外部委託業者の募集

References: IO/25/OT/10032691/CPT

“Develop the sensitive surface of the 55.GD First Wall Samples Diagnostic"

（55.GD ファーストウォールサンプル計測の感応面の開発）

IO 締め切り 2025 年 8 月 4 日(月)

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。

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

今回の入札プロセスは、55.GDファーストウォールサンプル計測の感応面を開発するためのサービス契約を開発し、PDR-2を実施するためのすべての文書を提供する契約を設定することを目的としています。

契約は技術仕様書に定義された技術要件を満たすことも確認します。

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）

  事前通知（Prior Indicative Notice）は、公開入札プロセスの最初の段階です。IO は、国内機関に対して、今後の入札に関する情報を公開するよう正式に招待し、企業、機関、またはその他の団体に入札の機会を事前に知らせます。入札に興味のある企業は、下記の調達スケジュールに示された期限までに、表明書（付属書Ⅱ）を E メールでご提出くださいますようお願いいたします。

- ステップ 2-入札への招待（IIT）

  PIN の発行から 14 作業日以内に、関心を示した入札者に対して入札への招待（IIT）が送付されます。この段階では、PIN を確認した関心のある入札者が入札書類を入手し、入札指示

に従って提案書を準備・提出することができます。

- ステップ 3-入札評価プロセス
  入札者の提案は、ITER 機構の公正で専門的な技術評価委員会によって評価されます。入札者は、技術範囲に従い、入札への招待（IIT）に記載された特定の評価基準に基づいて作業を実施できることを示す技術的な適合性の詳細を提供する必要があります。

- ステップ 4-落札
  認定は、入札への招待（IIT）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	2025 年 7 月 21 日
関心表明フォームの提出	2025 年 8 月 4 日
提案依頼書（RFP）−入札への招待（IIT）の発行	2025 年 8 月 11 日
明確化のための質問（もしあれば）	2025 年 9 月 12 日
明確化のための質問回答	2025 年 9 月 17 日
入札提出	2025 年 9 月 22 日
契約授与	2025 年 10 月中旬
契約調印	2025 年 10 月 E

*新しい契約者が現地の活動や手順に慣れるため、また旧契約者がスムーズに解約作業を行うために、3ヶ月の重複期間が予定されています。

〇契約期間と実行

予想される契約期間は、18か月とします。契約調印前の作業はありません。

〇経験

入札者は、付属書 I 詳述される作業範囲に従って、技術的、産業的な経験を実証する必要があります。

ITER での使用言語は英語で、流ちょうなプロレベルが求められます（口頭および文書)。

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。

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【※　詳しくは添付の英語版技術仕様書「**Develop the sensitive surface of the 55.GD First Wall Samples Diagnostic**」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。

Route de Vinon-sur-Verdon - CS 90 046 - 13067 St Paul Lez Durance Cedex - France

PRIOR INDICATIVE NOTICE (PIN)

OPEN TENDER SUMMARY

IO/25/OT/10032691/CPT

for

Develop the sensitive surface of the 55.GD First Wall Samples Diagnostic

Abstract

The purpose of this summary is to provide prior notification of the IO 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 award of a Service Contract for the Diagnostic I&C Quality Control and Configuration Management.

1 Introduction

This Prior Indicative Notice (PIN) is the first step of an Open Tender Procurement Process leading to the award and execution of a Service 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.
The Domestic Agencies are invited to publish this information in advance of the forth-coming tender giving companies, institutions or other entities that are capable of providing these supplies prior notice of the tender details.

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 set up a Contract to develop the sensitive surface of the 55.GD First Wall Samples Diagnostic and to provide all documentation to perform PDR-2.

The contract also ensures that the product meets the technical requirements defined in this Technical Specification.

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 Indicative Notice (PIN) :
  The Prior Indicative Notice is the first stage of the Open Tender process. The IO formally invites the Domestic Agencies to publish information about the forth-coming tender in order to alert companies, institutions or other entities about the tender opportunity in advance. **Interested tenderers are kindly requested to return the expression of interest form (Annex II) by e-mail by the date indicated in the procurement timetable below.**

- Step 2 - Invitation to Tender (ITT) :
  Within 14 days of publishing the Prior Indicative Notice (PIN), the Invitation to Tender (ITT) will be advertised. This stage allows interested bidders who have seen the PIN to obtain the tender documents and prepare and submit their proposals per the tender instructions.

- Step 3 – Tender Evaluation Process :

Tenderers' proposals will be evaluated by an impartial, professionally competent technical evaluation committee of the ITER Organization. Tenderers must provide details demonstrating their technical compliance to perform the work in line with the technical scope and per the criteria listed in the invitation to tender (ITT).

- Step 4 – Contract award :
  A Service contract will be awarded based on the best value for money according to the evaluation criteria and methodology described in the Invitation to Tender (ITT).

5 Procurement Timetable

The tentative timetable is as follows:

Milestone	Date
Publication of the Prior Indicative Notice (PIN)	21 July 2025
Deadline for Submission of Expression of interest form	4 August 2025
Request for Proposals (RFP)- Invitation to Tender (ITT) advertisement	11 August 202
Clarification Questions (if any) and Answers deadline	12 September 2025
Answers to Clarifications	17 September 2025
Tender Submission in IPROC	22 September 2025
Tender Evaluation & Contract Award	Mid October 2025
Contract Signature	End October 2025

6 Quality Assurance Requirements

Prior to the commencement of any work under this Contract, the selected Contractor shall produce a "Quality Plan" and submit it to the IO for approval, describing how they will implement the ITER Procurement Quality Requirements.

7 Contract Duration and Execution

The duration shall be for 18 months. No work shall commence before the date of final signature of the Contract.

8 Experience

The tenderer shall demonstrate experience related to the scope of work as detailed in Annex I.
Working language of ITER is English. A fluent professional level is required (spoken and written).

9 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 with legal rights and obligations established within an ITER Member State.

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 constituted informally for a specific tender procedure. All consortium members (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 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 lead will explain the composition of the consortium members in a covering letter at the tendering stage. Following this, the Candidate’s composition must not be modified without notifying the ITER Organization of any changes. Evidence of any such authorisation 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.

10 Sub-contracting Rules

All sub-contractors who will be taken on by the Contractor shall be declared with the tender submission in IPROC. 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 (or disapprove) any sub-contractor which was not notified in the tender and request a copy of the sub-contracting agreement between the tenderer and its subcontractor(s). Rules on sub-contracting are indicated in the RFP itself.

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VERSION CREATED ON / VERSION / STATUS
03 Jul 2025 / 2.8 / Approved

EXTERNAL REFERENCE / VERSION

Technical Specifications (In-Cash Procurement)

Technical Specification to develop the sensitive surface of the 55.GD First Wall Samples Diagnostic

The scope of this technical specification is to develop the sensitive surface of the 55.GD First Wall Samples Diagnostic and to provide all documentation to perform PDR-2.

SERVICE

Technical Specification to develop the sensitive surface of the 55.GD First Wall Samples Diagnostic

SERVICE
Table of Contents

SERVICE

1 Preamble

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

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

2 Purpose

The 55.GD First Wall Samples (FWS or CX-Samples) are integral components of the ITER Boundary and First Wall diagnostics system. Positioned on the First Wall, these samples are tasked with two measurement functions: monitoring the erosion of the First Wall under bombardment by charge exchange neutral (CXN) particles, and quantifying fuel retention within the wall due to particle implantation processes and codeposition. Figure A and B illustrates the 55.GD First Wall Samples geometry and positioning at the FW as presented at the PDR-1 (Sensitive Surface out of Scope) [ITER_D_8MV7R3 v1.0)].

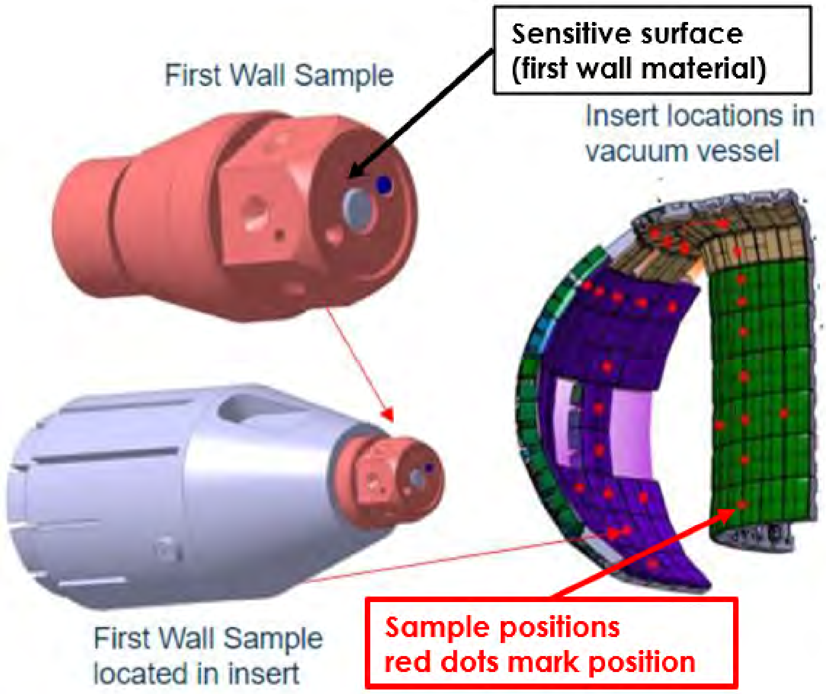

Figure A General description of the 55.GD FWS Diagnostic. The sensitive surface is located on the top flat surface of the First Wall Sample

SERVICE

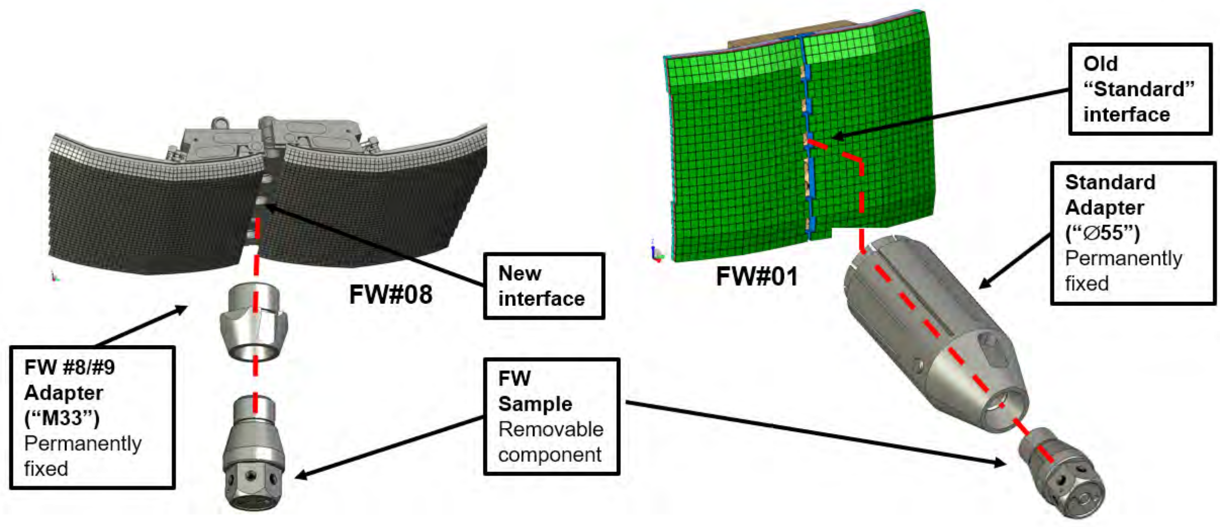

Figure B Interfaces of 55.GD First Wall Samples. Please note that the sample design is standardized, independent of the FW Adapter design.

2.1 Introduction to 55.GD First Wall Samples

The FWS have two primary measurement goals, which are:

a. **Measurement of Charge Exchange neutral (CXN) induced erosion. Table 1**

b. **Measurement of fuel retention in the First Wall. Table 2**

These requirements are independent of the first wall material choice (e.g. Tungsten or Beryllium).

Table 1 - Table referenced in the s-SRD 13[R60] in the requirement [55GDs1511-R]. Parameter 040b is applicable to the FWS, 040a not.

Parameter	Condition	Range	Time Res.	Spatial Res.	Accuracy	Role
040a. Fine surface metrology - Divertor	Default	0 – 1 mm	< 1 per discharge	1 mm	10 microns	2. PHY
040b. Fine net erosion and redeposition - first wall	LTM	0-100 µm	Sample retrieval possible only during LTM	50 locations on 700 m2	1 microns	

Table 2 - Table referenced in the s-SRD [R60] in the requirement [55GDs1516-R]. Parameter 099b is applicable to the FWS, 099a not.

Parameter	Condition	Range	Time Res.	Spatial Res.	Accuracy	Role
099a. Divertor Surface H, D, T Concentration (Inner baffle)	Outside plasma pulses under vacuum condition	10^{21}-$2x10^{24}$ m^{-2}	on demand	Individual points 5mm lateral resolution	50% abs, 20% relative	2. PHY
099b. First Wall Surface H, D, T Concentration	LTM	10^{18}-$2x10^{23}m^{-2}$	On request during LTM	50 locations on 700m2	20%	2. PHY

SERVICE

The FWS plays a supplementary role in measuring the concentration of tritium in the Vacuum Vessel (VV). The sensitive surface of the FWS shall be compatible to be analysed in a laboratory (either on-site or off-site) to provide data on the retention of Hydrogen isotopes (H, D, T) in the First Wall. The results of these measurements contribute to the overall in-vessel Tritium balance.

The measured erosion rate, representing the FW sputtering rate induced by charge exchange neutrals (CXN) can be translated into a contribution to the production of dust within the VV.

Note that erosion measured by the FWS represents the difference between gross erosion and redeposition. Therefore, the FWS effectively measures net erosion at the sample locations. Drawing conclusions from this data necessitates detailed modeling of the exposure conditions and surface interactions at the FWS. To ensure optimal information can be extracted from the measurements, the sensitive surface must be carefully designed.

Erosion and Tritium Retention measurements are crucial for ensuring the safe operation of ITER and gaining insights into the physics of Plasma Wall Interaction (PWI).

The analysis of exposed material substrates has been a standard practice since the inception of fusion science. This approach can be divided into

- post-mortem analysis of the Plasma Facing Components (PFC)
- markers on the PFC
- removable samples
  - human assisted
  - with remote handling
- and reciprocating or rotating material sample probes.

Furthermore, the samples and probes can be classified based on their intended purposes, such as collector probes, erosion probes, material testing probes, deposition probes, and more.

Those samples serve various purposes, including measuring erosion and/or deposition rates, determining deposition composition, measuring altering surface properties, or conducting material testing, for instance. More details and many references to existing fusion devices using these components can be found in [R1].

In ITER, the operational functionality of the First Wall Samples (FWS) is intrinsically tied to the performance and compatibility of a Remote Handling (RH) system for their replacement. According to the current plan, FWS will be periodically removed and replaced with new samples during each Long-Term Maintenance (LTM) cycle using the PBS 23.11 Agile Robot Transporter (ART) RH system. The number of samples exchanged in each cycle will depend on the availability and operational efficiency of the RH system. 6 LTMs are currently foreseen until the end of the DT-1 phase (see Fig. C for the operational plan for the execution of the ITER re-baseline 2024).

The system shall be fully operational for the SRO phase. A first assessment of fuel (deuterium) retention and removal efficiency, dust production and in-vessel material analysis with the FWS diagnostic shall be conducted at the end of the Start of Research Operation Phase (SRO) [Ref: ITER Research Plan].

The samples removed from the vessel will be activated. The activation of the samples removed from the vessel will depend on the duration of their exposure within the VV and the specific operational campaign during their stay in the VV. The activation values of the replaced samples have been investigated and are reported in [R42].

Once the FWS samples are removed, they will be transferred into a shielded container, enabling their safe transportation. [R4].

Another factor to consider is the delay in sample export. Sending samples to external laboratories for analysis often results in considerable time lags, which can hinder the timely evaluation of results and impact overall project timelines.

To address these challenges, the surface analysis systems foreseen shall be compatible with the requirements coming from the challenges listed above.

The revised ITER 2024 baseline introduced tungsten (W) as the primary first wall material, replacing beryllium (Be).

This transition raises the risk of increased core plasma radiation, potentially jeopardizing H-mode plasma sustainment and increasing the likelihood of radiative collapses due to high-Z impurities in the plasma. Therefore, the updated baseline incorporates a boronization system, which plays a crucial role in managing plasma radiation and maintaining operational stability [97S4QU v1.1].

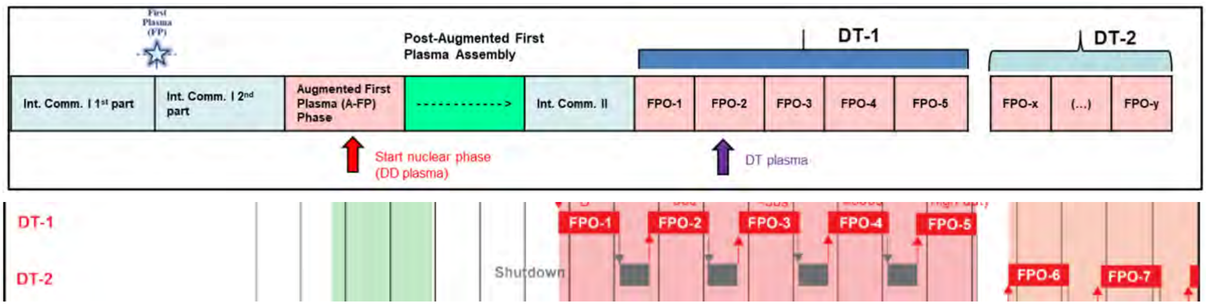

Figure C: Operational plan for the execution of the new baseline 2024 ITER Research Plan to the demonstration of the Q ≥ 10 500 MW fusion power goal. Note the grey marked shutdown phases (LTM) indicate the timeslots that can be used for FWS extraction.

2.2 Scope of this technical specification

The scope of this technical specification is to develop the sensitive surface of the 55.GD First Wall Samples Diagnostic and to provide all documentation to perform PDR-2 (see design review plan in Fig.G.)

SERVICE

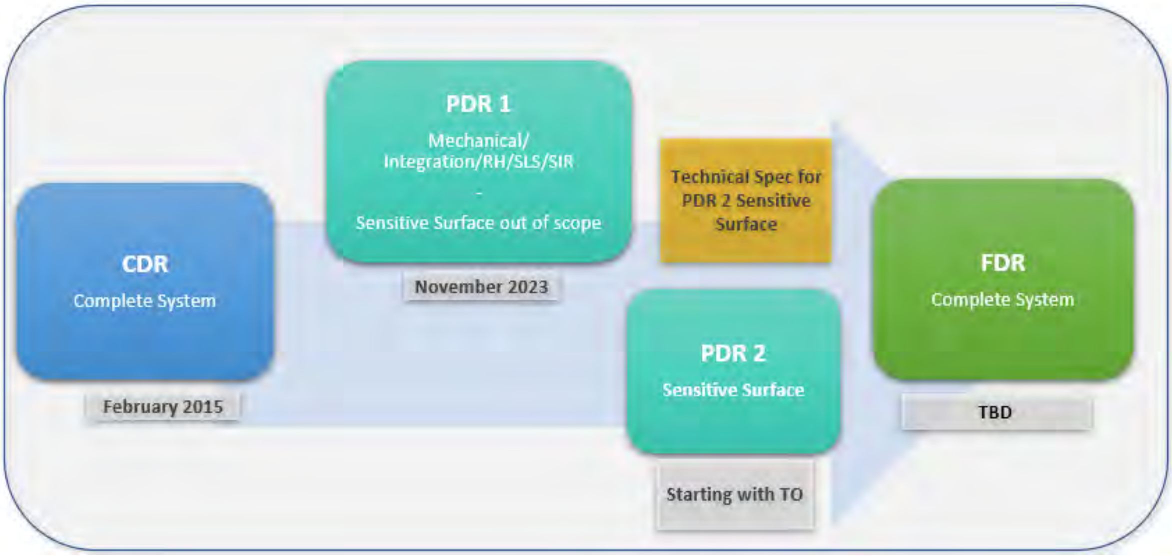

Figure G 55.GD Design review plan

Please note that most of the deliverable contents will be reviewed at a Final Design Review (FDR) level. Ensuring that the documentation and data meet FDR standards is essential for moving forward with production and compliance with ITER's strict quality and design requirements.

It is expected that a fast-track to PDR-2 / FDR-2) can be justified by the completeness of input load definitions, the maturity of the design through prototyping, and the progress achieved in qualification activities. These elements provide sufficient technical confidence and risk mitigation to support an accelerated path to final design validation and approval.

The planned FDR in the future ("Complete System" - green box) is primarily driven by administrative requirements and the need to conduct a mandatory full-scope review in order to comply with design review regulations.

3 Acronyms & Definitions

3.1 Acronyms

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

Abbreviation	Description
CRO	Contract Responsible Officer
CXN	Charge Exchange Neutrals
DFW	Diagnostic First Wall
DIVIMP	Divertor Impurities: Monte Carlo code that follows the trajectories of individual impurity particles in the edge plasma of a divertor tokamak
EIRENE	Neutral gas transport code
EPP	Equatorial Port Plug
FM	First Mirror
FW	First Wall

SERVICE	
FWP	First Wall Panel
GM3S	General Management Specification for Service and Supply
IO	ITER Organization
OEDGE	OSM + EIRENE + DIVIMP for edge plasma analysis
OSM	Onion-Skin Modelling
PFC	Plasma facing Component
PRO	Procurement Responsible Officer
SOL	Scrape-off layer
SOLPS	Edge and SOL transport model
VV	Vacuum Vessel
CDR	Conceptual Design Review
PDR	Preliminary Design Review
FDR	Final Design Review
FWS	First Wall Samples
PIE	Post Irradiation Examination
DDD	Design Description Document
DM	Detailed Model (full details as required for manufacturing)
CM	Configuration Model (rough space reservation with simple geometry)

3.2 Definitions

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

3.3 Safety Classification & Requirements

Protection Important Components (PIC) and Protection Important Activities (PIA) shall respect strict Safety and Quality rules. Where there is a conflict between the safety rules and the quality program, the safety rules shall govern. The 2012 Order spreads across the entire supply chain and for the overall lifecycle of any SSC (Systems, Structures & Components) identified as PIC. Safety Important Class (SIC) components are part of Protection Important Components (PIC). SIC components are components that prevent or mitigate against radiological hazards, these components are classified into two categories with an additional Safety Relevant (SR) category:

- SIC-1: Are those components required to bring to and to maintain ITER in a safe state. No components of the FWS are required to bring to and to maintain ITER in a safe state.
- SIC-2: Are those components used to prevent, detect, or mitigate incidents or accidents, but not SIC-1 (not required for ITER to reach a safe state). No components of the 55-GD FW Samples are used for such purpose.
- SR: Are those components that are not defined as SIC-1 or SIC-2 but have some relevance to safety. The failure of these components will not impact any safety function. NO components of the FWS have any relevance to safety

SERVICE

All components of the 55.GD FWS are non-PIC.
This task is not PIA.

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.

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.

Ref	Title	IDM Doc ID	Version
[A1]	General Management Specification for Service and Supply (GM3S)	82MXQK	1.4
[A2]	ITER Research Plan (IRP) - Level 1 - ITER Research Plan (24QSG6 v2.0)	24QSG6	2.0

4.3 Reference documents

The contractor is not required to review all of the listed references, as they are provided for informational purposes only. These references are included to assist IO in addressing any future questions by easily referencing relevant documents.

Demonstrating compliance with these references is not required, as this will be ensured by the IO reviewers of the deliverables.

[R1]	Record of Experience in Tokamak Plasma Facing Samples	QNNFKY
[R2]	Input Data for HIRA	8SZFRX
[R3]	Design Compliance Matrix of 55.GD FW Samples	QNCMDZ
[R4]	FWS 55.GD lifecycle report	SA8MW4

SERVICE

[R5]	Functional Analysis of 55.GD FW Samples	QFGH4H
[R6]	Investigations of plasma loads on the central part of the ITER first wall panels	QPPXKW
[R7]	CXN induced redeposition on the FW Samples	QPGC76
[R8]	Photonic radiation decay in gaps and wells	QPJ6P6
[R9]	Load Specification for 55.GD FW Samples	QEPA2U
[R10]	Minutes of the meeting: "Position of the FW sample in the BMs. Results of field line tracing study"	PVKKRM
[R11]	Investigations of plasma loads on the central part of the ITER first wall panels	QPPXKW
[R12]	GDC influence on FW Samples	QPPNHT
[R13]	In Vessel Component Variants	983KQA
[R14]	Blanket Design Description Document (2013 FDR)	EBUDW3
[R15]	Summary of Interfaces for 55.GD FW Samples	QUB6WB
[R16]	IS-23.11-55-004 ART (PBS 23.11) and Diagnostics (PBS 55.GD)	8SGCHJ
[R17]	PBS 55 - Diagnostics (ICDs)	2FR6A3
[R18]	55.GD - schedule	QTHJZ5
[R19]	Risk Analysis of 55.GD FWS	QRU8UG
[R20]	IS-22-55-119 Interface Sheet between PBS 22 Machine Assembly and PBS FWS	TH93AR
[R21]	IS-16-55-023 Interface Sheet between PBS 16. FW Blanket First Wall mounted Diagnostics and PBS 55 Diagnostics System	4GFHY6
[R22]	FWS - Decommissioning Plan	96634V
[R23]	Radwaste Checklist 55.GD	SKJLN9
[R24]	RHCR-23.10-55.GD FW Samples	QEMH4U
[R25]	55.GD FW Samples RH PDF	QDHW2U
[R26]	55.GD FW Samples RH TDF	QEDDGY
[R27]	RAMI Summary Report of the First Wall Samples (PBS 55.GD)	PSREX9
[R28]	RAMI Functional Breakdown of the First Wall Samples (PBS 55.GD)	PSU4GS

SERVICE

[R29]	RAMI FMECA Table for the First Wall Samples (PBS 55.GD)	PSRWYL
[R30]	Safety Important Functions and Components Classification Criteria and Methodology	347SF3
[R31]	Functional Analysis of 55.GD FW Samples	QFGH4H
[R32]	IS-55-62.22-001 Interface between Diagnostics and TAPB	WS3JU2
[R33]	FWS 55.GD Construction Process Description	SADGH3
[R34]	Plant Description (PD)	2X6K67
[R35]	Interface Control Documents Folder	29D8MD
[R36]	Compliance Matrix SRD -55	3356ZK
[R37]	I&C Deliverables for Diagnostic Annex B	3MQKJS
[R38]	Methodology for Plant System I&C Specifications	353AZY
[R39]	ITER RAMI Analysis Program	28WBXD
[R40]	Summary of the ITER workshop on Erosion/Deposition/Dust/Tritium diagnostics, 12.-14.2. 2014	NEE8HV
[R41]	Draft of the technical specification for FWS surface	QQ5DAB
[R42]	Calculations of the activation and shutdown dose rate of 55.GD	9DP45D
[R43]	Manufacturing drawings development of FWS adapter, test bench and assembly tools. Manufacturing and assembly of the adapter and assembly tool. Installation of the adapter in the test bench. Results of metrology. Removal of the adapter from host structure	2N2AEL
[R44]	Availability modelling for ITER diagnostics	7PDDWW
[R45]	55.GD - Bill of Materials (BOM) and System Components Classification	X2VEER
[R46]	DEROGRATION from SDR, see comment Tim Luce " System Concept of Operation and Maintenance Pan is not required for this PBS node"	8SSFDH and 8MPCWJ
[R47]	Thermal analysis report of 55.GD First Wall Samples	8SSP9H
[R48]	Structural Integrity Report of 55.GD First Wall Samples	8SSGG7
[R49]	EM Analysis of 55.GD D4 - Final report of the activity describing the model, analysis assumptions and summary of comparative results plus delivery package compliant to all IO applicable documents	8Q5ZBK

SERVICE

[R50]	55.GD - Bill of Materials (BOM) and System Components Classification	X2VEER
[R51]	55.GD_SLS_Basic_Information_Record	6KX86A
[R52]	IC/STAC-29/3.1. Consequences of changing first wall material	97S4QU
[R53]	Technical Specifications of IO-Contract 4300001741: 3D simulations of beryllium erosion and transport	WF6RQ2
[R54]	Technical Specifications of IO-Contract IO/20/CT/4300002242: Erosion/deposition on ITER first mirrors	2V7ADT
[R55]	Deliverable 2 report of IO-Contract: IO/20/CT/4300002242	VS53CD
[R56]	Poloidal curves coordinates	2N9J75
[R57]	Predictive 3D modelling of erosion and deposition in ITER with ERO2.0 Eksaeva 2022 10.1088/1402-4896/ac454f	public
[R58]	Benchmark for PIE facilities	YVN4CG
[R59]	Initial evaluations in support of the new ITER baseline and Research Plan	public or public
[R60]	Sub-System Requirement Document sSRD-55.GD: FW Samples	WYX2PE

5 Scope of Work

This section defines the specific scope of work for the service, in addition to the contract execution requirement as defined in Ref [A1].

The organization of the deliverables for the 55.GD First Wall Samples project follows a structured approach, with each deliverable focusing on a critical aspect of the development, from initial planning and design calculations to manufacturing, testing, and review processes, ensuring alignment with ITER project milestones and quality standards.

- ❖ The first deliverable focuses on calculating the expected charge-exchange (CX) particle loads on the 55.GD First Wall Samples using advanced simulation tools, providing detailed data on erosion, energy distribution, and implantation for different ITER-relevant materials. This deliverable also includes an evaluation of how boronization layers may influence erosion measurements.
- ❖ The second deliverable involves documenting measurement requirements, researching manufacturing options, and assessing the feasibility of various approaches to create the sensitive surface for the 55.GD First Wall Samples, ensuring compatibility with future irradiation and post-exposure examination in a hot cell.
- ❖ The third deliverable entails propose a detailed manufacturing plan for the 55.GD First Wall Samples prototypes, including material properties, coating specifications, surface roughness, lifecycle expectations, and manufacturing quality control standards.

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- The fourth deliverable documents the manufacturing and assembly process of the 55.GD First Wall Samples prototypes, ensuring compliance with specifications through traceable records, certificates of conformity, process monitoring, and inspections to verify quality control.
- The fifth deliverable verifies that the FWS sensitive surface meets all specifications through a series of tests simulating expected loads, including erosion, thermal cycling, impact, and other tests, with pre- and post-test measurements to assess performance and suitability.
- The sixth deliverable supports the execution and closure of the Preliminary Design Review (PDR-2/FDR-2) by preparing input presentations, data packages, and expert recommendations for an action plan for chit resolution. This shall be based on the previous Deliverables provided. This deliverable will also contain suggestions on how the close the remaining issues identified leading to a full-scope Final Design Review (FDR).

A summary of the to-be-used plasma backgrounds and wall fluxes is given in Appendix

SERVICE

5.1 D1: Calculation of expected CX-loads of the 55.GD First Wall Samples.

Purpose: To compute the expected charge-exchange (CX) particle loads on the 55.GD First Wall Samples (FWS) for a range of scenarios, different timescales and materials. Estimate the erosion-deposition balance on the FWS sensitive surface.

Approach:

Utilize advanced simulation codes, including but not limited to: EMC3-Eirene / ERO2.0 / SOLPS-ITER / 3D-GAPS, other tools or combinations thereof, validated and accepted by IO using plasma backgrounds provided by IO/SCOD and using 55.GD First Wall Samples Detailed Model (DM), Temporary First Wall (TFW) DM (upon availability on the start of the Deliverable, otherwise CM will be used) and Final First Wall (FFW) DM.

Deliverables Content:

- **Obtain CX flux and energy distribution** on the 55.GD First Wall Samples and FW in 2- **or** 3D based (2D/3D up to supplier's choice and access to the codes) on following three scenarios for which SOLPS-ITER wide grid references exist:
    A. **SRO 15MA 5.3T L-mode in hydrogen**
    B. **SRO 5MA 2,65T H-mode in deuterium**
    C. **DT-1 15MA 5,3T H-mode in deuterium (Q=10)**
    - For this analysis all 55.GD First Wall Samples can be in one single poloidal plane or 1 sector). Ideally, the CXN flux on first wall and FWS are compared, which requires a 3D simulation approach, to link FWS erosion to FW erosion.
    - Dependencies that do not need to be considered during calculations: Non-toroidally symmetric CX loads in the case of neutral beam shine-through and the impact of glow discharge cleaning. (though an assessment of uncertainty based on expert evaluation would be appreciated).
    - Take into account two different recession depths of the FWS with respect to the leading edge of the FW (5mm and 25 mm, exact values will be provided at KOM). Calculate and discuss impact on expected loads due to that variation. The main variation due to this recession is a reduce flux as the recession creates a reduction of the line of sight cone of the sensitive samples. See the Appendix for the description of the term "recession depth" with respect to the 55.GD FWS diagnostic.

- **Calculate expected net TFW/FFW CX-wall erosion and 55.GD FWS erosion** in unit of [mass/time]**.**
    - **Assess lifetime of GDC boronisation layer on 55.GD FWS sensitive surface** to demonstrate impact of different Boronisation frequencies foresee in the operations phase. Frequencies to assume are: 1) min. (every campaign only, and 2) max. range (once every two weeks) Average layer thickness to be assumed after successful boronisation shall be 50nm.
    - Assess possible contribution of **conventional GDC** (Glow-Discharge-Cleaning) as a separate load on the sensitive surface. Detailed inputs will be provided by IO (see I3).
    - **Compare different materials relevant as sensitive surface.** ITER-relevant materials to be considered are: SS316, Mo, W, CuCrZr, Inconel. Take into account that due to the high sputtering threshold energy of tungsten the erosion

of tungsten is mainly (but not fully) caused by high-energetic particles originating from deeper inside the plasma.

- **Calculate expected H, D, T implantation in sensitive surface materials**
- **Analysis will be done for following timescales of the Baseline-2024**: After SRO shutdown and after each Lont-Term-Maintenance Shutdown of ITER (see Figure C for amount of LTMs to be considered) until end of life-time of ITER. Total discharge times, respectively campaign lengths will approximately vary between ~250.000 to ~900.000 plasma seconds. Taking into account the **varying operational lifetimes of different samples**, recognizing that some may be removed after a single cycle, while others could remain in the vacuum vessel for the entire operational duration of ITER, due to the unclear availability of the RH system.
- **Discuss uncertainties from the calculation and propose solutions how to implement those uncertainties in design decisions** (for D2 and D3).
- **Discuss uncertainties from the design differences** between Temporary First Wall (TFW) and Final First Wall (FFW) DM. (No dedicated calculations required)
- **Deliver raw data** and accompanying code to enable replication and re-analysis.

Deliverable Expectations and Review Process:

This Deliverable will be key input to PDR-2/FDR-2, however the documentation **level of those calculations shall be FDR level as it will be re-used in the final FDR;** which means final calculation will be independently reviewed by an IO expert, which needs access to the raw data and code. There is no plan to re-run this calculation in the future. Typical technical check still has to be done by the suppliers. Main additional reviewer of this Deliverable will be a Plasma Wall Edge Physics Expert from IO/SCOD.

Deliverables Documents:

- ❖ D1: Report on Calculation of expected CX-loads of the 55.GD First Wall Samples.

SERVICE

5.2 D2: Development of sensitive surface in conjunction with measurement method and assessment of manufacturing options.

Purpose: To document detailed measurement requirements and perform research on different manufacturing options and demonstrate full familiarity with the scientific scope of the work of the 55.GD FWS sensitive surface.

Approach: Perform research and document results.

Deliverables Content:

- **Develop detailed measurement requirements in conjunction with proposed measurement methods**, incorporating insights and lessons learned from similar contemporary experiments with similar measurement objective.
- The measurement requirements of 55.GD are outlined in sSRD (see Introduction), but they are quite general. The detailed measurement requirements established in this contract should consider what can be realistically achieved within PIE facilities.
- Requirements shall be identify coming from the fact that the sensitive samples will be irradiated in the future DT-1 phase and will need be **handled in a hot cell for post exposure examination**.
- The supplier is requested to propose a strategy that addresses the newly introduced factor of boronization. Ideally, the approach should facilitate **differentiation between substantial boron deposition and sputtering caused by CXN**. The proposed methodology should detail the suggested solutions, including alternatives, and explain how they will be validated to reliably distinguish between these phenomena.
- **Quantify measurement requirements** required for a post exposure examination facility: Required measurement accuracy, accepted uncertainty levels.
- **Identify and quantify functional requirements,** including expected erosion rate measurement accuracy taking into account typical performance of the proposed post examination process.
- **Provide a list of potential facilities** within EU (min. 3) and within the ITER member countries (min. 3) being able to perform the post exposure examination as identified. Contact facilities and provide justification of their (theoretical) capabilities to perform that post exposure examination in the future. First examination shall take place after the first shutdown, after completion of SRO phase. See Reference [R58] for similar work done in the past.
- **Identify and evaluate various manufacturing options** for the sensitive surface.
- Evaluate the use of multiple materials for the sensitive surface, ensuring the sputtering rate and depth resolution match those of the TFW/FFW. The surface must maintain integrity under ITER neutron flux, withstand thermal loads and cycling, and endure potential accidental conditions within ITER.
- A staged approach of the sensitive surface, taking into account the significant different loads during SRO and DT-1 should be considered. This would mean to propose for the final manufacturing to have different versions of the sensitive surface.
- Discuss pros and cons of various manufacturing options of the sensitive surface.
- Comparative evaluation of methods based on expected measurement performance, cost, technical feasibility, and production scalability.
- [**Hold Point – Cost Review & Market Survey for Future Manufacturing Feasibility]**

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- Compare the proposed manufacturing methods of the sensitive surface with the collected requirements. Identification of potential risks and constraints for each method.
- **Propose manufacturing method of the sensitive surface to be selected.**

Hold Point – Cost Review for Future Manufacturing Feasibility

A Hold Point shall be established to review and approve the proposed design strategy with respect to cost implications. This review is intended to ensure that the Contractor does not proceed with a design approach that may result in excessive costs or become incompatible with future manufacturing requirements.

Deliverable Expectations and Review Process:

There is no plan to re-do this assessment and research in the future. Therefore, the documentation level of this Deliverable shall be FDR level. Main additional reviewer of this Deliverable will be a Plasma Wall Edge Physics Expert from IO/SCOD, ITER Hot Cell Laboratory Expert and Manufacturing Expert.

Deliverables Documents:

- D2.1: Detailed measurement requirements for the 55.GD First Wall Samples.
- D2.2. Report on potential PIE facilities for the 55.GD First Wall Samples.
- D2.3. Report on manufacturing options for the sensitive surface for the 55.GD First Wall Samples.
- D2.4. Report on Market Survey on the options for the sensitive surface for the 55.GD First Wall Samples.
- D2.5 Report on the proposed baseline manufacturing method of the sensitive surface for the 55.GD First Wall Samples.

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5.3 D3: Development of manufacturing plan for the 55.GD First Wall Samples for the selected manufacturing method for the prototypes.

Purpose:

Provide a manufacturing plan for the 55.GD First Wall Samples, tailored to the selected prototype production method. The input shall address key aspects such as material selection, coating processes (if applicable), surface finish requirements, lifecycle expectations, and relevant quality control considerations, in alignment with the technical requirements defined in previous Deliverables (D1 and D2).

Approach:

Discuss with manufacturers, manufacturing experts and document results as manufacturing plan.

Deliverables Content:

Development of manufacturing plan for the 55.GD First Wall Sample containing, including, at a minimum:

- **General Specifications:**
  - Detailed geometry, dimensions, and tolerances. 2D/3D engineering drawings with cross-sectional views)
- **Design Strategy**
  - The original measurement requirements consider erosion and implantation.
  - For the case the newly introduced factor of GDC/Boronization plays a major role as part of the results obtained during Deliverable D1 the design strategy should take into account measuring deposition / erosion balance (e.g. to add a cavity with pinhole in the sample which traps deposition flux which will not be subjected to sputtering or any other measures proposed by the supplier to fulfil that function)
- **Material and (if applicable) coating specifications:**
  - Base material properties and quality requirements, e.g., material certification, cleanliness standards, chemical composition and purity standards.
  - Coating material details (if applicable), including type, thickness, and deposition method, typical technical specifications of facilities.
  - Thickness uniformity and adhesion criteria (e.g., ASTM standards).
  - Surface roughness (Ra) and finish specifications.
  - Lifecycle expectations under ITER operational conditions.
  - Quality control processes for manufacturing
- **Safety and Handling Guidelines (if applicable):** e.g. Instructions for managing hazardous materials (e.g., tungsten dust).
- **Packaging and Transportation Specifications** (e.g. Protective packaging to prevent mechanical or surface damage; environmental controls for transportation e.g., humidity, temperature. marking and labelling for safe identification).
- **Define post-manufacturing inspection and testing procedures.**

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Hold Point – Review of proposed Manufacturing Plan

A Hold Point shall be established for the review and approval of the proposed manufacturing plan for the 55.GD First Wall Samples. The purpose of this Hold Point is to ensure that IO formally reviews and assesses the proposed plan prior to implementation, confirming its alignment with the design requirements, manufacturing feasibility, and applicable quality standards. As part of this process, IO may request revisions or clarifications.

Upon acceptance, the reviewed and approved content will be incorporated into the final manufacturing specification, to be formally issued by IO.

Deliverable Expectations and Review Process:

Manufacturing plan shall be on IO MRR level with full quality control allowing the re-production and re-manufacturing in the future. Main additional reviewer of this Deliverable will be Manufacturing Expert(s).

Deliverables Documents:

- D3: Report on manufacturing plan of the 55.GD First Wall Samples for the selected manufacturing method for the prototypes.

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5.4 D4: Manufacturing and Inspection of 55.GD First Wall Samples prototypes.

Purpose:

Document the fabrication and assembly processes for producing FWS prototypes.

Approach:

Manufacture prototypes and document assembly in a manufacturing report.

Deliverables Content:

- **Provide documentation as typical for the selected manufacturing process.**
- Provide manufacturing records to ensure traceability by maintaining detailed records of material batches, process parameters, and operator details.
- **Photos** of prototypes and photos of manufacturing process.
- **Provide certificates** of conformity for materials and coatings.
- **Provide calibration records** for manufacturing and testing equipment.
- **Provide compliance reports** with ITER quality assurance (QA) protocols (e.g., ISO 9001) (for the case of sub-contracting).
- **Provide process monitoring documentation**; Monitoring of critical parameters such as temperature, pressure, and deposition rate e.g., in processes like PVD, CVD, or spray coatings.
- **Perform inspection of the supplier** (for the case the manufacturing is sub-contacted and if considered necessary).
- **Perform post-manufacturing inspection and testing procedures.**
- Records of deviations and corrective actions during manufacturing (if applicable).
- Perform inspection (Conduct a formal review with stakeholders, including technical leads and QA representatives, to confirm coating quality meets all requirements)
- Organize delivery of prototypes to supplier qualification facilities (D5) (for the case the manufacturing is sub-contacted).

Deliverable Expectations and Review Process:

This Deliverable is mainly to ensure quality of the process. The reviewers will focus on comparing the manufacturing specifications with the manufacturing report.

Deliverables Documents:

- D4.1: Report on Manufacturing and Inspection of 55.GD First Wall Samples prototypes.
- D4.2 Report on manufacturing supplier inspection of 55.GD First Wall Samples prototypes.

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5.5 D5: Qualification of 55.GD First Wall Samples prototypes.

Purpose: Verify the FWS sensitive surface meets all specifications.

Approach: Perform a range of tests that simulate the expected loads and show the selected sensitive surface design meets all requirements. For each qualification and/or test, the first step is to develop a comprehensive and detailed measurement/qualification plan, outlining the specific methodologies, parameters, and criteria to be followed. Once the plan is reviewed and approved, the subsequent step is to initiate the qualification test in accordance with the approved procedures and schedule.

The supplier shall provide a logical sequence for the testing to maximize the information gathered.

Deliverable Content:

- **Erosion Test of the FWS prototypes:** Conducted using a staged approach, following the specific expected erosion levels as calculated in Deliverable 1 the samples shall undergo erosion as expected in ITER .
  - A linear plasma device or a similar apparatus, such as an accelerator device, shall be employed to simulate charge-exchange (CX) erosion. The translation of CX erosion to direct plasma loads shall be calculated to target to replicate the effects of plasma interaction on the surface.
  - Calculated FWS erosion performance shall be compared to measured erosion for load conditions relevant to ITER, within limits of the capabilities of the supplier's proposed system.
  - Note that, charge exchange (CX) neutral energy distributions are typically characterized by heavy tails at low particle fluxes (~10^{18} particles/m^2·s), with average energies of a few hundred eV, and lighter tails at higher fluxes (~10^{20} particles/m^2·s), where average energies are closer to 100 eV.
  - Erosion measurements shall be done for representative energies and fluences.
- **Pre- and post-Erosion measurements** shall be performed to monitor the extent of erosion and assess the suitability and integrity of the sensitive surface, ensuring it meets the required performance standards. As a minimum, the following assessments should be conducted as Pre- and Post-Erosion Evaluations:
  - **Visual Inspection** using High-Resolution Cameras: A visual inspection with high-resolution imaging tools should be carried out both before and after testing to evaluate the extent of surface damage and erosion.
  - **High-Resolution Optical Microscopy**: Optical microscopy with high magnification can allow for the visualization of fine surface details and the measurement of erosion effects down to micrometer scales. Should be used to detect surface features such as micro-cracks, pitting, changes in surface roughness, erosion patterns, and any localized material removal or deposition at micrometer scale.
  - **Gravimetric (Weight Loss) Method**: This method should be used to assess the material loss due to erosion by measuring the change in weight of the sample.
  - Utilize one or more of the following **advanced imaging and analysis techniques**, as appropriate: Imaging & Morphological Analysis methods such as

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Scanning Electron Microscopy (SEM), Cathodoluminescence Photomicrography (CPS), Electron Probe Micro-Analysis (EPMA), and 3D Optical Profilometry; and/or Elemental & Chemical Analysis and Surface Properties & Thickness techniques. Expected to reveal [micro-nano] scale surface morphology changes, erosion-induced topography modifications, crack initiation sites, particulate deposition, and evidence of sputtering or material redeposition.

- These techniques should be employed to replicate the detailed post-erosion characterization processes expected during assessments in ITER. The selection of methods should be guided by the **practical availability of techniques** within the measurement facilities identified in Deliverable 2, ensuring compatibility with existing infrastructure while enabling an accurate and comprehensive evaluation of the surface condition.
- The supplier shall list their available characterization capabilities in the offer and justify their adequacy with respect to the required analyses.

- **Thermal shock test & LOCA test:** From room temperature to 100°C: This can be achieved by submerging the sample prototype in boiling water. This transition represents the phase with the steepest temperature gradient, making it the most extreme heating scenario. During operation, the 55.GD FWS typically experiences temperature gradients ranging from 1 to 10 °C/s. Therefore, this thermal shock test is highly conservative, as the sample rapidly heats in boiling water. The test must be conducted at least 15 times, aligning with the 15 ICE-II (Vacuum Vessel Ingress of Coolant Event, VV ICE) incidents anticipated during the ITER lifetime. It is important to note that this is a highly conservative assumption, as a single FWS is not expected to remain inside the VV for the entire ITER lifespan.

- **Tape Test:** In cases where a coating or a potentially delicate deposition technique is applied to manufacture the sensitive surface, tape pull tests and cross-cut adhesion test should be conducted according to ASTM D3359/Method B or ISO 2409 standards. These tests shall demonstrate adhesion quality and ensuring that the coating adheres sufficiently.

Note:

If necessary, alternative testing processes may be proposed, provided they can be justified as more conservative or better suited to the specific material or application in question. In cases where the tests prescribed in the relevant standards require specific equipment or conditions that are difficult or costly to procure, alternative methods may be considered as long as they can be demonstrated to provide equivalent or better reliability and accuracy.

For reference, please see the applicable and non-applicable tests and standards in the Appendix.

The Supplier shall deliver a limited number of tested samples to the IO upon completion of testing.

Deliverable Expectations and Review Process:

The Deliverable should provide all documentation to justify that the sensitive surface design has been designed fit for purpose.

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Test plans, outlining a step-by-step approach, must be submitted to IO prior to the execution of any tests. A well-documented test plan is essential to ensure that the testing process is well-structured, systematic, and consistent. It serves as a clear roadmap for the test, detailing objectives, procedures, equipment, and expected outcomes. Submitting the plan in advance allows for review and approval, ensuring that all stakeholders are aligned on the methodology and that the test is conducted in compliance with necessary standards or guidelines.

Main additional reviewer of this Deliverable will be a Plasma Wall Edge Physics Expert from IO/SCOD and PBS 55 experts.

Deliverables Documents:

- D5.1: Report on Qualification test plan of 55.GD First Wall Samples prototypes
- D5.2: Report on Qualification results of 55.GD First Wall Samples prototypes including Pre- and post-Erosion measurements.
- D5.3 Report on Thermal shock test & LOCA test of 55.GD First Wall Samples prototypes.
- D5.4 Report on Tape Test of 55.GD First Wall Samples prototypes.

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5.6 D6: PDR-2/FDR-2 of 55.GD First Wall Samples prototypes.

Purpose:

To provide comprehensive support and documentation for the execution and closure of Preliminary Design Review (PDR-2/FDR-2) and to lay the groundwork for the full scope Final Design Review (FDR). This includes preparing input to the required presentations, data packages, action plans, and supporting the resolution of PDR-2/FDR-2 chits. This Deliverable should also define the scope and challenges for subsequent tasks leading to the full scope FDR.

The design review process of PDR-2/FDR-2 will be led and managed by the IO TRO (Technical Responsible Officer). The supplier's role is to support this process by providing input, contributing to documentation, and assisting with the preparation of review materials as requested.

Approach:

Provide support documentation to perform PDR-2/FDR-2 [managed by 55.GD IO TRO].

Deliverables Content:

- Support the 55.GD TRO by contributing input to the development of documentation for the design review phase. Assist in compiling and organizing relevant materials—such as presentations, input data package lists, and supporting documents—necessary to carry out PDR-2/FDR-2 in accordance with IO's Design Review procedures.
- Additionally, provide support in compiling and organizing documentation for submission to IO, in accordance with the requirements for pre- and post-design review activities and any additional documentation specified by IO.
- Provide input to the development of a structured action plan (e.g. chit resolution reports) to address category 1, 2, and 3 chits raised during PDR-2. Propose potential resolution approaches aligned with technical requirements and project timelines. Support the identification of necessary documents and outline suggested updates or developments needed to meet FDR requirements.
- Contribute to the definition of proposed content for future technical specifications based on PDR-2 outcomes. Provide estimates of the effort required and highlight key challenges associated with completing the remaining documentation and tasks needed for FDR readiness.

Deliverable Expectations and Review Process:

The Review of this Deliverable will focus on ensuring the completion of a Design Review according to the IO Design Review Requirements. Numerous IO staff and external experts will be involved in reviewing the documentation and results obtained in the previous Deliverables(D1-5).

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Deliverables Documents:

- D6.1: Report on Input provided for the development of documentation for the design review phase of 55.GD First Wall Samples prototypes PDR-2.
- D6.2: Report on Input provided for pre- and post-design review activities for the Sensitive Surface of 55.GD First Wall Samples PDR-2/FDR-2.
- D6.3: Report on Input provided for System Design Description (DDD) for the Sensitive Surface of 55.GD First Wall Samples PDR-2/FDR-2.
- D6.4: Report on Input provided for Component, Manufacturing, and Assembly BTP Drawings for the Sensitive Surface of 55.GD First Wall Samples PDR-2/FDR-2.
  D6.5: Report on Input provided for Operations Plan (Including Pre- and Post-Exposure Measurement Descriptions) for the Sensitive Surface of 55.GD First Wall Samples PDR-2/FDR-2.

6 Location for Scope of Work Execution

The Contractor can perform the work at their own location.

7 Responsibilities

7.1 Contractor's Responsibilities

In order to successfully perform the tasks in these Technical Specifications, the Contractor shall:

- Update and/or create the documents within the due dates specified in the section 5 of this technical specification.
- Strictly implement all applicable IO procedures, instructions and use templates;
  - Note: Some examples of procedures and templates are linked in the deliverables section.
- Provide experienced and trained resources to perform the tasks;
- Contractor's personnel shall possess the qualifications, professional competence and experience to carry out services in accordance with IO rules and procedures;
- Contractor's personnel shall be bound by the rules and regulations governing the IO ethics, safety and security IO rules;
- Contractor shall provide a list of actions after each meeting with IO; and update the commonly used Action Tracking Table (XLS-Table that contains a list of all actions). IO will provide a draft of the Action Tracking Table (ATT). The ATT shall be updated min. on a monthly basis.
- Prior to the start of work on each activity/task, the Contractor shall review the input technical information provided to it by IO for completeness and consistency, and shall advise the IO representative of any deficiencies it may find;
- Where necessary, the contract shall collect the required input information by interacting proactively with IO staff and contractors.
- The supplier shall deliver a few samples of the prototypes to IO at the end of the contract.

7.2 IO's Responsibilities

In order to successfully perform the tasks in these Technical Specifications, IO shall:

- Nominate the Responsible Officer to manage the Contract (IO-TRO);

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- **The IO TRO will serve as the lead authority responsible for managing and directing the PDR-2/FDR-2 process.**
- Organise monthly progress meeting(s) on work performed;
- Organise technical meetings as required;
- Provide offices at IO premises, - if required - during a visit of the contractor to IO;
- Grant the access to the IDM as Author to the contractor, in order to upload documentations;
- IO shall make available to the Contractor all technical data and documents which the Contractor requires to carry out its obligations pursuant to this specification in a timely manner. For delays of more than two weeks in making them available, the Contractor shall advise IO representative of the potential impact on the delivery of the Work Packages, to agree and define all the correction actions to take in place.

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

Ref D#	Further Description / Title	Expected date
I1	SOLPS-ITER extended grid plasma backgrounds and wall fluxes for Q=10 case	T0
I2	SOLPS-ITER extended grid plasma backgrounds and wall fluxes for SRO cases	T0
I3	GDC Loads	T0

8 List of deliverables and due dates

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

A minimum, but not limited to, list of documents is available hereafter with associated due dates:

Ref D#	Further Description / Title	Expected date
X	Kick Off Meeting	T0 [during KOM**]
D1	Calculation of expected CX-loads of the 55.GD First Wall Samples.	T0 + 5 months
D2	Development of sensitive surface in conjunction with measurement method and assessment of manufacturing options.	T0 + 7 months
D3	Development of manufacturing specifications of the 55.GD First Wall Samples for the selected manufacturing method for the prototypes.	T0 + 9 months
D4	Manufacturing and Inspection of 55.GD First Wall Samples prototypes.	T0 + 11 months

SERVICE

D5	Qualification of 55.GD First Wall Samples prototypes.	T0 + 14 months
D6	PDR-2 of 55.GD First Wall Samples prototypes.	**T0 + 18 months**

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

(**) Kick Off Meeting shall be held ~ 2 weeks after contract signature.

A proposed total contract duration of 18 months is suggested.

However, if this duration is deemed unfeasible due to boundary conditions or constraints not known to IO, tenderers are invited to provide justified comments or propose an alternative timeline in their submission.

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

9 Quality Assurance requirements

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

The organisation conducting these activities should have an ITER approved QA Program or an ISO 9001 accredited quality system.

The general requirements are detailed in ITER Procurement Quality Requirements (ITER_D_22MFG4).

Prior to commencement of the task, a Quality Plan must be submitted for IO approval giving evidence of the above and describing the organisation for this task; the skill of workers involved in the study; any anticipated sub-contractors; and giving details of who will be the independent checker of the activities (see Procurement Requirements for Producing a Quality Plan (ITER_D_22MFMW)).

Documentation developed as the result of this task shall be retained by the performer of the task or the DA organization for a minimum of 5 years and then may be discarded at the direction of the IO. The use of computer software to perform a safety basis task activity such as analysis and/or modelling, etc. shall be reviewed and approved by the IO prior to its use, in accordance with Quality Assurance for ITER Safety Codes (ITER_D_258LKL).

10 Safety requirements

The scope under this contract does not cover for PIC and/or PIA and/or PE/NPE components.

11 Acceptance Criteria

These criteria shall be the basis of acceptance by IO following the successful completion of the services:

- The deliverables will be in the form of documents as indicated in section 8.

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- The contractor's deliverables (DX.X) are formal documents that serve as a basis for triggering payments and are directly linked to the technical documentation generated throughout the work.
- The deliverables will be posted in the Contractor's dedicated folder in IDM.
- The IO-CRO is the Approver of the delivered documents.
- The Approver can name one or more Reviewers(s) in the area of the report's expertise for all documents provided in this contract.
- The Reviewer(s) can ask modifications to the report in which case the Contractor must submit a new version.
- The contractor shall provide responses to reviewers' comments and revise the documents if necessary according to reviewers' comments. The documents shall be revised in a timely manner (normally within two weeks from the completion of the IDM review).
- The acceptance of the document by the Approver is the acceptance criterion.

12 Specific General Management requirements

Requirement for [Ref 1] GM3S section 6 applies in full.

Contractor's personnel visiting the ITER site will be bound by the rules and regulations governing safety and security.

12.1 CAD Design Requirements

No IO compliant CAD design tasks (e.g. in ENOVIA) are required for this contract.

CAD models and Drawings related to the manufacturing designs shall be provided in a data format chosen by the supplier.

IO will translate the data to IO Design Review compliant documentation.

13 Specific requirements and conditions

The Contractor shall work independently with minimum supervision to achieve the objectives and deliverables specified in this technical specification.

The Contractor shall have and maintain the necessary equipment and licenses to run the software tools required to carry out the tasks and produce the deliverables in accordance with the tools adopted by the IO. The Contractor shall ensure that experts are adequately supported and equipped. It shall ensure that there is sufficient administrative, secretarial and interpreting provision to enable experts to concentrate on their primary responsibilities.

Specific skills and techniques as required for the tasks described are in following sub-sections:

SERVICE

13.1 Technical skills required for the tasks described are:

The contractor shall possess and demonstrate the following technical competencies and qualifications:

- **Comprehensive Understanding of Fusion Systems:** Extensive knowledge of fusion systems or other similarly complex systems, including their operation, challenges, and requirements.
- **Manufacturing Expertise:** Proven experience in the manufacturing of components for fusion experiments, with a strong emphasis on precision and compliance with stringent specifications.
- **Research Contributions:** A track record of relevant publications in the field of fusion experiments, demonstrating expertise and contributions to the scientific community.
- **Knowledge of Fusion Experiment Diagnostic Systems:** Proficient understanding of fusion experiment diagnostic systems, including their design, functionality, and integration.
- **Mechanical Systems Development:** Hands-on experience in the design, development, and operation of mechanical systems, particularly those relevant to fusion or high-complexity environments.
- **Design Compliance Assessment:** Expertise in evaluating and ensuring that designs adhere to technical requirements and specifications, including iterative review and refinement processes.
- **Assembly Process Knowledge:** Familiarity with assembly processes, including detailed understanding and capability to document and describe these processes comprehensively.
- **Technical Documentation Skills:** Demonstrated ability to create clear, concise, and accurate technical documents and presentations to communicate complex information effectively.
- **Proficiency with Software Tools:** Competence in using MS Office applications, particularly Word and Excel, for documentation, data analysis, and communication purposes.

13.2 Language skills required for the tasks described are:

To ensure effective communication, prevent misunderstandings, and foster constructive discussions of diverse ideas, the following language skills are mandatory for tasks under this contract:

- **The official language of the ITER project is English.** Therefore, all input and output documentation relevant to this Contract shall be in English.
- The contractor must ensure that all professionals responsible for communication, particularly those participating in technical and progress meetings, possess a strong command of English. This proficiency should enable seamless communication and the clear and accurate drafting of technical documentation.
- During technical or progress meetings**, the contractor must ensure the regular attendance of at least one representative with sufficient English proficiency to effectively manage and facilitate discussions**, resolve problems, and engage openly in exploring and refining diverse ideas.

14 Work Monitoring / Meeting Schedule

The work will be started by a dedicated kick-off meeting (KOM) and managed by means of Progress Meetings.

Progress meetings will involve C-TROs (Contract – Technical Responsible Officer – nominated by the supplier) and the IO-TRO. For all Progress Meetings, minutes, including action items, shall be written by the C-TRO and be stored in the ITER IDM in order to ensure traceability.

A monthly update on the schedule progress shall be provided.

Regular technical meetings between IO and the contractor should be held on weekly/bi-weekly basis. External experts will be invited to discuss technical matters.

The main purpose of the Progress Meetings is to allow the ITER Organization/Diagnostics Division and the Contractor Technical Responsible Officers to:

- Allow early detection and correction of issues that may cause delays;
- Review the completed and planned activities and assess the progress made;
- Permit fast and consensual resolution of unexpected problems;
- Clarify doubts and prevent misinterpretations of the specifications.

15 Appendices

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15.1 Recession depth of 55.GD FWS

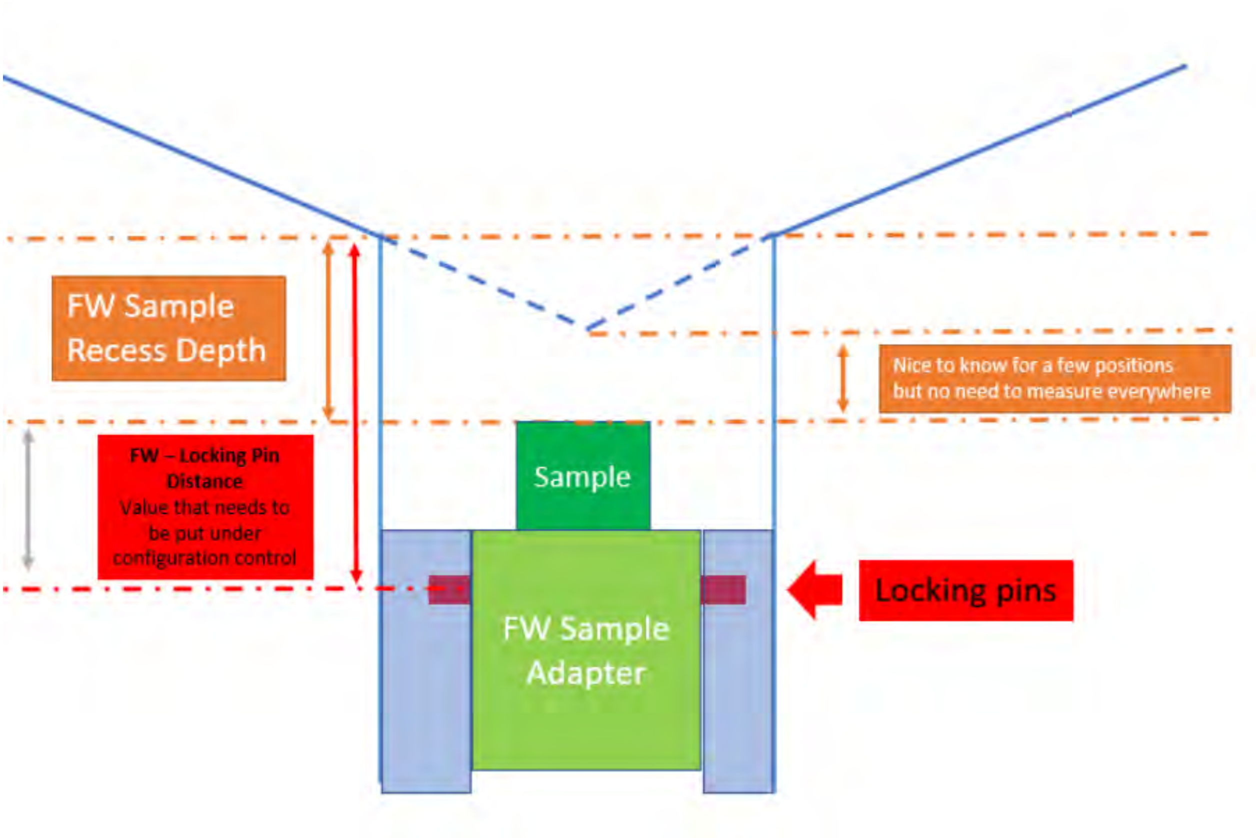

Figure A1 Definition of recession depth shown as a cut throught a toroidal plane.

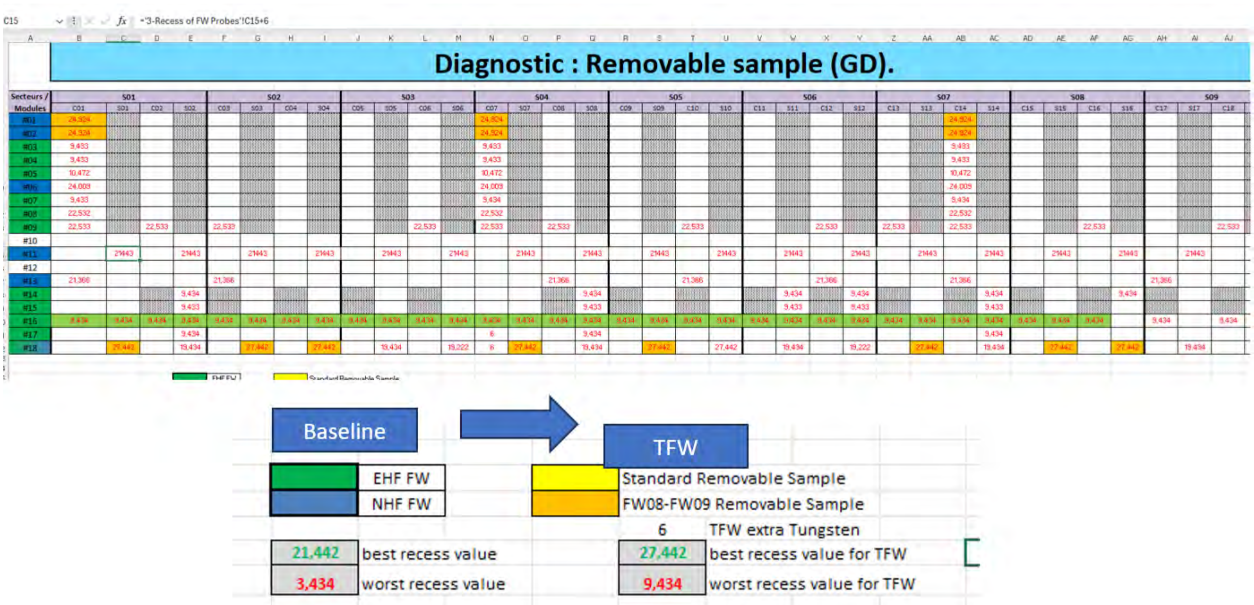

Figure A2 Distribution of 55.GD FWS including recession depth for each sample. The range of the recession depth ranges from ~ 30 mm and ~ 3 mm.

SERVICE

15.2 Qualification tests and their applicable standards.

Test Name	Method	Purpose	Relevant Standards	Applicabe
Thermal Shock Testing (Temperature Cycling)	Expose the coated sample to rapid temperature changes between extreme hot and cold environments.	Evaluates resistance to cracking, delamination, and adhesion loss due to thermal expansion and contraction.	IEC 60068-2-14, MIL-STD-810, ASTM D6944	**Yes** **(Boiling Water Test)**
Pull-Off Adhesion Test	Uses a tensile pull-off device to measure the force required to detach the coating.	Determines adhesion strength and failure mode (cohesive or adhesive).	ASTM D4541, ISO 4624	**Yes** **(Tape Test)**
Cross-Cut Adhesion Test (Tape Test)	A grid pattern is cut into the coating, adhesive tape is applied and pulled off.	Checks for peeling or adhesion loss in a simple, quick assessment.	ASTM D3359, ISO 2409	**Yes** **(Tape Test)**
Bending / Flexibility Test	The coated material is bent around a mandrel to check for cracks or peeling.	Evaluates coating flexibility and adhesion under mechanical stress.	ASTM D522, ISO 1519	**No** **(Not possible due to sample shape)**
Impact Resistance Test	A weight is dropped onto the coated surface to check for cracks or adhesion loss.	Measures resistance to sudden mechanical shock.	ASTM D2794	**No** **Not applicable load**
Water Immersion Test	The sample is submerged in water (or boiling water) for a set time and checked for damage.	Assesses moisture resistance and thermal stress effects in wet conditions.	ASTM D870	**Yes** **(Boiling Water Test)**
Salt Spray / Corrosion Resistance Test	Exposes the coated sample to a salt fog environment for a defined period.	Tests corrosion resistance, especially for marine or humid environments.	ASTM B117, ISO 9227	**No** **Not applicable load in ITER**

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15.3 Conceptual Design Review results

Two possible designs of the sensitive surface have been suggested during Conceptual Design Review (CDR) [*QUBKU9 v1.0)*] assuming a Be FW environment. The concepts are outlined below.

Please note that during the CDR (QEYNVF), beryllium was the baseline material established by IO. As such, the following text references beryllium. However, for this contract, no beryllium is to be used, as tungsten has now been confirmed as the updated baseline material for the first wall.

The contractor is therefore invited to submit other ideas for sensitive surfaces, along with associated analysis methods. These proposals may be considered and approved for development upon agreement with IO.

Please note that none of the following text in this Chapter 15.3 consists of a requirement for this contract and is provided purely as reference.

15.3.1 Sandwich-like surface structure, assuming 2016 ITER baseline

The baseline FWS sensitive surface design is shown in Fig.D. It consists of a number of beryllium layers with a given thickness alternating with special marker interlayers. In comparison with uniform thick beryllium layer sandwich structure results in increase of the precision of the measurement proportionally to the quantity of the interlayers. Beryllium proxy (Al, Mn, Ti) shall be used instead of beryllium. It is suggested to use aluminium as a beryllium substitute. The thickness of the aluminium layer shall be 10 +- 1 μm. Assuming that the error of the analysis tool is 15% resulting measurement uncertainty will be about 20%.

Various materials can play the role of the marker. The material of the marker layer should

1) be low-active and vacuum compatible material;
2) have low diffusion coefficient in beryllium;
3) not significantly influence on beryllium sputtering by hydrogen isotopes;
4) withstand possible Loss-of-Cooling Accidents (LOCA, see below).

It is highly desirable to avoid such materials like niobium, tantalum and cobalt due to their long-lived activation which might deteriorate analysis of the samples and their consequent decommissioning.

Low diffusion of the marker material in beryllium is necessary in order to avoid large overlapping of the layers caused by atomic inter-diffusion. Such smoothing of the inter-layer boundary will result in reducing of marker position detection when using ion sputtering during surface analysis. Ion sputtering itself will introduce additional errors in measurement due to inducing atoms mixing between beryllium and marker layers leading again to smoothing of the boundary.

Heavy metals especially those having high melting temperature like molybdenum or tungsten might strongly reduce beryllium sputtering yield. It can be either due to shielding effect when easy-to-sputter atoms are covered by heavy atoms or to surface morphology development. That is why special attention shall be paid to proper selection of marker material. The marker material can be considered as acceptable if it does not change the sputtering rate of the single beryllium layer by more than 10%. The required thickness δ of marker layer will be defined in the experiments. Experimental validation of the selected marker material and its thickness shall be demonstrated to IO.

LOCA should not lead to the disintegration of the marker layer. At least traces of the layer detectable in SIMS should remain on the surface.

Finally, the ideal marker layer should

- be as thin as possible;
- be detectable at SIMS;
- not affect significantly on sputtering of beryllium layer;
- meet other ITER requirements.

Whole sandwich structure should withstand ITER thermal cycling. It should not delaminate from substrate and should not get any cracks. Thermal cycling tests are described below in Section 6.2.

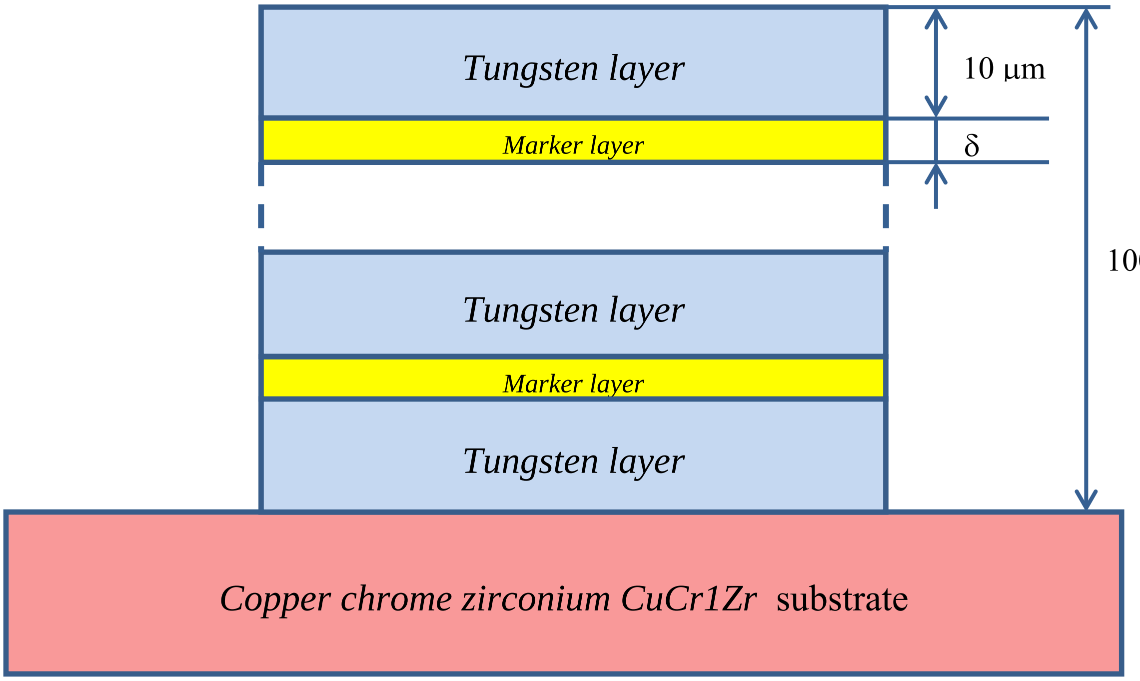

Figure D. Schematic view of proposed FWS sensitive surface design.

15.3.2 *Ion implanted surface, assuming 2016 ITER baseline*

High energy ion implantation technique of the marker atoms can be also considered as a promising design of the sensitive surface. The basic principle of sputtered depth detection is similar to the sandwich-like coating but realization is different.

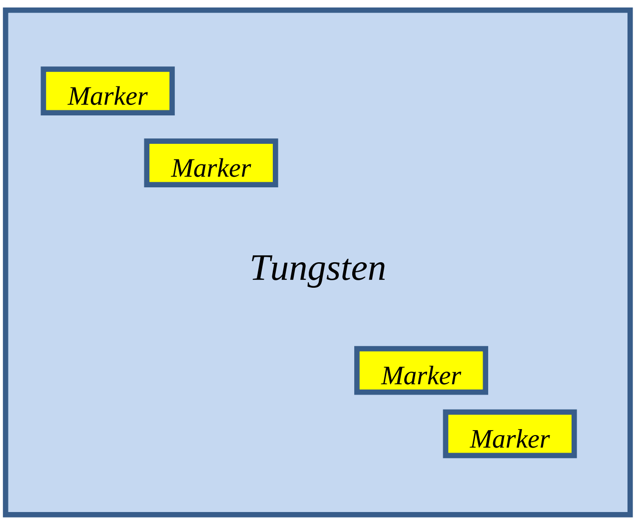

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Figure E. Schematic view of ion implanted sensitive surface.

The idea is to implant marker atoms at the given depths of the surface (Fig. E). The number of such group of markers can be similar to sandwich coating or even higher. The advantage of the implantation technique is that it should not change noticeably whole structure of the surface and the amount of admixed atoms (markers) can be significantly less than in sandwich structure. Also, bulk beryllium material can be taken for ion implantation technique instead of beryllium coating deposition.

The disadvantage is quite smooth marker atom depth profile after the implantation. This can result in poor depth resolution during the analysis. Figure F shows TRIM calculated depth profiles of carbon ions with energy 1 and 4 MeV/nucleon implanted in beryllium. Ion stopping ranges are about 10 µm and about 88 µm correspondingly. One can see there are peak concentrations of carbon atoms with a width approximately ~ 1 and ~ 3 µm correspondingly. After the continuous operation of the FWS at high temperature (400 – 500 C°) the implantation peak can become even smoother due to diffusion of marker atoms in different directions. Finally, it might result in loss of depth resolution, especially, in deep layers of the surface (~ 50 – 100 µm).

SERVICE

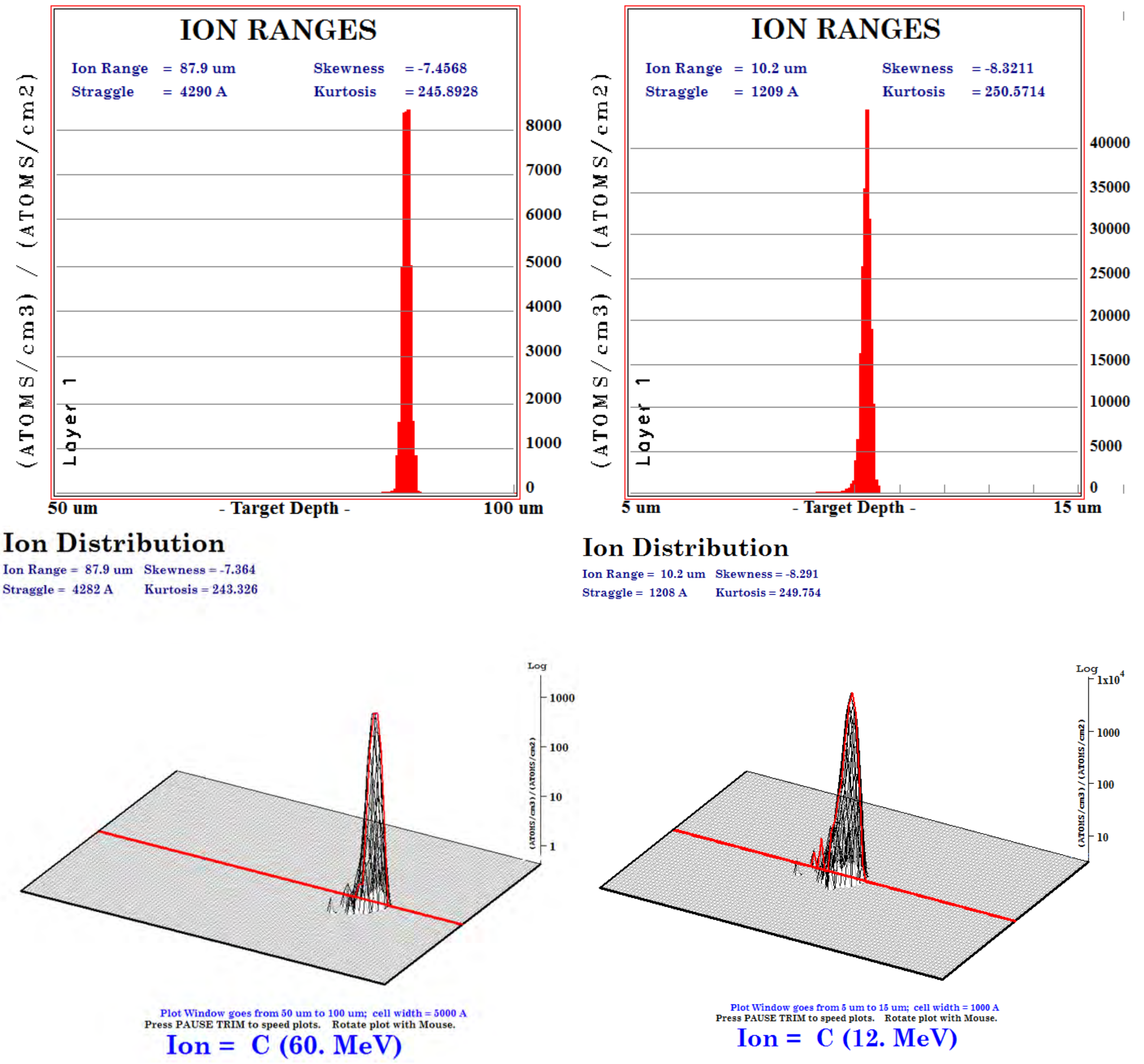

Figure F. Depth profile of carbon ions with energy 1 and 4 MeV/nucleon implanted in beryllium.

Location of markers in deep beryllium surface layers implies that ion implantation energy should be high (~ MeVs). This can be achieved in large extensively used particle accelerators.

Operational requirements to implanted sensitive surface are similar to sandwich-like one.

ANNEX I

EXPRESSION OF INTEREST & PIN ACKNOWLEDGEMENT

To be returned by e-mail to: chloe.perret@iter.org copy amankumar.joshi@iter.org

TENDER No.	**IO/25/OT/10032691/CPT**
DESIGNATION of SERVICES:	D**evelop the sensitive surface of the 55.GD First Wall Samples Diagnostic**
OFFICER IN CHARGE:	**Chloe Perret EXT – Procurement Division ITER Organization**

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

☐ WE INTEND TO SUBMIT A TENDER

☐ WE WILL NOT TENDER FOR THE FOLLOWING REASONS:

………

Company name:..

COMPANY STAMP

Signature:

Name: ....

Position: ....

Tel: ....

E-mail..

Date: ....