of the ITER safety system.

All I&C software created specifically for a given plant system shall become a property of IO. IO shall have full access to the software source codes. In the case these two requirements cannot be fulfilled, a long-term strategy of I&C software maintenance and support shall be defined by the supplier and agreed by IO.

I&C deliverables for all life-cycle phases are defined in the following document: ITER_D_3MQKJS - I&C deliverables for Diagnostics Annex B v2.0.

On general demand and in collaboration with Domestic Agencies the IO has developed templates and examples for the Diagnostics I&C documentation, covering the relevant deliverables:
(Link to all of the following documents : https://user.iter.org/?uid=BFQGX6)

- System Requirement Specification Template (SRS)
- System Design Specification Template (SDS)
- System Manufacturing Specification Template (SMS)
- System Test Plan/Reports Template (STP)

Furthermore, the IO has developed a template and an example for the required I&C diagrams using the System Engineering Tool “Enterprise Architect”

- System Diagrams Template and Examples (Enterprise Architect required)

The IO encourages Domestic Agencies to take the best use of these provided templates in order to streamline the I&C Development, Review and Acceptance efforts.

ECE diagnostic functional breakdown and allocation to controllers is given in Figure 7.

5.8.1 Plant I&C system integration with CODAC

During the various phases of plant I&C design (CDR, PDR, FDR) up to the final design review all of the following design specifications and technical specifications for manufacture shall be completed and documented by the DA as described in the PCDH.
(See ITER_D_27LH2V - Plant Control Design Handbook v6.1)

Design Specifications:

- Plant system I&C operation and control philosophy.
- Plant system functional analysis.
- Plant system PFDs, mechanical and electrical drawings needed at conceptual design phase.
- A list and short description of main plant system operating states for plant system operation.
- Plant system risk analysis and I&C RAMI requirements.
- System Interface Control Documents (S-ICDs) relevant for the plant system I&C.
- List and specifications of the main protection functions to implement within the plant system or with respect to other plant systems. The specifications include a risk analysis to identify the interlock functions from amongst all of the protection functions.
- List and specifications of the main safety functions to implement within the plant system or with respect to other plant systems.

Technical Specifications for manufacture:

- Plant system I&C architecture.
- Plant system I&C boundary definition.
- Plant systems I&C integration plan.
- Plant system P&IDs, mechanical and electrical drawings needed for I&C specifications.
- Plant system controller(s) performance and configuration requirements.
- List of inputs and outputs (I/O) of the I&C controllers.
- List of the process variables handled by the plant system I&C controllers.
- Configuration of I&C cubicles.
- Description of plant system state machines.

(I1) Plant System I&C Operation and Control Philosophy

The ECE diagnostic includes instrumentation and control for various monitoring, control, interlock and safety functions. The supported main functionalities for the ITER machine are in the areas:

- Plasma control
- Physics exploitation

Since the diagnostic systems provide measurements which are the essential input for the above described functions the diagnostics system must be operated in a way which guarantees the required measurement accuracy while ensuring high availability. The operation procedure of diagnostics plants usually includes the following steps:

- Health (check)
- Vacuum monitoring and control
- Configuration (perform or verify)
- Calibration (perform or verify)

- Measurement integrity verification (consistency check with other diagnostic measurement and comparison with previous pulses)
- Troubleshoot (in case of problem)
- Start and stop measurements (including scheduler)

The operating procedures will be automated as far as possible. Functions that cannot be automated will be executed manually by trained operators or plant system experts.

(I2) ECE functional analysis

The main I&C functions implemented in the ECE diagnostic are:

- Real time measurement – electron temperature and NTM amplitude
- Calibration
- Signal conditioning
- Data acquisition
- Signal processing and diagnostic self-protection
- Interface with CODAC.

Schematic of I&C breakdown for plasma control is given for information in Figure 8. I&C Functional breakdown and allocation to the controllers for 55F1 ECE system are given in Figure 9.

(I4) Plant System Operating States

ITER Plant operation is managed by system operating states, which are composed of three levels of hierarchy.

Global Operating States (GOS)

The GOS represent overall ITER plant system operating states defined by plant-wide operational activities associated with permission or prohibition of the plant operational activities. ITER GOS are defined in Operations Handbook - 2 Operational States (2LGF8N) and given in Table 18.

LTM	Long Term Maintenance
STM	Short Term Maintenance
TCS	Test and Conditioning State
POS	Plasma Operation State

Table 18. Definition of Global Operating States.

Plant System Operating States (PSOS)

The plant system operating states are specific to individual plant system I&C. The plant system operating state is a mandatory state property that implements detailed and plant specific state information. Each value of the plant system operating state shall map to one and only one value of the COS.

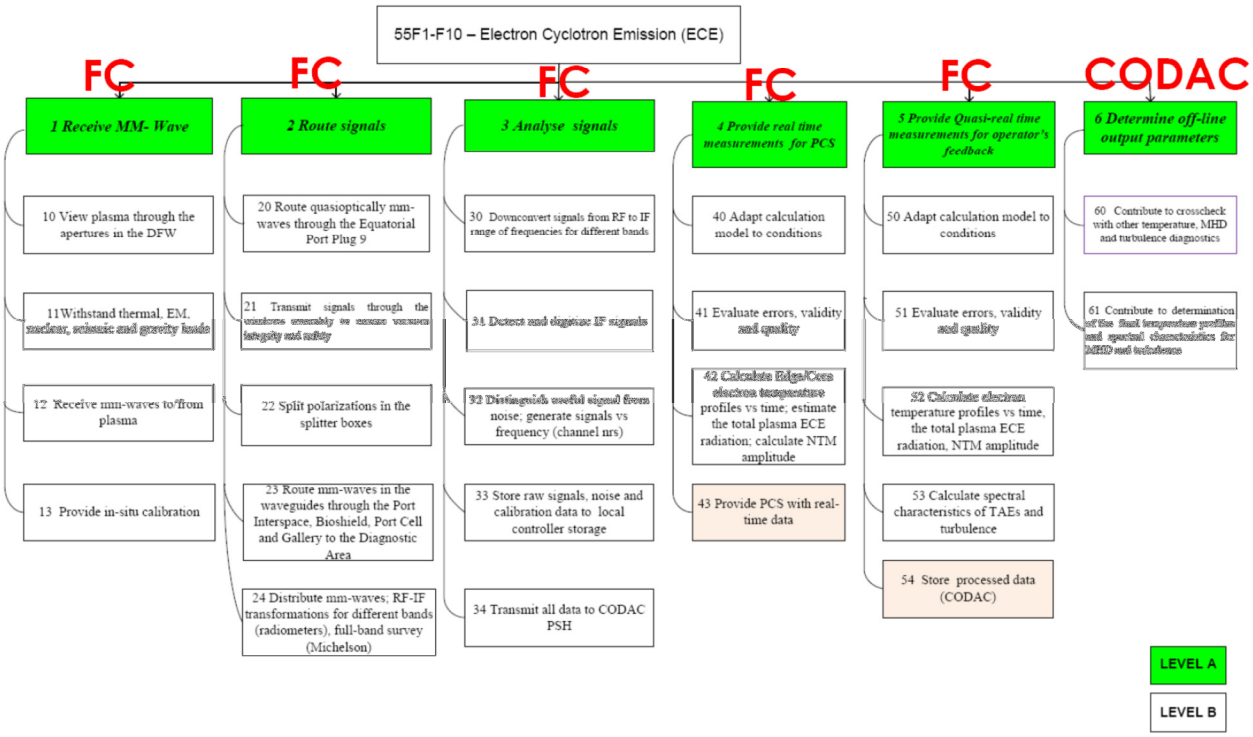

Figure 7. ECE diagnostic functional breakdown and allocation to controllers.

The plant operating states are given in Table 19. The mapping of the common operating states (PSOS) to the global operating states (GOS) are shown in Table 20.

Off	None of the measurements and controls is active
Stand-by	I&C operational
TCS	Test and conditioning (used also for commissioning)
Calibration	Calibration of detectors
Ready	Ready for plasma pulse
Pulse	Operational with continuous data acquisition

Table 19. Plant Operating States (PSOS).

GOS / PSOS	LTM	STM	TCS	POS
Off	**X**	**X**		
Stand-by	**X**	**X**		
TCS	**X**	**X**	**X**	
Calibration	**X**	**X**	**X**	
Ready	**X**	**X**	**X**	
Pulse	**X**	**X**	**X**	**X**

Table 20. Mapping of common operating states (PSOS) to global operating states (GOS).

(I6) System Interface Control Documents

The system interface between diagnostics (PBS 55), CODAC (PBS 45) and PCS (PBS 47) are described in corresponding ICDs. The detailed information will be described in the Interface Sheets (ISs). The content of the IS's must be agreed upon between the RO's for PBS-55 and PBS-47.

(I7) Main I&C Protection Functions

The vacuum machine protection function (monitoring vacuum) is implemented in the vacuum system (PBS 31).

(I8) Main I&C Safety Functions

There will be no safety functions (nuclear, access and occupational) implemented in the instrumentation and controls section of the 55F1 ECE system.

(D1) Plant I&C Architecture

The plant I&C architecture, as it is applicable to the ECE diagnostic, is shown in Figure 9. A plant system I&C consists of one and only one plant system host, one or many OSI (Open System Interconnection) layer 2 switches and one or more plant system controller(s) interfacing to actuators and sensors via signal interface(s). Plant system I&C components communicate with the CODAC System / Mini- CODAC over the Plant Operation Network (PON). CODAC System / Mini-CODAC implement the human-machine interface. Plant system controllers may be organized in a functional hierarchical manner using one plant system controller supervising the others. A possible use of any ECE signals by CIS or any other users shall not put any additional requirements to the 55F1 ECE (Front End and Receiver) design.

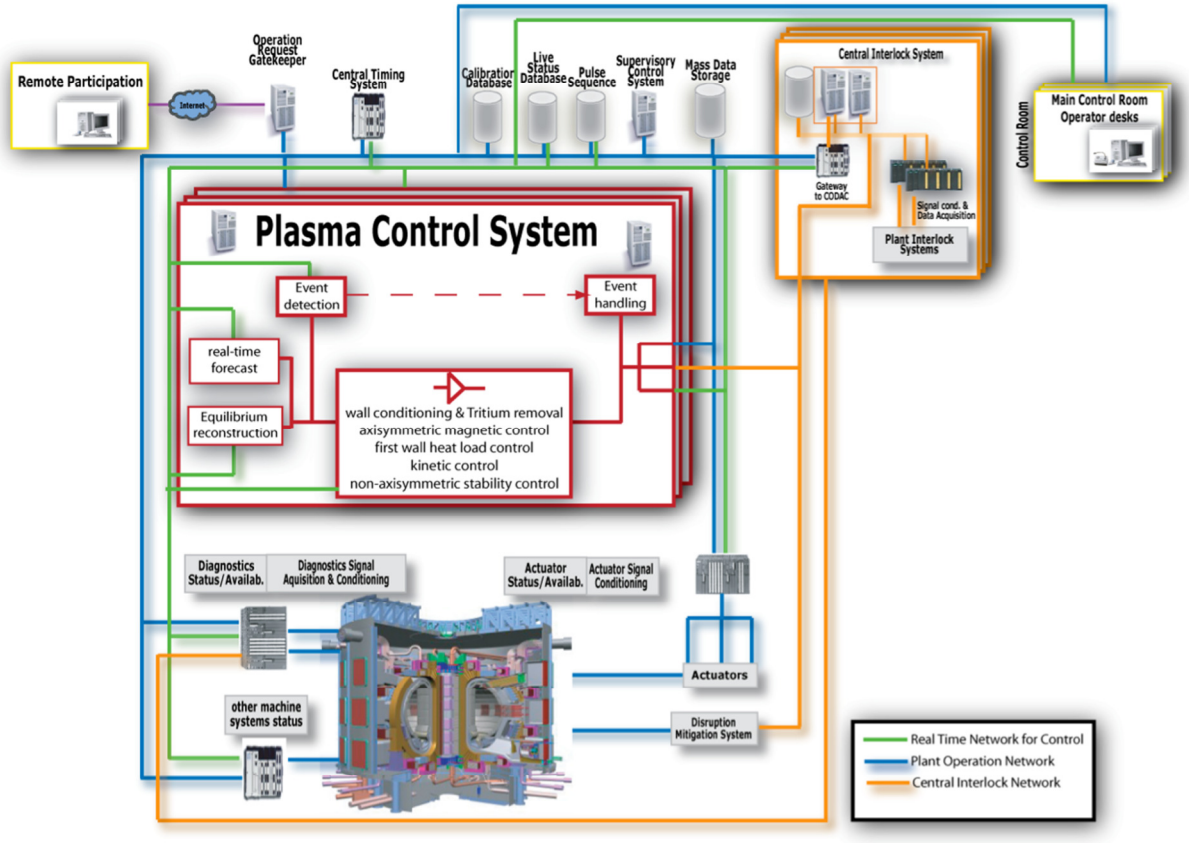

Figure 8. Schematic of I&C breakdown for plasma control.

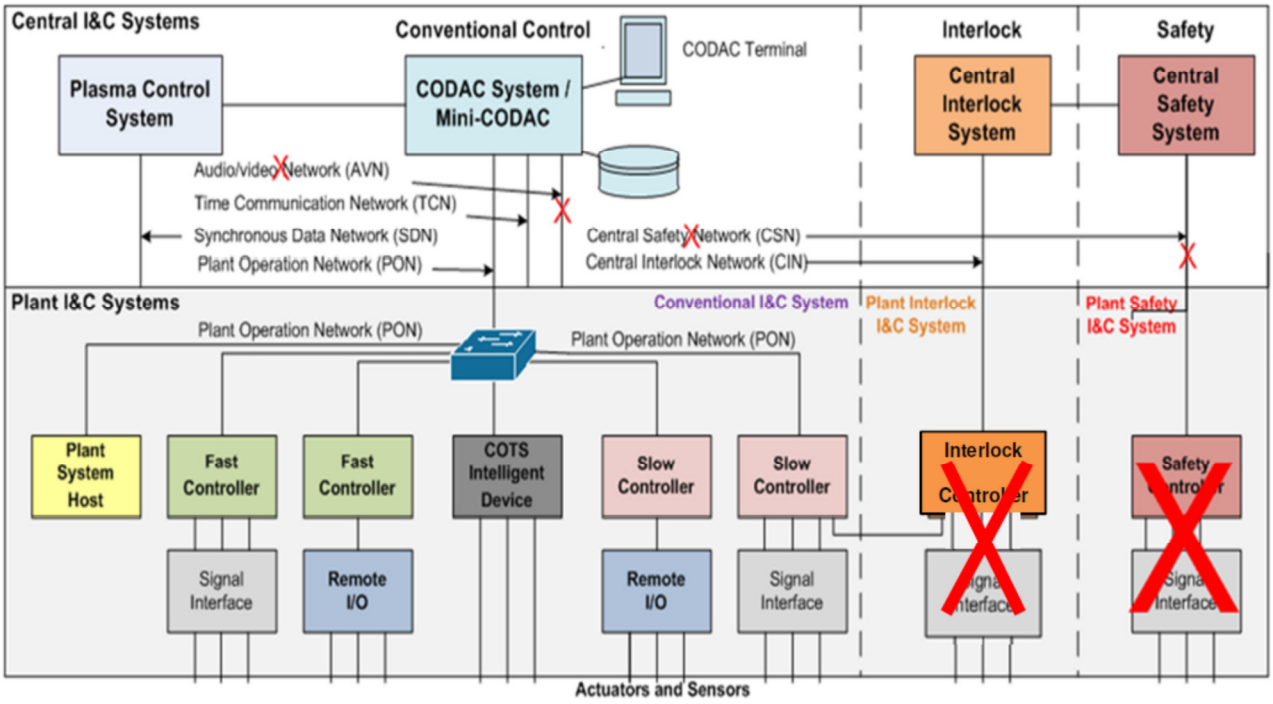

Figure 9. Standard I&C breakdown for the ITER plant system adapted for ECE Diagnostic.

PSH is a standardized computer supplied by IO that is a component of the plant system I&C.
It is connected to the Plant Operation Network and is designed for implementing the standard functions for plant system I&C, not for plant-specific programming.
The primary functions are:

- Handle commands from the CODAC system / Mini-CODAC and dispatch commands to the plant system controllers.
- Monitor the plant system state and status and update this in the CODAC system / Mini-CODAC.
- Transfer alarms from the plant system I&C to the CODAC system / Mini-CODAC.
- Transfer logging messages from the plant system I&C to the CODAC system / Mini-CODAC
- Distribute software events from the CODAC system / Mini-CODAC to the plant system controllers and vice versa.
- Monitor its own state and update this state in the CODAC system / Mini-CODAC.
- Reconfigure the plant system I&C when in maintenance mode.

Plant system controllers are local units in charge of implementing the functional and physical part of the control and data acquisition of the plant system. All plant system controllers include a processor and I/O interfaces, as required. I/O interfaces are either I/O embedded within the controller hardware system, or remote I/O, interfaced with a field bus.

Plant system controllers are split into two categories: slow controllers and fast controllers.
Performance is a discriminating criterion but the main characteristic of the slow controllers is that they are only using COTS industrial components (Programmable Logic Controllers, PLC).
It is planned to have an overlap in the performance ranges of the two categories of controllers.
It is assumed however, that only fast controllers implement control loops or data acquisition faster than 100 Hz.

The following rules apply to I&C associated with ECE:

- The plant I&C must be in full compliance with the rules and guidelines proposed by the current version of the PCDH (Plant Control Design Handbook, see ITER_D_27LH2V - Plant Control Design Handbook V6.1)
- The selection of the fast and slow controllers shall be performed according to the following rules:

  a. Standard controllers (form factors) supported by CODAC as described in the fast and slow controller roadmaps and catalogs shall be used for all I&C functions (see Fast Controller Roadmap and Selection Criteria ITER_D_4C4N8S v1.2, ITER Catalogue of I&C products - Fast Controllers ITER_IDM_345X28 v1.3, Siemens S7 PLC catalogue ITER_D_333J63 v1.7).

  b. In cases where the standard controllers do not meet the performance criteria for the I&C functions the DA and the IO will agree on a plan which allows improving the standard controller performance to the required level.

  c. If it is not possible to improve the standard controllers supported by CODAC to the desired performance the DA and the IO will agree on the custom design controller which can be supported by CODAC.

  d. In all cases, the controllers will be evaluated with respect to the controller selection criteria supplied by CODAC and documented in the controller roadmap.

  e. It is understood that specialized COTS controls such as vacuum controllers, mass spectrometers, industrial laser controllers, and other industrial controllers will be COTS components integrated with CODAC core system.

  f. The examples for plant I&C design and requirement documents provided by CODAC.

(ITER_D_4FDPEY - Example for plant I&C Design Document v1.0 and ITER_D_4EPE2H - Example for Plant I&C Requirements Document v1.0) illustrate the structure and quality of documents needed for plant I&C to pass PDR and FDR. This type of documents in combination with documentation of the details of implementation will allow CODAC to support FAT, SAT, Commissioning, Maintenance and Upgrades of the plant I&C. IO CODAC division has set-up Enterprise Architect with the Subversion repository to prepare the diagrams with version tracking. Support from IO with the tools and diagrams shall be provided by IO on request.

All pre-processed physically meaningful data shall be transmitted to CODAC using a data structure that contains:

a) Data
b) Calculated or measured error
c) Data quality tag
d) Diagnostic metadata
e) Time stamps

The data structure will enable PCS to assess the diagnostic data quality for its control processes. A draft of a generic quality tag structure can be found in ITER_D_354SJ3 “Sketch out of the data quality/status detection function” v2.0. In addition, each diagnostic plant system shall transmit global status information to CODAC.

The connection of the ECE I&C with CODAC is established via various network links as shown in Figure 10.

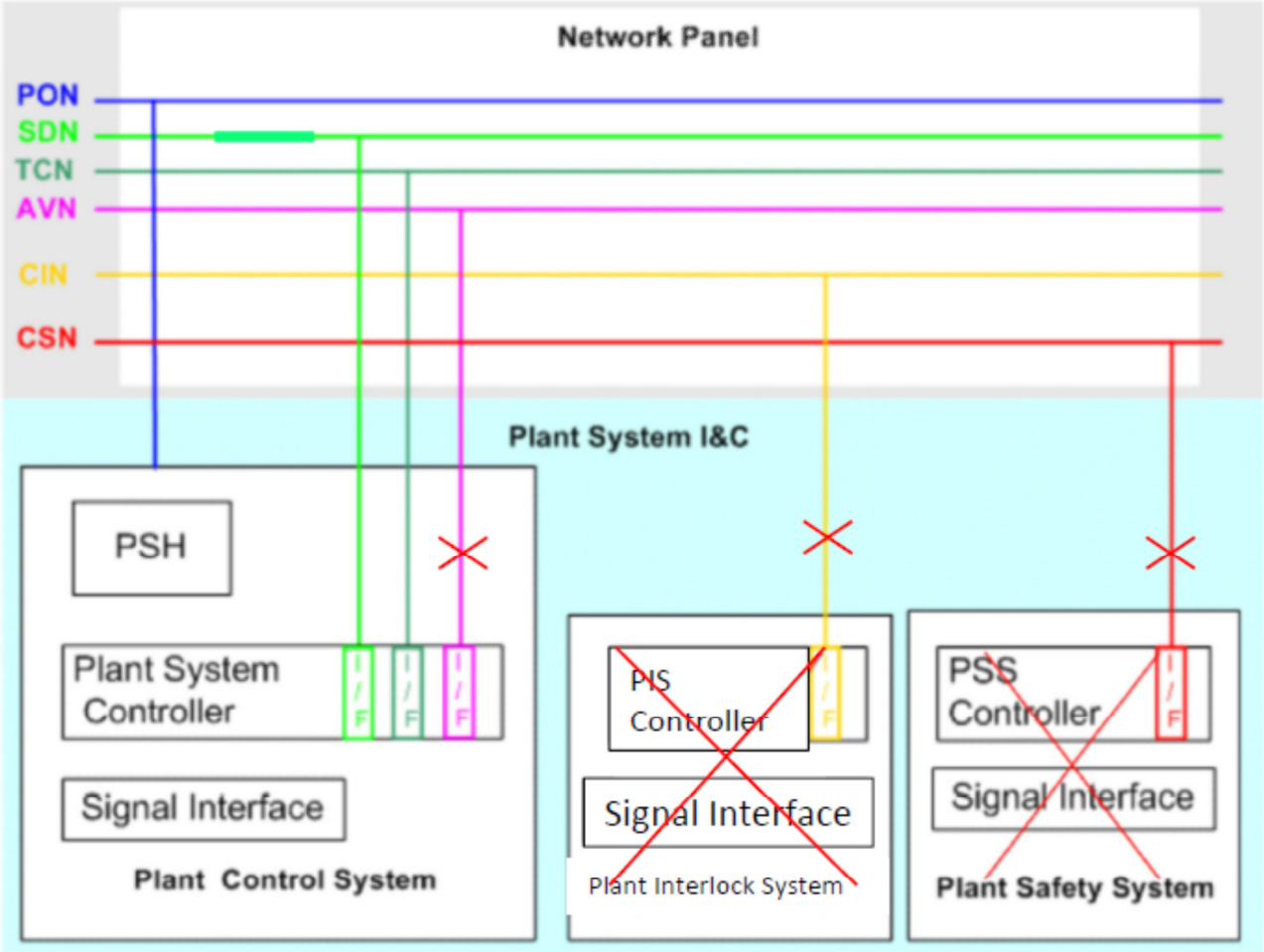

Figure 10. Connection of ECE I&C with CODAC.

- PON provides asynchronous interface between plant system
- TCN provides project-wide time synchronization
- SDN provides the synchronous interface and events plasma control
- AVN provides communication for audio and video signals (Not Applicable for 55F1 ECE system)
- PCIe : Peripheral Component Interconnect express (within plant)
- GbE : Gigabit Ethernet (within plant)
- CIN connects plant interlock system and the central interlock system (Not Applicable for 55F1 ECE system)
- CSN connects plant safety system and central safety systems (Not Applicable for 55F1 ECE system)

(D2) Plant System I&C Boundary Definition

The measurement and control functions of the 55F1 ECE system are used by PBS26, PBS34, PBS 45, PBS46, PBS47, and PBS51, PBS52, PBS53, and PBS54. 55F1 ECE system I&C parameters can be set through CODAC. These plant systems can access the measurements available in the 55F1 ECE system through CODAC. The operation of the 55F1 ECE system is accomplished via HMI through CODAC.

(D3) Plant System I&C Integration Plan

Factory acceptance test (FAT) will be performed with Mini-CODAC and site acceptance test (SAT) with connection to CODAC. All required network connections will be available for FAT and SAT.

(D5) Plant System Controller Performance

The plant system controller performance is documented in the Interface Sheets (IS).

(D6) List of Input and Output of the I&C Controllers

The list of inputs and outputs of I&C controllers is documented in the Interface Sheets (IS).

(D7) List of Process Variables handled by I&C Controllers

The list of process variables handled by the I&C controllers is documented in the Interface Sheets (IS).

(D9) Description of Plant System State Machine

The description of the plant system state machine will be available for the PDR.

5.8.2 Schedule for deliverables required for Annex B

- **Design Specification (Inputs):**

Schedule for design specification (Inputs) is shown in Table 21.

Design Specification (Inputs)	CDR	PDR	FDR
I1: Plant System I&C Operation	XX		
I2: Plant System Functional Analysis	XX		
I3: Plant System PFDs, Mechanical/Electrical Diagrams	XX		
I4: Main Plant System Operating States (short)	XX		
I5: Plant RAMI and I&C RAMI Requirements	X	XX	
I6: System Interface Control Document	XX		
I7: List of Main Protection Functions	X	XX	
I8: List of Safety Functions	X	XX	

Table 21. Design Specification (Inputs) schedule required for Annex B

XX: Approved, C: Concept proposed
X: Approved, dynamic document

- **Technical Specification (Deliverables):**

Schedule for technical specification (Deliverables) is shown in Table 22.

Technical Specification (Deliverables)	CDR	PDR	FDR
D1: Plant System I&C Architecture	C	X	XX
D2: Plant System I&C Boundary Definition	C	XX	
D3: Plant System I&C Integration Plan	C	X	XX
D4: Plant System P&IDs, Mechanical/Electrical Diagram		X	XX

D5: Plant System Controller Performance/Configuration Requirement	C	XX	
D6: List of I/O of the IO of the I&C Controllers	C	X	XX
D7: List of Process Variable	C	X	XX
D8: Configuration of I&C Cubicles	C	X	XX
D9: Description of Plant System State Machine	C	X	XX

Table 22. Technical Specification (Deliverables) schedule required for Annex B

5.9 Operation and Maintenance Requirements

5.9.1 Special Tools

The DA shall provide the tooling as defined in Table 2 and in Table 4.

5.9.2 Spare Parts

Standard Requirements:

During the Operation phase, many of the ITER components will have to be replaced, either on a regular basis for preventive maintenance or randomly if they fail for corrective maintenance. In order to maximize plant availability while containing the associated cost, and respect the timing for the scientific program, sufficient spare parts must be ready for use on site. The availability of “non-conventional, long delivery time spares required by RAMI analysis” being essential to minimize average repair times, the DA shall thus procure the spares to be readily available during the Testing phase and at the beginning of the Operation Phase.
Other spares required by RAMI to address major risks, but with a short delivery time and which could be ordered and procured at the very beginning of the Operation without undue delay, as well as spares recommended by RAMI to address medium risks, shall be procured on Operation Budget and are not covered by this PA. Any change in the design of the procured components that could lessen the need for spares shall be demonstrated in updated RAMI analysis, submitted by the DA to the approval of the IO RAMI RO. Recommendation for further spares provisioning shall be provided by the DA, both for scheduled and unscheduled maintenance taking into account the operating conditions. Within this frame, the DA shall provide a costing for each spare part.

An evaluation of spares required during assembly is required by the DA.

The DA will provide critical spares as identified in Table 2.

Within the scope of Article I.6 of the main PA, the DA shall inform IO of any risk regarding critical components that are no longer available. The DA shall make all necessary recommendations to mitigate that risk.

5.9.3 Training of Operators

The DA shall provide the initial training for installing, operating and maintaining the Diagnostic and its related tools and ancillaries.

The DA shall provide preparation and submittal of a training program. Training support documents shall be delivered to IO for further training.

Three sessions of training shall be held:

- *A first session at DA Site, for ensuring the correct integration of the diagnostic on the Port Plug.*
- *A second session at ITER site, regarding installation.*
- *A third session at ITER Site, regarding installation, operating, calibration and maintenance of the diagnostic.*

5.9.4 RAMI requirements

The general requirements for Reliability, Availability, Maintainability and Inspectability are specified in ITER_D_27ZRW8 - Project Requirements (PR) v4.6.

The US DA is in charge to update the RAMI analysis performed by IO at the CDR level according to ITER RAMI ANALYSIS PROGRAM ITER_D_28WBXD - ITER RAMI ANALYSIS PROGRAM v4.3.

A preliminary Functional Analysis of the ECE for the purposes of RAMI analysis can be found in ITER_D_4DASEP - RAMI Functional Analysis of ECE for CDR (folder). The preliminary analysis should be updated at the PDR if necessary and a final RAMI analysis shall be done prior to the FDR by the US DA.

5.9.4.1 Special Methods and Tools

Standard Requirements:

As a first step, the Preliminary Design Review shall include presentation of an updated RAMI analysis based on the functional breakdown and preliminary Reliability Block Diagram (RBD) and Failure Modes Effects and Criticality (FMEC) analyses initially performed by the IO. In a second step, the Final Design Review shall demonstrate that the functions fulfilled by the design proposed by the DA meets the Availability requirements defined in the PR document ITER_D_27ZRW8 - Project Requirements (PR) v 4.6. The Reliability Block Diagrams shall provide availability estimate with the same software tool as the one used by the IO.

5.10 General Software requirements

The supplier shall utilize IO prescribed software (see list of applicable codes, standards and handbooks in Annex B2) the following areas of activity:

- All phases of plant system design, including mechanical, electrical, fluid, and controls design;

- Management of documentation and drawings;
- Management of data that requires database storage facilities (e.g. plant system inventory list, signal list, etc.);
- Development of I&C software;
- Management of administrative information (e.g., planning);
- Management of quality assurance and quality control data;
- Metrology.

Only suitably certified and/or qualified design software packages for the calculation and generation of design solutions shall be used. All calculation software shall have a specific qualification manual developed with underlying theoretical explanatory notes defining basic engineering theory, methodologies and assumptions employed in the software algorithms. Calculation software shall comply and be consistent with the requirements of the IO MQP. A software developer quality statement of compliance and appropriate user certificates and statements shall also be made available for inspection if requested by IO.

Software used for ITER Safety calculations shall meet the requirements of ITER_D_258LKL - Quality Assurance for ITER Safety Codes v2.2.

6 Inspection and Testing

All diagnostics items under this Annex B shall demonstrate full performance and be qualified for the planned lifetime of the Diagnostic prior to installation.

Standard Requirements:

The DA shall execute adequate inspection and testing, following the applicable codes and standards, and respecting IO quality control procedure, in order to ensure that the procured system can meet the performance described in the SRD document ITER_D_28B39L - SRD-55 (Diagnostics) from DOORS v3.1. Phases and milestones regarding the testing and procurement arrangement are described in the chart in Figure 11.

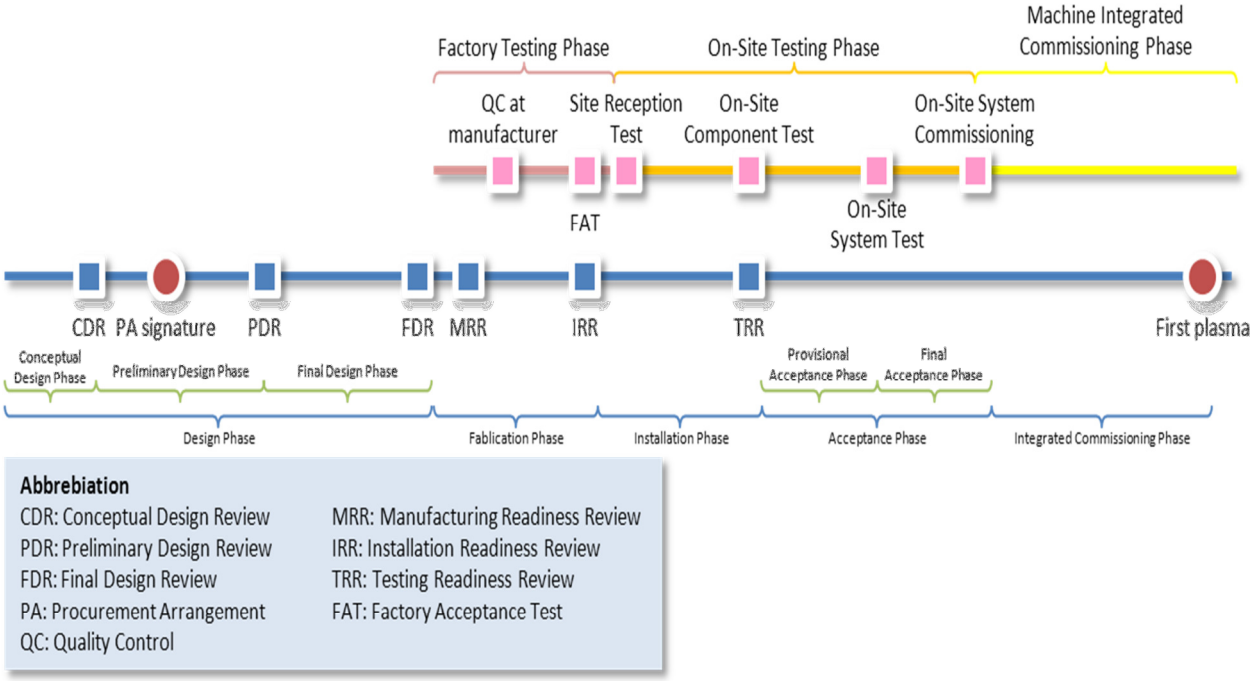

Figure 11. General Phases and Milestones chart.

The DA shall ensure that the Suppliers of the component shall perform factory testing before shipping the Items to the IO. For each milestone the DA shall perform necessary testing of the component/system to demonstrate that the required performance meet the criteria. The results of tests shall be delivered to the IO. In order to coordinate the on-site testing, the DA shall prepare sufficiently in advance and submit to the IO the list of testing tasks (date, location, duration, type, prerequisites, interfaces, etc...), in accordance with Table 23, including any kind of activities during site reception test, on-site component test, on-site system test and on-site system commissioning.

Test ID	Corres DWS activity ID	PBS #	Concerned system	Name of test	Description of test	Testing phase*	Pre-requisite or interfacing system	Location	Necessary equipments	Utilities	Responsibility	Start/End date	Safety**	Comment

Table 23. Testing Tasks

*Testing should be consistent with definition described in the ITER testing strategy document [ITER_D_44U2Y4 v1.3].
**Any safety requirements shall be described

The performance requirements are specified in section 5.4.3 and in section 5.4.4. They shall be checked throughout the production by means of the several testing programs foreseen within the frame of this Annex B.

DA shall prepare and update throughout the production a compliant matrix of the performance requirements, which gives a clear status of the performances validation.

All diagnostics Items under this Annex B shall demonstrate full performance and be qualified for the planned lifetime of the Diagnostic prior to installation.

There are three stages of Testing and Qualification (T&Q) for the 55F1 ECE system:

- Supplier-side T&Q is the responsibility of the US-DA and includes:
    - Prototype component testing
    - Factory testing
- User-side T&Q is the responsibility of the IO and includes:
    - Testing at a Port Plug Test Facility
    - Delivery acceptance inspection
    - Testing during installation
- Commissioning T&Q (responsibilities are defined in the Main Part of the present Procurement Arrangement).

For prototype testing and factory testing, the DA shall prepare a testing plan in collaboration with IO including acceptance criteria. These plans shall be approved by IO before execution. IO reserves the right to witness all or a portion of these tests.

The commissioning program at ITER site shall be prepared by the DA and approved by IO.

All tests carried out before shipment shall be done on DA's responsibility in accordance with the approved plan. The DA shall submit the test results to IO and wait for IO approval before shipping the diagnostic components to the next destination.

Final acceptance testing at ITER site is done on IO's responsibility. Figure 12 gives an overview of 55F1 ECE (Front end and Receiver) acceptance tests.

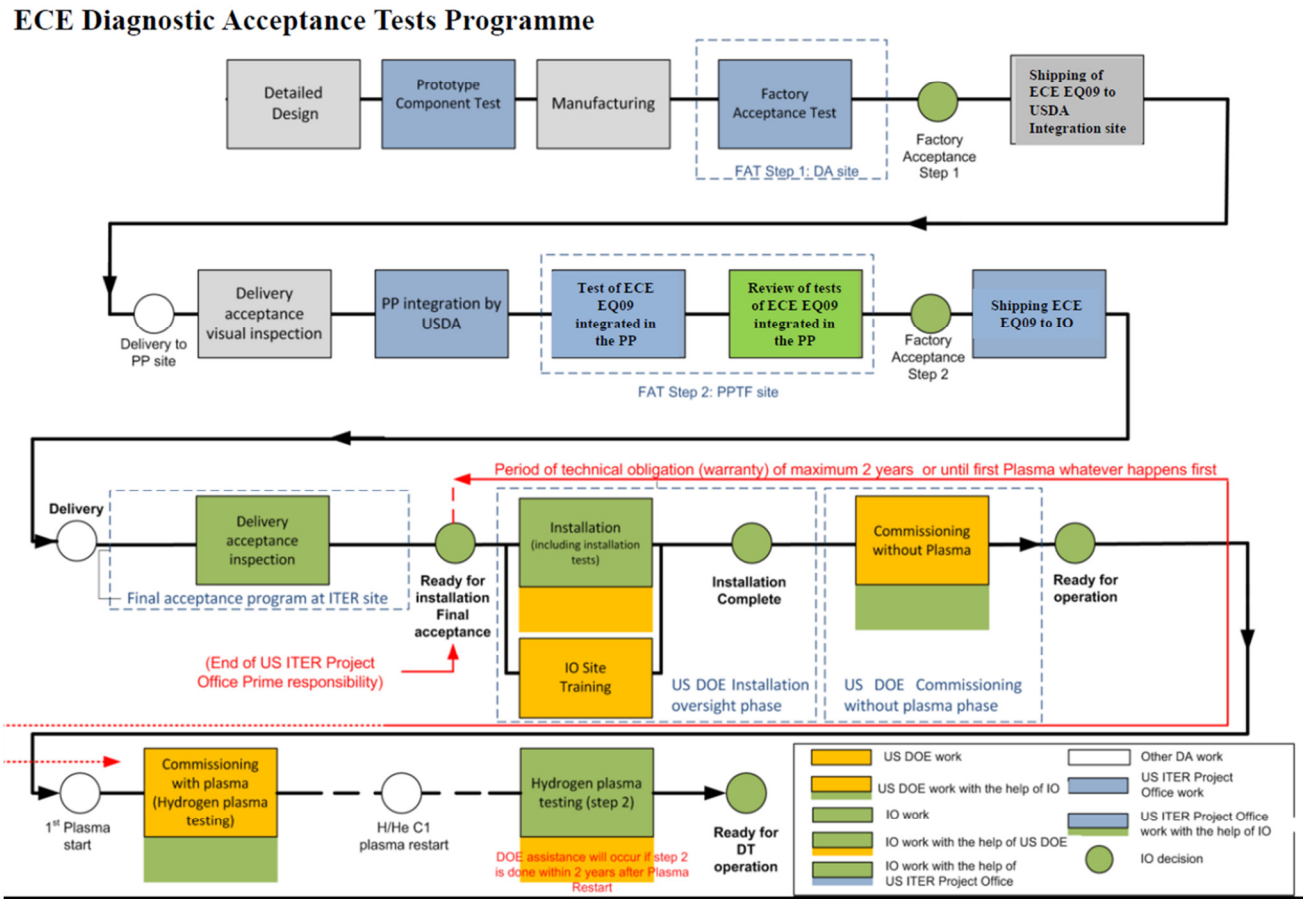

Figure 12. ECE Diagnostic Acceptance Tests Programme.

6.1 Examination and Tests

6.1.1 Factory Testing

6.1.1.1 Examination

For equipment non-destructive tests of permanent joints must be carried out by suitable qualified personnel. The personnel must be approved by a third-party organization.

The examination requirements depend on the classification of the components and on the selected Codes and Standards.

In any case, the minimum required examinations, the examination procedures and the acceptance criteria are given hereinafter. They shall be carried out by experienced personnel. The supplier is recommended to envisage all the additional examinations he deems to be necessary to detect possible non-conformities at an early stage of the manufacturing process and thus to be able to perform suitable and timely corrective actions.

The non-destructive examinations to be applied shall be performed in accordance with a written procedure that shall include, as a minimum, the following information in addition to the requirements of the applicable standards:

- Scope of examination and stage of manufacture at which it is conducted;
- Surfaces on which examination will be performed: drawings may be used to indicate areas of examination for each procedure, and any limitations due to size, shape or other physical characteristics;
- Data to be recorded.

The approval of all the non-destructive testing protocols represents a Hold Point.

The supplier or his sub-tier supplier shall prepare a report for each non-destructive examination carried out. All reports shall, as a minimum, contain the following information in addition to the requirements of the applicable standards:
All procedural, equipment and calibration parameters shall be identified sufficiently to provide a basis for comparison with later examinations;
A marked up drawing or sketch indicating the weld or part examined, the item or piece number, the datum points and co-ordinate conventions used for location, and other identification information necessary;
An acceptance or rejection statement on the detected defects.

6.1.1.2 Factory acceptance test

The factory acceptance test shall be performed to ensure compliance of the manufactured component relative to the final design. The details of the factory acceptance test will be developed only after concluding the prototype tests.

The factory acceptance tests shall include the tests that will be carried out during the manufacture, in accordance with the classification of the component with respect to Quality, Safety, Vacuum, RH, ESP and ESPN.

The DA has to provide a draft factory acceptance test program **including the acceptance criteria** prior to the Preliminary Design Review and a final Factory acceptance test program prior to the Final Design Review(s). This test program shall be reviewed by IO in the scope of the PDR and FDR and the program will be revised according to any generated CHITs. This program shall be approved by IO.

At least following tests shall be performed by the DA before delivery to ITER site:

1. Vacuum integrity qualification of any components which may be under vacuum (if needed),
2. Measurements performance qualification.

Part (1): All vacuum testing will be done in accordance with the ITER_D_2EZ9UM - ITER Vacuum Handbook V2.3.

Part (2) The DA shall demonstrate that the ECE system meets the measurement requirements under conditions simulating those expected on ITER, including vibration and noise levels comparable to normal and disruption scenarios.

The detailed design of the measurement performance test stand shall also be part of the PDR work.

The test program shall include CODAC Interface testing by using the Mini CODAC provided by IO.

6.1.2 On-Site Testing

The IO shall provide a draft version of the Final acceptance test guideline at ITER site at the Preliminary Design Review and a Final version prior to the Final Design Review(s).

The Final acceptance test program at ITER site will be prepared by DA in parallel with the Factory acceptance tests being developed by the DA in accordance with IO guideline. This Final acceptance test program will be reviewed by the IO in the scope of the PDR and FDR and the program will be revised accordingly. This program shall be approved by IO.

The acceptance test program at ITER site shall include the following steps:

- Delivery acceptance, including visual inspection,
- Simple tests verifying 55F1 ECE Items integrity including at least powering all equipment as far as can be done without vacuum.

After all these tests, IO shall confirm Final Acceptance. Final Acceptance is based on the criteria of section I.5 of the Main PA.

The warranty / technical Obligation after PA completion is based on the criteria contained within Section I.6 of the Main PA.

The commissioning tests with plasma will be performed by IO, see article I.6 of the Main PA.

6.1.3 Commissioning test without plasma

After commissioning: a series of tests comprising (not exhaustive) of the electrical connectivity test, the vacuum leakage test and the diagnostic acquisition test shall be carried out as defined in Main PA. Commissioning tests shall include:

a) Vacuum acceptance test (vacuum handbook),
b) Post- installation leak checking,
c) Commissioning after installation (no torus vacuum yet),
d) Commissioning with torus vacuum,
e) Microwave transmission line test.

After all these tests, IO shall confirm “ready for operation” status.

6.1.4 Commissioning test with plasma

The commissioning tests with plasma will be performed as defined in Main PA. Commissioning tests shall include at least:

a) Remote Operation of 55F1 ECE during ITER pulse
b) Check correct change of 55F1 ECE system states through pulse sequence
c) Data acquisition synchronized with ITER pulse, triggering, archiving

d) Check of data timing synchronization
e) Analysis of the density profile sample and comparison with other density profile diagnostics.

6.2 Metrology and Tolerances

After manufacturing the geometrical shape and tolerances shall be measured according to a testing protocol agreed with IO, who may also witness the geometrical measurements. IO shall have access to the measurement data (including raw data if there has been some post-processing) as part of the QA file for the component. This information shall be sent upon each measure.
The mandatory requirements for dimensional control of the components, assemblies and systems for the ITER machine are outlined in the Metrology Handbook (refer to ITER_D_46FN9B - ITER Dimensional Metrology Handbook v2.1).

6.3 Acceptance Criteria

The DA has to provide a draft acceptance test program including the acceptance criteria prior to the Preliminary Design Review and a final acceptance test program prior to the Final Design Review(s). This test program shall be reviewed by IO in the scope of the PDR and FDR and the program will be revised according to any generated Chits. This program shall be approved by IO.

6.4 Final Acceptance

The acceptance criteria for the tests done until the factory acceptance testing will be provided by DA, included in the corresponding test plans, and approved by IO.

The final list of the acceptance criteria for Final Acceptance Test Program will be provided by IO prior to the Final Design Review.

The Final Acceptance of the Item will be based on:

- Validation of the performance requirements,

- Compliance with the technical requirements of this PA,

- Compliance with the approved construction designs and specifications,

- Rectification of any defects,

- Provision of all required as-built documentation.

7 Requirements for Labeling, Cleaning, Packaging, Handling, Shipment and Storage

The procedures concerning Cleaning, Packaging, Handling, Transport and Storage shall be prepared by DA with IO collaboration in accordance with requirements given in this Section and agreed by IO before carrying out these activities.

These procedures shall include **at least**:

- Issues relating to identification, marking, naming and labeling (ITER Numbering System for Parts/Components (28QDBS) v2.0).
- Technical requirements for packaging, handling, transport and storage of each component in frame of this PA.
- Definition and constraints on the packaging where appropriate; plastic sealing and dry nitrogen packaging atmosphere are desired.
- Specific requirements to take into account for hazardous and sensitive item.
- The requirements of the Applicable Codes and Standards.
- The requirements of ITER_D_2EZ9UM - ITER Vacuum Handbook v2.3 regarding the cleaning of all equipment.
- The requirements of ITER_D_2EL9Y6 - Appendix 2 Environmental Cleanliness v1.4 regarding the post cleaning handling of equipment.
- Arrangement of delivery dates and scheduling with IO.

The ITER_D_27ZRW8 - Project Requirements (PR) v4.6, section 8.8.1, lists the limitations in size and weight of the components (including packages and frames). The packaging and movement of components larger than a standard pallet should be discussed with Machine Assembly and Installation (PBS 22).

7.1 Scope of Application

The following generic requirements apply both for the shipment of equipment, etc from the manufacture/assembly site to the ITER site or to any intermediate site.
Suitable precautions shall be taken to avoid damage to the equipment. The parts shall be fitted with the required accelerometers and shall be shipped in wooden boxes, as defined below.
In all cases (intermediate site or ITER Site) the equipment, etc. shall be subject to control and inspection, as defined below.

The requirements given in this Section apply both for the shipment of any Item from the manufacture/assembly site to the ITER site or to any intermediate site.

Suitable precautions shall be taken to avoid damage to the equipment. The parts shall be fitted with the required accelerometers and shall be shipped in wooden boxes, as defined below. In all cases (intermediate site or ITER Site) the Item shall be subject to control and inspection, as defined below.

7.2 Labelling and Traceability

Standard Requirements:

The IO and the DA shall agree to a permanent identification and numbering system. 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 Parts/Components" ITER Numbering System for Parts/Components (28QDBS) v2.0. A detailed 'IO component identification standard' together with label templates should be developed and provided.

CE Marking shall be affixed by Manufacturer as per Annex A.

7.3 Cleaning

Standard Requirements:

During assembly and cleaning, particular attention shall be given to the removal of weld spatter, debris and other foreign matter, particularly from the coolant passages and sealing surfaces. Final cleaning shall ensure effective cleaning without damage to the surface finish, material properties or metallurgical structure of the materials. The DA shall ensure that the Supplier submits to them the proposed cleaning procedure for approval.

The demonstration of meeting the above cleaning requirements represents an Authorization-To-Proceed Point (ATPP).

7.4 Packaging and Handling

Standard Requirements:
Any special IO or regulatory transportation requirements shall be documented and provided to the DA prior to shipment. The DA shall be responsible for ensuring that the Items and associated transportation packaging satisfy the special IO or regulatory transportation requirements.

Subsequent to the Factory Acceptance Test, the components shall be partially disassembled to the maximum size that can be shipped. All Items requiring re-assembly at the ITER Site shall be clearly labeled and tagged.
The Items shall be properly packed to prevent damage and properly fixed inside wooden boxes. These boxes shall be sufficiently rigid to avoid deforming under the component weight. Supports shall avoid the potential for impact loading on the components due to sudden movements or accidental drop. Shock absorbing material shall be used.
At least two accelerometers shall be rigidly fixed onto each box and shall be capable of recording the acceleration along three perpendicular directions.
Prior to packing each box, a Delivery Report shall be prepared by the DA, stating as a minimum:

- the packaging date;
- the full address of the place of delivery and the name of the person responsible to receive the package, as well as of the sender's name and full address;

- the number and type of components contained in the package;
- the enclosed documentation;
- the declaration of integrity of the package;
- the declaration of integrity of the components;
- any additional relevant information on the status of the components.

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

7.5 Shipment, Transportation and Delivery to the ITER Site

The Items shall be delivered to the ITER Site, as specified in Annex A under the responsibility of the DA.
Before the shipment, a Release Note shall be prepared in accordance with ITER Project Management and Quality Program related to the document ITER_D_22F52F - ITER Requirements Regarding Contractors Release Note v4.1 and accepted by the IO.

Upon receipt of the package, the DA and the IO shall open the package and make a visual inspection of its content to check:

- the integrity of the package;
- the number and type of components contained in the package;
- the enclosed documentation;
- the reading of the accelerometers;
- the integrity of the components.

In the case of anomalies the IO shall make any additional relevant remark on the status and physical condition of the components.
The IO and the DA will conjointly inspect the accelerometers 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 components will be made by the DA after consultation with the IO.
In the case whereby the components are in an acceptable condition, the DA and the IO will jointly sign the Delivery Report and the DA will start re-assembly of the Items. The signature of the Delivery Reports is an IO Hold Point.
The original of the Delivery Report shall be kept by the IO and a copy shall be kept by the DA.

8 Commissioning

Commissioning tests are described in section 6.1.2 of present Annex B.

DA and IO commissioning responsibilities are defined in Main PA.

9 Applicable and Reference Documents

9.1 Applicable Documents

Management and Quality Program

ITER_D_2NS3UH - ITER Management & Quality Programme (MQP)	V 1.2
ITER_D_22MDZD - Manufacturing and Inspection Plan	V 2.1
ITER_D_258LKL - Quality Assurance for ITER Safety Codes	V 2.2
ITER_D_28WBXD - ITER RAMI ANALYSIS PROGRAM	V 4.3
ITER_D_2DWU2M - Procedure for the Management of CAD Work & CAD Data (Models and Drawings)	V 1.7

Project Requirements

ITER_D_2DY7NG - IC-2/ 7.1 Project Specification	V 2.0
ITER_D_27ZRW8 - Project Requirements (PR)	V 4.6
ITER_D_2A9PXZ - 600000-CCS-SHB-01 ITER Coordinate Systems	V 3.7
ITER_D_2EZ9UM - ITER Vacuum Handbook	V 2.3
ITER Vacuum Handbook (IVH)	folder
ITER_D_3VTBNK - Group#5 proposal for System Design Process Working Instruction Update	V 1.2
ITER Research Plan (IRP) (2FB8AC)	V 2.2

System Requirements Documents

ITER_D_28B39L - SRD-55 (Diagnostics) from DOORS	V 3.1

Interface Documents

ITER_D_2W4WEJ, Interface Control Documents (ICDs) (folder)	-
ITER_D_A6UBTX - The 3D and 2D CAD Model Approval Interfacing System Control Sheet (PC-CMAF ECE-CMM-L1-level)	V 1.0

Guideline / Handbook

Codes and Standards for ITER Mechanical Components (25EW4K)	V4.0
Guideline for Structural Analyses (35BVV3)	V 1.1
ITER_D_2EL9Y6 - Appendix 2 Environmental Cleanliness	V 1.4
ITER_D_2E7BC5 - ITER Remote Handling Code of Practice	V 1.2
Electrical Design Handbook (EDH) (folder) Part 1 ITER_D_2F7HD2 - EDH Part 1: Introduction Part 2 ITER_D_2E8QVA - EDH Part 2: Terminology & Acronyms Part 3 EDH Part 3: Codes & Standards (2E8DLM)	 V 1.4 V 1.4 V 1.3

Part 4 EDH Part 4: Earthing, EMC and Lightning Protection (2ELREB)	V 3.0
ITER_D_2LAJTW - Tritium Handbook	V 1.4
ITER_D_46FN9B – ITER Metrology Handbook	V 2.1
ITER_D_33TTPJ - Guideline for ITER System Load Specifications	V 1.3
ITER_D_27LH2V - Plant Control Design Handbook	V 6.1
Operations Handbook ITER_D_2LGF8N - Operations Handbook - 2 Operational States	 V 1. 3
ITER_D_32SAC7 - ITER material property handbook (Folder)	-
ITER_D_2W3SFF - Requirement Allocation Document	V 1.1
ITER_D_2LULDH - Heat and Nuclear Load Specifications	V 2.3
ITER_D_222QGL - Load Specifications (LS)	V 6.0
ITER_D_222RHC - In-vessel Components, SDC-IC	V 2.0
ITER_D_347SF3 - Safety Important Functions and Components Classification Criteria and Methodology	V 1.8
ITER_D_2DRVPE - ITER Seismic Nuclear Safety Approach	V 1.6
ITER_D_2E2U9X - ITER Building Code II-SDCB	V 1.1
ITER_D_2FMAJY - ITER Remote Maintenance Management System (IRMMS)	V 1.6
ITER_D_283B24 - ITER Structural Design Code for Buildings (I-SDCB) - Part1: Design Criteria	V 2. 10
Magnet Structural Design Criteria Part 1 ITER_D_2FMHHS - Magnet Structural Design Criteria Part 1 Part 2 ITER_D_2ES43V - Magnet Structural Design Criteria Part 2 Part 3 ITER_D_2FKTTG - Magnet Structural Design Criteria Part 3 Part 4 ITER_D_2FDCA3 - Magnet Structural Design Criteria Part 4	 V 2.0 V 2.0 V 2.0 V 2.0
ITER_D_22GRQH - Magnet Superconducting and Electrical Design Criteria	V 1.2
MPH Material Properties Handbook (Folder)	-
ITER_D_35QTKD - Guideline for Structural Integrity Report	V 1.2

ITER_D_2NRTWR - RH Compatibility Procedure	V 2. 3
Procedure on procurement documentation exchange between IO, DAs and contractors (35BVQR)	V 2.1
ITER Numbering System for Parts/Components (28QDBS)	V 2.0
ITER_D_2UUZ23-Rooms_Hazards_and_Environmental_Conditions_Oct-09	V 2.1
ITER Document Breakdown Structure Overview (43327Q)	V 1.1
ITER Plant Breakdown Structure (28WB2P)	V 2.0
Quality Classification Determination (24VQES)	V 4.1
ITER_D_2DKFR2 - Procurement Arrangement related Documentation Exchange, Access and Storage Conventions	V 2.6
ITER_D_2LJS3K - Cryogenic Handbook	V 2.0
ITER_D_22MFG4 - ITER Procurement Quality Requirements	V 4.0
ITER_D_229D49 - Structural Design Criteria - General Section	V 2.0
ITER_D_2NT3E2 - Standardization Work Plan	V 1.2
ITER_D_76ZBR5 - Technical Specifications for Window Assembly Integration	V 1.0
ITER_D_27LH2V - Plant Control Design Handbook	V 6.1

Manuals

Manual of Radiation Hardness (RAD) (folder)	-
Manual of CAD (folder)	-

Report

ITER_D_2FTVKV - Scenarios for Coil, Power Supply and Cryoplant Analysis	V 1.10
Preliminary Safety Report (RPrS) (3ZR2NC)	V 3.0

Procedures

ITER_D_2EGQKE - Configuration Management Model (CMM)	V 1.7
ITER_D_2832CF - Design Review Procedure	V 1.12
ITER_D_22MAL7 - Analysis and Calculations	V 4.0
ITER_D_22F52F - ITER Requirements Regarding Contractors Release Note	V 4.1
ITER_D_28VNJG - Procedure for Design Interface Control of ITER systems	V 3.0

9.2 Reference Documents

The documents which can be usefully consulted for exercising the activities related to the project are listed below.

03_Conceptual Design Review (CDR)	Folder
Design Description Document for 55F1 ECE Diagnostic (679HW9)	V 1.1
ITER_D_2X6K67 - PD - Plant Description - Chapter 08.	V 1.1
ITER_D_27X5FM - 610000-CCS-QXP-01 Site Master Plan	V 2.11
55N Diagnostic Engineering DDD	Folder
ITER_D_3G2T8J - Diagnostic System Classifications	V 2.9
ITER_D_35UVAQ - ITER Standard Component Register	V 4.0
Fast Controller Roadmap and Selection Criteria ITER_D_4C4N8S	V 1.2
ITER Catalogue of I&C products - Fast Contollers ITER_IDM_345X28	V 1.3
https://user.iter.org/?uid=A6GZ66 – ECE CDR closure document	V 1.0
ITER_D_44BZDB - Technical specs for plant system I&C	V 1.0
ITER_D_35XUDM - Interface Control Document (ICD) between Diagnostics (PBS 55) and Radwaste Treatment and Storage System (PBS 66)	V 1.0
ITER_D_2LKT6H - Summary Report: Type B and purely tritiated waste amount estimate revision	V 1.0

Annex B1 – List of Appendices

These four documents have to be printed out with the original document and are part of this Annex B:

ITER_D_734AZL - Design Compliance Matrix of ECE	V 1.0
ITER_D_6XRG6J Loads Specification for 55F1 ECE Diagnostic	V 3.1
ITER_D_3MQKJS - I&C deliverables for Diagnostics Annex B	V 2.0
ITER_D_9B9MGL - Deliverable_Document_List (to be tailored for each diagnostic)	V 1.1
https://user.iter.org/?uid=4E8SWC – Remote handling compatibility documents for ECE system	folder