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EXTERNAL REFERENCE / VERSION

Technical Specifications (In-Cash Procurement)

Transmission Line Compensator Technical Specification

This document defines the technical requirements for the design, the manufacturing and the testing of the Transmission Line (TL) compensators, including the proposal for their installation.

ICRH Compensators

Technical Specification for the Design of ICRH Compensators

Abstract

This document specifies a R&D activity to design compensators that shall be fitted between the ITER ICRH South wall penetration sleeves and the ICRH Transmission Lines.

The work also requires the demonstration and validation of a suitable installation sequence for the designed compensators.

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1 Preamble

The ITER Ion Cyclotron Heating and Current Drive (ICH&CD – PBS51) system is the 40 to 55MHz, 20MW radio-frequency (RF) system used to heat plasmas for pulsed operations of up to 3600s at ITER.

The Ion Cyclotron (IC) Transmission Line (TL) compensator, as described in Section 5, is a component in the transmission line part of the ICH&CD System and the focus of this contract.

2 Purpose

The TL compensator forms part of the last confinement barrier of the ICH system and is a component that needs to be developed in order to meet the stringent ITER requirements.

The compensator at ITER is a Protection Important Component (PIC) with a Safety Important Class 2 (SIC-2) and its installation is a Protection Important Activity (PIA). However, the described task(s) in this contract is/are not PIC/PIA.

The scope and purpose of this contract has two distinct parts:

- The first part requires the design, development, build and test of a suitable compensator. This work shall include the construction of a suitable mock-up for testing purposes.
- The second part of the contract is based on the successful completion of the first part of the work. In this case, the work shall continue to develop an installation plan and the mock-up shall then be extended to test the proposed installation process. Further tests will also be carried out on the compensators involved in this installation process.

The aim of this task is only for the design, development, manufacture and test of the compensator(s), and once complete, the delivery of the test articles/equipment to IO. It is not for the qualification or production of the final components.

3 Acronyms & Definitions

3.1 Acronyms

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

Abbreviation	Description
ASN	French Nuclear Safety Authority (from French “Autorité de Sûreté Nucléaire”)
A&M	Alignment and Metrology
B11	Building 11 – The RF Building
B13	Building 13 – The Assembly Hall
B15	Building 15 – The Tokamak Building
CAD	Computer Aided Design

Abbreviation	Description
CMM	Configuration Management Model
DDD	Design Description Document
ESPN	Nuclear Pressurized Equipment (from French "Equipements Sous Pression Nucléaire")
HP	Hold Point
ICD	Interface Control Document
IDM	ITER Document Management
ICRH	Ion Cyclotron Resonant Heating
IO	ITER Organization
IS	Interface Sheet
I&C	Instrumentation and Control
MIP	Manufacturing and Inspection Plan
MQP	Management and Quality Program
NP	Notification Point
PBS	Plant Breakdown Structure
PED	Pressure Equipment Directive
PFD	Process Flow Diagram
PIA	Protection Important Activity
PIC	Protection Important Component
P&ID	Process and Instrumentation Diagram
QP	Quality Plan
R&D	Research and Development
RF	Radio Frequency
RO	Responsible Officer
SIC	Safety Important Class
SRD	System Requirement Document
TL	Transmission line
TRO	Technical Responsible Officer

3.2 Definitions

Supply Contract: shall mean any Contract for the delivery of a defined set of products, goods or items.
Off Site: Anywhere that is not on the ITER Site.

Contractor: shall mean an economic operator who has signed the Contract in which this document is referenced.
Subcontractor: shall mean an economic operator who is under contract to a Contractor providing supplies, services or works to the IO, being understood that the subcontractor shall perform, under responsibility of the Contractor, with independence and free from any subordination, a specific part of the obligations of the Contract.

4 Applicable Documents & Codes and standards

4.1 Applicable Documents

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

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

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

Ref	Title	IDM Doc ID	Version
1	Ion Cyclotron Heating and Current Drive (ICH&CD) Subsystem Design Description Document (sDDD) – USDA Scope	ITER_D_CVZYVA	4.0
2	SRD-51 (ICH&CD) from DOORS	ITER_D_28B33K	6.0
3	Leak Tight Solutions for the IC South Wall Penetrations	ITER_D_4ZHEBW	1.0
4	MPH - Part 1 - Materials for vacuum vessels, in-vessel, and other systems	ITER_D_29DDCW	Folder
5	Order dated 7 February 2012 relating to the general technical regulations applicable to BNI - FR (7GJHSE) translated for guidance in Order dated 7 February 2012 relating to the general technical regulations applicable to BNI - EN (7M2YKF) and the subsequent ASN decisions linked to this Order	ITER_D_7M2YKF	1.7
6	Load Specification for ICH&CD Transmission Line PBS 51.TL, 51.TF, 51.MS, 51.CI.TL	ITER_D_UX5PNC	1.1
7	Procedure for Management of Non-conformities	ITER_D_22F53X	9.1
8	ITER Numbering System for Components and Parts	ITER_D_28QDBS	5.0
9	ITER Requirements Regarding Contractors Release Note	ITER_D_22F52F	5.0
10	Procedure on procurement documentation exchange between IO, DAs and contractors	ITER_D_35BVQR	5.0
11	ITER Procurement Quality Requirements	ITER_D_22MFG4	5.1
12	Quality Classification Determination	ITER_D_24VQES	5.2
13	Procurement Requirements for Producing a Quality Plan	ITER_D_22MFMW	4.0

Ref	Title	IDM Doc ID	Version
14	Requirements for Preparing and Implementing a Manufacturing and Inspection Plan	ITER_D_22MDZD	3.7
15	Quality Assurance for ITER Safety Codes Procedure	ITER_D_258LKL	3.1
16	Overall supervision plan of the chain of suppliers for Safety Important Components, Structures and Systems and Safety Related Activities	ITER_D_4EUQFL	7.4
17	General Management Specification for Service and Supply	ITER_D_82MXQK	1.4
18	System Load Spec(s) (SLS) for Supports (IN-55.SUPT), Hard Core Components Valves (IN-55.HCCV), Hard Core Components Windows (IN-55.HCCW) and Penetrations (IN-55.PNTR)	ITER_D_X4W3DR	1.10
19	Complete OPEN database	ITER_D_Y32JEY	1.16
20	Accident Analysis Report (AAR) Volume II - Reference Event Analysis	ITER_D_2DJFX3	4.10

5 Scope of Work

The present chapter details the technical requirements applicable to the contractor. The requirements in the present technical specification are focused on the TL compensator design, manufacturing, and testing. The completion of the design work and testing represents a Hold Point (HP) in the contract.

If the above work is successful then the contractor shall develop and confirm a proposal for the installation process of the compensators at the South Wall of the Tokamak building (B11).

Once the work is complete, the contractor shall deliver the compensators and mock-up(s) used for test purposes to the ITER site.

5.1 Scope of Supply

5.1.1 Background

The ITER Ion Cyclotron Heating and Current Drive (IC H&CD – PBS51) has nine (eight operational and one spare) RF sources which are connected by transmission lines (TLs) to two ICRH antennas. (Figure 1).

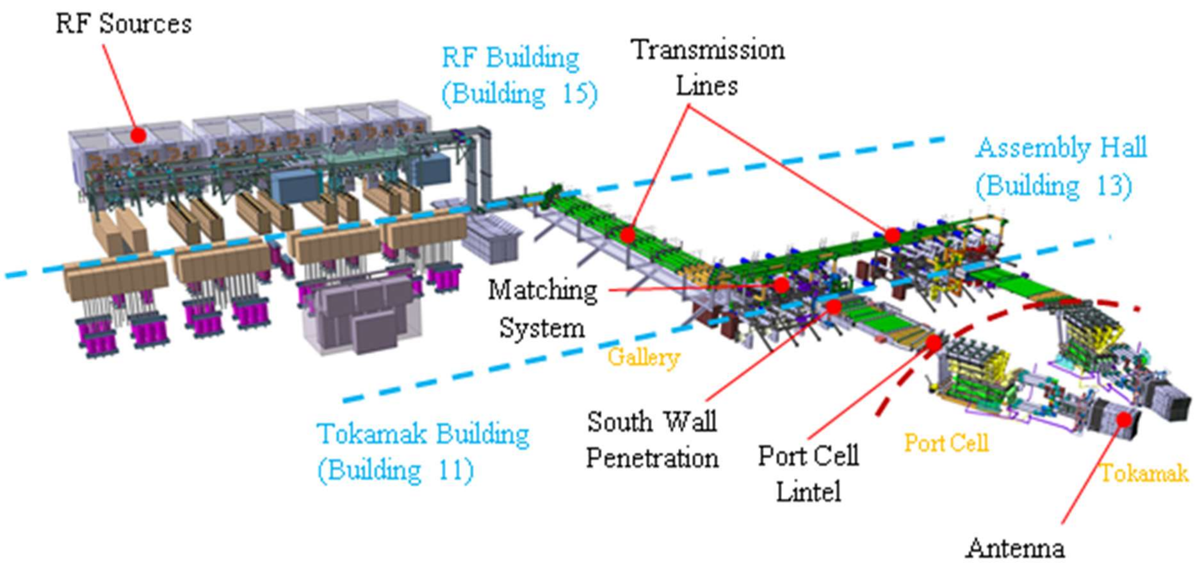

Figure 1: ITER ICH System

The IC system's transmission lines are coaxial lines with cylindrical aluminium outer conductors and copper inner conductors. The transmission lines have to pass through a number of penetrations, which include:

- The penetrations from the RF building (building 15) to the assembly building (building 13)
- The penetrations from the assembly building to the gallery of the tokamak building (building 11), called the South wall penetrations

- The penetrations from the gallery to the port cell through the port cell lintel.

The main area and concern of this contract is at the South wall of the Tokamak building (building 11).

The South wall penetrations have sleeves inserted in them, which overhang the installed equipment (cable trays, pipework, etc.) that run along the South wall in the gallery (Figure 2). It is these sleeves that will allow the IC transmission lines to be installed over the equipment.

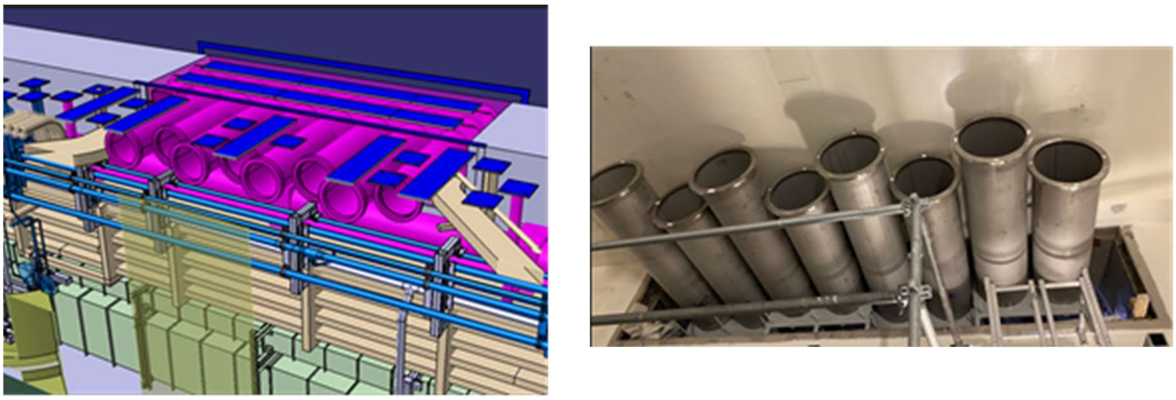

Figure 2: Sleeves in the South Wall Penetration of the Tokamak Building

The transmission lines that are to be installed (in and around the sleeves) include 90-degree elbows at the assembly hall end of the South wall penetration sleeves. Straight transmission line sections that run through the sleeves and connect to the gas barriers within the gallery area of the tokamak building. (Figures 3 and 4)

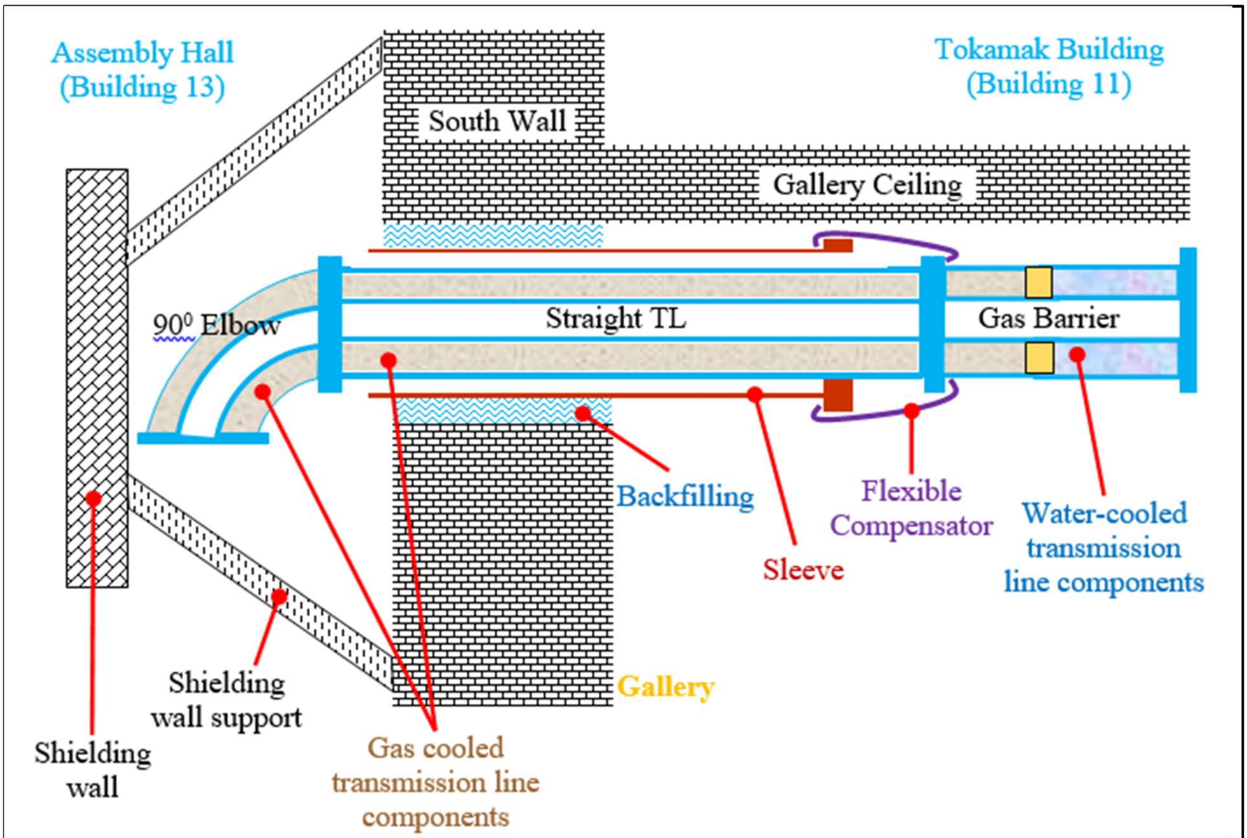

Figure 3: Transmission Line Connection details in and Around the South Wall Penetration

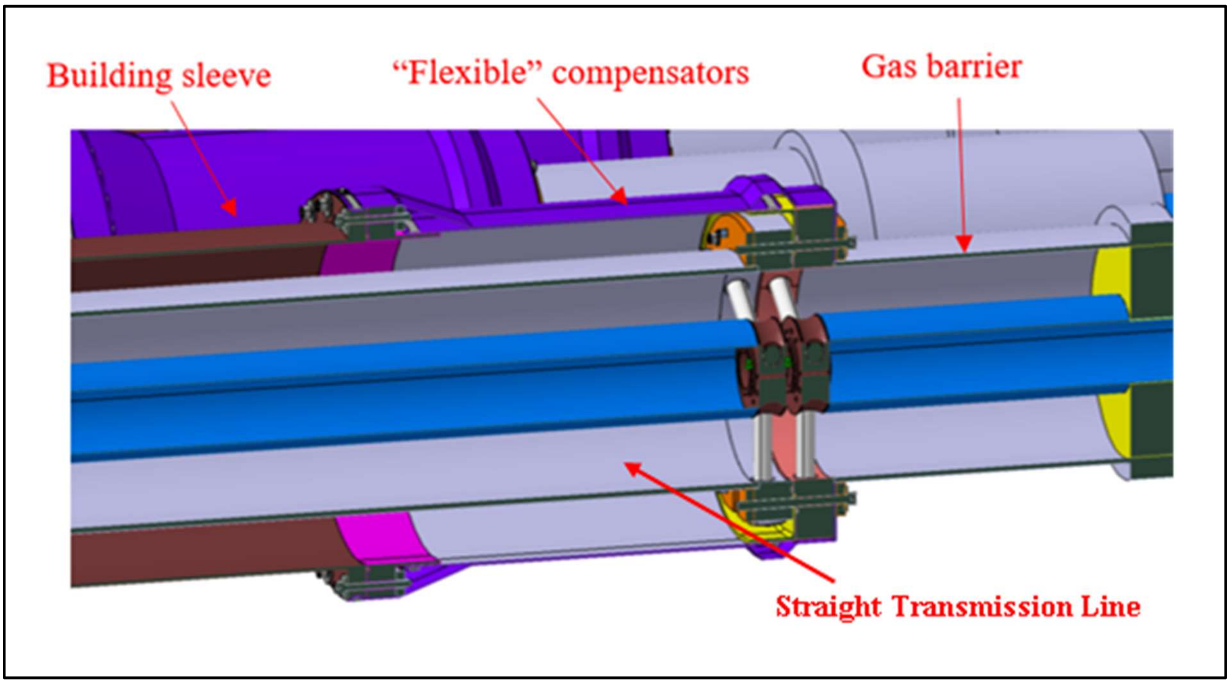

Figure 4: Section through Sleeve and Transmission Line Components

The transmission line components from the assembly hall up to the gas barrier in the gallery of the tokamak building have inner gas cooling with the outers of the transmission lines having trace water-cooling. The gas barrier and all other transmission line components in the gallery have the inner lines water-cooled and the outer transmission lines again have trace water-cooling.

The compensator connects between the sleeve and the transmission line gas barrier and is a component that ensures a safety function by being part of the last ITER confinement barrier. The safety boundary for the ICH system is the combination of the TL gas barrier and the compensator. The compensator has to withstand the thermal expansion of the transmission lines during operations and maintain the confinement in the case of an earthquake or fire.

The actual finally designed compensator, when installed at ITER, will have to fulfil all the SIC-2 safety classifications, which means that it needs to maintain confinement and limit exposure. The supporting functions for this include the management of pressure, mechanical impacts (seismic, load drops, etc.), fire detection/mitigation, etc., as well as any necessary monitoring to ensure confinement.

The SIC-2 criteria shall be considered but not be applied to the compensator in this case, as this contract is to determine if a suitable compensator design can be found, which potentially meets the SIC-2 requirements, and if this suggested design can actually be installed. A full SIC-2 impact and verification assessment will be made at a later date.

For further information, additional descriptions can be found in the following IC system documents:

- Ion Cyclotron Heating and Current Drive (ICH&CD) Subsystem Design Description Document [1]
- SRD-51 (ICH&CD) from DOORS [2]
- Leak Tight Solutions for the IC Wall Penetrations [3]

5.1.2 Design requirements

The present chapter specifies the requirements to be taken into account by the contractor to design the compensators, including the sealing system and the leak tightness tests. The contractor shall demonstrate compliance with all the requirements in the [DL2].

5.1.2.1 Dimensions, Shapes and Space Allocation

The compensators shall be compatible with the IC system design [1].

The distances between each of the flanges and the adjacent sleeve is extremely limited, approximately 2.5mm, and the distance to the gallery ceiling is restrictive. (Figure 5)

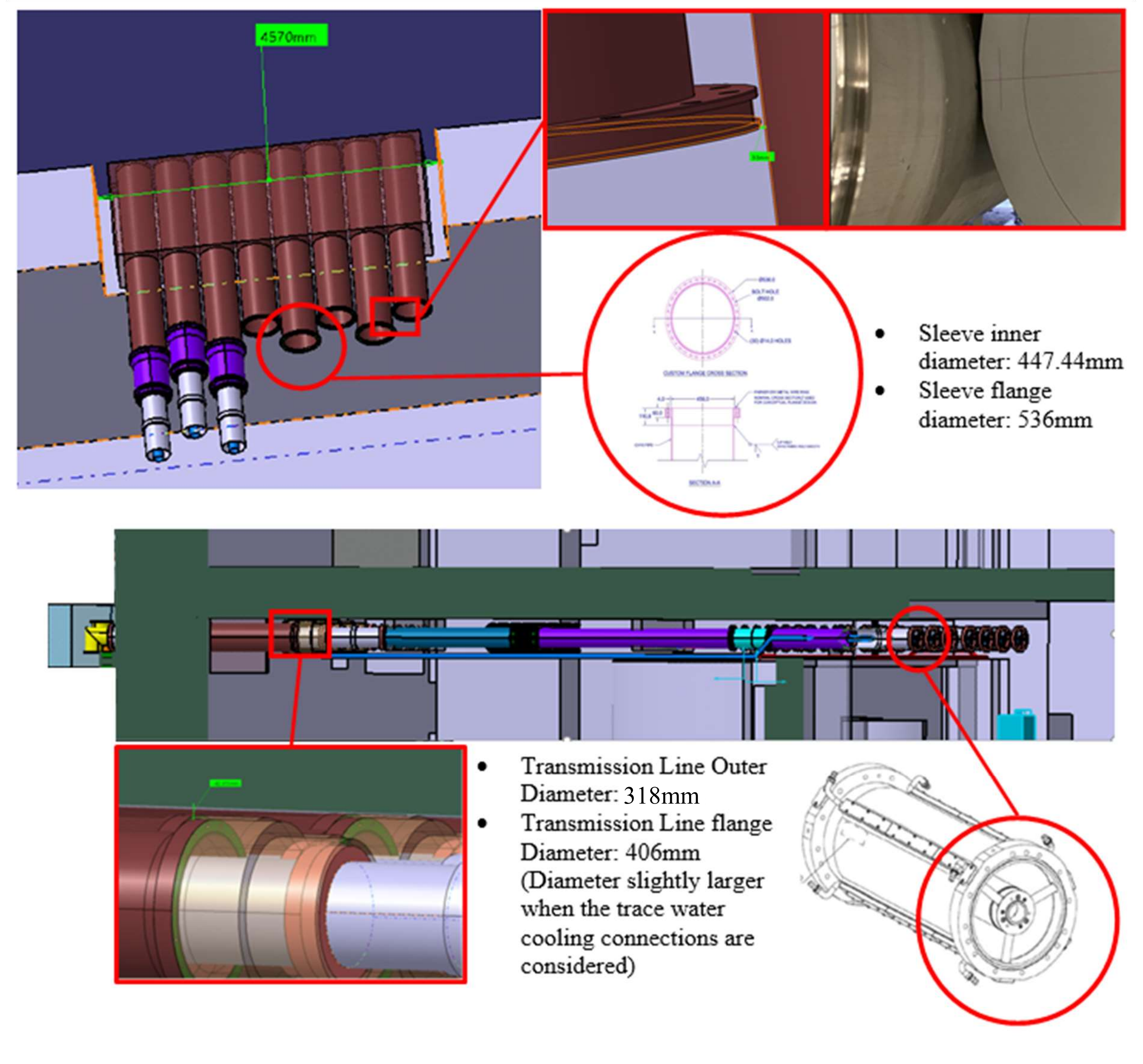

Figure 5: South Wall Penetration Dimensions

The design of the interface between the compensator and the transmission line components is also required. The contractor shall work with the IO to either adapt the flange of the transmission line gas barrier to accommodate the requirements of the compensator connections, or produce a connecting piece that will allow the connection of the transmission line gas barrier to the compensator.

Within the current IC system 3D model, the compensator has been implemented from the sleeve to the connection flange of the transmission line to the gas barrier.

In the following Figure 6:

- The transparent volume showing the expected area in which the compensator is likely to be implemented;
- The maximum available space to the ceiling for the installation of the compensator (The red dashed line).
- The flanges to which the compensator will be connected (The blue dashed lines).
- The sleeve flange details to which the compensator has to be connected at the sleeve end.
- The transmission line flange details to which the compensator has to connect.

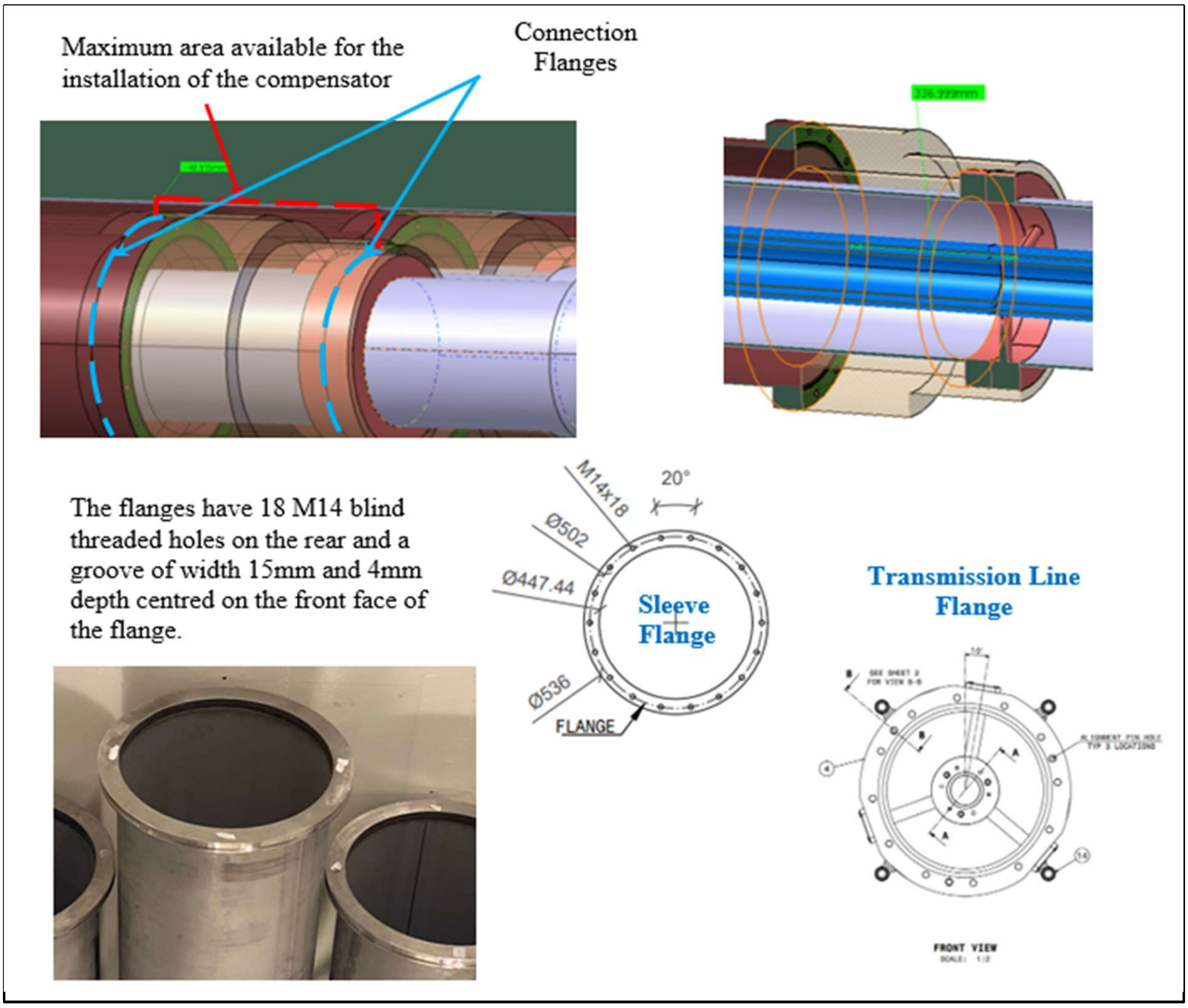

Figure 6: Compensator Space Availability with Transmission Line and Sleeve Flange Details

5.1.2.2 Sealing, Leak Tightness, Compression, Pressure and Temperature Requirements

The contractor shall design the compensator, as if were to be installed in ITER, and build a simplified mock-up of the ITER environment to test the compensator. The contractor shall then be able to demonstrate that the compensator is able to maintain the confinement through not only normal operational conditions but also through accidental events such as fire and earthquake.

The maximum pressure differential expected according to the System Load Specification used for the diagnostic system [18] is 20kPA during an ex-vessel LOCA III event in the gallery.

The overall leak rate provided in the overall open database [19] can be flowed down to define the acceptable leak rate for a single penetration, with the following approach adapted:

The mechanical penetration is the sleeve, which has an inner diameter of 447.44 mm and an area of 0.15724 m^2, with the transmission line fitting inside the sleeve with an outer diameter of 318mm and area of 0.0794226 m^2.

As part of the overall nuclear confinement, which fulfil the requirements under specific environmental conditions of normal or accidental events, the openings sealing shall contribute to the overall air tightness requirement of rooms, confinement zones or buildings.
Based on the information in the open database [19], the acceptable leak rate allotment is defined at a standard overpressure of 2000 Pa, which is, for the PBS 51 openings in B11, taken as 0.01 $m^3/h/m^2$. In determining the leakage requirement, only the pressure (Pa) is taken into account in the calculation.
Extrapolating the leak rate to different pressures from the AAR [20] using

$$LR_1 = LR_2 \times \sqrt{\frac{P_1}{P_2}}, \text{ where P > 300 Pa}$$

Therefore, the allowed leak rate for a single penetration, which is considered as being between the sleeve and the transmission line from the gallery (B11) to the assembly building (B13) shall be interpolated as follows:

a) In normal operation scenario with leak rate LR = LR per m^2 x cross sectional area (where the cross sectional area is the gap between the sleeve and the transmission line)

$$Leak\ Rate = 0.01 \times \frac{\sqrt{300}}{\sqrt{2000}} \times (0.15724 - 0.0794226) = 3.014 \times 10^{-4}\ @\ \Delta 300Pa$$

So to convert into standard unit *Pa.m³/s*, multiply by 100kPa, which is the absolute pressure outside that the leak discharges into, thus

$$Leak\ Rate = (1.9256 \times 10^{-4}) \times \frac{100000}{3600} = 0.00837 Pa.\frac{m^3}{s} = 0.0837 mbar.\frac{l}{s}$$

b) In the fire scenario

$$Leak\ Rate = 0.01 \times \frac{\sqrt{5000}}{\sqrt{2000}} \times (0.15724 - 0.0794226) = 1.23 \times 10^{-3}\ @\ \Delta 5000Pa$$

Converting in the same way as previously described

$$Leak\ Rate = (1.23 \times 10^{-3}) \times \frac{100000}{3600} = 0.0342Pa.\frac{m^3}{s} = 0.342mbar.\frac{l}{s}$$

c) In LOCA III scenario with ΔP 20 kPa

$$Leak\ Rate = 0.01 \times \frac{\sqrt{20000}}{\sqrt{2000}} \times (0.15724 - 0.0794226) = 2.46 \times 10^{-3}\ @\ \Delta 20000Pa$$

Converting in the same way as previously described

$$Leak\ Rate = (2.46 \times 10^{-3}) \times \frac{100000}{3600} = 0.0683Pa.\frac{m^3}{s} = 0.683mbar.\frac{l}{s}$$

Consequently, a maximum leak rate of 0.0837 mbar.l/s at all the delta pressures above, shall therefore be considered for the design.

The contractor shall achieve the requested leak rate. However, if this is not possible the contractor shall provide the maximum leak rate the compensator is able to achieve.

The contractor shall design the fastenings between the compensator and the sleeves and between the compensator and the transmission line gas barrier flanges, developing the interface with the transmission lines as necessary.

The contractor shall provide the method of demonstrating the leak tightness of the compensator, including the way it can be tested once the complete system is installed on the mock-up.

For the compensator installed in ITER, the confinement at the south wall penetration shall be maintained under the following conditions:

Movement

- 12.5mm movement in Normal Operations (average transmission line temperature of 65^{0}C)
- 131mm movement in a Fire Event (temperature around 600^{0}C in non-protected area).
  [Note: The compensator movement shall first be tested to ~45mm, which demonstrates the transmission lines movement if all the TLs are housed in a firebox where the temperature is reduced to 200^{0}C in the TL area]

Other Accidental Case

- Overpressure of 20kPa on the gallery side of the penetrations

5.1.3 Material Requirements

The materials currently defined at the South wall penetration are the following:

- Stainless steel 304L for the sleeves
- Aluminum for the outer of the transmission lines and transmission line gas barrier
- Copper for the inner of the transmission lines and the water pipework cooling
- Heavily borated concrete for the backfilling penetration material

Materials proposed by the contractor in the design shall be validated as acceptable by IO.

In interface from the compensator to the transmission line gas barrier flange is not yet defined. The contractor shall assess the solution and propose a design with the help of IO regarding the environment and equipment the compensator will be connecting to.

The contractor shall manufacture the associated compensator and the mock-up (see section 5) within the material chosen by IO based on [DL2] conclusions.

5.1.4 Simplified Load Considerations

(Note: this section is provided for information only as the compensator test article shall pass the tests detailed in section 5.1.8.)

The final compensators will be assessed against the load specification [6], with the following tables 1 and 2 summarizing the loads that affect the components at the South wall penetration.

No.	Single Load Event	Description
1	DW	Load due to the components self-weight
2	PresO	Water pressure during operation + air/gas pressure during operation
3	ThO	Thermal load during operation
4	SL1, SL2, SMHV	Seismic events (1)
5	Loss of power	Thermal stress due to structural temperature change
6	Helium leak in galleries	Pressure load in the galleries
7	Internal fire	
8	External loads acting on the nuclear buildings	Applicable to B11 51.TL penetrations
9	Hydrostatic test	Max pressure test in the cooling channel and in the TL section
10	System fault conditions	See chapter 6.18 of ITER_D_222QGL_v6.2.
11	ATMP	Atmospheric pressure
12	Bolt pre-tension	Load due to the different bolts

Table 1: Single Loads Applicable to the Components at the South Wall Penetration

(1) Contract only considering SL 1 events
SL 1 – category II (Likely event)
SMHV – Category III (very unlikely)
SL 2 - Category IV (Extremely unlikely)
Seismic requirement is defined by European Norms - EN 1998 Eurocode 8 Earthquake
LOCA – Loss of Cooling Accident (outside the Cryostat)

No.	Load Combinations	Description	No. of Events
1	DW, PresO, ThO, ATMP, Bolts pre-tension, VV Normal OP	Category I	30,000
2	DW, PresO, ThO, ATMP, Bolts pre-tension, VV Normal OP	Category I – Initiating event SL1	1
3	DW, PresO, ThO, ATMP, Bolts pre-tension, VV Normal OP	Category III – Initiating event LOCA gallery III	
4	DW, PresO, ThO, ATMP, Bolts pre-tension, VV Normal OP	Category III – Initiating event He in gallery	
5	DW, ATMP, room temperature, Bolts pretension	Category III – Initiating event hydrostatic test (water pressure max)	
6	DW, PresO, ThO, ATMP, Bolts pre-tension	Category IV – Initiating event internal fire.	

Table 2: Load Combinations Applicable to the Components at the South Wall Penetration

5.1.5 System Classification

All the test articles to be produced as per the present specification are classified Quality Class 3. They are not safety classified.

5.1.6 Manufacturing requirements

The contractor shall manufacture/procure the following components:

- Compensator:
  - Five compensators shall be used for the tests described in chapter 5.1.8. One compensator will be used for the first phase of the contract and if this is successful, following the HP, a further four will be used for the second phase. The compensators shall then be delivered to IO following the completion of the work;
  - One compensator shall be delivered to the IO without being tested;
- Sealing assemblies, as determined by the design and test requirements, for the Compensator:
  - The contractors shall procure enough sealing assemblies for performing all the tests foreseen in chapter 5.1.8;

- Mock-up test assembly
  - The contractor shall design and procure the necessary equipment to produce a mock-up area that can firstly be used to demonstrate and test of the first compensator and secondly to validate the assembly and installation sequence. [DL4 / DL5].
  - The mock-up assembly for the second phase of the contract shall also include all the necessary installation tooling identified during the definition of the installation process.

Note: All parts manufactured shall be identified and delivered to the IO (see section 12 for delivery requirements).

The contractor shall issue the manufacturing report [DL3] before testing the components. The contractor shall control that the components that have been manufactured in accordance with the drawings approved in [DL2], and the inspections performed shall be reported in the [DL3]. The standard components (flanges, seals, bolts, etc.) shall be procured in accordance with the BOM given in [DL2].

All potential non-conformities shall be submitted to IO for acceptance according to procedure [7].

Note: If welds are implemented on the parts (flanges) to be manufactured to perform the different tests, the contractor shall ensure that the welds will be compatible with the leak rate requirements as given in section 5.1.2.2.

5.1.7 CE Markings

CE Markings shall be implemented in accordance with European directives requirements. The list of products for which the CE marking may be applicable is available on the following web-site: https://ec.europa.eu/growth/single-market/ce-marking/manufacturers_en.

Comprehensive guidance on the implementation of EU product rules can be found in the so-called Blue Guide (https://ec.europa.eu/docsroom/documents/18027/).

Except where otherwise specified, IO shall not be considered to bear the role of manufacturer.

5.1.8 Testing Requirements

In order to validate the design of the compensator assemblies, the contractor is responsible for the design and manufacturing of a mock up for the assembly, test and validation of the compensator.

If the initial compensator tests fail, then the contractor may propose an alternative solution, otherwise the contract will be terminated.

If the initial compensator tests are successful then an extension or additional mock up for validating the assembly and installation of the compensators shall be provided. The design(s) shall be approved by IO and meet the functional test purposes.

The contractor is free to implement the necessary technical solutions to meet the requirements and will submit the mock-up design to the IO for validation. This included any necessary installation displacement requirements that are needed to allow the compensator to work correctly over its range. The mock-up used to validate the functionality of the compensator shall include at least:

- 1x mock-up sleeve with flange (reduced length)
- 1x mock-up TL with flange (reduced length)
- 1x mock-up TL gas barrier with flange (reduced length)
- 1x compensator
- 1x sealing assembly (as determined needed by design)
- Any necessary supporting pieces

(If the compensator tests are successful then it is expected that the mock up will be expanded for the assembly and installation validation tests.)

The mock-up used to validate the assembly and installation sequence of the compensators shall include at least:

- 4x mock-up sleeves with flanges (reduced length)
- 4x mock-up TLs with flanges (reduced length)
- 4x mock-up TL gas barrier with flange (reduced length)
- 4x compensators
- 4x sealing assemblies (as determined needed by design)
- Part representing the ceiling
- Any necessary supporting pieces (considering the equipment is at height)

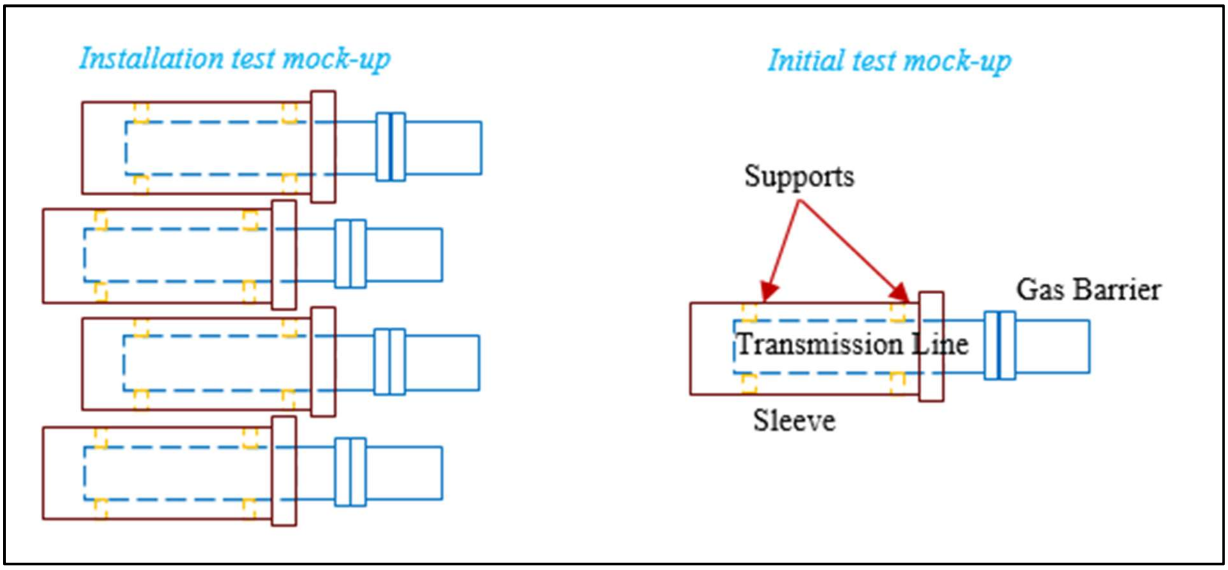

Figure 7:Mock-up Layout Proposals

The types of tests shall be performed on the compensator validation mock-up:

- Pressure tests
- Leak tightness tests
- Thermal Cycling test
- Movement tests

5.1.8.1 Pressure Tests

5.1.8.1.1 On Mock-up

The contractor shall mimic the accidental overpressure on one side of the compensator (gallery side) up to a ΔP = 0.02 MPa. The contractor shall perform the pressure test at 20°C and shall maintain and monitor the pressure during at least 1 hour.

5.1.8.2 Leak Tightness Tests

These tests shall be performed after the pressure test described in chapter 5.1.8.1

5.1.8.2.1 On Mock-up

The contractor shall provide the test plan for the testing of the compensators.

5.1.8.3 Mechanical Tests

These tests shall be performed after the pressure and leak tests described in chapter 5.1.8.1 and 5.1.8.2.

5.1.8.3.1 On Mock-up

The tests shall mimic the thermal expansion of the transmission lines during operations, i.e. a movement of 12.5mm over 1,000 cycles to demonstrate that the compensator is able to withstand the operational expectations. As the displacement of the transmission lines in operations will be slow, the test for the cycling rate will be discussed with the contractor at the kick off meeting.

Following the tests, the leak tightness shall then be checked as per the tests agreed and validated in chapter 5.1.8.2.

Finally, the transmission line shall be moved 135mm (toward the assembly building) to demonstrate the compensator is able to withstand the transmission line displacement in the case of a fire.

The leak tightness shall then again be checked as per the tests agreed and validated in chapter 5.1.8.2.

5.1.8.4 Thermal Cycling Tests

5.1.8.4.1 On Mock-up

The test for the mimicking of the normal operation thermal cycling will be discussed with the contractor at the kick off meeting. The contractor shall also mimic the conditions that a fire would have on the compensator when it is exposed to 200^0C.

5.1.8.5 Factory Acceptance Tests (FAT) Criteria

5.1.8.5.1 During Pressure Tests

The Supplier shall perform the described testing before shipping the components to the IO. The Supplier shall provide support necessary to test the component/system and to demonstrate that the required performance meets the given criteria.

Acceptance criteria 1: Leak test results

The contractor shall monitor and provide results of the leak rate during the pressure tests, noting that a desired leak rate detailed in section 5.1.2.2.

Acceptance criteria 2: The pressure shall remain constant during 1 hour (within the tolerance of the contractor measurements equipment).

5.1.8.5.2 During Mechanical Tests

The contractor shall check the integrity of the compensator before the tests to ensure no failures or cracks. These checks shall be repeated after the tests.

The contractor shall also provide the initial leak rate measurements before the tests and the subsequent leak rate measurements following the tests. Leak rate measurements shall be identical (within the instruments tolerances).

5.1.8.6 Final Acceptance

The components shall be handed over to the IO when they have been delivered in accordance with this Technical Specification and once all related documentation has been accepted by the IO, and a Certificate of Final Acceptance has been issued (Final Acceptance). The Certificate of Final Acceptance shall be signed by both the IO and the Supplier, after the definitive acceptance of each component and its related documentation.

Ownership of the components shall be transferred from the Supplier to the IO upon Final Acceptance at the ITER Site. The transfer of ownership to the IO shall not relieve the Supplier of its obligations under this Contract in case of non-conformities of the components for the duration of the warranty period.

5.1.9 Delivery Time

The maximum expected duration of the contract is 12 months. The due dates of the deliverables are detailed in section 8.

6 Location for Scope of Work Execution

The Contractor shall perform the work at their own choice of location.

7 IO Documents & IO Free issue items

No input nor free issue item is expected from IO

8 List of deliverables

8.1 General

In the initial phase of this two-stage contract, the supplier shall provide the IO with a compensator designs compliant with the technical requirements presented in section 5. The supplier shall also manufacture the compensators and prepare any necessary mock-up(s) to test the compensators. The tests shall be performed in accordance with a procedure agreed with, and witnessed by, IO.

In the second phase of the contract, if an appropriate compensator design is found and approved in the first phase of the contract, the work is to validate a suitable installation process for the compensators at the South wall penetration.

Following the completion of the work, all the components and mock-ups used in the contract shall then be delivered to the ITER site.

8.2 Responsibilities and Contract Execution

The responsibilities between the Parties is summarised in Table 1 (below) and is further detailed in the following sections.

Activity	**IO**	**Supplier**
Design	A	R
Manufacturing	A	R
Assembly and tests	W / A	R
Delivery	A	R

Table 3: Summary of the Responsibilities between the IO and the Supplier

R = Responsible for organizing, performing and for the content

A = Review/Comment/Accept/Approve

W = Witness the operation

IO is responsible for:

- The overall contract monitoring.
- Providing the necessary input data to the contractor on time, as well as providing the necessary clarifications upon the contractor's request.
- Providing support, if requested
- Performing the verification and the integration of the compensators design within the IO environment
- Reviewing the deliverables and other technical documents produced by the contractor

The contractor is responsible for:

- The maintenance of Quality Procedures as specified in the following chapters and scheduled throughout the contract.
- Producing the requested documentation, as specified in section 8.6.
- The production of the design (3D and drawings) of the compensators and the mock-up;
- The production of the test plan detailing the tests and measurements to be performed;
- The manufacturing of the components in compliance with manufacturing drawings;
- The production of the manufacturing report;
- Performing all the tests allowing the validation of the assembly, and the leak rate measurements;
- Inviting the IO to witness the tests and measurements;
- Deliver all the deliverables listed in section 8.6 within the due dates specified in Table 4;
- Organizing meetings and producing minutes of meetings as specified in section 11;
- The delivery of the components on ITER site.
- Submitting Background Intellectual Property (BIP) provisions.

8.3 Design and Related Activities

After delivery of the quality plan [DL1] (see requirements in section 11), the Supplier shall provide the IO with the design package [DL2].

The design package shall include:

- A design report detailing:
  - The design of the compensators;
  - The design of the fittings to seal the compensators;
  - The design of the transmission line interface flange;
  - The choice of the seals, bolts and any other parts that are linked to the installation of the compensators
  - The design of the mock-up to verify the assembly and the leak tightness of the compensator, including details of the proposed assembly sequence and the tests to be performed. (see section 5.1.8 for tests details)
  - A chain of dimensions justifying the functional tolerances (for manufacturing and assembly)
- The following CAD packages (STEP files for 3D models and PDF for 2D drawings) for each product:
  - Compensator assembly – including flanges and sealing system
  - Mock-up(s) for compensator tests
  - Tools for the installation process

8.4 Manufacturing of the Equipment

The contractor shall manufacture the different assemblies, and mock-up(s), based on the drawings approved by IO, which are to be detailed in the design package [DL2].

The number of components to be manufactured is detailed in section 5.1.8.

The manufacturing report shall be completed and delivered [DL3] after completion of the manufacturing and the different inspections validating the tolerances given in the manufacturing drawings [DL2].

Following successful testing of the first stage of the contract [DL4], the contractor shall propose and demonstrate the installation process for the compensators, using the appropriate mock-up (section 5.1.8) and complete further leak tightness tests. [DL5]

Following either the failure of the first stage of the contract, or the completion of the full contract, the contractor shall pack and deliver the different components to the ITER site and produce the delivery report [DL6] according to requirements detailed in section 12.

8.5 Assembly and Testing

The main aim of the mock-up(s) is to validate, with tests, the assembly and installation feasibility and the leak-tightness of the compensator assemblies. The contractor shall perform the tests and issue the tests report [DL4] detailing:

- The steps needed to complete the assembly. The aim is to verify the different tolerances for centering, insertion and the use of tools if needed.
- The leak rate measurements after pressure tests and thermal cycling.
- Mechanical stroke tests to ensure the compensator does not fail due to the operational movement of the transmission lines.
- Mechanical stroke tests to ensure the compensator does not fail in the case of movement of the transmission line due to a fire

The tests shall be performed in accordance to the procedures produced in [DL2] approved by IO.

The tests acceptance criterion are defined in section 5.1.8.

8.6 Deliverables

DL#	Deliverable title	Deliverable description	Due date (in months)
DL1	Quality plan	Refer to section 11	T0+0.5
DL2	Design package {Design report + 3D model (step files + BoM + manufacturing and assembly drawings}	The design report shall detail the compensator design with interface components (sleeves and transmission lines) as well as the mock-ups design. 3D model and assembly and manufacturing drawings (with BoM) shall be also delivered.	T0+2
DL3	Manufacturing report	The manufacturing report shall validate the manufacturing of the different components. Manufacturing controls shall confirmed that the components have been manufactured according to the drawings in DL2.	T0+5
DL4	Test report	The test report shall detail the different tests performed and record the different measurements as specified in section 5.1.8.	TO+7
DL5	Installation Process and test report	The installation process shall be determined, using the appropriate mock-up, to validate that the compensators can indeed be installed in the ITER environment. The leak tightness tests will be repeated and a report generated to demonstrate that the installation process works.	TO+10
DL6	Delivery	The final installation and test report shall be delivered along with the manufactured components to the ITER site, with a release note. (See all requirements in section 5.)	T0+12

Table 4: List of Deliverables (T0 is the date of the kick off meeting)

The supplier shall prepare their document schedule based on the above and using the template available in the GM3S Ref [17] appendix II (click here to download).

9 Quality Assurance requirements

The present contract is classified QC3, Quality Plan [DL1] is needed. The "Manufacturing and Inspection Plan" MIP is not mandatory as per "Quality Classification Determination" [12]. Only the manufacturing report [DL3] shall be delivered.

Quality Requirements shall be in accordance with the "ITER Procurement Quality Requirements" [11]. The ITER Quality Assurance Program shall be applied to all the work under this Contract. The ITER QA Program is based on IAEA Safety Standard GS-R-3 and on conventional QA principles and integrates the requirements of the INB Order dated 7 February 2012 [5] on the quality of design, construction and operation in Basic Nuclear Installation. For this purpose, the Supplier and Subcontractors carrying out contracts placed under this Contract shall be in compliance with the QA requirements under the relevant ITER QA classifications, the requirements of the INB Order and shall have an IO approved QA Program or an ISO 9001 accredited quality system, complemented with the above mentioned requirements.

Prior to commencement of any work under this Contract, a "Quality Plan" (QP) [13] shall be produced by the Supplier and Subcontractors and submitted to the IO for approval, describing how they will implement the ITER Procurement Quality Requirements.

Prior to commencement of any manufacturing, a "Manufacturing and Inspection Plan" (MIP) [14] shall be produced by the Supplier and Subcontractors and approved by the IO, who will mark up any intended intervention point. MIPs are used to monitor Quality Control and acceptance tests during the execution of the Contract. It should be noted that interventions additional to those required in this Technical Specification may be included on the MIP by the IO. The right of the IO listed above shall apply in relation to any Subcontractor and in this case the IO will operate through the Supplier. The overseeing of the quality control operation by the IO shall not release the Supplier from his responsibility in meeting any aspect of this Technical Specification.

Subcontractors not performing Critical Quality Activities (i.e. activities that if not performed correctly may affect safety, functionality or reliability) may be exempted from the requirement to supply Quality Plans and Manufacturing & Inspection Plans, subject to agreement by the IO.

All requirements of this Technical Specification and subsequent changes proposed by the Supplier during the course of execution of this Contract are subject to the Deviation Request process described in "Contractors Deviations and Non-conformities Procedure" [7].

Documentation developed as the result of this Contract shall be retained by the Supplier for a minimum of 5 years and then may be discarded at the direction of the IO. The use of computer software to perform a safety basis task activity such as analysis and/or modelling, etc. shall be reviewed and approved by the IO prior to its use, in accordance with "Quality Assurance for ITER Safety Codes Procedure" [15].

In case of Contracts concerning SIC components and/or a Safety Related Activity, or PIC and/or Protection Related Activities, the Quality Assurance Programme of the Supplier shall comply with the requirements of the INB Order dated 7 February 2012 [5] and the subsequent ASN decisions linked to this Order. For this purpose, the Supplier and Subcontractors carrying out contracts placed under the Contract shall be in compliance with the QA requirements under the relevant QA classifications as defined in "Quality Classification Determination" [12] and additional requirements of the INB Order dated 7 February 2012 [5] and the subsequent ASN decisions linked to this Order.

In particular for SIC, the IO, as the Nuclear Operator, will supervise the whole production cycle of the Supplier and Subcontractors in accordance with the document "Overall supervision plan of the chain of Suppliers for Safety Important Components, Structures and Systems and Systems and Safety Related Activities" [16], which shall be identified in the MIP [14].

10 Safety requirements

The present task is not a Protection Important Activity (PIA).

However, the contractor needs to appreciate the requirements for PIA as described below.

ITER is a Nuclear Facility identified in France by the number-INB-174 ("Installation Nucléaire de Base").

For Protection Important Components and in particular Safety Important Class components (SIC), the French Nuclear Regulation must be observed, in application of the Article 14 of the ITER Agreement.

In such case the Suppliers and Subcontractors must be informed that:

- The Order 7th February 2012 [5] applies to all the components important for the protection (PIC) and the activities important for the protection (PIA).
- The compliance with the INB-order must be demonstrated in the chain of external contractors.
- In application of article II.2.5.4 of the Order 7th February 2012 [5], contracted activities for supervision purposes are also subject to a supervision done by the Nuclear Operator.

For the Protection Important Components, structures and systems of the nuclear facility, the Supplier shall ensure that a specific management system has to be implemented by any Supplier and Subcontractor working on Protection Important Activities, following the requirements of the Order 7th February 2012 [5] on the basis of activities defined and executed by the Supplier and Subcontractor. This system could be included in the Quality Plan, as set out in Section 9.

11 Specific General Management requirements

The specific general management requirements taken from GM3S section 6 [17] applies with the below specific requirement amendments noted:

11.1 Contract Gates

In addition to the contract gates as defined in the specific general management requirements taken from GM3S [17] section 6.1.5, the scope of work calls for a contract gate for the completion of the design and test of the compensator, as defined in section 5 of this document.

11.2 CAD design requirements

This contract requires CAD activities where the specific general management requirements taken from GM3S [17] section 6.2.2.2 applies

12 Delivery of Equipment used in Contract

12.1.1 Requirements for Labelling, Cleaning, Packaging, Handling, Shipment and Storage

12.1.1.1 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 components shall be fitted with the required accelerometers or other sensors and shall be packed as defined below.

The equipment shall be subject to control and inspection, as defined below.

12.1.1.2 Labelling and Traceability

All components and the main subcomponents shall be clearly marked in a permanent way and in a visible place with the IO official numbering system according to the document "ITER Numbering System for Components and Parts" [8]

For simplicity purpose, IO will provide the identification numbers to the contractor.

12.1.1.3 Cleaning

During cleaning, particular attention shall be given to the removal of weld spatter, debris and other foreign matter. Final cleaning shall ensure effective cleaning without damage to the surface finish, material properties or, if metal, metallurgical structure of the materials. The Supplier shall submit to the IO the proposed cleaning procedure for approval/acceptance.

12.1.1.4 Package and Handling

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

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

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

Each shipment shall be accompanied by a Delivery Report [DL6] shall be prepared by the Supplier, stating as a minimum:

- The packing date;
- The full address of the place of delivery and the name of the person responsible to receive the package, as well as of the Supplier's name and full address;
- Bill of Materials
- Security Measures
- Release Note [9];
- Packing List;
- Material Safety Sheet;
- The declaration of integrity of the package;
- The declaration of integrity of the components;
- Any additional relevant information on the status of the components.

The Delivery Report [DL6] shall be signed by a representative of the IO and its Supplier. The signature by the IO of the Delivery Report prior to shipment represents a Hold Point (HP).

12.1.1.5 Shipment, Transportation and Delivery to the ITER Site

The components shall exclusively be delivered to the ITER Site using the ITER Global Logistic Provider (DAHER) under the responsibility of the Supplier.

Before the shipment, a Release Note shall be prepared in accordance with the "Contractor Release Note" [9] and approved by the IO.

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

- The integrity of the package, including identifying visible damage;
- The number and type of components contained in the shipment;
- The enclosed documentation;
- The reading of the accelerometers or other sensors;
- The integrity of the components.