外部委託業者の募集

References: IO/24/OT/10029715/JPK

“Antenna Transmission Lines Interface Section (ATLIS) prototype and series manufacturing"

（アンテナ伝搬ラインインターフェースセクションプロトタイプとシリーズ品の製造）

IO 締め切り 2024 年 10 月 31 日(木)

〇はじめに

本事前情報通知（PIN）は、作業契約の入札授与および実行につながる公開入札調達プロセスの最初のステップです。

本文書の目的は作業範囲と入札プロセスに関する技術的な内容の基本的な要約を提供することです。

国内機関は、次回の入札に先立って、これらのサービス/工事を提供することができる企業、機関またはその他の団体が入札の詳細を事前に通知する前に、この情報を公表するよう求められます。

〇背景

ITER は平和利用の核融合発電の科学的および技術的な実現可能性の実証を目的とした、国際共同研究開発プロジェクトです。ITER 機構の 7 つのメンバーは、;欧州連合（EURATOM が代表）、日本、中華人民共和国、インド、大韓民国、ロシア連邦、および米国です。

ITER の敷地はフランス南東部のブーシュデュローヌ地区にあり、ITER 本社（HQ）もあるフランス CEA サン・ポール・レ・デュランス に近いところに位置しています。詳細については、ITER のウェブサイト http://www.iter.org を参照して下さい。

〇作業範囲

現在の入札プロセスは、アンテナ伝送ラインインターフェースセクション（ATLIS）のプロトタイプおよびシリーズ生産に関連するサービスおよび供給契約の確立を目的としています。この契約の範囲と目的は、二つの異なる部分に分かれています：

- 第一部は、ATLIS（アンテナ伝送ラインインターフェースセクション）のプロトタイプの設計開発、製造、試験を要求するもので、これは確定的な部分（フェーズ1）です。
- 契約の第二部は任意（フェーズ2）で、フェーズ1の作業が成功裏に完了した後にITERによって発注されます。第二部では、ATLISのシリーズ生産の製造および試験、並びにITERサイトへの納品が含まれます。

この範囲は、ATLIS（アンテナ伝送ラインインターフェースセクション）のプロトタイプおよびシリーズ生産の設計開発、製造、試験を提供することを目的としています。フェーズ1ではATLISプロトタイプ（1 x ATLISプロトタイプ）の納品が行われ、フェーズ2ではATLISパッケージ（ATLISユニットx 8）の納品が行われ、どちらもインコタームズDAP ITERサイトに基づいてITERサイトへ出荷されます。

アンテナ伝送ラインインターフェースセクション（ATLIS）は、核安全のための安全重要クラス1（SIC-1）および耐震クラスを有する保護重要コンポーネント（PIC）であり、その設置は保護重要活動（PIA）に該当します。本契約の品質クラスはQC1です。

作業はオフサイトで実施されます。

〇調達プロセスと目的

目的は、競争入札プロセスを通じて供給契約を落札することです。
この入札のために選択された調達手続きは公開入札手続きと呼ばれます。
オープン入札手順は、次の 4 つの主要なステップで構成されています。

- ステップ 1-事前情報通知（PIN）
  事前情報通知は公開入札プロセスの第一段階です。IO は、関心のある企業、機関又はその他の団体に事前に入札機会について通知するために、国内機関に対し、今後の入札に関する情報を公表するよう正式に要請します。

  特に注意:
  関心のある候補企業は、IO Ariba の電子調達ツール 「IPROC」 に登録してください（まだ登録していない場合）。手順については、https://www.iter.org/fr/proc/overview を参照してください。

  Ariba (IPROC) に登録する際には、お取引先様に最低 1 名の担当者の登録をお願いします。この連絡担当者は、提案依頼書の発行通知を受け取り、必要と思われる場合は入札書類を同僚に転送することができます。

- ステップ 2-入札への招待（ITT）
  事前指示通知（PIN）の公表から 14 日以内に、入札への招待（ITT）が公告されます。この段階では、PIN を見た関心のある入札者が入札書類を入手し、入札説明書に従って提案書を作成して提出することができます。
  特に注意:
  このツールに登録されている企業のみが入札に招待されます。

- ステップ 3-入札評価プロセス
  入札者の提案は、IO の公平な評価委員会によって評価されます。入札者は、技術的範囲に沿って、かつ、入札への招待 (ITT)に記載された特定の基準に従って作業を実施するために、技術的遵守を証明する詳細を提供しなければなりません。

- ステップ 4-落札

認定は、公開されている入札への招待（ITT)に記載されている、コストに見合った最適な価格または技術的に準拠した最低価格に基づいて行われます。

〇概略日程

概略日程は以下の通りです：

マイルストーン	暫定日程
事前指示書（PIN）の発行	2024 年 10 月 24 日
関心表明フォームの提出	2024 年 10 月 31 日
入札への招待（ITT）の発行	2024 年 11 月 16 日
明確化のための質問（もしあれば）	2025 年 1 月 6 日
入札提出	2025 年 1 月 25 日
入札評価と契約授与	2025 年 2/3 月
契約調印	2025 年 3/4 月

〇契約期間と実行

ITER機構は2025年5月ごろに授与する予定です。予想される契約期間は33か月の予定です。

〇経験

入札者は付属書 I に詳述された作業範囲に関連する技術的および産業上の経験を実証する必要があります。

ITERでの作業に使われる言語は英語です。プロレベルの流暢さが求められます（話す、書く両方)。

〇候補

参加は、個人またはグループ/コンソーシアムに参加するすべての法人に開放されます。法人とは、法的権利及び義務を有し、ITER 加盟国内に設立された個人、企業又は機構をいいます。ITER 加盟国は欧州連合(EURATOM メンバー)、日本、中華人民共和国、インド共和国、大韓民国、ロシア連邦、アメリカ合衆国です。

法人は、単独で、またはコンソーシアムパートナーとして、同じ契約の複数の申請または入札に参加することはできません。共同事業体は、恒久的な、法的に確立されたグループ又は特定の入札手続のために非公式に構成されたグループとすることができます。

コンソーシアムのすべての構成員(すなわち、リーダーと他のすべてのメンバー)は、ITER 機構に対して連帯して責任を負います。

コンソーシアムとして許可されるために、その点で含まれる法人はコンソーシアムの各メンバーをまとめる権限をもつリーダーをもたなければなりません。このリーダーはコンソーシアムの各目メンバ

一のために責任を負わなければなりません。

指名されたコンソーシアムのリーダーは、入札段階で、コンソーシアムのメンバーの構成を説明する予定です。その後、候補者の構成は、いかなる変更も ITER 機構に通知することなく変更してはなりません。かかる認可の証拠は、すべてのコンソーシアムメンバーの法的に授権された署名者が署名した委任状の形式で、しかるべき時期に IO に提出しなければなりません。

どのコンソーシアムメンバーも IPROC に登録する必要があります。
【※　詳しくは添付の英語版技術仕様書「**Antenna Transmission Lines Interface Section (ATLIS) prototype and series manufacturing**」をご参照ください。】
ITER 公式ウェブ　http://www.iter.org/org/team/adm/proc/overview からもアクセスが可能です。

「核融合エネルギー研究開発部門」の HP：　http://www.fusion.qst.go.jp/ITER/index.html
では ITER 機構からの各募集（IO 職員募集、IO 外部委託、IO エキスパート募集）を逐次更新しています。ぜひご確認ください。

イーター国際核融合エネルギー機構からの外部委託
に関心ある企業及び研究機関の募集について

＜ITER 機構から参加極へのレター＞

以下に、外部委託の概要と要求事項が示されています。参加極には、提案された業務に要求される能力を有し、入札すべきと考える企業及び研究機関の連絡先の情報を ITER 機構へ伝えることが求められています。このため、本研究・業務に関心を持たれる企業及び研究機関におかれましては、応募書類の提出要領にしたがって連絡先情報をご提出下さい。

china eu india japan korea russia usa
Route de Vinon-sur-Verdon - CS 90 046 - 13067 St Paul Lez Durance Cedex - France

October 10, 2024

To: Domestic Agencies (DAs)

IO Tender Reference: IO/24/OT/10029715/JPK

Title: Antenna Transmission Lines Interface Section (ATLIS) prototype and series manufacturing

Subject: Prior Indicative Notice (PIN)

Dear colleagues,

The ITER Organization intends to launch an Open Tender process in the coming weeks as indicated above and in accordance with the details in the attached Prior Indicative Notice (PIN). In this regard, and to provide some introductory information about the forthcoming tender, we kindly request the attached PIN to be published on your DA website with immediate effect for a period of 15 working days.

The advance notification is to alert companies, institutions, or other eligible entities to the forthcoming tender, and provide information to promote healthy competition, allowing interested parties time to decide whether to participate in the tender or not.

Please could you kindly acknowledge receipt of this e-mail and confirm once the PIN is published on your website.

Yours sincerely

JunHyung PARK
Procurement Officer
Procurement Division

Contact: JunHyung PARK – Procurement Division - Tel. +33 (0)4 42 17 61 59 - e-mail: junhyung.park@iter.org

PRIOR INDICATIVE NOTICE (PIN)

OPEN TENDER SUMMARY

IO/24/OT/10029715JPK

For

Antenna Transmission Lines Interface Section (ATLIS) prototype and series manufacturing

Annexes
Annex I– Expression of Interest Form
Annex II – Technical Specifications

Abstract

The purpose of this summary is to provide prior notification of the IO's intention to launch a competitive Open Tender process in the coming weeks. This summary provides some basic information about the ITER Organisation, the technical scope for this tender, and details of the tender process for the procurement of the services related to the design development, manufacturing, and testing of ATLIS (Antenna Transmission Line

Interface Section) prototype. After the successful completion of the prototype, the IO intends to carry out the manufacturing and testing of the ATLIS series of productions and delivery to the ITER site.

1 Introduction

This Prior Indicative Notice (PIN) is the first step of an Open Tender (OT) Procurement Process leading to the award and execution of a Contract.

The purpose of this document is to provide a basic summary of the technical content in terms of the scope of work, and the tendering process.

2 Background

The ITER project is an international research and development project jointly funded by its seven Members being, the European Union (represented by EURATOM), Japan, the People's Republic of China, India, the Republic of Korea, the Russian Federation and the USA. ITER is being constructed in Europe at St. Paul–Lez-Durance in southern France, which is also the location of the headquarters (HQ) of the ITER Organization (IO).

For a complete description of the ITER Project, covering both organizational and technical aspects of the Project, visit www.iter.org.

3 Scope of Work

The present tender process aims to establish a Service and Supply Contract related to the Antenna Transmission Lines Interface Section (ATLIS) prototype and series of productions. The scope and purpose of this contract has two distinct parts:

- The first part requires the design development, manufacturing, and testing of an ATLIS (Antenna Transmission line Interface Section) prototype which is a firm part (Phase 1).
- The second part of the contract is optional (Phase 2). It will be released by the ITER based on the successful completion of the first part of the work. In this second part, the work shall cover the manufacturing and testing of the ATLIS series production and delivery to the ITER site.

This scope intends to deliver design development, manufacturing, and testing of the ATLIS (Antenna Transmission Line Interface Section) prototype and series of productions. The delivery of the ATLIS prototype (1 x ATLIS prototype) in Phase 1 and the full ATLIS Package (Atlis units x 8) in Phase 2 shall be shipped to the ITER site respectively based on the Incoterms DAP ITER site.

The Antenna Transmission Lines Interface Section (ATLIS) is a Protection Important Component (PIC) with a Safety Important Class 1 (SIC-1) for nuclear class safety and Seismic class and its installation is a Protection Important Activity (PIA). The Quality class under this contract is QC1.

The work shall be performed off-site.

4 Procurement Process & Objective

The objective is to award a Service Contract through a competitive bidding process.

The Procurement Procedure selected for this tender is called the **Open Tender** procedure.

The Open Tender procedure is comprised of the following four main steps:

- Step 1- Prior Information Notice (PIN)

  The Prior Information Notice is the first stage of the Open Tender process. The IO formally invites interested Suppliers to indicate their interest in the competitive process by returning to the Procurement officer in charge the attached "Expression of Interest and PIN Acknowledgement" by the date indicated under the procurement timetable.

  Special attention:

  Interested tenderers are kindly requested to register in the IO Ariba e-procurement tool called "IPROC". You can find all links to proceed along with instruction going to: https://www.iter.org/fr/proc/overview.

  When registering in Ariba (IPROC), suppliers are kindly requested to nominate at least one contact person. This contact person will be receiving the notification of publication of the Request for Proposal and will then be able to forward the tender documents to colleagues if deemed necessary.

- Step 2 - Invitation to Tender

  After at least 15 working days of the publication of the PIN, normally the Request for Proposals (RFP) will be published on our digital tool "Iproc". This stage allows interested bidders who have indicated their interest to the Procurement Officer in charge AND who have registered in IPROC to receive the notification that the RFP is published. They will then prepare and submit their proposals in accordance with the tender instructions detailed in the RFP.

  Only companies registered in this tool will be invited to the tender.

- Step 3 – Tender Evaluation Process

  Tenderers proposals will be evaluated by an impartial evaluation committee of the IO. Tenderers must provide details demonstrating their technical compliance to perform the work in line with the technical scope and in accordance with the particular criteria listed in the RFP.

- Step 4 – Contract Award

  A Service contract will be awarded on the basis of the Best Value For Money methodology according to the evaluation criteria and methodology described in the RFP.

Procurement Timetable

The tentative timetable is as follows:

Milestone	Date
Publication of the Prior Indicative Notice (PIN)	10th October 2024
Submission of expression of interest form	31st October 2024
Invitation to Tender (ITT) advertisement	15th November 2024
Clarification Questions (if any) and Answers	6th January 2025
Tender Submission	25th January 2025

Tender Evaluation & Contract Award	February /March 2025
Contract Signature	March/April 2025

5 Quality Assurance Requirements

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

6 Contract Duration and Execution

The ITER Organization shall award the Service Contract around May 2024. The estimated contract duration shall be 33 months.

7 Experience

The tenderer shall demonstrate their technical and industrial experience related to the scope of work as detailed in Annex I.

The working language of ITER is English, and a fluent professional level is required (spoken and written).

8 Candidature

Participation is open to all legal entities participating either individually or in a grouping/consortium. A legal entity is an individual, company, or organization that has legal rights and obligations and is established within an ITER Member State, being, the European Union (represented by EURATOM), Japan, the People's Republic of China, India, the Republic of Korea, the Russian Federation and the USA.

Legal entities cannot participate individually or as a consortium partner in more than one application or tender of the same contract. A consortium may be a permanent, legally established grouping, or a grouping which has been constituted informally for a specific tender procedure. All members of a consortium (i.e. the leader and all other members) are jointly and severally liable to the ITER Organization.

In order for a consortium to be acceptable, the individual legal entities included therein shall have nominated a consortium leader with authority to bind each member of the consortium, and this leader shall be authorised to incur liabilities and receive instructions for and on behalf of each member of the consortium.

It is expected that the designated consortium leader will explain the composition of the consortium members in its offer. Following this, the Candidate's composition must not be modified without notifying the ITER Organization of any change. Evidence of any such authorisation to represent and bind each consortium member shall be submitted to the IO in due course in the form of a power of attorney signed by legally authorised signatories of all the consortium members.

Any consortium member shall be registered in IPROC.

9 Sub-contracting Rules

All sub-contractors who will be taken on by the Contractor shall be declared together with the tender submission. Each sub-contractor will be required to complete and sign forms including technical and administrative information which shall be submitted to the IO by the tenderer as part of its tender.
The IO reserves the right to approve any sub-contractor which was not notified in the tender and request a copy of the sub-contracting agreement between the tenderer and its sub-contractor(s).
Sub-contracting is allowed but it is limited to one level and its cumulated volume is limited to 30% of the total Contract value.

EXPRESSION OF INTEREST & PIN ACKNOWLEDGEMENT

To be returned by e-mail to: Junhyung.park@iter.org copy to Andrew.Brown@iter.org

Company Name:__________________________________

TENDER No.	**IO/24/OT/10029715/JPK**
DESIGNATION of SERVICES:	**Antenna Transmission Lines Interface Section (ATLIS) prototype and series manufacturing**
OFFICER IN CHARGE:	**JunHyung PARK – Procurement Division ITER Organization**

☐ WE ACKNOWLEDGE HAVING READ THE PIN NOTICE FOR THE ABOVE MENTIONED TENDER

☐ WE INTEND TO SUBMIT A TENDER

Are you registered in Iproc (only entities registered in iPROC will be invited to tender)?:

☐ YES

Please indicate your registration number: ………………

☐ NO, but we shall register before the indicated tender launch date

………

Signature:

COMPANY STAMP

Contact person: ....

Position: ....

Tel: ....

E-mail...

Date: ....

IDM UID
B2XE43

VERSION CREATED ON / VERSION / STATUS
27 Aug 2024 / 2.0 / Approved

EXTERNAL REFERENCE / VERSION

Technical Specifications (In-Cash Procurement)

Technical specification for Antenna Transmission Lines Interface Section prototype and series manufacturing

The present document specifies the requirements for:Designing, manufacturing and testing an Ion Cyclotron Heating and Current Drive system (IC H&CD, PBS-51) ATLIS (Antenna Transmission line Interface Section) prototype.Manufacturing and testing the ATLIS series production.The phase breakdown is specified hereafter:Phase 1 – Design, manufacturing and testing of the ATLIS prototype (see section 5.4)Phase 2 [OPTIONAL] – ATLIS series production (see section 5.5)

SUPPLY

Table of Contents

SUPPLY

SUPPLY

SUPPLY

1 Preamble

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

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

2 Purpose

The present document specifies the requirements for:

- Designing, manufacturing and testing an Ion Cyclotron Heating and Current Drive system (IC H&CD, PBS-51) ATLIS (Antenna Transmission line Interface Section) prototype.
- Manufacturing and testing the ATLIS series production.

3 Acronyms & Definitions

3.1 Acronyms

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

Abbreviation	Description
ATLIS	Antenna Transmission Line Interface Section
CRO	Contract Responsible Officer
GM3S	General Management Specification for Service and Supply
IC	Ion Cyclotron
IO	ITER Organization
KOM	Kick-Off-Meeting
MTO	Material Take Off
PRO	Procurement Responsible Officer
SRD	System Requirement Document
UHV	Ultra-High Vacuum

3.2 Definitions

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

4 Applicable Documents & Codes and standards

4.1 Applicable Documents

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

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

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.

SUPPLY

[1] General Management Specification for Service and Supply (ITER_D_82MXQK v1.4)
[2] ICRH Antenna components classification (Q4MQRL v2.5)
[3] IC H&CD Antenna Functional Analysis (ITER_D_XQ5SZ7 v1.2)
[4] ITER Vacuum Handbook ITER_D_2EZ9UM v2.3
[5] Vacuum Handbook Appendices (folder) ITER_D_2FHLMC
[6] Vacuum Handbook Attachments (folder) ITER_D_2MUS3U
[7] Propagation of the Defined Requirements for Protection Important Components Through the Chain of External Interveners (BG2GYB v3.3)
[8] 51.AN.W3 PFD - ATLIS alternative cooling with 20kg/s (ITER_D_AQLEYA v1.0)
[9] IS-26.CC-51-001 (ITER_D_334USK v4.6)
[10] Load Specification for the IC H&CD Antenna (ITER_D_33CETP v6.1)
[11] ITER_D_22MAL7 v5.1 – Procedure for Analyses and Calculations
[12] Codes and Standards for ITER Mechanical Components (25EW4K v4.0)
[13] RCC-MR Edition 2007
[14] In-vessel Components, SDC-IC, ITER_D_222RHC v3.0
[15] Procedure for the management of Deviation Request (2LZJHB v5.5)
[16] Requirements for Producing an Inspection Plan (22MDZD v3.7)
[17] #162_ Analysis _CFD of the 2023 ATLIS design (ITER_D_9NCZ3F v1.0)
[18] #458_Update _ Analysis _CFD of the 2023 ATLIS design (ITER_D_AKE8UD v1.1)
[19] #486_Update _ Analysis _CFD of the 2023 ATLIS design continue (ITER_D_APKJFW v1.0)
[20] Appendix 13 Cleaning and Cleanliness (ITER_D_2ELUQH v1.2)
[21] Requirements for Producing a Contractors Release Note (22F52F v5.0)
[22] 20230511_ATLIS_Elbows_Transitions (ITER_D_8SQFV2 v1.3)
[23] 20231011_dBextraction_ATLISv2v3 (ITER_D_9EWTDW v1.0)
[24] ITER_51ANG3_PID_001 (ITER_D_AB4C69 v1.1), *only for information*
[25] Job#1052_ATLIS redesign_PBS-51_Engineering and ATLIS redesign_Engineering_activity_PBS-51_REPORT_DESIGN (ITER_D_YSGPR2 v2.1)
[26] Global Tokamak Seismic Analysis Report (ITER_D_33W3P4 v2.1)
[27] Order dated 7 February 2012 relating to the general technical regulations applicable to INB - EN (ITER_D_7M2YKF v1.7)
[28] Quality Classification Determination (ITER_D_24VQES v5.2)
[29] Procedure for Management of Nonconformities (ITER_D_22F53X v9.1)
[30] Working Instruction for Manufacturing Readiness Review (ITER_D_44SZYP v5.0)
[31] Procedure for Inspection and Testing (ITER_D_TVL3Y5 v2.0)
[32] Quality Management System Audits (ITER_D_2DQTA8 v5.0)
[33] Surveillance Plan for PBS 51 – Ion Cyclotron H&CD System (ITER_D_U44GYC v1.1)
[34] Surveillance Plan for PBS51 - Annex 2 - Detailed List of PIAs (ITER_D_TXAC52 v1.2)
[35] 071734 - ATLIS_1_INTERFACE_DRW, AEPNRX_v1
[36] # 339 and #523 ATLIS and ATLIS Frame Structural analysis (ITER_D_AS3EUS v1.1)
[37] ATLIS flange drawing - FW side (ITER_D_B2X9QK v1.0)

[38] Specification for CAD data Production in ITER direct contracts (ITER_D_P7Q3J7 v2.0)
[39] ITER Materials Properties Handbook, Introduction, baseline 2009 (ITER_D_2NRCSB v1.3)
[40] Static and Transient Magnetic Field Maps in Tokamak Building (ITER_D_3BQBVY v3.1)
[41] Working Instruction for the Delivery Readiness Review (DRR) (ITER_D_X3NEGB v2.0)
[42] SRD-51 (ICH&CD) from DOORS (ITER_D_28B33K v6.0)
[43] Chemical composition and impurity requirements for materials (ITER_D_REYV5V v2.3)
[44] Procedure for Identification and Controls of Items (ITER_D_U344WG v2.2)

4.2 Applicable Codes and Standards

This is the responsibility of the Contractor to procure the relevant Codes and Standards applicable to that scope of work, with respect to the *Codes and Standards for ITER Mechanical Components* [12].

- **[51ICs692-R;Defined Requirement]** The manufacturing of the IC H&CD components that are exposed to the tokamak vacuum, and of nuclear safety relevant equipment located in the nuclear buildings, shall comply with the requirements listed in Table 1 of *Codes and Standards for ITER Mechanical Components* [12].

Note: In the present document, all the requirements labelled 51ICsxxx-R have been extracted from the SRD [42].

5 Scope of Work

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

The scope of work is broken down into two phases, which will allow a stepwise progression toward the final delivery of ITER compliant ATLIS units. The present document specifies the requirements for designing, manufacturing and testing the prototype as well as for the manufacturing and the testing of the series.

The phase breakdown is specified hereafter:

- Phase 1 – Design, manufacturing and testing of the ATLIS prototype (see section 5.4)
- Phase 2 **[OPTIONAL]** – ATLIS series production (see section 5.5)

5.1 Background

5.1.1 System overview & vacuum boundary

In its baseline configuration the ITER Ion Cyclotron Heating and Current Drive (IC H&CD – PBS51) system has to couple 20MW of radio-frequency (RF) power in quasi-CW operation (pulses up to 3600s) for a variety of ITER plasma scenarios, in a frequency range of 40-55MHz. The ICH&CD system includes only one IC antenna. The following Figure 1 is showing the IC Antenna package.

SUPPLY

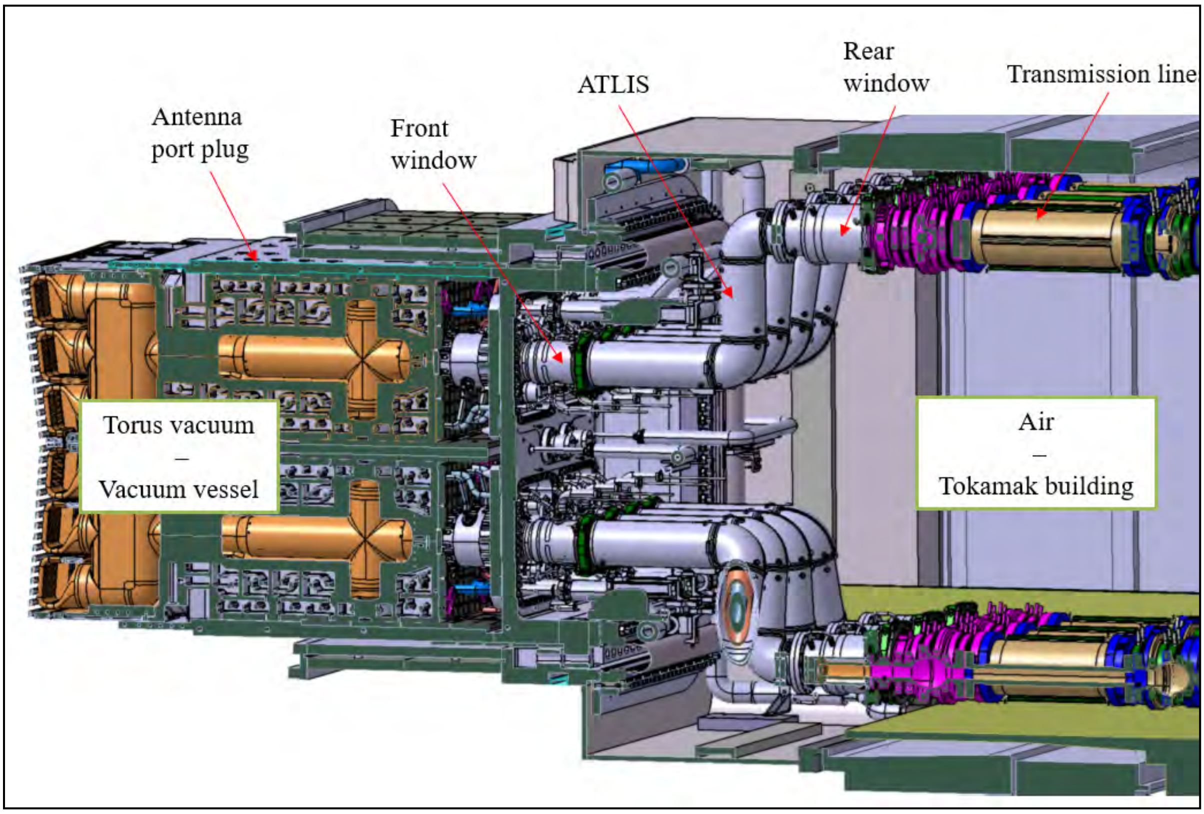


Figure 1: ICRH Antenna design (in vessel port plug & ex vessel designs)

The IC Antenna is part of the first confinement system therefore it shall ensure sealing between the Vacuum Vessel (UHV: Ultra-High Vacuum) and the Port Cell of Tokamak Complex (atmospheric pressure).

On radio frequency conductors, this first confinement barrier is made of the following three main components:

- The front window: boundary between ITER torus vacuum and ATLIS pressurized volume,
- The ATLIS: transmission line pressurized with 6 bars (absolute pressure) dry air,
- The rear window: boundary between the ATLIS (6 bars absolute pressure) and the TL (3 bars absolute pressure).

The following Figure 2 is representing the confinement scheme.

SUPPLY

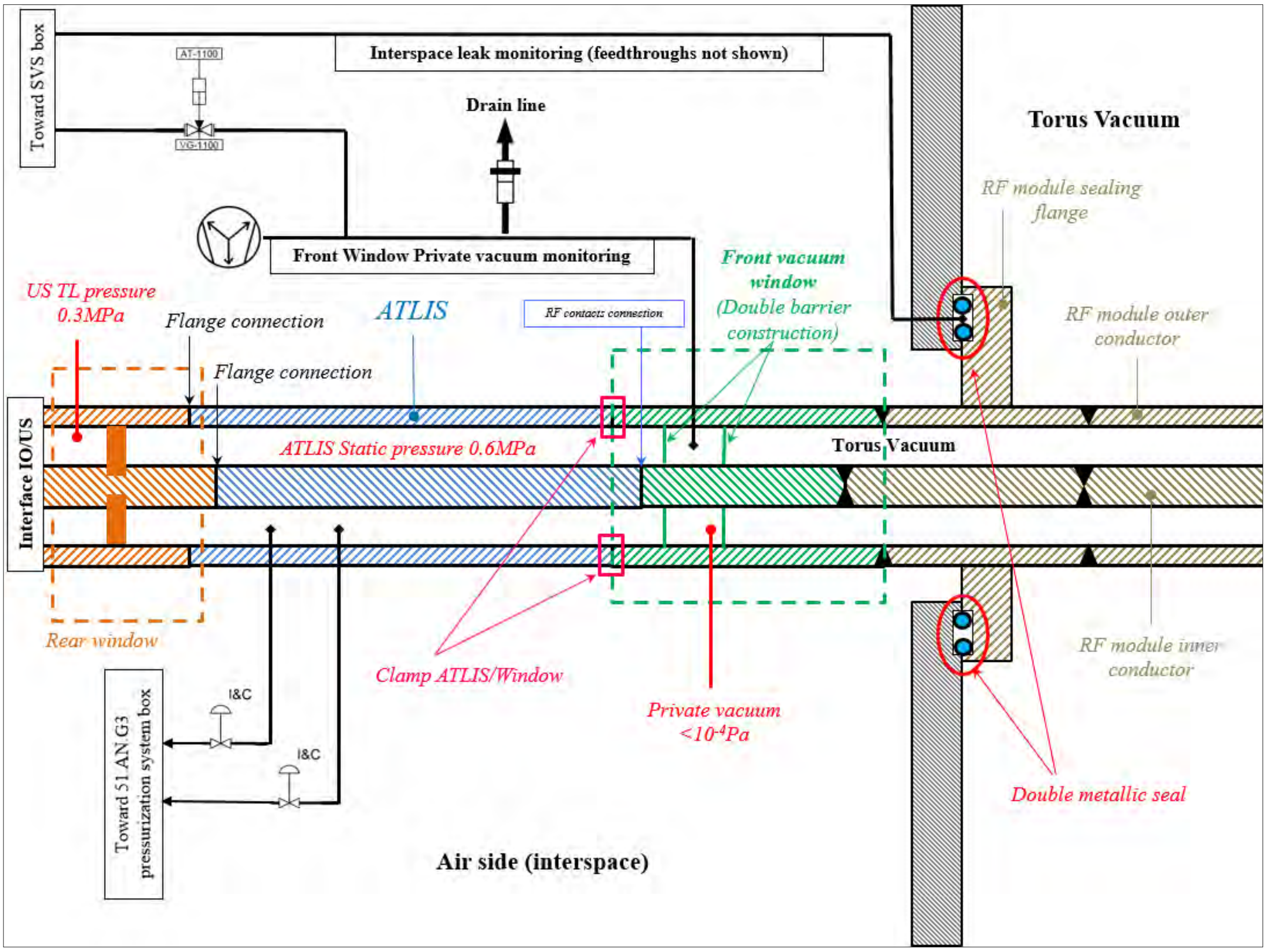


Figure 2: ICRH Antenna first confinement system

During operation, the front and rear windows are providing the only supports for ATLIS inner conductors (no dielectric support directly implemented in the ATLIS design).

The front window is welded on the Antenna and cannot be disconnected during Antenna installation or removal. Quick connector solution has been implemented to connect the ATLIS outer conductor to the front windows outer conductor (aiming to reduce maintenance time and to decrease the flange/hub diameter of the front window).

5.1.2 Interspace components supports & main load paths

The interspace components (ATLIS and transmission lines) are in interface with two sub-systems structurally independent, see Figure 3:

- The Antenna port plug, rigidly attached to the vacuum vessel.
- The transmission lines, rigidly attached to the Tokamak building.

A Set of compliance devices (swivel joints, see Figure 3) is implemented in the transmission line to mitigate the antenna displacement, by providing flexibility in the transmission line assembly.

SUPPLY

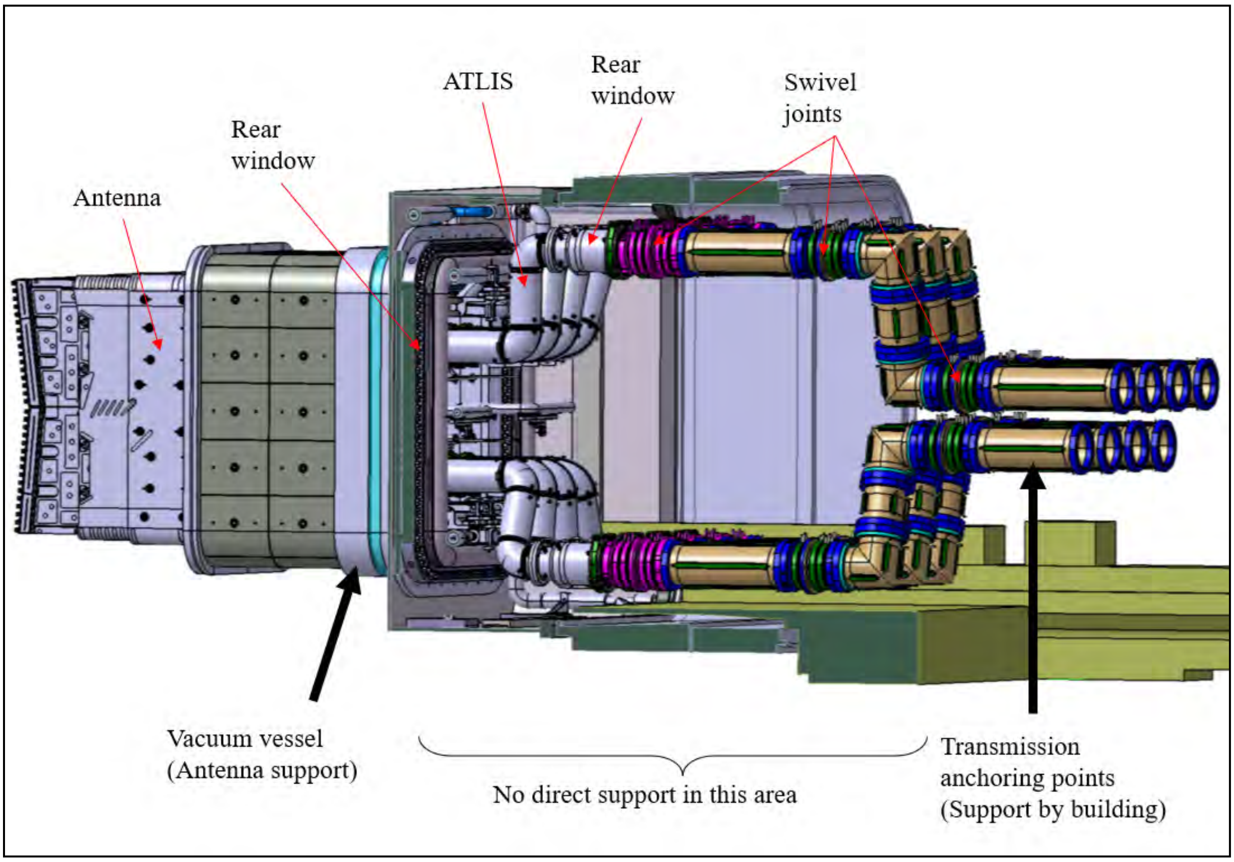


Figure 3: Interspace components supports

The eight ATLIS are connected to the Antenna front windows with customed connector developed for this purpose (see Figure 4).

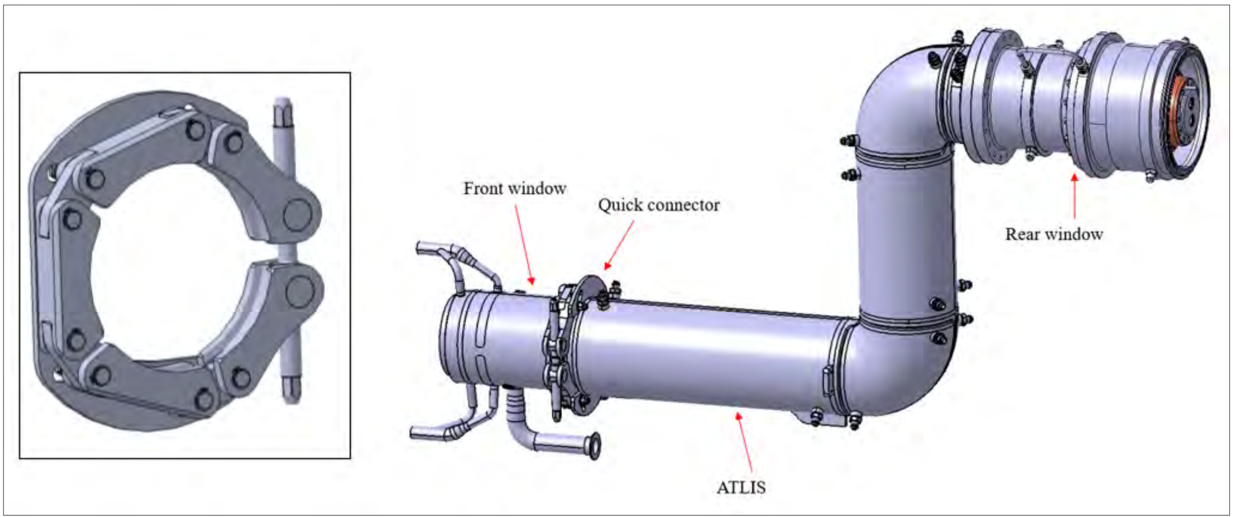


Figure 4: Connector supporting the ATLIS on the Antenna

It has already been identified through preliminary analyses [36] that stiffeners will have to be added between the different ATLIS and between the ATLIS and the Antenna for two main reasons:

- Make the full assembly stiffer and avoid low frequency resonances
- Help the connector to support the mass of the full ATLIS assembly

SUPPLY

The Figure 5 is illustrating the implementation of the stiffening elements. These components are not yet designed. IO will issue a preliminary design for the KOM (T0) of the present task.
The stiffening elements are out of scope of the present technical specification.

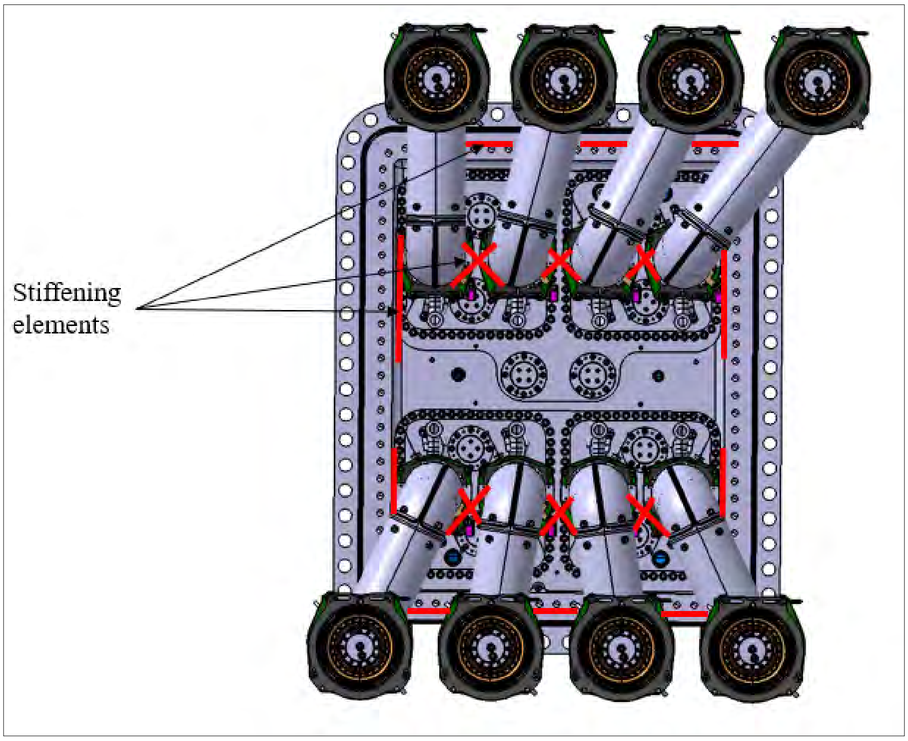


Figure 5: Representation of stiffening elements (replacing the ATLIS frame previously implemented)

5.1.3 Component classification

The following Table 1 is presenting the ATLIS classification according to ICRH Antenna components classification [2] regarding QA, safety, Tritium, seismic, remote handling and vacuum as follow.

Component	Safety Class	Quality Class	Seismic Class	Vacuum Class	Tritium Class	RH Class	NPE Class
ATLIS	PIC/SIC-1	QC1	SC1(S)	VQC 3A	TC 2B	N/A	N/A

Table 1: Components classification

Note about Pressurized Equipment (PE) classification: The ATLIS are exempted from the PE classification according to the following letter ITER_D_F84DLU - French Ministry 25 February 2013 letter on ESP/ESPN.

5.2 Work phases and reviews

The scope of work is broken down into two phases, which will allow a stepwise progression toward the final delivery of ITER compliant ATLIS units. The present document specifies the requirements for designing, manufacturing and testing the prototype as well as for the manufacturing and testing of the series.

The phase breakdown is specified hereafter:

SUPPLY

- Phase 1 – Design, manufacturing and testing of the ATLIS prototype (see section 5.4)
- Phase 2 **[OPTIONAL]** – ATLIS series production (see section 5.5)

The Phase 2 is optional. According to the conclusion of the Phase 1 but also to the project needs, IO can decide to activate the option or not.

IO will organise several reviews during the two phases. These may be focused on particular areas of production and will be organised by IO as required by the progress and performance. IO will appoint the review panel and define its terms of reference. The main reviews are identified as follows:

- End of phase 1 (see section 5.4.10):
  - End of Manufacturing and test review
  - Prototype Final Design review
  - Delivery Readiness Review (DRR), to be organized before the delivery of the ATLIS prototype to the IO site
- Beginning of phase 2 – Manufacturing Readiness Review (see section 5.5.4),
- End of the phase 2 – Delivery Readiness Review (see section 5.5.11).

The review panel comprises representatives from IO and technical experts appointed by IO.

The contract includes PIC components, Safety RO will be involved throughout the different phases of the project.

In case of IO disapproval, or request for revision of a document (procedure, drawing…), the contractor shall submit a revised version to IO within 15 working days.

5.3 Requirements applicable to all the phases.

The requirements presented in this section are applicable to both phases 1 and 2.

The ATLIS normally operates under pressurized environment. Nevertheless, as it is integral part of the Vacuum Vessel (VV) vacuum boundary (composed by front window + ATLIS + rear window, for redundancy), the ATLIS manufacturing is requiring specific provision that are specified in the ITER Vacuum Handbook. The ATLISs are vacuum classified VQC3A (according to reference [2]), the contractor shall comply with the requirements specified in the ITER Vacuum handbook [4].

The ITER Vacuum Handbook [4] with appendices [5] and attachments [6] provide strong design requirements for UHV components. This reference document is applicable to the design, manufacturing and control of the UHV components. The contractor shall identify the requirements applicable to the scope of this contract and shall ensure compliance with them.

The following requirements have been extracted from the SRD [42] and are applicable to the ATLIS prototype (phase 1) and series (phase 2).

The following requirements are applicable because the ATLISs are vacuum classified components:

- **[51ICs180-R]** The equipment of the IC H&CD system shall comply with the requirements of the ITER Vacuum Handbook (IVH) [4].
- **[51ICs626-R]** All equipment of the IC H&CD system operating under vacuum shall be designed and qualified in compliance with the requirements of its VQC.

SUPPLY

- **[51ICs838-R]** The IC H&CD system components inside the primary vacuum or at the primary vacuum boundary shall be replaceable, and shall be replaced rather than repaired and reused.

In addition, the ATLISs shall also be compatible with ITER ambient magnetic environment:

- **[51ICs140-R]** All IC H&CD equipment shall be designed to be compatible with the ambient magnetic environment for any operating mode, as defined in the ITER specifications (Static and Transient Magnetic Field Maps in Tokamak Building [40]).

The following requirements shall be considered for the materials selection:

- **[51ICs1371-R]** Materials and their joints which are in contact with fluid shall be selected taking into account their corrosion resistance during ITER lifetime.
- **[51ICs1047-R]** On all IC H&CD demineralized water cooling circuits, the use of brass and other materials subject to corrosion by demineralised water shall be prohibited. This requirement applies to all pipework and fittings.
- **[51ICs664-R]** Commercial materials shall conform to the applicable standards (ASTM, JIS, DIN) for the definition of their grade, physical, chemical and electrical properties and related testing.
- **[51ICs671-R]** 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.
- **[51ICs672-R]** The vacuum compatibility of the materials to be used under vacuum shall be established as specified in the IVH [4].
- **[51ICs674-R]** A complete traceability of all the materials, including welding materials, shall be provided.
- **[51ICs1451-R; Defined Requirement]** The level of activated corrosion products in the IC H&CD cooling systems shall be minimized, for example through the selection of materials.
- **[51ICs1809-R]** Magnetic materials with a relative permeability exceeding 1.03 shall not be used inside the vacuum vessel nor within the IC H&CD port cell interspaces without formal project approval.
- **[51ICs176-R]** The antenna components that experience the torus vacuum shall be non-magnetic, radiation resistant and high temperature (240˚C) resistant, such as SS316.

The following requirements are more general but also applicable to the ATLIS design, manufacturing and testing:

- **[51ICs1290-R]** The International System of Units (SI) and its derived units shall be used throughout the IC H&CD System design and procurement.
- **[51ICs1269-R]** The system shall be compliant with the applicable version of each Complementary Applicable Document (ADc) that is given in the IDM document REFS-51-IC ITER_D_YJLU5L, under configuration control). (Compliance of the system with the present SRD ensures its compliance with the applicable versions of the Input Applicable Documents (ADi) that are listed in the same reference.)
- **[51ICs692-R;Defined Requirement]** The manufacturing of the IC H&CD components that are exposed to the tokamak vacuum, and of nuclear safety relevant equipment located in the nuclear buildings, shall comply with the requirements listed in Table 1 of *Codes and Standards for ITER Mechanical Components [12]*.

SUPPLY

5.4 Scope of Supply for the phase 1

5.4.1 Description and objectives of phase 1

Prior to start the design of the components, the contractor shall issue the Quality Plan [DL1] for the Phase 1.

The Phase 1 is the proof of concept phase. **The Phase 1 does not contain PIAs**. The contractor shall prepare the manufacturing, carry out the manufacturing activities to procure and test one ATLIS prototype.

The aim of the Phase 1 is to produce one ATLIS prototype compliant with the requirements defined in the present technical specification.

IO is providing a design (see drawings [35]) that is close to be a compliant design. Several preliminary checks have been performed:

- Radio frequency performance has been checked in the studies [22] and [23]
- Cooling efficiency has been verified in analyses [17], [18] and [19]
- Stress assessment on a single ATLIS for thermal and pressure loads is given in [17]
- Stresses values during seism are available in the global model analysis [36]

The design has now to be checked and completed by the contractor before to be submitted to final analyses. The contractor shall design the ATLIS prototype based on the IO design, including the details needed to be manufactured and tested. and shall produce the whole documentation required to justify the design choices.

The contractor is free to define the quantity of material, the manufacturing processes, the NDTs, to achieve a compliant ATLIS prototype. Nevertheless, if during this phase, design modifications are required, the contractor shall inform IO by providing a Deviation Request [15] which shall include a detailed justification.

During phase 1, the manufacturing sequences [DL2] of the ATLIS prototype shall also be prepared.

5.4.2 Component functions

The functions breakdown is described in [3] up to the component level.

The ATLIS are participating to the following functions:

- Performance function – “To inject 20MW within the plasma, to generate current and to control saw teeth activity & To assist the first wall conditioning” and the sub-function: “to ensure Antenna monitoring & protection”
- Safety function – “To ensure the 1st confinement boundary integrity / tritium confinement”

In addition, the ATLIS are also participating to this strong design driver:

- “To be compatible with hands-on and RH processes in Port Cell, with RH processes in Hot Cell and with test processes in PPTF”

5.4.3 Design requirements

This section is providing the design description and requirements useful for understanding the ATLIS final design as well as the ATLIS prototype.

In phase 1, only requirements on prototype are applicable to the contractor.

SUPPLY

5.4.3.1 Quantity and positions

The 8 (eight) ATLIS are all different. IO has already pre-designed the ATLISs and their frame in order to prepare the design work. Eight ATLIS volumes are already defined by IO (see Figure 6). These volumes are drafted in ENOVIA (ENOVIA reference: AMWPMF) and will be given by IO to the contractor at the Kick-Off-Meeting.

In phase 1, the contractor shall define only the prototype design, associated to the ATLIS #1 (see Figure 6) within the space reservation drafted by IO. The drawing [35] is presenting dimensions compatible with this space reservation.

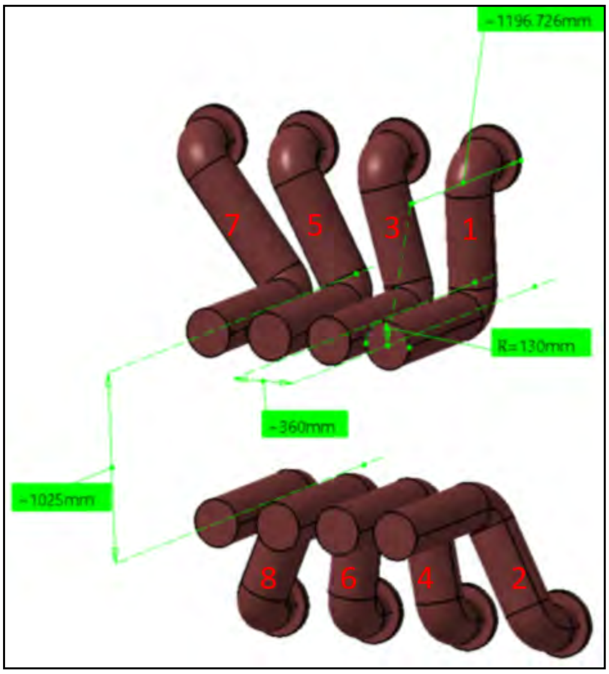


Figure 6: Space reservation for the eight ATLIS volumes (dimensions are in mm)

5.4.3.2 ATLIS RF surfaces

The preliminary design of the ATLIS is based on the RF analysis [22] and [23]. This analysis is defining the shapes of "RF surfaces" of the ATLIS which are:

- Internal surface of the outer conductor
- External surface of the inner conductor

The contractor shall issue ATLIS prototype design in accordance with the shapes of the RF surfaces, detailed in drawing [35] and presented in Figure 7 for the ATLIS #1.

SUPPLY

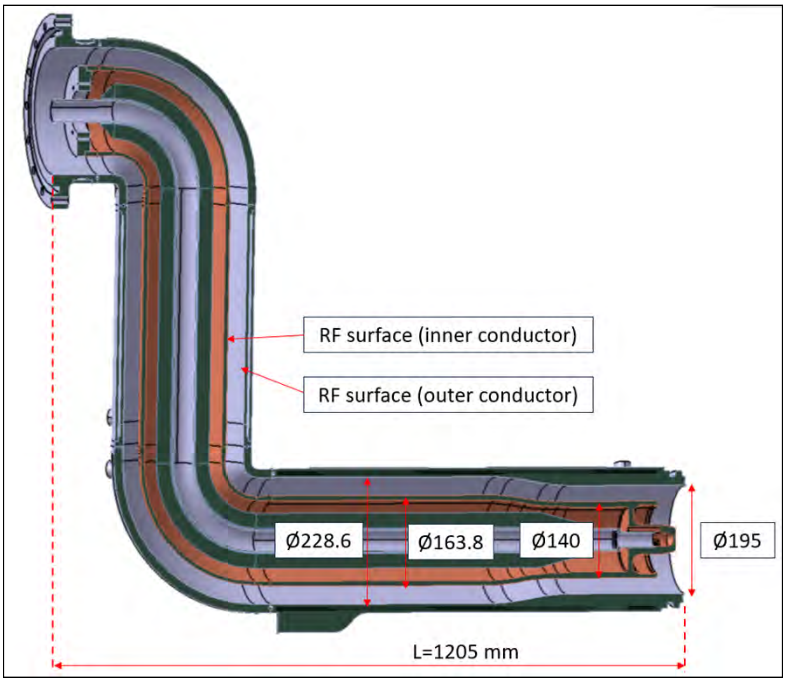


Figure 7: Main dimensions of the ATLIS #1

Prior to perform any modification of the ATLIS RF surfaces, the contractor shall have the agreement of the IO.

In order to minimize the RF losses in the conductors, the material of the RF surfaces shall have a high electrical conductivity (very close to the one of copper). In the design prepared by IO, the material for both conductors is Stainless steel with copper coating, see requirements in sections in 5.4.3.4 and 5.4.3.7 for conductors material and copper coating respectively.

5.4.3.3 ATLIS water cooling

Due to RF losses in both conductors, the ATLIS shall be water cooled.

The cooling water is shared with other sub-systems, so the water parameters are fixed (as per diagram [8] and interface sheet [9]):

- Total flow rate for each inner conductor: 0.9kg/s
- Total flow rate for each inner conductor: 0.26kg/s
- Water inlet temperature: 28°C min, 34°C max
- Water supply pressure: 1.0MPa (g) max
- Water design pressure: 1.75 MPa (g) max

In the present configuration, the cooling water flow is based on the following configuration (see Figure 8 and Figure 9):

- For cooling the outer conductor, the water flow is entering through two inlet connections at the front of the ATLIS, cooling the outer conductor by crossing pockets, and then exiting through two outlet connections.
- For cooling the inner conductor, the water flow is entering through a central pipe, reaching the end of the ATLIS and then flowing back directly in the inner conductor.

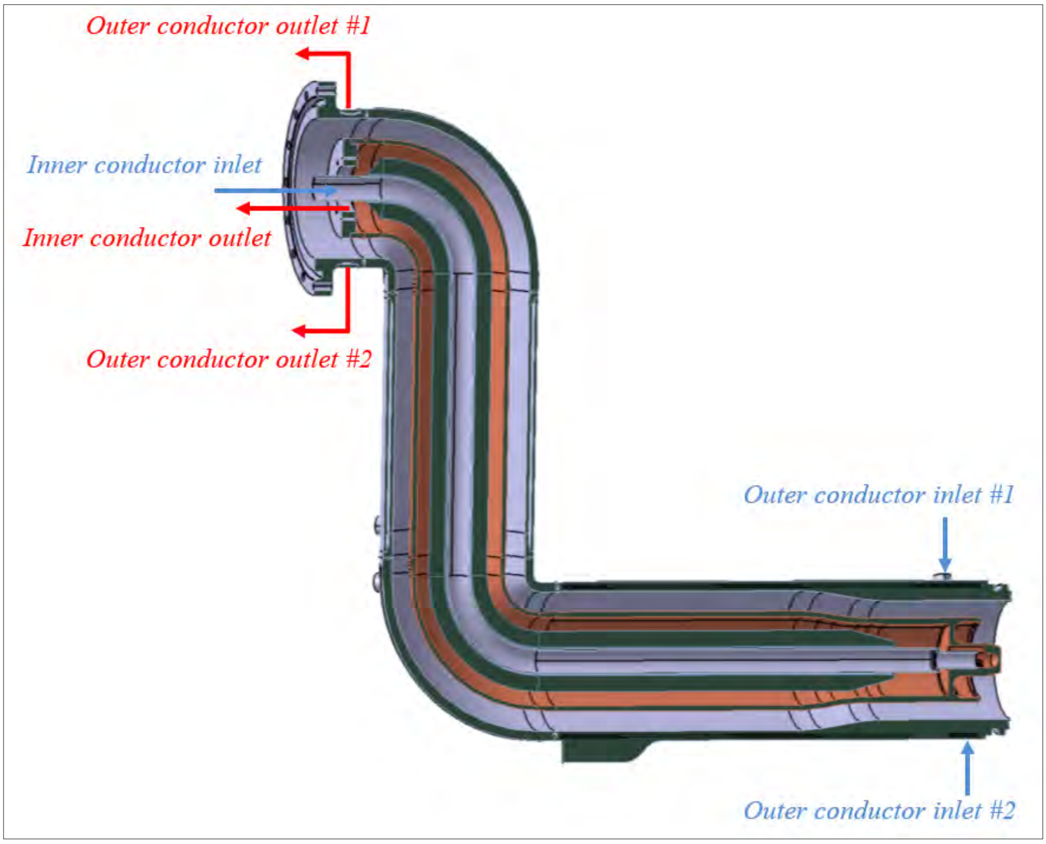


Figure 8: Cooling water inlets and outlets

The Figure 9 represents the water volumes for both inner and outer conductors. These shapes can be adapted by the contractors according to their manufacturing choices. If the contractor modifies the water volumes, the contractor shall inform and get formal approval from IO.

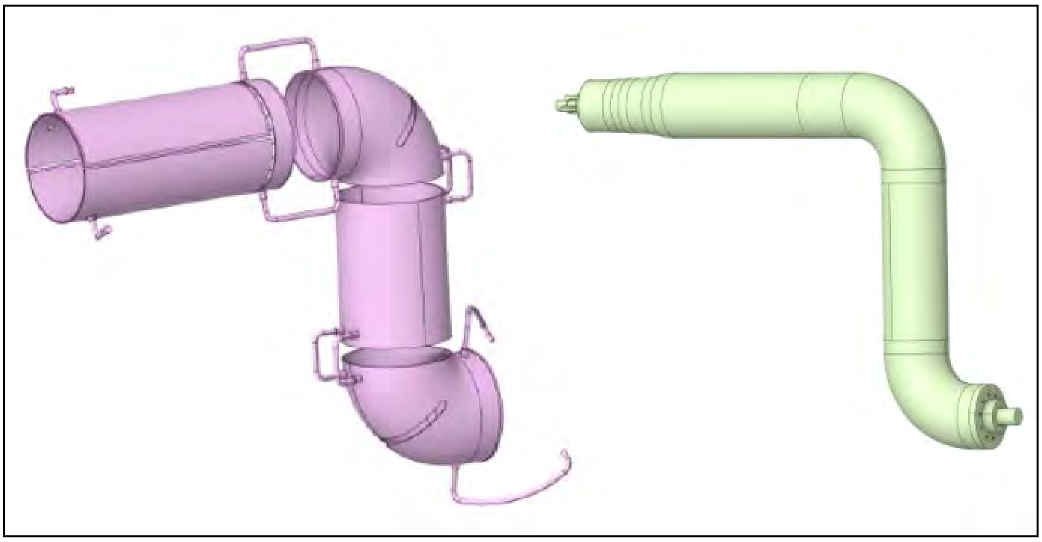


Figure 9: ATLIS water volume for outer conductor (on the left) and inner conductor (on the right)

In the centre of the inner conductor, there are two parts (see Figure 10):

- ➢ One central water pipe carrying water from the rear window to the nozzle of the ATLIS

SUPPLY

- Another part, around this pipe for limiting the water flow against the inner conductor shell only. The dimension of this part has already been studied for the studies [17], [18] and [19].

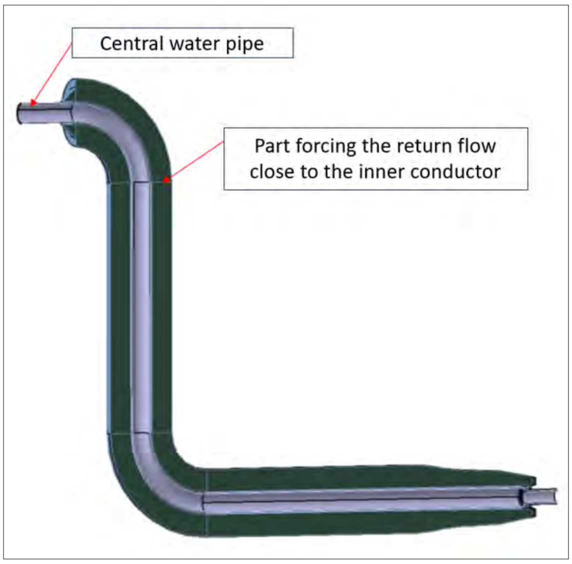


Figure 10: Parts inside the inner conductor improving the water flow

5.4.3.4 Material requirements

IO has already set the materials for the ATLIS assembly:

The main body of both ATLIS conductors shall be in 316L (EN grade 1.4404 steel) except the nose of the inner conductor that shall be in pure copper (or copper alloy CuCrZr), see Figure 11 and drawing [35].

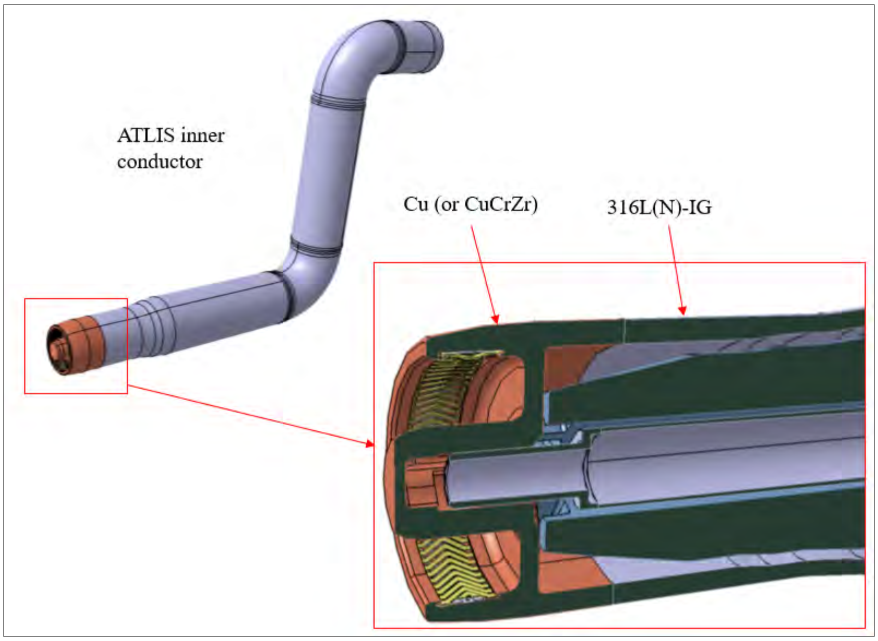


Figure 11: ATLIS inner conductor materials

The central water pipe (see Figure 10) is also in 316L (EN grade 1.4404 steel) and the other parts inside the water volume are in plastic. IO has selected PETP for these parts, but can be replaced by another plastic after IO's agreement.

The SRD [42] is specifying this additional requirement for the material selection.

SUPPLY

- **[51ICs669-R]** The materials for the IC H&CD system shall be selected in accordance with the properties specified in the Material Properties Handbook (MPH) [39]

5.4.3.4.1 Vacuum compatibility

The metallic material shall be compatible with UHV application. Reference [5] appendix 3 provides the list of acceptable materials for the design of VQC components.

The contractor may propose materials that are not included in appendix 3 of [5]. In this case the contractor shall submit a request for acceptance (see [5], appendix 3, and section 3.4). The request for acceptance will be reviewed by IO.

The welding / brazing materials may also be subjected to specific acceptance.

5.4.3.4.2 Material compatibility

For 316L stainless steel parts, the material procured by the contractor shall be within specific impurities limits for radiation protection purpose. Two cases are possible:

- Case 1: The manufacturer is machining the components from pipes. The EN 10216-5 standard shall be used and the following impurities limits shall be respected (values extracted from document [43]):
  - Co: max 0.05 wt.%
  - Ta: max 0.01 wt.%
  - Nb: max 0.1 wt.%
- Case 2: If the manufacturer is machining the components from plates and forgings, the material shall be 316L(N)-IG.

The 316L(N)-IG alloy is based on X2CrNiMo17-12-2 (1.4406 or 316LN) with additional restrictions on impurities (for radiation protection).

	X2CrNiMo17-12-2 controlled nitrogen
Elements	RCC-MR 2007 [13]
	max or range (wt.%)
C	0.030
Mn	1.60-2.00
Si	0.50
P	0.030
S	0.015 - (0.010)**
Cr	17.00 - 18.00
Ni	12.00 - 12.50
Mo	2.30 - 2.70
N	0.060 - 0.080
Cu	1.00 - (0.3)**
B	0.0020
Co*	0.05 [class 2]
Nb*	0.10 - (0.01)**
Ta*	N/A - (0.01)**
Ti	0.10

SUPPLY

Table 2: Chemical composition of the 316L(N) with radiation protection requirements

* Maximum Co is based on the Cobalt purity class 2, Nb and Ta content are based on Radioprotection requirements.
** The market availability shall be checked by the contractor with the values specified within brackets. If the material cannot be procured in relevant quantity for the phase 1, the other values shall be specified. Values within bracket shall are required for the phase 2.

<u>For the ATLIS prototype, the contractor can replace the 316L(N)-IG by standard 316L.</u>

5.4.3.5 Manufacturing sequence

In order to install the outer conductor around the inner conductor, it is necessary to split the design of the outer conductor in several parts and then to assembly the different parts together. Two solutions have been envisaged for each connection between outer conductor parts:

- ⇨ The first one is to weld the parts together.
- ⇨ The second one is to bolts the parts together.

Each solution has pros and cons. For example, radio frequency losses will be higher in a welded solution due to the lack of coating on the welded areas (see proposal in section 5.4.3.6 to solve this issue) while the bolted solutions will be probably cooled less efficiently due to the presence of flanges.

The Figure 12 is presenting two solutions (pictures extracted from [17]). On left side the solution called “version 2” which is a hybrid solution with welded joints and one bolted connection. The design on the right side, called “solution 4” is relying only on welded joints.

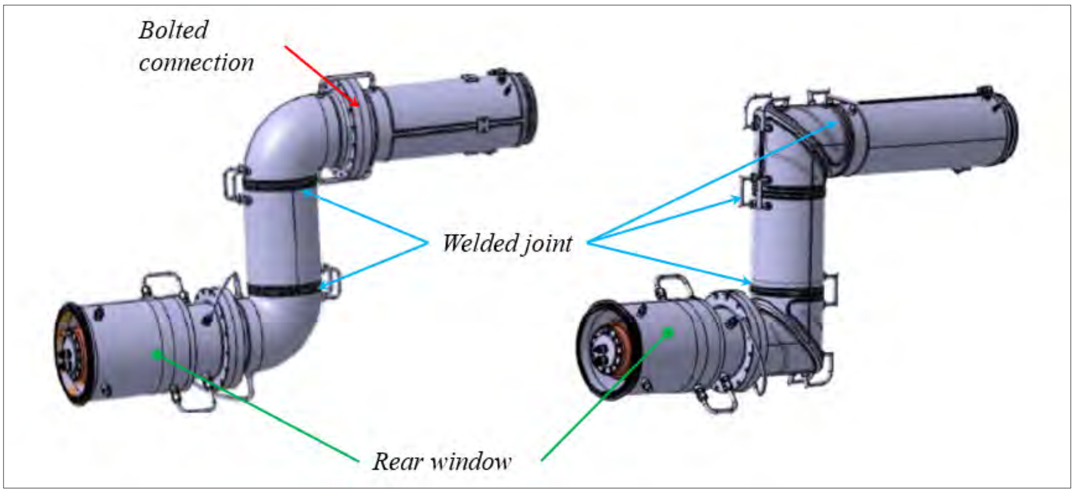


Figure 12: Two examples of ATLIS design with or without bolted connection on the outer conductor.

IO has finally developed a fully welded version (see Figure 13 and drawings [35]). The contractor shall propose to the IO a fully welded solution considering the design requirements listed in the present document as well as manufacturing means and the assembly feasibility around the inner conductor. The different design choices shall be documented in the [DL3] and the full manufacturing sequence shall be detailed in the [DL2].

Note 1: the present technical specification is requiring a fully welded ATLIS design. In case of derogation to this requirement and of implementation of bolted connection with sealing system, the qualification process will need to be updated as well as the Factory Acceptance Tests (FAT).

SUPPLY

Note 2: The connection with the outer conductor of the rear windows has to be a bolted connection (see details in the interface section 5.4.4.3).

5.4.3.6 Joint design

5.4.3.6.1 Joint design requirements

The design of welded joints shall be developed on the basis of the RCC-MR 2007, section 1, volume C. The rules for shell are the rules to be followed (RC 3300).

For VQC 3A joints on the boundary to air or water, full penetration welds are required. The design of welded joints shall ease the joint inspection.

The requirements for brazed joints are specified in [4]. **Brazed joints in contact with water are not permitted.**

The contractor shall deliver in the [DL3] package the welds and brazed joints definition drawings identifying the RCC-MR classification of all the joints.

5.4.3.6.2 Joint design proposal

As explained in section 5.4.3.5, one of the main challenges will be to assemble the outer conductor around the inner conductor.

IO already studied a joint concept that may solve the problem of the welding of copper coated conductors (see Figure 13). The concept is based on a full penetration butt weld (as recommended in RCC-MR) but not on the full thickness of the conductor. The thickness of the conductor would be split in three parts:

- The RF knife edge on the inner surface of the outer conductor, which is a small edge (copper coated) which is compressed against the other side of the outer conductor due to the weld retrain. Typical pressure value requested for a "good" RF contact is assessed between 30 and 60 MPa
- A groove, needed to separate the RF knife edge from the weld
- The butt weld on the external surface of the outer conductor.

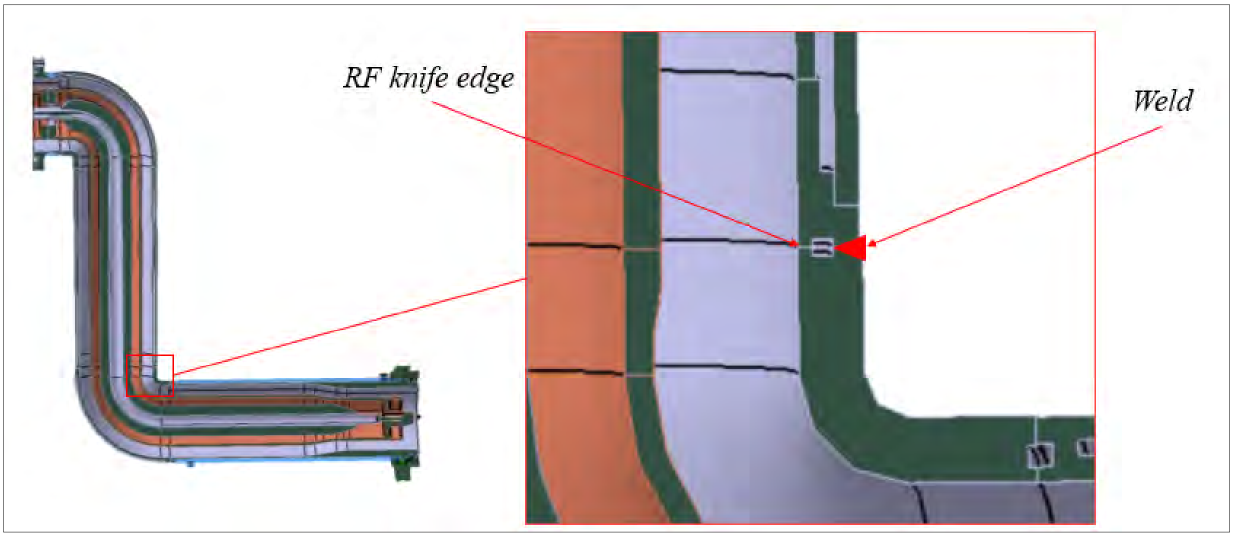


Figure 13: Joint with RF knife edge

SUPPLY

Please note that this type of contact has not been tested and remains conceptual. It would probably require preliminary testing on small samples in order to check the aspect of the coating after welding.

5.4.3.7 Coating

The surfaces carrying RF current shall have low resistivity material, for reducing RF losses. The contractor is free to choose a coating method. The coating shall be carried out with pure copper. The contractor shall make sure that the coating will not be altered by the welding processes as well as the coating process will not alter the welds. Provisions shall be taken for preventing coating damages, such as:

- ➢ Keeping free uncoated area for welding, if the coating is performed before welding or performing the coating after the welding operations
- ➢ Designing specific joint (butt weld with knife edge…), enabling to weld without affecting the coating

The coating thickness shall be at least 60µm.
The surface finish of the coated surface shall be compliant with the Ra specified for RF surfaces (3.2µm maximum). If the coating method cannot achieve such Ra, a polishing phase shall be implemented post coating. The adhesion shall at least be 30MPa (under tension).

- **[51ICs148-R]** The design shall make use of low resistance metallic coatings (such as Cu, Ag, Au, Be, Ni, thickness on the order of 50 µm) to reduce the RF skin losses on relevant antenna in-vessel components.

<u>Requirements for inner conductor RF surfaces:</u>

- ➢ The inner conductor RF surfaces shall be 100% copper coated (except the part which is in copper or CuCrZr).

<u>Requirements for outer conductor RF surfaces:</u>

- ➢ The contractor shall minimize the non-coated areas in the ATLIS outer conductor. A solution with full copper coating is preferred if feasible. If not feasible, the non-coated areas shall not exceed 4% of the total RF surface.

5.4.3.8 Design assessment by FEA

No Analysis is expected to be done by the contractor in this contract. Nevertheless, the contractor is free to conduct preliminary assessments if it is deemed necessary.

The different analyses will be performed by IO according to procedure [11] before phase 2 to validate the design produced during phase 1 by the contractor against the load specification [10].

According to reference [12], the RCC-MR Edition 2007 [13] is the selected code for the component providing first confinement barrier of the plasma chamber.

5.4.4 Interface requirements

In addition to the previous design requirements, there are several geometrical constraints on the ATLISs, linked to interfaces and integration purposes. This section is given to the contractor to better understand the constraints on the ATLIS design, but the contractor has to be compliant with the drawing [35] for building the prototype.

The physical interfaces with the Antenna components are the following:

- ➢ Interface #1: between ATLIS outer conductor and Antenna Front window (FW)

SUPPLY

- Interface #2: between ATLIS inner conductor and Antenna Front window (FW)
- Interface #3: between ATLIS outer conductor and Antenna Rear window (RW)
- Interface #4: between ATLIS inner conductor and Antenna Rear window (RW)
- Interface #5: between ATLIS and their stiffeners
- Interface #6: between ATLIS and cooling water circuit
- Interface #7: between ATLIS and pressurization system

In addition to these physical interfaces that will be described in the present section, the ATLISs have also a functional interface with the environment. Sufficient gaps have to be considered to allow the installation of the components without risking damaging the equipment. The representation of the Interspace environment as well as its main dimensions are presented in Figure 14 and Figure 15.

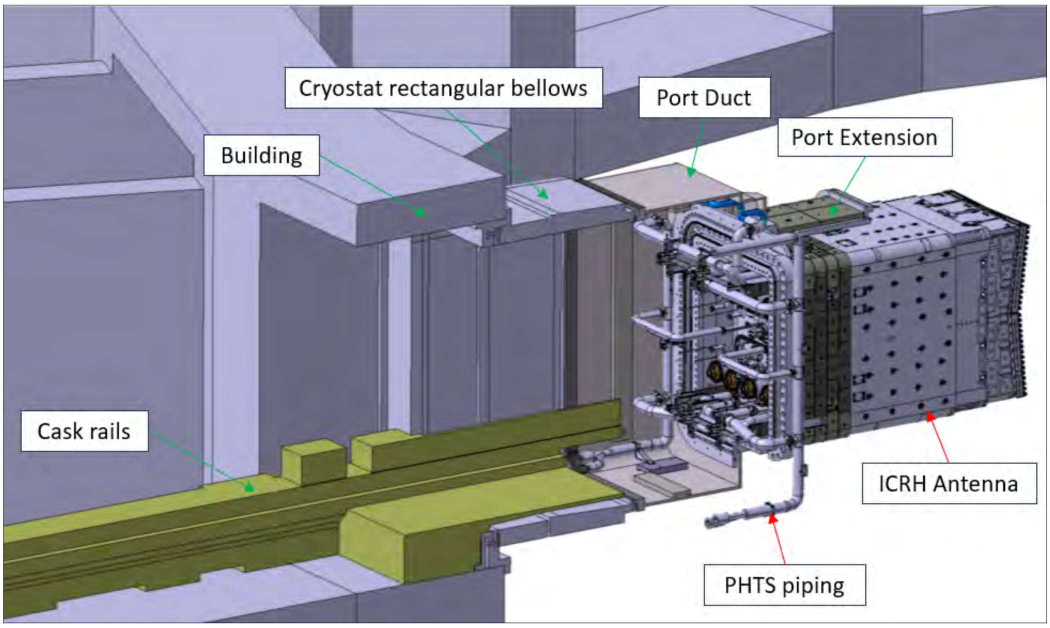
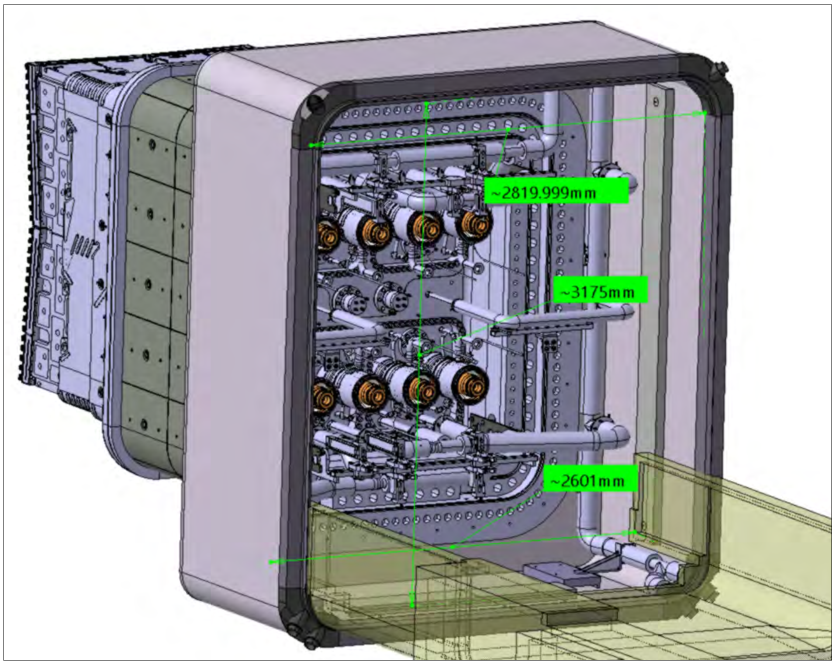


Figure 14: Interspace environment (cut view) and Antenna



SUPPLY
Figure 15: Interspace environment main dimensions

The main interfaces are described in the interface drawing [35].

5.4.4.1 Interface #1: between ATLIS outer conductor and Antenna Front window (FW)

The interface #1 is the connection between outer conductors of the ATLIS and the FW. In order to ease the connection, quick connectors have been implemented in the design. At the time of writing, a task is being executed to define hubs and quick connector design. The contractor shall manufacture an ATLIS hub compliant with the drawing [37]. The contractor shall implement in the prototype 3D model [DL3] an ATLIS hub design in accordance with the drawing [37]. For illustration purpose only, the Figure 16 is presenting this interface. Please note that a metallic seal (Helicoflex® type) will be implemented in between both outer conductors.

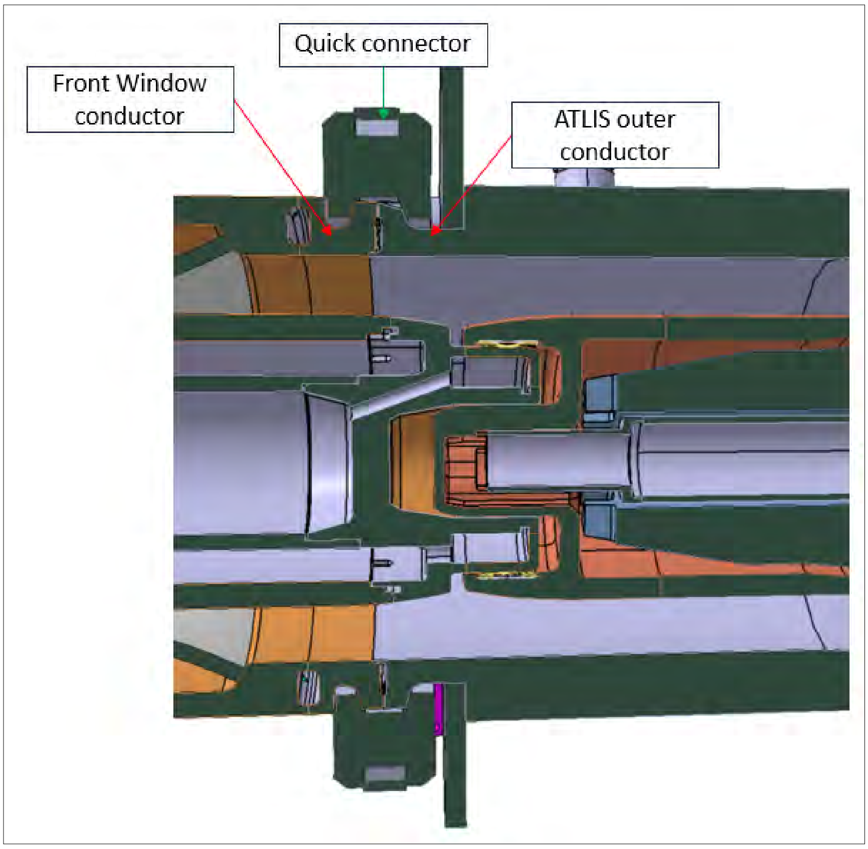


Figure 16: Interface #1 representation

5.4.4.2 Interface #2: between ATLIS inner conductor and Antenna Front window (FW)

The interface #2 is the connection between inner conductors of the ATLIS and the FW. This interface can be broken down in two parts (see Figure 17):

- The electrical connection made by an RF contact band. This interface has already been defined by IO. The contractor shall ensure to report the dimensions from the drawing [35] in the 3D model [DL3] to be produced.
- The mechanical connection made by the central nose of the conductor. This interface has to be designed by the contractor according to the assembly sequence and the tolerance needed for installation. The contractor shall design the inner conductor nose. Please note that the interface of the nose in the window can be adapted by IO. Interface modifications requested by the contractor shall be validated by the IO prior to implementation in the 3D model [DL3].

SUPPLY

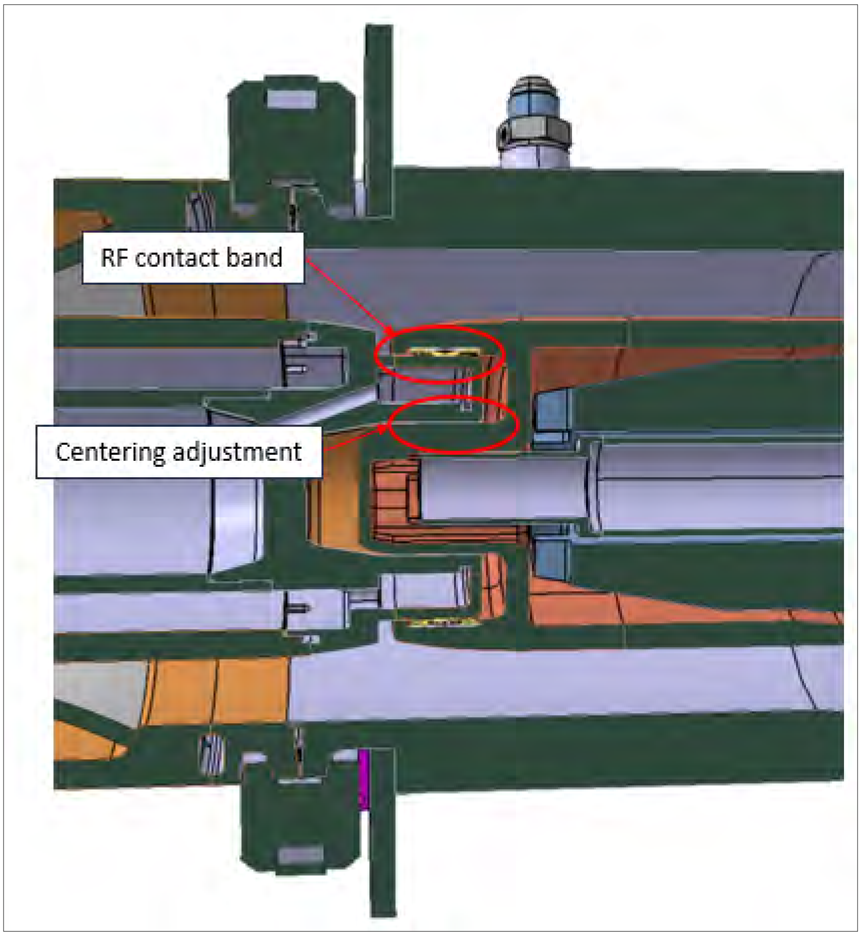


Figure 17: interface #2 representation

5.4.4.3 Interface #3: between ATLIS outer conductor and Antenna Rear window (RW)

The interface #3 is the connection between outer conductors of the ATLIS and the RW (see Figure 18). This interface is made of:

- A bolted connection for 16x M12 bolts
- Groove for seal (Helicoflex® type)
- RF knife edge, for RF connection
- Centering/alignment features

This interface has already been defined by IO in drawing [35] and shall not be modified by the contractor without IO agreement.

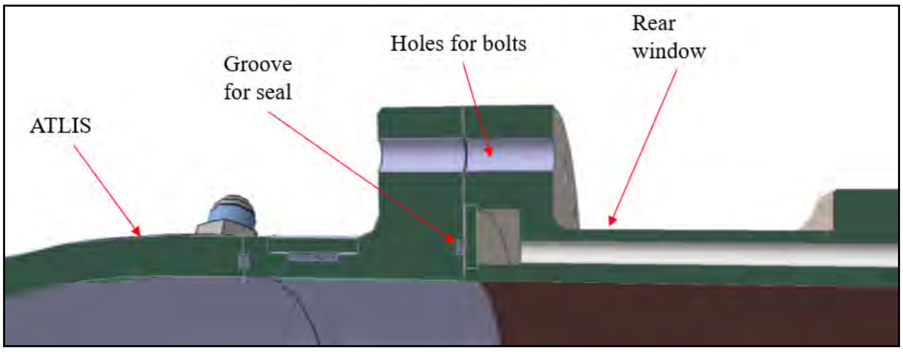


Figure 18: Interface #3 representation

SUPPLY

5.4.4.4 Interface #4: between ATLIS inner conductor and Antenna Rear window (RW)

The interface #4 is the connection between inner conductors of the ATLIS and the RW (see Figure 19). This interface is made of:

- A bolted connection for 24x M6 bolts
- Groove for seal (Helicoflex® type)
- RF knife edge, for RF connection
- Sliding connection for inlet and outlet water flow
- Centring/alignment features

This interface has already been defined by IO in drawing [35] and shall not be modified by the contractor without IO agreement.

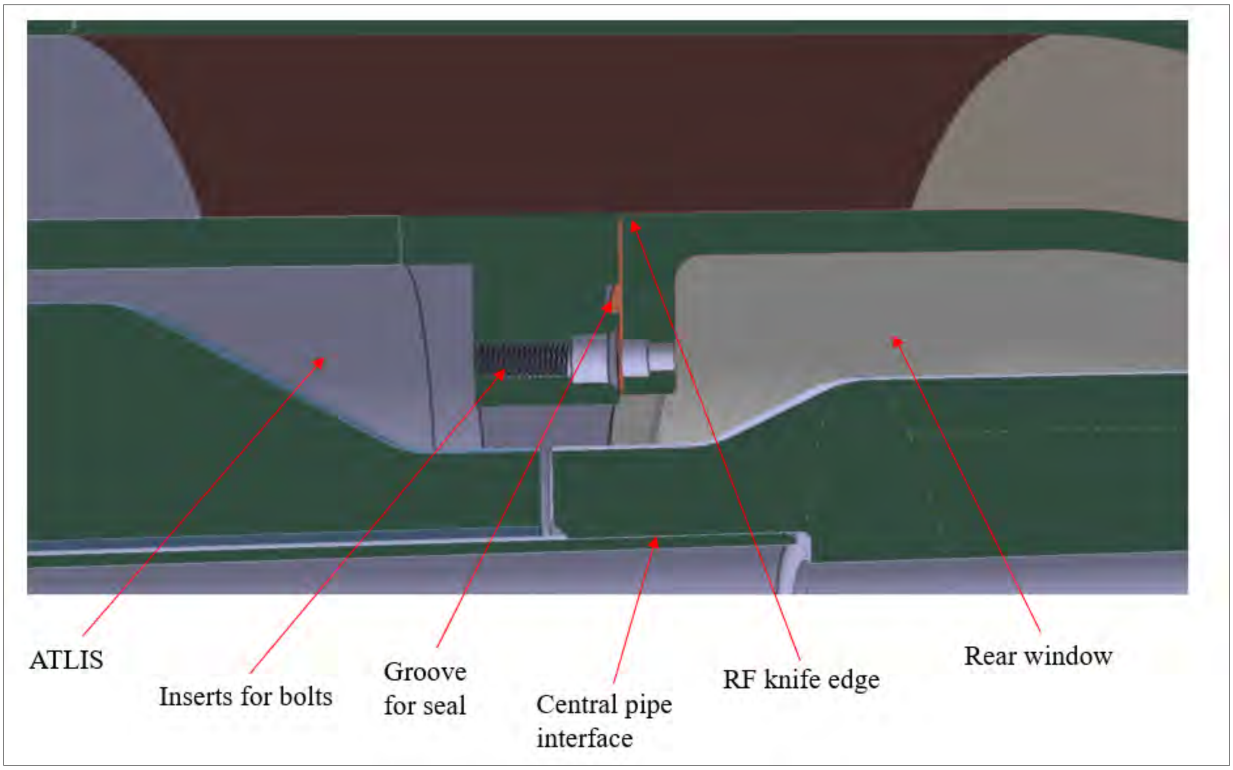


Figure 19: Interface #4 representation

5.4.4.5 Interface #5: between ATLIS and their stiffeners

This interface is not applicable to the ATLIS prototype.

The ATLISs have to be linked together and to antenna with the help of brackets. The design of these components are not totally finalized but their interfaces will not challenge the ATLIS design. The IO will provide the contractor with these interfaces at the kick-off-meeting.

Note: In some of the reference documents, one can see a design for an “ATLIS frame”. This frame is not anymore in IO’s strategy and will be replaced by a set of stiffeners (bars / rods).

5.4.4.6 Interface #6: between ATLIS and cooling water circuit CCWS1-A

According to the diagram [8], the contractor shall implement the following water connectors the ATLIS outer conductors:

- 2x DN 10 connectors by ATLIS (on FW side) for water inlet.
- 2x DN 10 connectors by ATLIS (on RW side) for water outlet.

SUPPLY

The choice of the commercial references has not been performed yet. IO is proposing to use double ferrule compression fittings from the company Swagelok. IO is proposing to weld straight 3/4" connectors with welded end (see Figure 20) on the ATLIS.

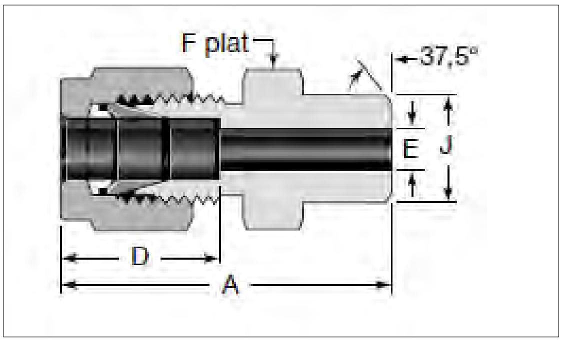


Figure 20: Double ferrule welded end connector

The contractor shall review this choice according to manufacturing feasibility and implement the connectors in BOM, design and drawings to be delivered in [DL3] with IO's agreement.

5.4.4.7 Interface #7: between ATLIS and pressurization system

The ATLISs are individually pressurized by the pressurization system (51.AN.G3). According to the diagram [24], the contractor shall design the following interfaces:

- 1x DN08 connector for gas inlet
- 1x DN08 connector for gas outlet
- 1x DN40 hub for rupture disk connection

These connections have not been implemented by IO in the design and the contractor shall propose a location for each of them according to manufacturing design (position of welds and welding feasibility mainly). The connections shall be implemented in the prototype design [DL3].

- **[51ICs246-R;Defined Requirement]** The IC H&CD system contributions to the confinement systems and barriers (such as penetrating equipment, ducts, penetrations, and seals) shall be designed and constructed to allow initial and periodic leak testing, inspection, monitoring and maintenance. All these operations shall be designed to assure the initial and continuing performance assumed in the Safety Analysis, both for confinement and pressure requirements.
- **[51ICs803-R;Defined Requirement]** The IC H&CD system contributions to the confinement barriers (such as equipment, ducts, penetrations, and seals) that must contain the design pressure to fulfill the assigned confinement function shall allow for initial and periodic pressure integrity tests.

5.4.4.7.1 <u>Gas inlet and outlet interfaces</u>

Here also, the choice of the commercial references has not been performed yet. IO is also proposing to use double ferrule compression fittings from the company Swagelok. IO is proposing to weld straight 1/2" connectors with welded end (see Figure 20) on the ATLIS.

SUPPLY

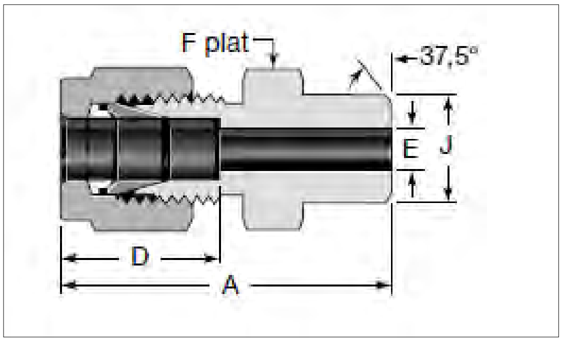


Figure 21: Double ferrule welded end connector

The contractor shall review this choice according to manufacturing feasibility and implement the connectors in BOM, design and drawings to be delivered in [DL3] with IO's agreement.

5.4.4.7.2 DN 40 connection for rupture disk

The contractor shall implement a DN 40 connection on the ATLIS prototype design to be compatible with a DN40 UKB LS rupture disc from the company REMBE. **The contractor shall not procure any rupture disc**. The contractor shall implement the DN40 hub in the prototype, and then use a simple cap to close the ATLIS prototype volume and pass the different tests presented in section 5.4.9. The choice of the technical solution and the location of the hub shall be submitted to IO for approval.

5.4.5 Maintenance & Installation Requirements

5.4.5.1 Requirements

A solution shall be proposed and designed by the contractor in the [DL3] to support the inner conductor inside the outer conductor during the maintenance phases (since the front window is not yet connected to the ATLIS). In previous ATLIS design (see report [25]), a temporary support was implemented, replaced by a cap with a seal once installed (see Figure 22).

SUPPLY

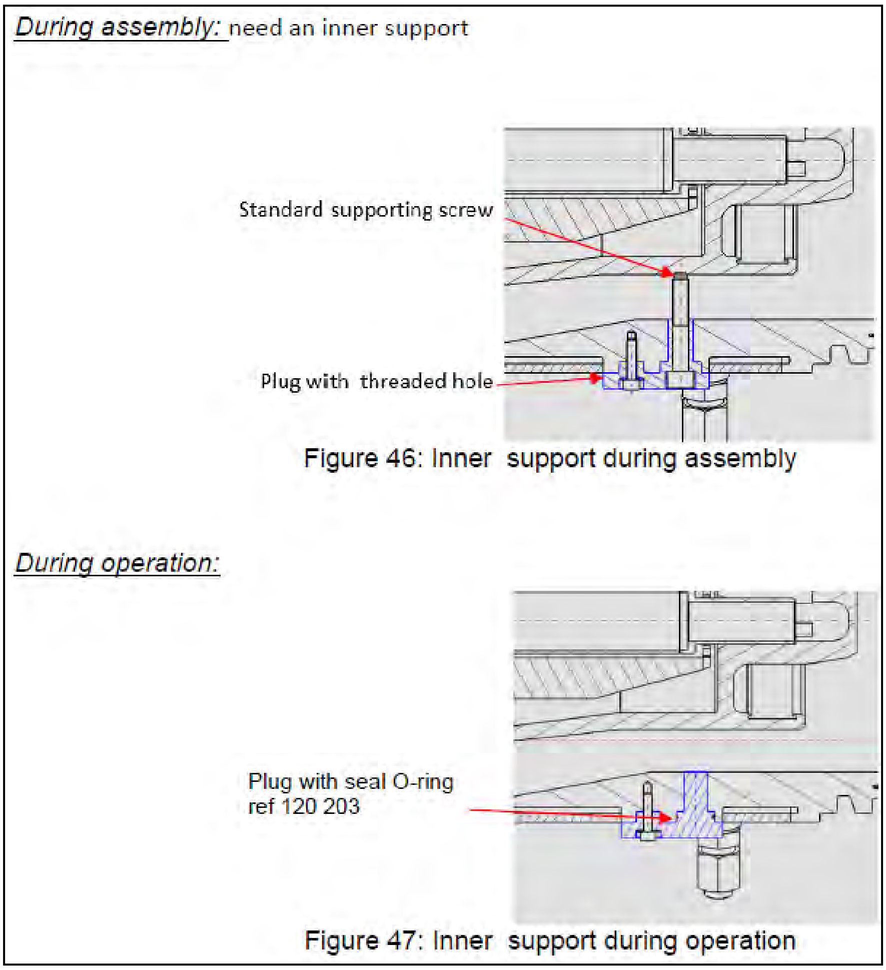


Figure 22: concept of temporary support in previous ATLIS design (extracted from [25])

The different parts to be installed/removed (like caps for example) during the assembly sequence shall be designed by the contractor also in [DL3], and manufactured in both phases 1 and 2.

5.4.6 Manufacturing requirements

After completion of the [DL3], the contractor shall issue the Manufacturing & Inspection Plan for the ATLIS prototype [DL4] according to requirements available in [16].

The contractor shall define and manufacture test parts to conduct the tests presented in section 5.4.9 as well as transport box needed to transport the ATLIS prototype on IO site (see section 5.4.10).

The aim of the different controls and tests are to:

- Validate the manufacturing process of the ATLIS
- Confirm that the ATLIS design pass the tests described in section 5.4.9.

The contractor shall deliver the test parts design package [DL5] made of:

- A detailed presentation of all the tests to be performed within Phase 1 and the test sequence.
- The Bill of Materials (BoM), 3D models (native files + STEP files) and the manufacturing drawings of all the components to be manufactured and to be procured in order to perform the tests
- A description of the transport box for the components to be delivered during phase 1.

SUPPLY

5.4.7 Material procurement requirements

The contractor shall produce the "phase 1" material purchase specification. The contractor is responsible for the conformity of the material used during the prototype manufacturing.

All materials shall be free from surface cracks, fissures and any other tool marks, burns, delamination and other defects, as this would make them incompatible with high vacuum and high frequency environments. The material certificate 3.1 as per EN10204:2004 shall be provided to IO, and shall be attached to the MIP [DL4].

5.4.8 Material, welding and fabrication requirements

The overall manufacturing will be qualified during the next phase of the contract. During Phase 1, the contractor has the flexibility to implement its own procedures. Evidence of process qualification is not required. Nevertheless, some operations may affect the vacuum performance of the prototype, for this purpose, reference to the ITER Vacuum Handbook [4] and appendices are specified hereafter. As part of the acceptance criteria of the phase 1, outgassing measurements that meet IVH requirements (table 5-1 of [4]) are requested (see section 5.4.9.2).

5.4.8.1 Machining requirements

The contractor shall take care that cutting and machining processes do not introduce contaminants into surfaces which may be difficult to remove later and which might result in degraded vacuum performance. Cutting fluids used for machining shall be water based, oil free, non-halogenated, sulphur and phosphorus free. The contractor can choose from those listed in ITER Vacuum Handbook Appendix 4 [5].

As standard for the machined surfaces used as sealing surfaces, the surface roughness of 0.8µm is required. For vacuum seal surfaces the machining marks must be in a circular lay, free from scratches across the lay and be protected at all times from subsequent damage. IO will not accept damaged seal faces. The maximum average surface roughness of surfaces within vacuum shall be 6.3 µm. The RF surfaces shall have a surface roughness of 3.2 µm maximum (RF surfaces have red dashes in Figure 23). The sealing surfaces of the prototype shall be protected with non-permanent covers after manufacture in order to prevent any type of damage during shipment.

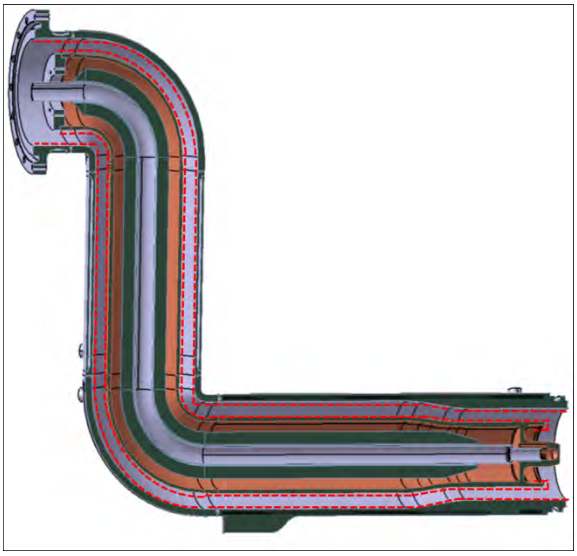


Figure 23:ATLIS RF surfaces

- **[51ICs1215-R]** The surface quality and surface treatment of parts that operate under vacuum in the presence of RF fields, shall be compatible with high voltage and with the IVH [4].

SUPPLY

Note: Surface quality and surface treatment required for RF components are applicable to the ATLIS even if the ATLIS is not under vacuum in the presence of RF fields.

5.4.8.2 Joining requirements

The contractor is free to choose the fusion joining process, based on his experience. WPS and WPQR are not part of the deliverable of Phase 1. Nevertheless, the contractor shall use welding procedures compatible with RCC MR [13] RS 3000. If the welding procedures are not already qualified according to RCC MR [13] RS 3000, the contractor will have to follow the qualification process in Phase 2 (see section 5.5.6.6).

Only the operator qualifications are required for Phase 1 (they shall be attached to the MIP [DL4]) in accordance with NF EN ISO 14732 (or equivalent). The contractor is free to define the post weld heat treatment, as required. Note that the weld seam shall be free from defect, such as:

- Cracks
- Crater
- Surface pore
- Lack of fusion
- Incomplete penetration
- Undercut (continuous or intermittent)…

As per the Vacuum handbook, the weld zones can be machined to match the surface finish of the parent material.

The maximum leak rate for the full ATLIS prototype shall be less than 10^{-9} Pa.m^3/s air equivalent. The requirements for brazed joints (not permitted in contact with water) are specified in [4].

5.4.8.3 Coating requirements

The selection of the most adequate deposition process and the application of this coating are the responsibility of the contractor. The coating specification is given below:

- Material: copper
- Thickness: minimum 60µm (≈5 times the skin depth at 40 MHz for copper at 100°C)
- Surface finish: 3.2 µm maximum (as per RF surfaces specified roughness, can be achieved by another operation post plating)
- Adhesion: > 30 MPa under tension

The contractor shall produce the coating procedure specification and shall take into account the provision specified in [4].

Even if the coating qualification will be executed in phase 2 only, the contractor shall execute coating tests during phase 1, as described in paragraph 5.4.9.2.

5.4.8.4 Cleaning requirements

The contractor shall pay attention to the cleanliness throughout the manufacture of the prototype. The ITER Vacuum Handbook, appendix 13 [5] provides relevant methods. The contractor shall follow the appendix 13 guideline by producing an ATLIS prototype cleaning plan, which includes all relevant steps for the different parts, before and after the different manufacturing processes. The ATLIS prototype cleaning plan shall be delivered to the IO TRO before starting the manufacturing in attachment of the MIP [DL4].

- **[51ICs190-R]** The manufacturing and assembly of the components that will be installed in vacuum shall comply with the cleaning and cleanliness requirements of IVH Appendix 13 [5].

SUPPLY

Note: Even if the ATLIS is not installed in vacuum, the ATLIS is VQC3 classified and shall comply with cleaning and cleanliness requirements of the IVH Appendix 13 [5].

5.4.8.5 Manufacturing of auxiliary parts and tools

The auxiliary parts (test parts), handling tools, storage support and transport box needed in Phase 1 shall be manufactured. The auxiliary parts are all the parts needed to perform the tests presented in section 5.4.9. It includes the caps for the ATLIS interspace volume (see section 5.4.9.1) as well as connectors, caps for water and gas ports.

The contractor shall identify the applicable standard(s) for the lifting/handling tool(s) and qualify the tools accordingly.

The contractor shall propose standard(s) for auxiliaries manufacturing and manufacture them accordingly.

5.4.9 Factory Acceptance Test of the ATLIS prototype (FAT)

The following sections are describing the validation process of the prototype manufactured by the contractor. The FAT are divided in six main sub-tasks (NDT, coating tests, outgassing tests, hydrostatic tests, pressure tests and final leak tests). The successful completion of these sub-tasks and consequently of the deliverables [DL6] will clear the FAT Hold Point, which is set up at this stage. The following flow chart (Figure 24) is showing the FAT phase, and the impact of test results if requirements are not met.

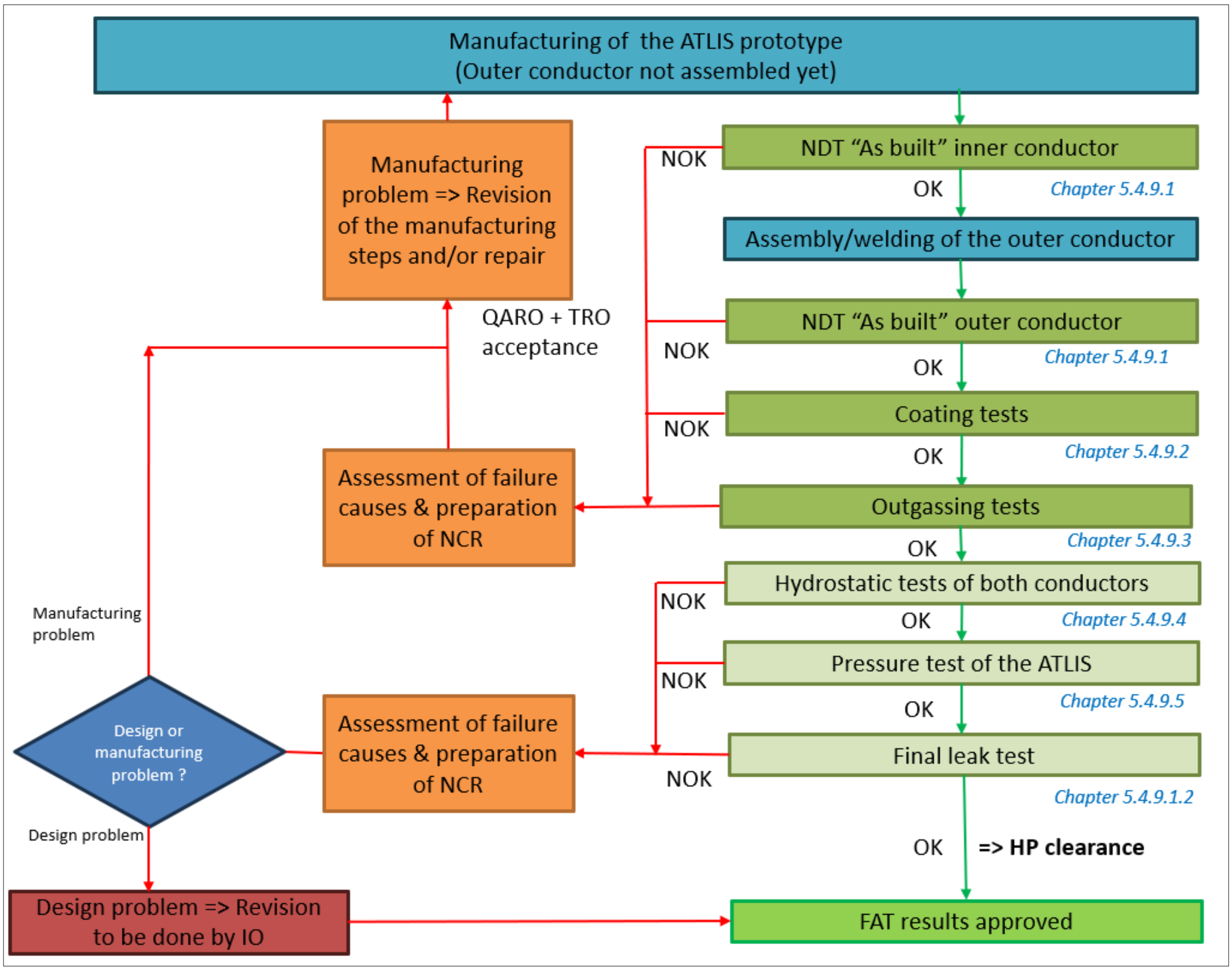


Figure 24: Flow chart for conducting the FAT

Nevertheless, the contractor is free to implement additional NDT all along the manufacturing phase, as required and based on his experience, aiming to limit the risk of issues while the FAT stage is reached. These intermediate NDTs results are not formally requested. In addition, if destructive tests are deemed required by the contractor for risk reduction purpose, the contractor has the freedom to implement these tests.

5.4.9.1 Non-destructive examination of the "As Built" prototype

The contractor shall control the prototype during and after the manufacture. The contractor is free to use its own procedure for the different NDT tests. The NDT operator shall be qualified and certified according to the NF EN ISO 9712 (or equivalent, the contractor has to select the more relevant standard). The contractor shall produce the prototype NDT within the FAT package [DL6].

For the ATLIS prototype the NDT shall include at least:

- 100% of the weld control by volumetric testing (radiographic or ultrasonic testing)
- 100% of the joints (welded or brazed) shall be Helium leak tested (maximum leak rate is $1x10^{-9}$Pa.m^3/s air equivalent for the full component)
- Visual examination of the prototype (weld inspection, coating inspection and geometrical inspection)

If a post-weld heat treatment is defined (as per the section 5.4.8.2), the NDT shall be carried out before and after the execution of heat treatment.

The contractor shall take into account the following acceptance criteria:

- The radiographic inspection shall be preferred when feasible. The weld quality assessment shall be carried out using the ISO 5817:2014. The quality level B shall be considered.
- Where volumetric examination by UT is the only option, the contractor shall provide the method, and shall provide evidence that the method is viable for the present application. The weld quality shall be carried out using the NF EN ISO 11666.
- The leak testing of the joints shall be performed in accordance with the NF EN ISO 20485. The required leak rates for all permanent joints shall be less than 10^{-9} Pa.m^3/s, as per [4] (VQC3 leak rate, table 25-1).
- The visual examination of the welds shall be performed in accordance with the NF EN ISO 17637.

The contractor shall add the calibration certificate of equipment that will be used for NDT. This certificate shall be attached to [DL6].

The contractor shall perform the leak tests in two steps:

- Step 1: leak testing of the inner conductor (see section 5.4.9.1.1)
- Step 2: leak testing of both conductors (see section 5.4.9.1.2).

5.4.9.1.1 Leak test of the inner conductor:

The Figure 25 is representing an example of leak test configuration for the inner conductor. The contractor is responsible for designing and manufacturing the tools/caps needed to perform this test.

SUPPLY

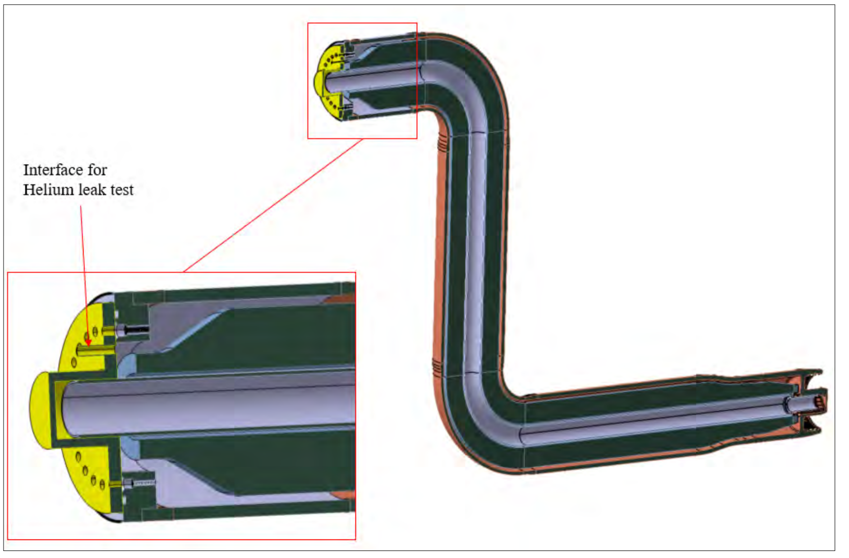


Figure 25: Inner conductor leak test configuration (cap in yellow)

5.4.9.1.2 Leak test of the volume in between inner and outer conductors

The Figure 26 and Figure 27 are representing the leak test configuration for the volume between both conductors. Since the outer conductor will certainly be built around the inner conductor (to be confirmed during phase 1), the contractor shall foresee caps on both side of the ATLIS to support the inner conductor inside the outer conductor. The contractor is responsible for designing and manufacturing the tools/caps needed to perform his test.

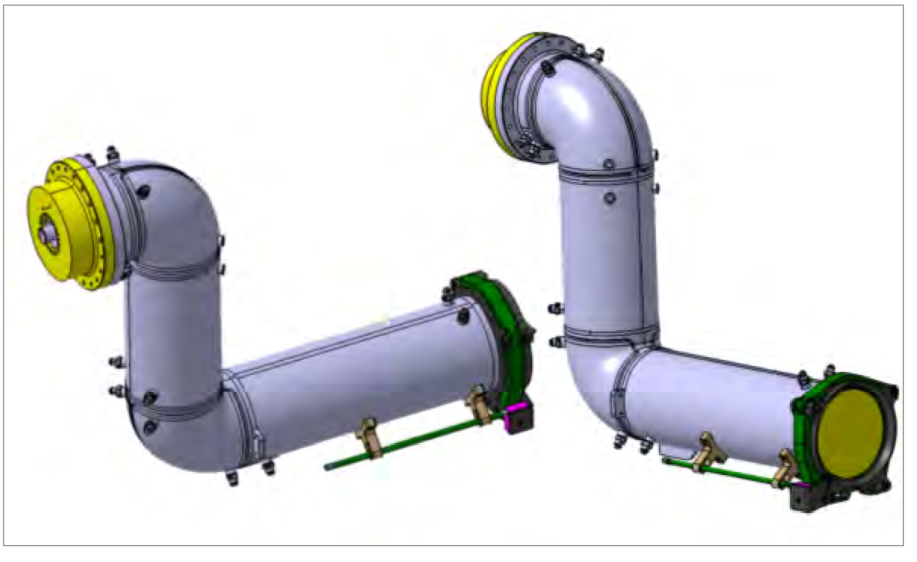


Figure 26: Leak test configuration for the volume between both conductors (caps in yellow)

SUPPLY

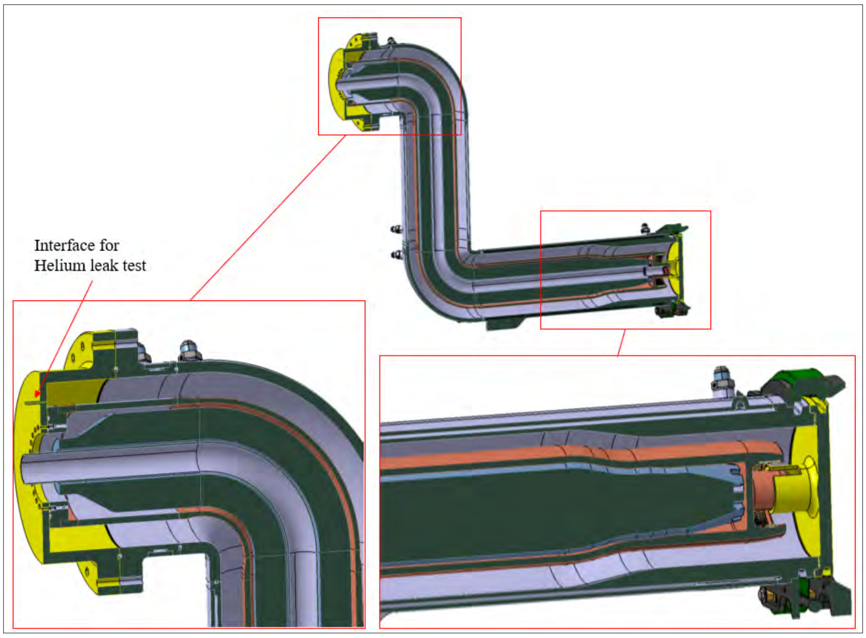


Figure 27: Leak test configuration for the volume between both conductors – section view (caps in yellow)

Note: IO will supply the front window quick connector to the contractor to perform this test, but the seals will have to be procured by the contractor.

The leak test of the volume between both conductors shall be done before and after all the other tests (hydrostatic and pressure tests).

Before to perform final leak test, all internal volumes wetted during acceptance testing shall be drained completely and dried by purging with dry air until the purge gas has a water content <4000 ppm before helium leak testing. The water content can be measured at the outlet of the water circuit being dried out. The section 27 of the ITER vacuum handbook [4] is providing requirements for draining and drying.

The final leak test result shall be identical to the result of the leak test done prior to the different test. Hence, the final leak test shall be compliant with ITER vacuum handbook [4] leak rate for VQC3 component.

5.4.9.2 Coating tests

The contractor shall perform the coating on test pieces of the same shape and relevant dimensions and extract test specimens from these test pieces. The following tests shall be carried out as part of the FAT:

- Inspection
  - 100% Visual Examination continuity, uniformity of the coating: no cracks, no flaking, no chipping, no burning, no blistering.
  - Surface roughness measurement
- Destructive tests
  - Macros: with photographs – No pores, no voids, homogenous layers.
  - Thickness measurements of underlayer and final layer coating.
  - Material analysis of deposited layer to identify all constituents.
- Mechanical tests
  - Adhesion check (ASTM B571 or equivalent)
- Thermal tests

- Bake to 300°C at <50°C/hr under vacuum of <0.01Pa. No cracks, no flaking no blistering.

The tests shall be performed before and after the 300°C baking. The results of the test shall be recorded in a test report part of the FAT package [DL6].

5.4.9.3 Outgassing tests

The contractor shall perform outgassing tests on test pieces that have followed the same manufacturing cycle (machining, cleaning, passivation, welding, heat treatment, coating…) than the real component, according to guidelines of the appendix 17 of [5]. The procedure shall be submitted to the IO TRO prior to the test execution, for review and approval. Visual inspection of the coating shall be carried out after outgassing in order to verify that the coating quality remains identical to the previous verification.

Acceptance criteria:

- The outgassing rate of material used for ITER vacuum system shall be consistent with the values specified in [4] table 5-1, ie $1x10^{-8}Pa.m^3.s^{-1}.m^2$.
- No visible effect on the coating.

The tests and the results shall be detailed in the FAT report [DL6].

Note: The contractor may investigate the possibility of having the same samples for coating thermal tests (see section 5.4.9.2) and for these outgassing tests.

5.4.9.4 Hydrostatic testing of the ATLIS prototype

After completion of the NDTs required for the validation of the manufacturing correctness, the contractor shall perform the hydrostatic test of the ATLIS prototype. The aims of these tests are to check if the safety factor introduced in the design phase is fit for purpose. This is a way to determine the margin between design by analysis and design by experiment.
The hydrostatic tests are based on the load specification [10]. This is not a qualification of the design.
The contractor shall set up the test stand to perform the hydrostatic tests of the inner and outer conductors cooling circuits with a water pressure of 1.85 MPa absolute. The contractor shall maintain and monitor the water pressure during at least one hour.

Acceptance criteria:

- No visual deformation shall be seen on the ATLIS
- No water leak shall be detected

The tests and the results shall be detailed in the FAT report [DL6].

Note: After hydrostatic tests the ATLIS shall be drained and dried, see requirements in section 5.4.9.1.2

5.4.9.5 Pressure testing of the ATLIS prototype interspace

After completion of the hydrostatic tests, the contractor shall perform the pressure testing of the ATLIS prototype. The aim of this test is also to check if the safety factor introduced in the design phase is fit for purpose.
This pressure test is based on the load specification [10]. This is not a qualification of the design.

SUPPLY

The contractor shall set up the test stand to perform the pressure test of the interspace between inner and outer conductors with a pressure (gas to be selected by manufacturer, dry air for example) of 0.9 MPa absolute. The contractor shall maintain and monitor the gas pressure during at least one hour.

Acceptance criteria:

- No visual deformation shall be seen on the ATLIS
- No variation of pression in the ATLIS (at the level of tolerance of the monitoring equipment)

5.4.10 Delivery of the ATLIS prototype to IO premises

A successful completion of the FAT sequences is required prior to delivery to the IO site. The ATLIS prototype shall be prepared in accordance with [4] section 29.

Each shipment shall be accompanied by a Delivery Report [DL7] shall be prepared by the contractor, 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;
- A manufacturing dossier that compiles all manufacturing documents
- The ATLIS prototype FAT package [DL6]
- Bill of Materials
- Security Measures
- Release Note according to instructions in [21];
- 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.

Before the shipping, a Delivery Readiness Review (DRR) shall be organized with the contractor according to procedure [41]. IO will check the availability of the required documentation as specified hereabove.

The ATLIS prototype Delivery Report [DL7] shall be signed by a representative of the IO and its Supplier. Successful completion of the DRR and signature by the IO of the Delivery Report prior to shipment represents a Hold Point that enables the contractor to deliver the ATLIS prototype package.

The ATLIS prototype [DL8] 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” [21] 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.

5.4.11 Acceptance criteria for phase 1

The following acceptance criteria are set up for the phase 1:

- Completion and Approval of all deliverables according to the agreed schedule (see Table 4)
- Evidence that all requirements to be fulfilled for phase 1 are met.

5.5 Scope of Supply for the Phase #2

5.5.1 Phase description and scope of supply

5.5.1.1 Preamble & Equipment qualification documentation

After Phase 1, IO will perform an FDR for the full Antenna package (including ATLIS) and then decide to go to phase 2 or not.
A tentative period of 6 months is considered for the closure of all actions relating to the ATLIS FDR.

If the IO choose to activate the Phase 2 option, a preliminary work will have to be performed by IO in order to prepare the qualification package and run the different thermo-structural analyses justifying the manufacturing design.

Prior to phase 2 beginning, the IO will issue the following qualification package:

- The Qualification strategy. The current IO strategy is relying on the analysis method.
- The equipment identification file
- The qualification plan
- The analysis reports
- The Qualification follow-up documents
- The Qualification synthesis report
- The qualification preservation sheet (preliminary version)
- The reference file (preliminary version)
- The qualification file (preliminary version)

The contractor shall take into account this qualification package and shall maintain it up-to-date all along the Phase 2 (during MRR, the manufacturing and the testing of the ATLIS series) and deliver the full qualification package within the delivery report [DL12].

- **[51ICs785-R;Defined Requirement]** The PIC components shall be qualified through a qualification program that shall demonstrate that each component is able to perform its functions in the conditions and events that are foreseen for its functioning."

5.5.1.2 Scope of Supply

According to the components classification [2], the ATLIS is classified PIC/SIC 1 and QC 1. **The phase 2 contains PIAs**, they are detailed in next section 5.5.1.3.

The aim of this phase is to manufacture the overall ATLIS quantity for one IC Antenna. For this purpose, the contractor shall issue the manufacturing documentation and procedures, using the knowledge developed during the phase 1 of the present contract. **The phase 2 aims to manufacture the 8 (eight) ATLIS necessary for the IC Antenna.**

SUPPLY

At this stage, an update of the QA plan is required. The contractor shall produce the updated quality plan **{MRR#23}** of the package [DL9]. The contractor shall then deliver the full set of manufacturing drawings **{MRR#3}** of the package [DL9] for the eight ATLIS. The contractor shall issue the Manufacturing & Inspection Plan for the phase 2 **{MRR#10}** of the package [DL9]. The Manufacturing & inspection plan shall include all activities falling in the scope of PIA. The Manufacturing & Inspection Plan for Phase 2 shall be submitted to the IO acceptance before starting the manufacture of the components.

- **[51ICs1198-R]** Any special tools and/or test equipment needed for maintenance or test of IC H&CD components on site shall be part of the components' procurement scope.

Note regarding to the previous requirement: **the installation tools necessary to connect the ATLIS to the Antenna in ITER facility are not in the scope of the present specification.** The lifting tools and eye-bolts procured and used for the purpose of the ATLIS manufacturing, handling and testing shall be delivered with the ATLIS to the IO.

- **[51ICs1199-R]** Any special equipment needed for packaging, handling, storage or transport of IC H&CD components are part of these components' procurement scope. The level of protection required by each component shall be established on the basis of the conditions of transport and of the environmental conditions at the ITER site. The supplier of the components shall document the level of protection provided by its packaging.

Please find requirements for packing, storage and delivery in sections 5.5.9, 5.5.10 and 5.5.11 respectively.

5.5.1.3 List of Protection Important Activities (PIAs) for the different Phases of Work.

The following PIAs are specified in accordance with [34], and shall be taken into account by the contractor during the execution of the phase 2. The list of PIAs shall be verified at the beginning of the phase, with the support of the IO safety responsible officer.

Life Cycle PIAs

- Management of Deviation Requests, in accordance with the IO procedure
- Management of Non Conformities, remedial actions, preventive and corrective actions, in accordance with the IO procedure.
- Propagation of the Defined Requirements in the contract and quality plans.

Design Phase PIAs

- Safety Demonstration (any tests that are used to prove that a safety function is met)

Manufacturing PIAs

- Writing of technical manufacturing specifications (for sub-contracted activities)
- Material procurement
- Construction / manufacture / assembly carried out in factory
- Welding, Brazing and joining technologies, in accordance with qualified joining procedure
- Non Destructive Examination (NDE), in accordance with qualified NDE procedures
- Qualification of components and demonstration of the compliance with compliance matrix
- Factory acceptance test (FAT), following approved FAT procedures

SUPPLY

- Transportation of PIC component, after successful completion of factory acceptance tests, formal acceptance of the PIC by IO and prior to final shipping and handover to IO at the ITER Site
- Reception of PIC component at ITER site, in accordance with the procedure for reception of component at the ITER site
- Storage of PIC component at the ITER site, in accordance with the component preservation plan

Manufacturing PIAs shall be implemented in the MIPs **{MRR#10}**.

5.5.2 Design requirements

The components to be manufactured in Phase 2 shall be compliant with the models/drawings provided by IO in the equipment identification file. IO will produce 3D models of the ATLIS final design as close as possible from the ATLIS prototype design. The design modifications performed by IO, if any, will be the ones requested by the final CFD and structural analyses.

5.5.3 Requirements propagation & Compliance matrix

All the Defined Requirements, named "51ICsxxx-R;Defined Requirement", provided by IO in the present document shall be propagated by the contractor and translated into technical requirements. Some requirements are provided directly in the different sections of the document while some others are given in Appendix A – Technical & Defined Requirements.

The contractor shall also produce a compliance matrix that references the technical requirements and defined requirements that are specified in the present document. The compliance matrix shall be used to track the implementation of the various requirements over the project, and consequently shall be regularly updated. The contractor is free to propose the compliance matrix template. The template will be reviewed and approved by IO. The contractor shall deliver at the MRR, a first version of the compliance matrix. This is the deliverable **{MRR#9}** of the package [DL9]. This matrix shall be updated at the end of the phase 2 and delivered with the delivery report [DL12].

5.5.4 Manufacturing readiness review

IO will organize the MRR according to IO procedures [30]. IO will give the Authorization To Proceed (ATP) once the MRR is approved.
A hold point shall be associated to this review. The aim of the MRR is to:

- Confirm that the manufacture of the concerned component is ready to start without incurring unacceptable risks.
- Give the ATP with manufacturing to the contractor.

The MRR shall cover:

- The material
- The personnel
- The machines and tools
- The manufactures methods
- The transportation of components
- The requirements

The contractor shall produce the MRR input package [DL9] on the basis of the required documentation as specified in the Annex 1 – MRR Input Data Package of [30]. IO and contractor will propose the MRR agenda, and it will be approved by the MRR panel Chair.

SUPPLY

The contractor shall produce the necessary presentation (ppt files) to be used during the MRR.

The contractor shall provide the [DL9], containing:

- The exhaustive MRR documentation list.
- The documentation package, up to date, in accordance the Annex 1 of [30] for phase 2 use (see the summary in the Table 3).
- The different presentations, as needed, to comply with the agenda.

MRR documentation package [DL9]		
#doc	**Title of document**	**Comments**
Engineering		
MRR#1	List of Deviation Requests (if any)	Record during all phases
MRR#2	List of NCR, identified and resolved during Phase 1	Record during all phases
MRR#3	Manufacturing drawings (2D) and models (3D)	
MRR#4	Bill of material for ATLIS series	Based on the 3D models
MRR#5	List of standards, codes and regulations applicable for each step of the series manufacturing	
MRR#6	Item Identification & tagging	
MRR#7	Load analysis as part of the manufacturing process	
MRR#8	Design description and justification of transportation boxes	
MRR#9	Verification Compliance Matrix (requirements and evidence)	
Manufacturing processes		
MRR#10	Manufacturing and Inspection Plans (MIPs covering all phase 2)	
MRR#11	Manufacturing schedule and work flow/assembly sequences	
MRR#12	Material procurement technical specification and sub-orders (including e.g. consumables	Requirements for material procurement in section 5.5.5
MRR#13	Material management process: - identification and control of material - material certificates - material traceability procedure - Storage conditions - Handling procedures	
MRR#14	Manufacturing procedures including special processes (e.g. machining, forming, wiring, brazing, soldering, welding, deep drill, 3D printing, cleaning, heat treating, others and non-destructive examination, etc.). E.g.: - components processing and assembly specification - cleanliness program - surface treatment program - pipeline inspection program - non-destructive testing program - coating program - preservation, packaging, storage and transportation program	
MRR#15	Welding data package - Welding procedures/welding Procedure Specification (WPS) - Welding procedure qualification record (WPQR) - Welding quality inspection and procedure plan (WQIPP) - Welding map - Cleaning procedure and requirements for welded parts / components with particular attention on welded joints forming parts of the vacuum boundary according to requirements of ITER Vacuum Handbook.	
Test methods		
MRR#16	Control specifications, Testing plan and Test procedures	

SUPPLY

MRR#17	Qualification through Mock-ups and prototype	
MRR#18	Qualification of special processes	
MRR#19	Manufacturing process qualification procedure	
MRR#20	Manufacturing quality control procedure	
MRR#21	Non-Destructive Examination procedures	
MRR#22	Factory acceptance test program identifying all factory acceptance tests as defined at design stage and including details on extent of the tests, type, examinations and inspections of the Items (verification of requirements for acceptance stage)	
Quality acceptance		
MRR#23	Quality Plan	
MRR#24	List of Suppliers/Subcontractors and their attributions	
MRR#25	Sub-contractors Quality Plans	
MRR#26	Third party list for review and checks	
MRR#27	MRR deliverables list (list of documents deliverables to be provided by the Manufacturer)	
Tooling		
MRR#28	List of machines, test equipment and tools including relevant calibration protocols: - the calibration status and records of the machines and tools - Measuring and test equipment qualification and maintenance - Requirements regarding special tooling / spares and any special pieces of equipment or tools needed for packaging, handling, storage, transportation up to IO site	
Training and qualification		
MRR#29	- list of personnel qualifications to perform a special process as may be applicable - list of qualified welders, welding equipment operators, NDE personnel - training records and certificates	
Assembly		
MRR#30	ATLIS Final assembly procedure	
Transportation and preservation		
MRR#31	- Packing and packaging procedure - On site preservation procedure - planned delivery list	

Table 3: List of MRR documents

The [DL9] shall be submitted to the IO review and acceptance, and will be provided to the MRR panel.
Once the [DL9] will be approved by IO, the MRR will take place. The contractor shall attend the MRR (remote and physical attendance).
Upon closure of the MRR, the Chair will issue a formal report detailing the recommendations, if any, and the outcome of the MRR, as follow:

- Successful, in this case IO shall give the ATP
- Unsuccessful, in this case the contractor shall resolve the issues identified, and a new MRR will take place.
- Conditionally successful, in this case the contractor shall complete the activities (deemed minors) to comply with the MRR report recommendations. A new MRR is therefore not required in that case.

It should be noticed that a conditionally successful or unsuccessful MRR might have several contractual implications (financial, delay, unforeseen task) that will be discussed between IO and the contractor. A hold point is set up at this stage. A successful completion of the MRR will clear the hold point and IO will give the ATP to the contractor to start the manufacturing activities.

5.5.5 Material Requirements

The contractor shall procure, test and qualify the material in accordance with the RCC-MR approach.

The management of material and material procurement specifications have been presented during the MRR. The contractor shall proceed to the material purchase covering the whole phase 2, including filler materials in accordance with the approved strategy **{MRR#13}.** The contractor shall use the approved material purchase specifications **{MRR#12}**.

All material certificates shall be provided and shall be recorded in IO IDM.

5.5.5.1 Metallic material

The contractor is responsible of the definition of the “Reference Procurement Specifications” or “Special Procurement Specification” (depending of the material type) for the metallic material, in accordance with RM 0112 or RM 0115.

All material shall be clearly specified and certified in accordance with EN 10204:2004. Material certificate 3.1 shall be delivered providing the evidence that material meet the requirement of the “Reference Procurement Specifications”. The material and the material supplier shall be qualified as per the RCC-MR approach, as specified in RM0140. The contractor shall include all data related to material procurement in the [DL10]**.**

- **[51ICs782-R;Defined Requirement]** Low activation materials shall be selected when this enables to reduce the contact dose, decay heat and the activation level of radioactive waste.

The contractor shall comply with the requirements in section 5.4.3.4 and therefore with impurities limits provided for 316L.

5.5.5.2 Filler material & brazing material

The contractor shall procure the joining material quantity that covers phase 2 of the present contract. All welding consumables shall be specified in accordance with a standard accepted by IO (e.g. ISO 14344:2010) with additional requirement for impurities for chemical composition as described in [43].

The contractor shall select the filler material in accordance with the RCC-MR Tome 4:

- ➢ Filler material for welding
    - ✓ Acceptance of filler material (RS2000)
    - ✓ Qualification of the filler material (RS5000)

The brazing process is not included in the RCC-MR 2007. The contractor might propose equivalent standard to those specified hereafter:

- ➢ Braze material for Brazing
    - ✓ Identification of filler material or filler alloy (NF EN ISO 3677:1995)
    - ✓ Acceptance conditions of filler materials (NF EN ISO 17672:2010)

The contractor shall include all data relating to welding and brazing material procurement in the [DL10]**.**

5.5.5.3 Coating material

The contractor shall procure the coating material required for phase 2 of the present contract. The coating material shall be specified and certified in accordance with EN ISO 10204:2004.

SUPPLY

The contractor shall specify all materials required to achieve the coating (i.e. if the process necessitates electrolytic baths or necessitates different layers, such as Nickel layer…). The contractor shall include all data related to coating material procurement in the [DL10]**.**

5.5.6 Fabrication requirements

The contractor shall produce the series production schedule. The schedule shall be discussed and agreed by IO. The schedule shall be maintained up to date by the contractor.

The contractor shall manufacture the different components required to cover the manufacturing of the ATLIS series, in accordance with the BoM specified in **{MRR#4}** and the batch of manufacturing drawings **{MRR#3}**. As specified in **{MRR#23}** and **{MRR#24},** the contractor quality plan and its sub-contractor quality plans shall be approved by IO before the start of the manufacturing activities.

The contractor shall ensure that the MIPs **{MRR#10}** are correctly propagated at any stage of the manufacturing process (contractor and sub-contractors level).

The approved procedures provided and approved for the MRR shall be followed:

- Manufacturing Codes, as per **{MRR#5}**
- Manufacturing of components, as per **{MRR#14}**
- Welding of components, as per **{MRR#15}**
- Control of components, as per **{MRR#16}**
- NDE of components, as per **{MRR#21}**

The contractor shall implement the manufacturing resources and hardware according to **{MRR#28}** and **{MRR#29}.**

The contractor shall ensure the quality control throughout the complete manufacturing process **{MRR#20},** and shall monitor any deviation or non-conformities, in accordance with [29] and [15].

- **[51ICs692-R;Defined Requirement]** The manufacturing of the IC H&CD components that are exposed to the tokamak vacuum, and of nuclear safety relevant equipment located in the nuclear buildings, shall comply with the requirements listed in Table 1 of Codes and Standards for ITER Mechanical Components [30]."

5.5.6.1 Machining operations

All machining operations, qualification, control and inspection shall be performed according to the ITER Vacuum Handbook [4]. Machined parts shall be 100% dimensionally measured. All measurements are recorded in a dimensional report included in the manufacturing file. The contractor shall take care of the cutting and machining processes, avoiding the introduction of contaminants into surfaces which may be difficult to remove later and which might result in degraded vacuum performance.

Cutting fluids used for machining shall be approved before use and shall be water based, oil free, non-halogenated, sulphur and phosphorus free. They shall be chosen from those listed in ITER Vacuum Handbook Appendix 4 [5].

5.5.6.2 Surfaces finish

A surface roughness of 0.8µm is required for the sealing surfaces. For seal surfaces, the machining marks must be in a circular lay, free from scratches across the lay and be protected at all times from subsequent damage. <u>IO will not accept damaged seal faces</u>.

The maximum average surface roughness of the surfaces carrying RF current shall be 3.2µm maximum. The roughness measurement shall be done with an electrical stylus. The contractor will indicate the norm used for the roughness measurement. The RF surfaces of the prototype shall be protected after manufacture in order to prevent any type of damage.

5.5.6.3 Inspection post machining

All components shall have full dimensional inspection after machining and before special processes execution. The inspection reports shall be recorded. Approval of these reports is required prior to executing special process (i.e. brazing, welding and coating). These reports include the roughness measurement of each vacuum sealing and RF surfaces.

5.5.6.4 Marking

Each ATLIS shall have an identification number implemented on the external surfaces which are not VQC or exposed to RF current. IO will provide the identification number. The series components shall be individually marked with a unique identification, which is traceable to the component document package. They shall only be marked by scribing with a clean sharp point or by a laser scribing method.

- **[51ICs1783-R]** Where traceability is required, as for all PIC systems, structures or components, or for parts whose lifecycle has to be monitored during the life of the project, unique identification of individual items or batches shall be implemented [44].
- **[51ICs1708-R;Defined Requirement]** All identification, labelling, colour coding and signage on the IC H&CD system shall comply with the Specification for Labelling of Equipment on ITER Project ITER_D_TL25DK and the ITER Site Signage & Graphics Standards ITER_D_4ALJEU.

5.5.6.5 Cleaning

The cleaning shall be executed in accordance with the ITER Vacuum Handbook, appendix 13 [20]. A cleanliness plan shall be submitted to IO for approval before the beginning of any manufacture operation. It shall include the precautions undertaken, so that the tools and technics used during the manufacture do not contaminate the VQC surfaces.

5.5.6.6 Joining

The joining processes shall be carried out in accordance with the RCC-MR approach [13]. The Vacuum Handbook attachment 1 [6], which provides complementary guidelines for the welding of vacuum equipment shall be used as well. Where requirements differ, the more stringent standard shall be applied. For the special joining process which is not included either in RCC-MR or ITER Vacuum Handbook, the section 5.5.6.6.3 is providing the guideline.

5.5.6.6.1 Technical qualification of the production workshop (in accordance with RS6000)

A technical qualification of the contractor’s workshop is required to demonstrate its capacity and its technical resources for carrying out the joining operations. The contractor shall provide the documentation and evidences as specified below:

- Qualification conditions (RS6200)
- Qualification report (RS6300)
- Workshop qualification period (RS6400)
- Transfer of welding procedure qualification (RS6500)

5.5.6.6.2 Welding process (in accordance with RS7000)

The different welds on the series shall be performed according to RCC MR [13] RS 7000. If the contractor’s welding procedures are not yet qualified according to RCC MR [13] RS 3000, the contractor shall perform the qualification prior to start the welding of the ATLIS series.

SUPPLY

Prior to perform the welding operation, the contractor shall submit to the IO approval the weld plan that includes:

- The preliminary verification weldability of materials (according to RS1200)
- Acceptance of filler material lots (according to RS2000)
- The Welding Procedure Specification WPS (according to RS3000).
- The Weld Repair Procedure (according RS3000).
- The Welding Procedure Qualification WPQR, (according to RS3000).
- The Welding Qualification Report (according to RS3000).
- The Welder Qualification (according to RS4000).
- The Operator Qualification (according to RS4000).
- The Qualification of filler material when concerned by RS 5000 (according to RS5000).
- The workshop qualification (according to RS6000), as detailed in 5.5.6.6.1.

The qualification of the welding process shall cover every weld design. This will imply several WPS. If proof samples are required, they shall be produced in accordance with the references [6] and [13].

The weld plan shall be delivered in attachment to the MIP **{MRR#15}**.

5.5.6.6.3 Special joining process (other than welding)

For special joining process (other than welding), the qualification process shall be proposed by the contractor according to nuclear codes and accepted by IO.

The tests defined shall be conducted on the different types of special joints used in the construction of the ATLIS series (if any). The special joining acceptance tests shall be performed before the manufacture of the ATLIS series can commence. Typical tests to be performed by the contractor on test samples on each type of joint include:

- A visual examination of the brazed joint to be photographed and comments recorded,
- Micro-graphics Examination (×5 magnification) to be photographed and comments recorded,
- Destructive tests.

All inspection methods and related acceptance criteria implemented by the manufacturer shall be approved by IO before use, in accordance with the phase 2 Manufacturing & inspection plan **{MRR#10}**.

If production proof samples are required, they shall be clearly identified and justified, and the execution and the qualification of the proof sample shall be carried out based on the reference quoted in this section.

All data shall be recorded in the Welding/Brazing Procedure Qualification Record and delivered in the manufacturing dossier to be delivered within the delivery report [DL12], see section 5.5.11.

5.5.6.7 Coating (in accordance with RF5000)

The copper coating of the conductors shall be performed according to RCC-MR section 5 (RF5000) [13].

The selection of the most adequate deposition process and the application of this coating are the responsibility of the contractor. The coating specification is given below:

- Material: copper
- Thickness: minimum 60µm (≈5 times the skin depth at 40 MHz for copper at 100°C)
- Surface finish: 3.2 µm maximum (as per RF surfaces specified roughness, can be achieved by another operation post plating)
- Adhesion: > 30 MPa under tension

SUPPLY

The contractor shall produce the coating procedure specification and shall take into account the provision specified in [4]. The contractor shall demonstrate the validity of the copper coating process on sample shapes of relevant complexity. The RCC-MR section 5 (RF5000) [13] shall be used in support to the qualification.

The contractor shall qualify the coating process, by coating test pieces of the same shape and relevant dimensions. Test specimens shall be extracted from these test pieces. The following test shall be carried out as part of the qualification:

- Inspection
  - 100% Visual Examination continuity, uniformity of the coating: no cracks, no flaking, no chipping, no burning, no blistering.
  - Surface roughness measurement
- Destructive tests
  - Macros: with photographs – No pores, no voids, homogenous layers.
  - Thickness measurements of underlayer and final layer coating.
  - Material analysis of deposited layer to identify all constituents.
- Mechanical tests
  - Adhesion check (ASTM B571 or equivalent)
- Thermal tests
  - Bake to 300°C at <50°C/hr under vacuum of <0.01Pa. No cracks, no flaking no blistering.

The results of the tests shall be recorded in the coating procedure qualification record and delivered in the manufacturing dossier to be delivered within the delivery report [DL12], see section 5.5.11.

5.5.6.8 Outgassing (identical to section 5.4.9.3)

The contractor shall perform outgassing tests on samples that have followed the same manufacturing cycle (machining, cleaning, passivation, welding, heat treatment, coating…) than the real component, according to guidelines of the appendix 17 of [5]. The procedure shall be submitted to the IO TRO prior to the test execution, for review and approval. Visual inspection of the coating shall be carried out after outgassing in order to verify that the coating quality remains identical to the previous verification.

Acceptance criteria:

- The outgassing rate of material used for ITER vacuum system shall be consistent with the values specified in [4] table 5-1, ie $1x10^{-8}Pa.m^3.s^{-1}.m^2$.
- No visible effect on the coating.

The tests and the results shall be attached to the delivery report [DL12].

- **[51ICs630-R]** The maximum acceptable outgassing rate and the maximum allowable leak rate of the IC H&CD VQC components shall comply with those that are specified in the IVH [4] (Outgassing: see section 5.4 and Table 5-1; leak rates: see section 25.2 and Table 25-1).

5.5.7 Factory Acceptance Test (FAT)

Prior to start the tests, 100% of the ATLIS dimensions shall be controlled according to the drawings **{MRR#3}**. The dimensional control shall be delivered within the FAT package [DL11].

Each ATLIS shall be tested before storage and shipment according to the following sequence:

SUPPLY

1/ Leak testing of the volume in between both conductors, identical to section 5.4.9.1.2

2/ Hydrostatic test of the water circuits (inner and outer conductors), identical to section 5.4.9.4

Note: After hydrostatic tests the ATLIS shall be drained and dried, see requirements in section 5.4.9.1.2

3/ Pressure tests of the volume between both conductors, identical to section 5.4.9.5

4/ Final leak test of the volume between both conductors, identical to section 5.4.9.1.2.

Note: The FATs have been defined in accordance with the current ATLIS design and may have to be updated if this design is challenged during Phase 1, made of welded conductors without any bolted connection.

The contractor shall produce the test procedure detailing the following:

- Definition of the test conditions
- Test procedures
- The test pressure with the reference of the corresponding FE analysis
- The temperature of the component during the test
- The measurement to be performed during and after the test
- The location, the type and the properties of the measurement equipment
- The type of water or gas used for the test
- Instruction to be observed to ensure the safety of workers during the test
- The drawing showing the test configuration, with the bill of material

Test procedure shall be submitted to the IO review and acceptance before the beginning of the tests. The IO approval of the FAT procedure enables the contractor to perform the test.

The acceptance criteria for the Phase 2 Factory Acceptance Tests are the following:

- Maximum leak rate conformed to VQC3A specification for the interspace boundary (either with atmosphere or with water), ie $1x10^{-9}Pa.m^3/s$ air equivalent for the full ATLIS as per [4]
- No visible strain of the ATLIS structure or on the coating
- No water leak for hydrostatic tests.

The contractor shall produce the test report covering each tested ATLIS. The test report shall include at least:

- The equipment manufacturer
- Identification of the ATLIS
- Name of the inspector
- Test pressure and diagram effectively showing pressure as a function of time
- Fluid used for the test, and temperature of the fluid
- Duration for which the test pressure is maintained
- Identification of test manometers
- Results of examinations performed during the test
- Conclusions.

The test report shall be submitted to the IO review and acceptance. The contractor shall deliver to IO the phase 2 FAT package [DL11] that includes all document produced during the FAT.

5.5.8 Cleaning

The contractor shall perform the cleaning of all ATLIS units after completions of FAT. The cleaning procedure shall issue in accordance with the reference [5] appendix 13. A cleanliness plan shall be submitted to IO for approval before the beginning of any manufacture operation. It shall include the precautions undertaken, so that the tools and technics used during the manufacture of the ATLIS do not contaminate the vacuum classified surfaces.

5.5.9 Packing

As defined in **{MRR#31}**, the contractor shall proceed to the ATLISs packing and shall install them in dedicated transport boxes. The contractor 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.

Shock absorbing material shall be used.

- **[51ICs1172-R]** The IC H&CD equipment shall be delivered to ITER site in packaging designed to provide environmental protection and to maintain cleanliness during transport and on-site storage.
- **[51ICs1403-R;Defined Requirement]** The design of the IC H&CD system and subsystems, and the planning of their shipping, storage, construction and operation, shall take into account the meteorological conditions and the risks of abnormal conditions. The meteorological conditions, and some Cadarache specific criteria that are imposed by French and European norms, are reported in [70].

The packing of each individual ATLIS units shall be performed in accordance with the reference [4] section 29.

5.5.10 Storage

The contractor shall produce the storage procedure **{MRR#14}** that shall be applied during the series production. Each ATLIS units produced shall be stored up to the shipment within the contractor premises. The storage procedure shall describe how the ATLIS units will be stored, in which state. The reference [4] section 31 provides storage requirement that shall be applied. The storage procedure shall be submitted to IO for review and acceptance.

5.5.11 Shipment, Transportation and Delivery to the ITER site

Each shipment shall be accompanied by a Delivery Report [DL12] that 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;
- A manufacturing dossier that compiles all manufacturing documents
- The ATLIS FAT package [DL11]
- Bill of Materials
- Security Measures
- Release Note according to instructions in [21];
- 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.

SUPPLY

Before the shipping, a Delivery Readiness Review (DRR) shall be organized with the contractor according to procedure [41]. IO will check the availability of the required documentation as specified hereabove.

The Delivery Report [DL12] shall be signed by a representative of the IO and its Supplier. Successful completion of the DRR and signature by the IO of the Delivery Report prior to shipment represents a Hold Point that enables the contractor to deliver the ATLIS packages.

The ATLIS units packages [DL13] 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" [21] 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.

- **[51ICs759-R]** The specific tooling, fixtures and auxiliary test equipment shall be provided to IO and stored on ITER site after use.

5.5.12 SAT & final acceptance

Site acceptance test of the ATLIS package [DL13] will be performed by IO representatives. The following points shall be checked before acceptance;

- Checking of backfilled volumes
- Seal face inspection
- Checking the integrity of packing and status of accelerometers
- Cleanliness check
- Leak test (at room temperature)

Successful inspection of the different ATLIS units is required by IO for the package [DL13] final acceptance.

5.5.13 Delivery Time

All deliverables shall be delivered within the delays detailed in Table 4.

6 Location for Scope of Work Execution

The work is expected to be performed at Contractor's facility. Some tasks can sub-contracted elsewhere.

No work is expected on ITER site.

7 IO Documents & IO Free issue items

7.1 IO Documents:

Under this scope of work, IO will deliver the following documents by the stated date:

Ref	Title	Doc ID	Expected date

SUPPLY

1	ATLIS qualification package	TBD	T1

7.2 Free issue items:

Under this scope of work, IO will deliver the following equipment/parts by the stated date:

Ref	Equipment / Part Description	Part Nbr	Expected date
1	1x Quick connector (FW-ATLIS)	TBD	Just after approval of the MIP [DL4]

8 List of deliverables

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

The dues dates are specified on the following main milestones:

- T0: Date of the KoM for Phase 1
- T1: Date of KoM of phase 2

Phase	Deliverable (DL)	Type of DL	Due date (in months)
1	[DL1] Quality plan	docx/pdf	T0+1
	[DL2] ATLIS prototype manufacturing sequence	docx/pdf	T0+3
	[DL3] ATLIS prototype manufacturing design package	docx/pdf + 3D model (native files and step files) + drawings (pdf and dwg/dxf files) (storage in SMDD)	T0+5
	[DL4] MIP for the ATLIS prototype	docx/pdf	T0+5
	[DL5] Design package of the test parts and transport box	docx/pdf + 3D model (native files and step files) + drawings (pdf and dwg/dxf files) (storage in SMDD)	T0+6
	[DL6] ATLIS prototype FAT package	docx/pdf	T0+13
	[DL7] ATLIS prototype delivery report	docx/pdf	T0+14
	[DL8] Reception of the ATLIS prototype	1x ATLIS prototype	T0+15
2	[DL9] MRR package:	docx/pdf + 3D model (native files and step files) + drawings (pdf and dwg/dxf files) (storage in SMDD)	T1+5
	[DL10] Material records	docx/pdf	T1+14

SUPPLY

	[DL11] Phase 2 FAT Package	docx/pdf	T1+16
	[DL12] ATLIS Series Delivery report	docx/pdf	T1+17
	[DL13] Reception of the full ATLIS package at IO site	ATLIS units (x8)	T1+18

Table 4: Deliverables table

9 Quality Assurance requirements

The Quality class under this contract is QC1, GM3S section 7 [1] applies in line with the defined Quality Class.

10 Safety requirements

The scope under this contract covers for PIC components and PIAs, GM3S section 5.3 [1] applies.

10.1 Nuclear class Safety

According to components classification [2], the ATLIS are classified PIC/SIC-1,

10.2 Seismic class

According to components classification [2], the ATLIS are classified SC1(S).

11 Specific General Management requirements

Requirement for [Ref 1] GM3S section 6 applies completed/amended with the specific requirements detailed in the present section.

11.1 Meeting Schedule

Meetings can be organised face to face or remotely as agreed by the Parties with the exception of the KOM that has to be face to face at IO site (if permitted by sanitary measures). The kick-off meeting will mark the starting date in the contract planning (referred to as time T0). At this meeting, the contractor will have the opportunity to request and receive answer to any outstanding clarification / questions about the project. IO will confirm all applicable document versions. The KoM will cover the overall project detail with a focus on the phase 1 scope.

During the execution of the contract, videoconference meetings shall be held to monitor the project progress. The videoconference software will be defined at the kick off meeting. These meetings shall be organized by the contractor, who will also be responsible to maintain the meeting records (minutes, actions and decisions). The Contractor representative has to provide the MOM to the CRO for review no later than one (1) week after the meeting took place. The meetings will be held bi-weekly unless otherwise agreed during the execution of the different phases. At the beginning of the contract, the contractor shall provide a meeting plan covering the whole Phase 1.

11.2 Audits and surveillance

Audits, reviews, surveillance and inspection of the contractor's quality assurance arrangements and the compliance with the French 2012 INB order will be carried out as required by IO appointed representatives according to [31] and [32]. These activities may be extended to cover sub-contractors. In respect of any deficiencies revealed, the contractor shall implement, or ensure that every sub-contractor implements, corrective actions in accordance with an agreed timescale. IO shall inform the contractor for audits, reviews, surveillance and inspection activities including those involving a sub-contractor.

The contractor shall provide to IO the access to documentation, personnel and to his subcontractor’s premises during all stages of the contract for purposes of audit, review, surveillance and inspection.

There could have the ASN/ITER scheduled or non-scheduled inspection/surveillance and the right of access to the contractor property have to be granted.

11.3 CAD design requirements

The reference scheme is for the Contractor to work in an asynchronous manner on the ITER CAD platform as described in [38]. The use of CATIA V5 is not required. No work in ENOVIA is requested.

Drawings and 3D native files shall be stored in SMDD by the contractor in a dedicated folder given by IO at the KOM.

SUPPLY

Appendix A – Technical & Defined Requirements

A Preliminary filtering has been performed by IO on the full list of requirements applicable to the IC H&CD system available in the SRD [42]. The contractor shall take into account the following technical and defined requirements during the execution of the work. Note that sometimes a defined requirement refer to a top-level reference that has been already propagated down to the IC antenna documentation.

The contractor shall provide the justification for the requirements applicable to the phase 2.

- System functions:

[51ICs8-R] The Ion Cyclotron Heating and Current Drive system (IC H&CD, or in short, IC) shall provide ion cyclotron radio-frequency (RF) power for plasma heating, current drive, control of sawteeth activity, and wall cleaning.

[51ICs14-R] The IC H&CD shall provide bulk RF heating of the ITER DT, D, H and He plasma, with preference to bulk ion heating. This heating power shall assist in accessing the H mode and achieving Q=10.

The heating power shall also assist in accomplishing several functions of plasma control, such as control of plasma burn and transport.

[51ICs9-R] The IC H&CD system shall be capable of driving continuous on-axis current for the DT, D, H and He plasma. In particular, it shall provide central current drive in high bootstrap current fraction scenarios.

[51ICs12-R] The IC H&CD shall be capable of driving ion minority current at the outboard of the $q = 1$ magnetic surface for the control of the saw-tooth period, at the nominal BT = 5.3 T.

[51ICs16-R] The system shall deliver a nominal power of 20 MW to the ITER plasma in the frequency range of 40 to 55 MHz (inclusive), by means of phased IC antenna arrays incorporated in dedicated equatorial port plugs.

[51ICs11-R] The IC H&CD shall provide RF power to perform IC Wall Conditioning (ICWC). (An alternative term that is in use for ICWC is “IC resonance discharge cleaning” (ICR-DC).)

[51ICs10-R] The IC H&CD shall contribute to achieving plasma breakdown, burn-through and assisted current rise by delivering a fraction of the nominal power. These functions are assumed not to drive the system design.

- Classification of Systems, Structures and Components (SSCs):

[51ICs1332-R;Defined Requirement] The IC H&CD System, Sub-systems, Structures, and Components (SSC) shall be classified for quality class, seismic class, vacuum class, tritium class, remote handling class and safety class.

[51ICs1334-R] The Quality classification shall be determined in accordance with the ITER Quality Classification Determination [28].

[51ICs1335-R;Defined Requirement] The Seismic classification shall be determined in accordance with the ITER Seismic Nuclear Safety Approach ITER_D_2DRVPE.

[51ICs1773-R] The Vacuum Quality Classification (VQC) of the IC H&CD equipment shall be determined in accordance with Section 3 of the IVH [4].

SUPPLY

[51ICs1745-R] The Tritium classification shall be determined in accordance with the Tritium Handbook ITER_D_2LAJTW - Tritium Handbook .

[51ICs1787-R] The Remote Handling (RH) classification of the IC H&CD system components shall be determined in accordance with the ITER Remote Maintenance Management System ITER_D_2FMAJY - ITER Remote Maintenance Management System (IRMMS).

[51ICs1831-R;Defined Requirement] The Safety classification shall be determined in accordance with the Safety Important Functions and Components Classification Criteria and Methodology ITER_D_347SF (See also section 3.1.2, [51ICs1415].)

[51ICs32-R;Defined Requirement] As part of the first confinement system, the following components shall be PIC / SIC-1: the antenna port plug flange and attached welded/bolted flanges, the front (that is, primary) RF vacuum windows, the rear (that is, secondary) RF windows, the antenna transmission lines that are located between the RF windows, the diagnostics (probes, thermocouples) electrical feedthroughs, the PHTS external coolant lines. This list is not exhaustive, and the full safety classification of IC H&CD components shall be determined by the design activities (refer to [51ICs1415] and ITER_D_347SF).

[51ICs357-R] The qualification of the IC H&CD components shall comply with Attachment 1 of the *Quality Classification Determination* [28].

➢ Interfaces of the IC H&CD with other ITER systems

[51ICs1101-R] PBS 65-00-CA (Compressed Air System):

· Physical and functional interface

· Interface Control Document (ICD) between Compressed Air (PBS 65-00-CA) - Ion Cyclotron H&CD System (PBS 51) ITER_D_2EPYFH

[51ICs1104-R] PBS 65-00-NG (Nitrogen Gas Distribution):

· Physical and functional interface

· Interface Control Document (ICD) between Nitrogen Distribution (PBS 65-00-NG) – Ion Cyclotron H&CD System (PBS 51) ITER_D_2EQHAX

➢ General requirements

[51ICs1206-R] The IC H&CD system shall be designed to operate for the whole operating lifetime of ITER, namely not less than 20 years.

[51ICs1350-R] The IC H&CD system shall be designed for an active (D-T) phase lasting at least 14 years.

[51ICs1351-R] The design life specification of the IC H&CD system shall take into account any additional time due to early manufacturing / installation / commissioning before operation, as well as idle time during deactivation.

[51ICs1352-R] The IC H&CD system shall be capable of operating for at least 30,000 plasma pulses in order to satisfy the overall requirement specified in the Project Specification document ITER_D_2DY7NG - Project Specification (PS).

[51ICs1353-R] The IC H&CD system shall be designed to be capable of operating for periods of 11 consecutive days while accommodating three 8-hour shifts of daily plasma operation, followed by 3 days of routine maintenance.

SUPPLY

[51ICs1354-R] The IC H&CD system shall be designed to be capable of operating for periods of up to 16 months continuously in three 8 hour work-shift daily operating mode, to perform the following actions: plasma operations, test, conditioning, routine maintenance.

[51ICs114-R] The IC H&CD system shall operate in quasi-CW conditions with pulse lengths of up to 3600s.

The system shall be capable of executing the next pulse after a duration not exceeding three times the duration of the previous pulse or 1800s, whichever is longer.

[51ICs1834-R] For the purpose of design specification, the maximum number of IC Wall Conditioning sequences over the different phases of ITER operations shall be as estimated in ITER_D_3E2HPX.

[51ICs1366-R] The IC H&CD system shall be designed to accommodate 500 baking cycles from the commissioning phase to the end of life of ITER.

[51ICs460-R] At the nominal operating conditions given in Section 1.2, the overall RF losses in the transmission, matching and antenna sub-systems shall not exceed 4MW (that is, 20% of the baseline coupled RF power of 20MW). An indicative repartition of the maximum RF losses under these conditions is 500kW in the transmission lines, 2MW in the matching systems and 1.5MW in the launchers.

(When the system operates under its maximum design voltage ([51ICs476], [51ICs495]), the indicative repartition of RF losses is 2.5% of the coupled power in the transmission lines, 10% in the matching systems and 7.5% in the launchers.)

[51ICs120-R] All of the IC H&CD system components shall use technology that is available and which reliability can be demonstrated before being installed in ITER.

[51ICs649-R] The internal RF electrical insulation of the IC H&CD power transmission components shall rely on ceramic supports and either vacuum, dry air or nitrogen gas.

[51ICs462-R] The IC H&CD system shall be locally or remotely controlled and monitored by local subsystem controllers, for debugging, commissioning, operation and data acquisition.

[51ICs985-R] Each IC H&CD subsystem shall supply sufficient diagnostic signals to characterize the operation of the system during normal operating conditions, and to troubleshoot the system during abnormal operation.

[51ICs464-R] The IC H&CD system components located in a high radiation zone (refer to ITER_D_RJLLFY) shall be capable of operating in this environment for a period at least covering the interval between maintenance periods scheduled for that zone.

[51ICs1355-R] The Configuration Management Model (CMM) shall be used to assure consistency between all IC H&CD components and the interfacing buildings:

(·) Collision analysis

(·) Interface constraint definition and checking between systems

(·) Space allocations for systems to be designed considering supports and penetrations

(·) Tolerance studies

(·) Assembly and RH maintenance simulations

[51ICs1356-R] The IC H&CD system elements shall conform to the space envelope constraints and interface characteristics specified in the CAD assemblies, parts, and drawings in the CMM.

- System specific requirements

SUPPLY

[51ICs632-R;Defined Requirement] The in-vessel components of the IC H&CD System shall be capable of being baked at 240°C by controlling the PHTS coolant temperature, below saturation, for the design pressure of the primary cooling systems.

- Structural requirements

[51ICs124-R] Codes and standards for IC H&CD mechanical components shall follow the general ITER specifications: *Codes and Standards for ITER Mechanical Components [12]*.

- Mechanical requirements

[51ICs147-R] The mechanical structure of the IC H&CD system components shall satisfy the design criteria that are specified in the applicable codes and standards. See [51ICs124-R] and [12]; in particular, for the in-vessel components, the SDC-IC [14] applies.

[51ICs569-R] The IC H&CD system equipment shall accommodate (with adequate clearances) differential displacements, or incorporate automatic compensation for these displacements. In particular, the movements between the vacuum vessel ports and the building structure shall be accommodated.

- Seismic requirements

[51ICs155-R;Defined Requirement] The design of the IC H&CD system shall take into consideration loading values that result from seismic events that are categorized under SL-1, SMHV and SL-2, inclusive of any applicable amplification factor.

[51ICs1438-R;Defined Requirement] The combination of loads from earthquakes with other loading events shall be considered.

[51ICs1436-R;Defined Requirement] Those PIC components that are required to perform safety functions during, or after, a SL-2 earthquake, shall be designed such that their capabilities are maintained.

[51ICs1437-R;Defined Requirement] The collapse, falling, dislodgement or any other spatial response of a component, as a result of an earthquake, shall not jeopardize the functioning of other components that provide a safety function during or after the earthquake.

[51ICs1875-R;Defined Requirement] The PBS 51 penetrations into the Vacuum Vessel and through fire or confinement barriers shall be classified as SC1-S.

- Fire protection requirements:

[51ICs1876-R;Defined Requirement] The PBS 51 PIC/SIC components and their support systems shall be able to continue to fulfil their safety functions in fire conditions; in particular under exposure to the resulting variations of temperature and pressure, to humidity and to soot. Their failure shall send an alarm to CSS.

[51ICs1603-R;Defined Requirement] The quantity of combustible materials and loads from IC H&CD components in each room or area (including materials brought in to perform maintenance activities) shall be limited to the minimum process requirements, with appropriate control and monitoring measures.

[51ICs1604-R;Defined Requirement] Potential ignition sources in the IC H&CD system shall be prevented or limited. Where an ignition source is present in a room, area or component, appropriate protection measures shall be taken.

SUPPLY

[51ICs225-R;Defined Requirement] The IC H&CD equipment shall be designed to limit the propagation of fire to adjacent components.

- vacuum requirements

[51ICs635-R;Defined Requirement] The capability shall be provided to allow the in-situ vacuum leak testing of the IC H&CD equipment and vacuum leak localisation to the Antenna subsystem.

- Thermal management requirements

[51ICs394-R] Ex-vessel components shall be designed to have their water drained off in situ. Otherwise, those components that cannot be drained off shall be designed with hydraulic connections that allow disconnection from the feeding loop without leakage. Connections to the pressurized nitrogen distribution and the draining circuit shall be provided, where needed, to perform these operations.

- Chemical requirements

[51ICs1369-R;Defined Requirement] The methods for controlling the corrosion behaviour during operation shall be established for the IC H&CD system and its subsystems.

[51ICs172-R] All IC H&CD components shall be compatible with the water coolant chemistry. (For the cooling water properties, see interface documents [51ICs1087], [51ICs1088]).

[51ICs1373-R;Defined Requirement] All solid, liquid and gaseous toxic products needed for construction and operation of the IC H&CD system shall be identified and their quantity and characteristics estimated for normal operation, including maintenance operations.

[51ICs1374-R;Defined Requirement] The inventory for all solid, liquid and gaseous toxic products on the IC H&CD system shall be limited to the maximum extent possible in the design, and their impact maintained As Low As Reasonable Achievable (ALARA) during operation.

[51ICs1375-R;Defined Requirement] Specific design provisions shall be undertaken to avoid that solid, liquid and gaseous toxic products affect workers during normal operations and to avoid spread of these materials into rooms accessible to workers.

These provisions shall consider potential corrosive, inflammable and explosive issues associated with these toxic products.

- Material requirements

[51ICs667-R;Defined Requirement] Material choice considerations shall include IC H&CD system performance, vacuum and tritium compatibility, resistance to radiation, activation during operation, and minimizing the introduction of impurities in the plasma.

[51ICs1370-R;Defined Requirement] Depending on operational conditions (such as maximum expected neutron flux and fluence) and allowable dose rate, the admissible contents of materials in impurities significantly contributing to the activation shall be established. These limits on impurity concentration shall be technically feasible and reasonably achievable. The requirements for limit of impurities are defined in [43].

[51ICs655-R] The water cooling circuits of the matching systems shall be cooled by the CCWS either directly or through intermediate cooling loops.

[51ICs653-R] Flexible piping shall be made of material that is suitable for at least 10 years of normal operation conditions.

SUPPLY

[51ICs670-R;Defined Requirement] The use of halogenated materials is forbidden in areas or volumes that are served by the Detritiation System (DS) or by the Tokamak Exhaust Processing System (TEPS). Exceptions shall require a formal project approval. (The procedure for formal project approval shall include approval of the Nuclear Safety and Tritium Plant Responsible Officers.)

[51ICs1781-R] The selection of materials and fabrication processes for the antenna port plugs shall wherever possible take into account the minimization of the error fields.

- Manufacturing requirements

[51ICs186-R;Defined Requirement] All IC H&CD system components shall be qualified for compliance with their requirements; and the manufactured / assembled components shall be compliant with their design.

- Testing and inspection requirements

[51ICs758-R] Fabrication shall be subdivided into a number of sub-components, allowing independent factory qualification tests to the largest practical extent.

[51ICs760-R] Where relevant, the following types of factory tests shall be performed on sub-components or parts of sub-components:

- Dimensional checks
- Pressure and thermal tests
- Vacuum test (leak and outgassing)
- Hydraulic flow test
- Electrical test
- Mechanical test
- Functional test.

[51ICs1916-R] The pressurized TL sections of the Antenna subsystem shall be leak-checked prior to pressurisation with dielectric gas.

- Decommissioning requirements

[51ICs233-R] Modular components shall be used, to ease dismantling and to minimize the amount of radwaste.

[51ICs780-R] The IC H&CD system design shall ease the segregation of activated subsystems or components.

- Human factors engineering

[51ICs1703-R;Defined Requirement] The IC H&CD system shall be designed in accordance to the *ITER Human Factor Integration Plan (HFIP)* ITER_D_2WBVKU.

- Design verification

[51ICs1378-R;Defined Requirement] The scope of design verification shall be applied to all safety-related systems, structures and components of the IC H&CD. However, certain important non-safety-related systems and structures may be included in the design verification at the discretion of ITER Organization management.

[51ICs1379-R] Design verification by qualification testing shall be performed as early as possible and prior to the point when related system, structures, and/or components are installed.

SUPPLY

[51ICs1380-R] If an alternative calculation method or a qualification test method for design verification of a system, structure or component (SSC) has not been developed or if there is difficulty in its application, then the design review shall be used as the SSC's design verification method. The design review shall be performed either as specific review by one or more independent reviewers competent in a single discipline or by multi-disciplinary review performed by a multi-disciplinary review team.

[51ICs1381-R] If it is only possible to assess the integrity of a system, structure or component (SSC) by means of design calculations, and if an alternative calculation method has been developed, then the latter shall be used as the SSC's design verification method.

[51ICs1382-R] If performance of a related component has not been verified due to application of a new design concept, then the qualification test by model test under conditions that simulate the most adverse design conditions shall be used as the design verification method for the component.

- Safety design requirements
    - Safety design criteria

[51ICs1396-R;Defined Requirement] The potential for the public and workers to be exposed to radiological and other hazards shall be limited by design, construction, operation, and preparation for decommissioning. (Decommissioning is outside the responsibility of ITER Organization.) The policy shall be to ensure that exposures are As Low As Reasonably Achievable (ALARA) and to provide defence-in-depth for potential incidents and accidents.

[51ICs1400-R;Defined Requirement] The IC H&CD system design shall be failure-tolerant, and no single failure of components shall result in significant consequences to the personnel, public and/or environment.

[51ICs1401-R;Defined Requirement] PBS 51 shall contribute to the Project-level demonstration of absence of cliff-edge effect. The latter consists in showing that the magnitude of the consequences of a postulated event is bounded, and that there is no large increase of consequences as the safety functions are progressively degraded.

[51ICs399-R;Defined Requirement] The contributions of the IC H&CD to the tokamak first confinement system shall include static barriers; on this confinement system double windows shall be provided. These contributions shall comprise the following components:

- Antenna port plug flange and attached welded/bolted flanges
- The primary (that is, front) and secondary (that is, rear) RF windows
- The antenna transmission lines that are located between RF windows
- The vacuum pumping system of the antenna transmission lines and the vacuum circuit that is associated with the vacuum leak test system
- Diagnostics electrical feedthroughs (probes, thermocouples)
- The external coolant lines connecting to the PHTS

This list is not exhaustive, and the full list shall be determined by the design activities (refer to [51ICs1415] and ITER_D_347SF).

SUPPLY

[51ICs1414-R;Defined Requirement] Sub-systems, Structures and Components of the IC H&CD system that play an important role in the protection of ITER and its environment, shall be classified as Protection Important Components, as considered in the INB order of 7 February 2012 [27].

[51ICs1424-R;Defined Requirement] The design of the PIC sub-systems, structures, and components of the IC H&CD system shall include all loading events for which the components may be required to perform a safety function.

[51ICs1425-R;Defined Requirement] Design rules and standards shall be selected for each sub-system or component of the IC H&CD system, in consideration of PIC, using the guidelines in **Table 7-2**.

[51ICs1426-R;Defined Requirement] The IC H&CD system shall be designed to provide redundant and, where appropriate, diverse systems, as necessary to achieve the required reliability.

[51ICs1427-R;Defined Requirement] Operation, inadvertent actuation or damage to components of the IC H&CD system that are not PIC, shall not prevent PIC systems, structures or components from accomplishing their safety functions when required.

[51ICs1428-R;Defined Requirement] The IC H&CD system shall include appropriate design provisions to remove the accumulated heat (from its AC and RF electrical equipment) under any design basis situations, in order to protect the personnel and the PIC components.

Table 7-2: Guidelines related to Safety Importance Class (SIC) components

Issue	Guideline for Safety Important Class components
1. Design (use of codes and standards, degree of conservatism, margins, etc.)	a. Code and regulatory requirements for design, fabrication, testing etc. shall be followed. Deviations from code requirements shall be documented. b. Where an appropriate design code does not exist, an agreed surrogate developed specifically for ITER may be used. c. Testing, proven and documented manufacturing process, control of materials, etc. shall be provided for prototype/non-code items. d. Standard commercial components shall be acceptable if appropriate to conditions of use.
2. Materials (restrictions on which materials can be used, extent of testing, sources of data, margins in data, etc.)	a. Materials to be specified and compliance ensured. b. Materials in standard commercial component may be acceptable if appropriate to conditions of use.
3. Fabrication and Installation	a. Manufacturing, assembly and installation process/procedures to be specified and compliance ensured.

SUPPLY

(manufacturing process qualification, weld types, welding procedures and welder qualification, etc.)	b. Compliance with design code and regulatory requirements (if applicable). c. Standard, proven, commercial component fabrication may be acceptable.
4. Examination (extent of inspection, third party or owner, non-destructive examination, etc prior to operation.)	a. Examination and acceptance tests during fabrication/construction as needed to ensure safety function to be specified and compliance ensured. b. Compliance with design code and regulatory requirements (if applicable).
5. Testing (pressure testing, performance testing, etc prior to operation)	a. Testing required to demonstrate safety function to be specified and compliance ensured. b. Compliance with design code requirements (if applicable).

Issue	Guideline for Safety Important Class components
6. In-Service or Periodic Inspection (inaugural, frequency and extent of in-service tests)	a. In-service inspections, monitoring and/or tests or compensatory measures taken to ensure that the equipment can continue to provide its safety functions with the required level of reliability. b. Test records, calibration records, personnel training requirements, etc. to be specified as part of the normal maintenance procedures. c. Compliance with the regulatory requirements
7. Equipment qualification	a. Justification to be provided that component can withstand the normal and abnormal environmental conditions that may arise from an accident at the end of their service life for which their operation is needed. For equipment which is required in the event of an earthquake, this includes seismic qualification.
8. Reliability	a. System to perform its credited safety function even with single active fault/failure (or alternative system available to provide the safety function). b. Use of proven, good industrial quality components may suffice as a justification.
9. Independence, physical separation	a. Safety function shall not be undermined by underlying common cause or cascading failures. b. Protective I&C for a system should be separate and functionally isolated from process instrumentation for that system (separate signal channels appropriately de-coupled

SUPPLY

	and shielded), and with physical separation between redundant channels.
10. Equipment status indication	a. Status under normal conditions and functioning of system under emergency use as appropriate available to operators, possibly at remote location.

[51ICs1456-R;Defined Requirement] When a confinement system of the IC H&CD system is removed, compensatory measures shall be taken to limit the risk in the unlikely event of a challenge to the remaining confinement system. Those include, but are not necessarily limited to:

- Limiting the mobilizable source term (e.g. inventories must be segregated or stabilized to a safe state)

- Confinement measures (e.g. use of detrititation system or cask transfer interface, pressure gradients during dynamic confinement, use of temporary systems and or barriers (such as bags or tents).

[51ICs1462-R;Defined Requirement] The IC H&CD confinement systems shall be designed to ensure their function in all conditions and events for which their function is credited in the safety analysis.

[51ICs1463-R;Defined Requirement] The IC H&CD confinement systems shall be capable of withstanding all loads and conditions that result from accident sequences.

[51ICs1465-R;Defined Requirement] Fire loading from IC H&CD components shall be such as to prevent the spread of fire between fire sectors.

[51ICs1467-R;Defined Requirement] Penetrations through a confinement system shall be justified with respect to their impact on the effectiveness of the confinement system.

[51ICs1468-R;Defined Requirement] The penetrations through a confinement system shall neither increase the likelihood or consequences of failure of the confinement system, nor introduce new failure modes beyond those that are addressed in the safety analysis: a penetration crossing a fire or a confinement barrier shall reconstitute the barrier properties. Provision of adequate reliability may require the use of such items as double barriers, double bellows, double windows, double isolation valves, and robust sealing.

[51ICs1469-R;Defined Requirement] Analyses shall be performed to identify credible failure modes, and to provide assurance of reliable performance of credited safety functions.

[51ICs1471-R;Defined Requirement] Systems/components to ensure the confinement function shall be independent, and physically separated, to avoid common mode failure that could lead to loss of both systems.

[51ICs1472-R;Defined Requirement] The routing/piping of confinement barriers shall be such as to avoid potential damage to confinement systems by movement of equipment during maintenance.

SUPPLY

[51ICs1473-R;Defined Requirement] Systems shall provide the capability for testing and for monitoring parameters, as necessary, to ensure availability and function, as credited in the safety analysis.

[51ICs1475-R;Defined Requirement] Confinement systems shall be designed and constructed to allow testing, inspection, monitoring, and maintenance, as needed, to assure the initial and continuing performance that is assumed in the safety analysis.

[51ICs1485-R;Defined Requirement] All sub-systems, structures and components of the IC H&CD system shall provide means to accommodate the pressure loads that are due to unplanned release of coolants, in particular those that are used for in-vessel components, vacuum vessel and superconducting magnets.

[51ICs1487-R;Defined Requirement] Components of the IC H&CD system (such as high energy fluid piping/containers and components with risk of explosion or with potential failure of moving parts) that could impact SIC systems or confinement, shall be designed to prevent the generation of a missile or to limit the consequences associated with this hazard. This shall include periodic control, testing and inspection in order to detect precursor signs of associated missile risks.

[51ICs1489-R;Defined Requirement] The IC H&CD PIC components shall be protected against the risk that is associated with potential missiles from high energy fluid circuits (pressures greater than 20 bar absolute or temperatures greater than 100ºC), or from other potential sources of missiles (such as internal explosion or failure of a machine with moving parts).

[51ICs1490-R;Defined Requirement] The IC H&CD PIC components shall be protected against the risks that are associated with potential pipe whipping from high energy fluid circuits (pressures greater than 20 bar absolute, or temperatures greater than 100ºC)

[51ICs1491-R;Defined Requirement] The design of the IC H&CD system shall be such that chemical energy inventories are controlled to avoid energy and pressurization challenges to confinement.

[51ICs1503-R;Defined Requirement] The design of the IC H&CD shall include provisions to minimize the potential for other hazards that could challenge confinement systems. These include internal aggressions, such as fire or flooding, and external aggressions, such as earthquakes or extreme weather conditions.

[51ICs1883-R;Defined Requirement] In the event of internal building flooding (due to the fire-fighting water, collapse of tank, or water pipe break), the IC H&CD confinement systems shall maintain the confinement against these external liquids.

[51ICs1509-R;Defined Requirement] The As Low As Reasonably Achievable (ALARA) principle shall be applied to minimize occupational doses.

[51ICs1510-R;Defined Requirement] An ALARA procedure shall be approved and implemented before work in a radioactive zone is authorized.

[51ICs1511-R;Defined Requirement] An assessment shall be made of the work that is to be performed during operation, maintenance, and repair so that the design may ensure that worker exposures to radiological and other hazards are ALARA and in all cases within the General Safety Objectives (Section 3.1.1) and the guidelines for exposure to such hazards.

[51ICs1514-R;Defined Requirement] The contribution of the IC H&CD system to the collective annual worker dose, averaged over the operational lifetime of ITER, shall be calculated and shall be ALARA. (The Project will not exceed an annual target of 0.5 person.Sv.)

[51ICs1515-R;Defined Requirement] Where hands-on maintenance activities in port cells and in other locations in the ITER facility requiring human access are performed, the dose rate shall be ALARA. The dose rate shall not exceed 100 µSv/h (microsievert per hour) in yellow zones and 10 µSv/h (microsievert per hour) in green zones at 10^6 s (about 12 days) after shutdown, without formal project approval. The dose rate shall be estimated 30 cm from the nearest accessible surface and shall take into account the surface contamination, airborne tritium, as well as activated materials.

[51ICs1516-R;Defined Requirement] To minimize radiation exposure to the workers in port cells, with the bioshield plug in place, the dose rate shall be ALARA and shall not exceed 10 µSv/h (microsievert per hour) at 24 hours after shutdown, without formal project approval. The dose rate shall be estimated 30 cm from the nearest accessible surface.

[51ICs1520-R;Defined Requirement] Shielding against ionizing radiation shall be maintained during all design basis situations (operations: see ITER_D_RJLLFY; maintenance: see ITER_D_F8UEXR, ITER_D_67CN24, ITER_D_HPX254).

[51ICs1529-R;Defined Requirement] The design of the IC H&CD system shall use the best available techniques for assuring reliable information on all operational events and accidents, and for monitoring the performance of the confinement and its protection during accidents.

[51ICs1537-R;Defined Requirement] The IC H&CD system shall comply with the different categories of zoning established in the nuclear buildings (Ventilation, Radiological, Anti-deflagration, Beryllium, Magnetic, Radiofrequency, Fire, Waste; refer to the detailed tables provided in PR section 7.9 ITER_D_27ZRW8), and with the room zoning listed in the Safety requirement Roombook ITER_D_KF63PB.

[51ICs1567-R;Defined Requirement] The IC H&CD contributions to fire sector boundaries shall ensure that there is no spread of radioactive or hazardous substances to a room or zone in which these substances cannot be confined and kept from spreading to the environment.

[51ICs1568-R;Defined Requirement] The IC H&CD contributions to fire sector boundaries shall ensure that there is no loss of safety function through failure of SIC components.

[51ICs1885-R;Defined Requirement] The IC H&CD contributions to fire sector boundaries shall contribute to maintaining fire sectorisation during two hours, under the conditions of the Eurocode / ISO 834 standard time-temperature curve.

[51ICs1886-R;Defined Requirement] The IC H&CD contributions to penetrations through fire barriers shall offer the same degree of fire resistance as the rest of the fire barrier.

[51ICs1887-R;Defined Requirement] The IC H&CD contributions to openings through fire barriers shall be filled-in using material that guarantees the same degree of fire resistance as the rest of the fire barrier, using a process verified by an approved organization.

SUPPLY

[51ICs1572-R;Defined Requirement] The IC H&CD transmission lines and pipes that traverse fire sector boundaries shall be protected by sufficient fire-resistant material to avoid fire propagation.

- Safety limits

[51ICs240-R;Defined Requirement] The leak rate through IC H&CD components that provide a confinement function shall contribute to achieving the overall boundary leak rate assumed in the safety analysis for the associated confinement barrier. These leak rates are listed in PR Table 7-4 ITER_D_27ZRW8.

[51ICs796-R;Defined Requirement] All primary vacuum boundaries shall be sufficiently robust to withstand all foreseeable accident or fault conditions, including possible failure or loss of control of handling tools as defined in the PBS51 Load Specification documents and the safety requirements roombook ITER_D_KF63PB.

[51ICs797-R;Defined Requirement] Where reasonably achievable, bellows and moveable joints, such as for motion feedthroughs, shall be avoided.

[51ICs1447-R;Defined Requirement] The IC H&CD system shall be designed and operated so that radioactive and hazardous inventories are maintained as low as reasonably achievable and within the limits that are authorized for the site, plants, zones, systems and components.

This shall include inventories of all hazardous substances and fuel that is stored on site, as well as radioactive and hazardous waste and effluents that are generated during ITER operation and decommissioning.

Both the quantity and level of toxicity of such inventories shall be minimized, controlled and monitored.

[51ICs781-R;Defined Requirement] The design of the IC H&CD system shall be such as to avoid contamination, or to allow easy decontamination of components.

- Monitoring requirements

[51ICs242-R;Defined Requirement] Monitoring of the IC H&CD Protection Important Components (PIC) shall be provided to indicate their status in all operational states and accident conditions, to ensure that the safety functions are being performed as assumed in the safety analysis. The monitoring program may require parameters to be displayed in the Main and Backup Control Rooms to ensure the assumed operability and reliability.

[51ICs1890-R;Defined Requirement] Provision and monitoring of signals from the IC H&CD PIC/SIC components associated with maintaining a safety function shall be established in accordance with the Plant Control Design Handbook for Nuclear control systems ITER_D_2YNEFU and the IO cabling rules ITER_D_335VF9.

[51ICs1576-R;Defined Requirement] All effluents (airborne and waterborne) of PBS 51 shall be identified, and their quantity and characteristics shall be estimated for normal operation and maintenance. (The characteristics will include, as a minimum, radioactive materials, hazardous materials, direct radiation, and thermal emission.)

SUPPLY

[51ICs1579-R;Defined Requirement] The fluid effluents of the IC H&CD system shall be monitored, characterized, controlled and discharged per approved procedures.

[51ICs1580-R;Defined Requirement] The IC H&CD system shall be designed to minimize leakage of water and liquid effluents.

[51ICs1581-R;Defined Requirement] The IC H&CD subsystems that contain water or liquid effluents shall be suitably monitored (including periodic inspection) in order to detect, as soon as possible, a leakage, and shall be equipped with an appropriate alarm system.

[51ICs1582-R;Defined Requirement] In the event of a water or liquid effluent leak on the IC H&CD system, it shall be possible to isolate the leaking system, purge it and/or collect the leakage.

- Safety related testing and inspection

[51ICs802-R;Defined Requirement] Any modifications that are made to any part of the confinement barrier shall require re-testing to ensure that the integrated confinement barrier leak rate is not degraded.

- Safety related operations and procedures

[51ICs1816-R;Defined Requirement] Procedures shall be defined to ensure human safety against nuclear hazards, in particular during maintenance operations.

- Occupational safety

[51ICs1588-R;Defined Requirement] The Hazard identification and risk assessment (HIRA) process shall be implemented during the design phase of the IC H&CD system in order to:

- identify workplace OHS hazards, the control of which shall have impact on ITER systems design
- assess the level of risk related to them in order to control them.

[51ICs252-R;Defined Requirement] The design of the IC H&CD system and its components, and its maintenance and operation procedures, shall minimize occupational radiation exposure and keep radiation dose to workers and the public as low as reasonably achievable.

- Environmental impact requirements

[51ICs254-R;Defined Requirement] The IC H&CD equipment shall be designed from material with the lowest reasonably achievable environmental toxicity. The recycling of the equipment that contains toxic materials or chemical products shall be taken into account as a design constraint.

[51ICs812-R;Defined Requirement] The volumes and radio-toxicity of material that may remain as long-term waste after decommissioning shall be minimized:

- By design-for-repair (particularly of large structural components)
- By design-for-re-use (particularly of large structural components)
- By limiting the impurities in the materials (see [43]).

SUPPLY

[51ICs814-R;Defined Requirement] The IC H&CD system shall be designed to minimize the amount and the level of radioactivity or toxicity of all radioactive and hazardous wastes along its life (from construction through to decommissioning and dismantlement).

- Other requirements

[51ICs1403-R;Defined Requirement] The design of the IC H&CD system and subsystems, and the planning of their shipping, storage, construction and operation, shall take into account the meteorological conditions and the risks of abnormal conditions. The meteorological conditions, and some Cadarache-specific criteria that are imposed by French and European norms, are reported in ITER_D_2UT36S.

- Operation and maintenance

[51ICs1194-R;Defined Requirement] Procedures shall be developed for all operations on the IC H&CD system (including commissioning, operations, tests, maintenance and decommissioning). These procedures shall describe the appropriate organization to guarantee their application, the authorizations required, as well as the actions to be taken in event of an emergency (such as in case of a fire, an equipment failure or ITER On-Site Emergency).

[51ICs1196-R;Defined Requirement] Training on operation and maintenance procedures shall be provided to all personnel performing operation or maintenance activities on the IC H&CD System. The training shall comply with the training rules set up by ITER Organization.

[51ICs347-R;Defined Requirement] The frequency, the duration and the procedures applicable to each of the maintenance operations shall be established in compliance with the ALARA principle, reducing the number of components and taking into account ease of maintenance in their design.

[51ICs826-R;Defined Requirement] The operations of hands-on maintenance on components, as well as hands-on assistance and preparation for RH tasks, shall be limited as much as possible.

[51ICs1680-R] Any specific handling equipment of the IC H&CD system (including transfer and lifting systems) shall be designed and operated to prevent injury to workers and damage to the handled equipment or surrounding components (especially SIC components and systems containing effluents). This includes the optimization of the required number of handling activities, the transfer trajectory and lifting height as well as protection measures to be put in place in the event of the failure (direct or indirect) of the handling system, or an operation error.

[51ICs1682-R] An ITER Maintenance Classification is applicable to any maintenance task defined by an ITER Designer or by the ITER Operator. The Maintenance Classification is intended to support engineering analyses and adequate implementation of the ITER limit regarding the annual collective radiation dose exposure. Therefore, this classification is maintenance environment oriented.

A maintenance class shall be assigned to any maintenance task on the IC H&CD system defined by the ITER Designer or ITER Operator. There are three maintenance classes (MC1, MC2 and MC3).

[51ICs1683-R] Maintenance tasks for the IC H&CD system are identified from RAMI analysis and Safety Analysis in order to meet the Project's safety and availability requirements. They shall be specified and verified as part of the design process for ITER systems, under the responsibility of their TRO.

SUPPLY

[51ICs1189-R;Defined Requirement] A maintenance plan shall be prepared for the IC H&CD system. The minimum information that is required within this maintenance plan is the following (a maintenance plan template is under preparation by IO):

- Scheduled operations (such as controls, checks, adjustments, calibrations, overhauls, and replacements) that are derived from Safety regulations, and that are identified as necessary by the supplier to ensure the best operation of the system in its intended operational scenario. At least task identification and interval is required.
- Critical unscheduled operations (such as replacements and repairs) that may impact ITER availability and / or introduce needs for additional support (spares, procedures, training, tools and test equipment, infrastructure).

[51ICs1894-R] Assembly tools shall be designed in such a way as they may be modified later to be used for maintenance during the operation phase of ITER, and shall thus be resilient and multi-purpose.

[51ICs1690-R;Defined Requirement] Provisions for remote maintenance shall be made for all environments where hands-on maintenance would result in ITER administrative limits (100 μSv/h) being exceeded.

[51ICs1190-R] In order to avoid inventory increase, the supplier shall make maximum use of off-the-shelf equipment and component catalogues identified by ITER Organization.

[51ICs1895-R;Defined Requirement] If spare parts and/or mobile devices are used as a back-up of the PIC components for any of the internal events/hazards, they shall be stored and housed in accessible rooms protected against any of the internal and external events/hazards considered for the facility.

➢ <u>Quality requirements</u>

[51ICs840-R;Defined Requirement] All records, "as-built" prints, information and equipment that are pertinent to decommissioning and dismantling purposes after deactivation shall be kept and maintained during the life of ITER.

➢ <u>Applicable Codes and Standards</u>

[51ICs359-R] The codes and standards shall be applied in support of the design, based on component function and safety importance classification.

[51ICs852-R] Where no appropriate codes or standards exist, alternate approaches shall be developed with supporting justification for the method used.

[51ICs845-R] Codes and standards for IC H&CD mechanical components shall follow the General ITER specifications: *Codes and Standards for ITER Mechanical Components* [12].

[51ICs853-R] In addition, the following codes and standards shall be applied:

- ASME section VIII, division 2 -alternative rules for construction of pressure vessels
- ASME B31.3, process piping
- ASME B31.1, Appendix X/EJMA – bellows
- ASME ANSI B16.25 - pipe, valve, fitting and flange butt weld ends
- ANSI-ASME B16.34 - valves - flanged, threaded, and welding end
- ASME B36.10 - carbon steel pipe
- ASME B36.19 - stainless steel pipe
- ASME Section IX - welding and brazing qualification

SUPPLY

- PED / ESP Decree 2015-799 of 1 July 2015 on dangerous products and equipment ITER_D_U5TKD4 - Décret n° 2015-799 du 1er juillet 2015 relatif aux produits et équipements à risques - EN
- NPE / ESPN Order dated 30 December 2015 (amended 03/09/2018) on nuclear pressure equipment Arrêté du 30 décembre 2015 modifié relatif aux équipements sous pression nucléaires - (TRANSLATION-EN) (ITER_D_SMP384 v2.2)

➢ Additional Requirements for the Staged Approach Phases

[51ICs1732-R;Defined Requirement] For the confinement of radioactive or toxic materials, definitive provisions shall be available for the start of Assembly and Integrated Commissioning phase IV (prior to FPO).

[51ICs1733-R;Defined Requirement] Prior to the definitive provisions being available, the safety functions to be achieved by the intermediate ITER configurations shall be guaranteed using temporary provisions with requirements similar to the definitive provisions (e.g. redundancy, back-up power supply) or with reduced requirements scope (case by case: no redundancy, limited use of back-up power supply, limited resistance to external events...).

[51ICs1734-R;Defined Requirement] The appropriateness of any temporary provisions shall be demonstrated by systematic safety analysis based on the quantities, location, and operation related to radioactive and toxic inventories.

[51ICs1735-R;Defined Requirement] Activities prior to the start of FPO shall not degrade definitive provisions installed for the previous phases (see also [51ICs1427]).