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Technical Specifications (In-Cash Procurement)

Technical Specification for Contact Electrical Conductance in Vacuum

The Blanket system provides the main thermal and nuclear shielding to the vessel and to external machine components. During plasma disruptions, electrical current is conducted through grounding components (called Electrical Straps) to the Vacuum Vessel. The purpose of this specification is to assess the contact electrical conductance under vacuum conditions for two pairs of contacts: CuCrZr/Stainless Steel and Stainless Steel/Stainless Steel

Table of Contents

1 Purpose

This document specifies the technical program for the testing of contact electrical conductance for two pairs of contact: CuCrZr/Stainless Steel and Stainless Steel/Stainless Steel in ambient conditions and in vacuum.

2 Definitions

The following definitions are used in this document.

VV	Vacuum Vessel
IO	ITER Organization
FW	First Wall
SB	Shield Block
ES	Electrical Strap

3 Introduction

3.1 The ITER project

The ITER project aims to demonstrate the scientific and technological feasibility of fusion power for peaceful purposes and to gain the knowledge necessary for the design of the next-stage device, DEMO, or the DEMOnstration fusion power plant.

ITER is a joint international research and development project currently under construction.

The seven Members of the ITER Organization are 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 will be constructed in Europe, at St Paul lez Durance, in southern France, where the ITER Organization (IO) has its headquarters.

Further information can be found on the ITER website (http://www.iter.org) and at the web pages of the ITER Parties that can be accessed via the ITER website.

3.2 The Blanket System

The Blanket System provides a physical boundary for the plasma and contributes to the thermal and nuclear shielding of the VV and external ITER components. It covers a plasma-facing surface of ~610 m^2 and consists of Blanket Modules (see Fig. 1). Each module comprises two major components: a plasma facing First Wall (FW) panel and a Shield Block (SB), of total dimensions about (1m x 1.4m x 0.5m) and with a maximum weight of 5T.

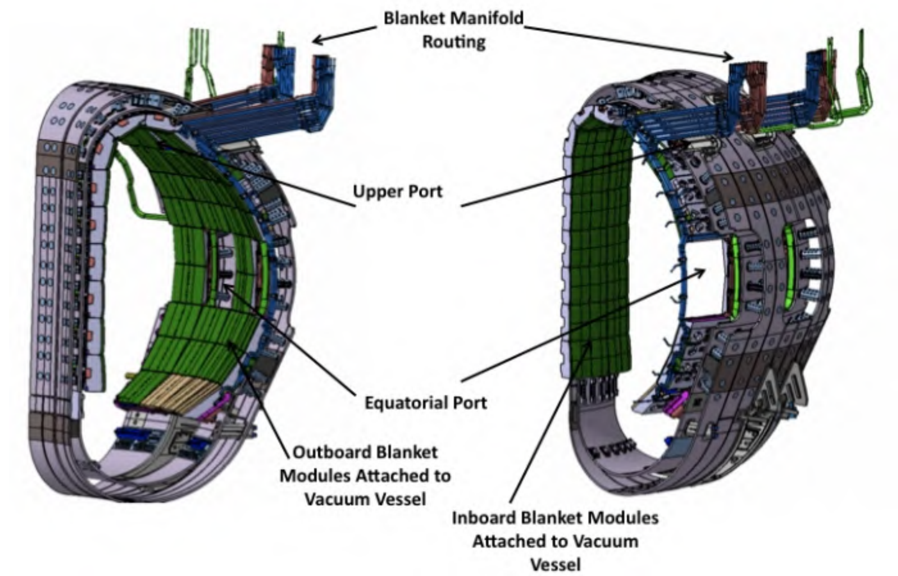


Fig. 1 - Schematic of VV Sector showing blanket modules in inboard and outboard regions

In the event of a plasma disruption, the plasma current shall be transmitted from Blanket FW to the Vacuum vessel (grounding) through the SB. Both electrical connections (FW to SB and SB to VV) are using the same CuCrZr Electrical strap (or pair of ES) given in Annex 1.

On SB side, the ES is directly bolted through 4 M12 studs to the Shield Block (SB) made from austenitic stainless steel grade SS316L at one end and connected to the VV by means of an M24 bolted joint to the ES pedestal which is welded to VV (see Annex 1 for details).

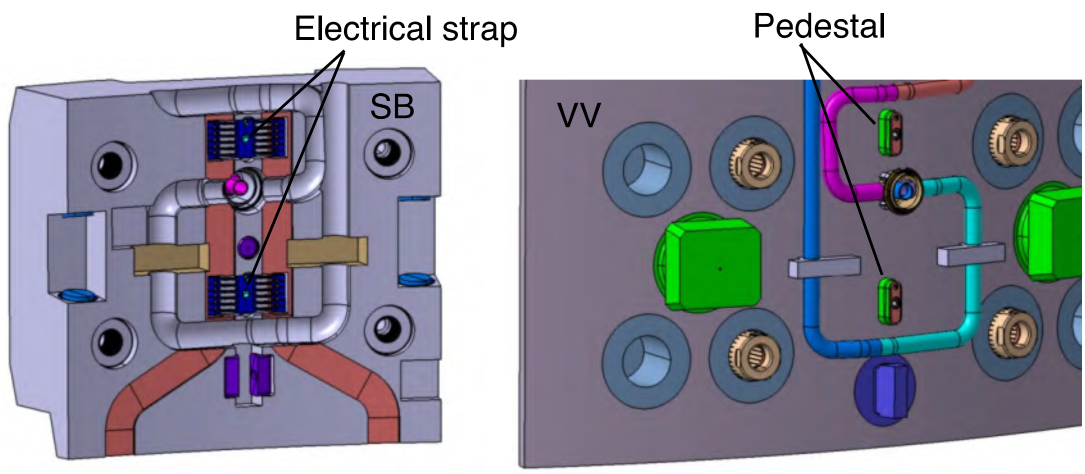


Figure 2. SB electrical connection to the VV.

The ES pedestal represents a hollow rectangular block with round corners made from austenitic stainless steel grade SS316L with a 4 mm copper alloy (CuCrZr) plate bonded on the top. The CuCrZr plate is used to improve electrical conductivity between the electrical strap and pedestal. An insert, made of SS660, with M60 outer thread and M24 inner thread is screwed into the pedestal flange to provide a bolted joint to the electrical strap. The insert is used to allow correct alignment (via a custom location of the inner threaded hole) considering the assembly tolerances of the pedestal onto the VV.

On the FW side, same ES and attachment scheme is used, the material combination are swapped: 4xM12 studs side are CuCrZr to CuCrZr while M24 side is CuCrZr to SS as shown in Figure 3.

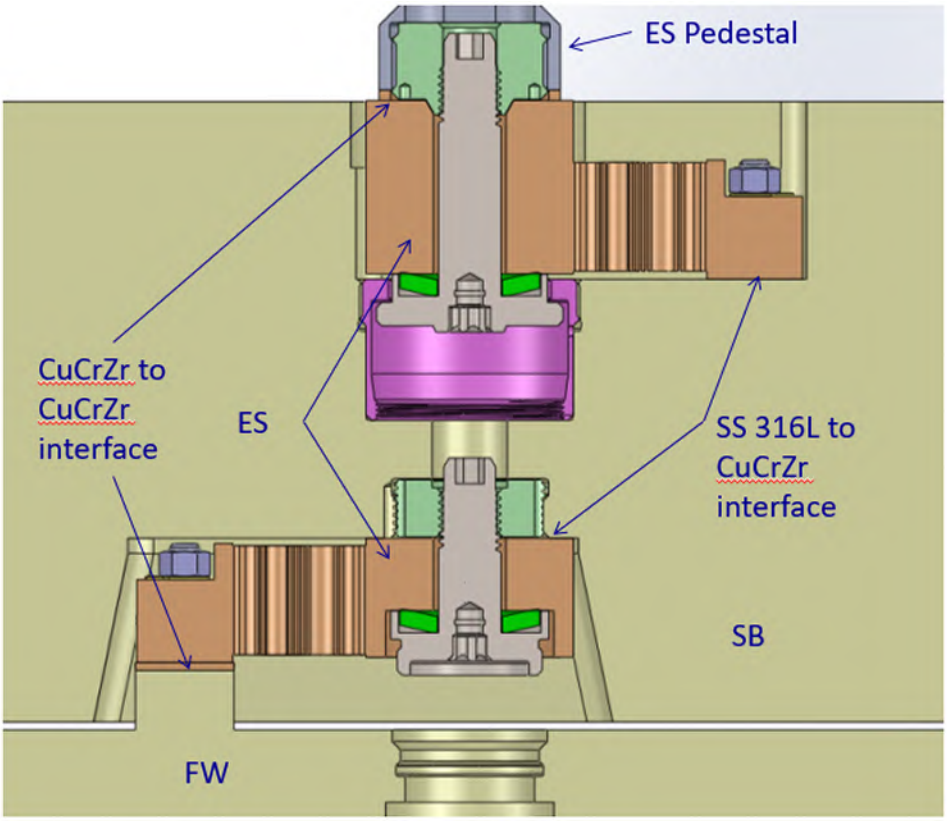


Figure 3. ES interfaces.

4 Background of the work

A main concern of the Electrical Strap design is the contact electrical conductance performance in vacuum, especially concerning the risk of melting at the Cu to SS joint from FW to SB (which would subsequently generate issues for maintenance).

The objective of this specification is to define the work related to investigation of the impact of High Vacuum conditions on the ES electrical conductance performance under high-pulsed current corresponding to the most demanding operation in the ITER blanket system or similar.

The tests in air are aiming to provide a reference for comparison.

The actual design of the blanket ES is shown in ANNEX 1. A proposed simplified mock-up is presented in ANNEX 2. Nevertheless contractor may propose a different scheme that shall remain representative of actual one.

5 Scope of the work

The scope of work is split into three phases:

- **Phase 1** – Development of the test protocol, set-up, and necessary parts/jigs to be manufactured
- **Phase 2** – Manufacturing and inspection of parts, installation of test set-up
- **Phase 3** – Testing and reporting for:
  - **Test 1** – three tests in air: normal pressure, ambient temperature and humidity.
  - **Test 2** – three tests in vacuum: High Vacuum (< 10^{-4} Pa), ambient temperature.

5.1 Phase 1 – Preparation of Manufacturing and Testing

The Contractor shall develop the test protocol for IO approval.

The Contractor shall develop a detailed proposal of the manufacturing of the test mock-up and test jig/fixtures, including the full set of manufacturing drawings and manufacturing inspection plan.

All drawings shall be agreed with IO prior manufacturing.

A proposal for the test set-up is provided in ANNEX 2 but the contractor can propose a different solution (subject to IO agreement).
The test shall simulate ITER actual design. Supplier can propose variation of these parameters in his offer considering his equipment and facility but it shall be justified that such variation will remain representative:

1) the two contacts shall be simulated:
   a. CuCrZr *(UNS Number C18150 or CW106C in EN standard EN 12420:2014)* and SS 316L *(ASTM A240/240M – 10 or European equivalent – steel number 1.4404 EN 10028-7:2007)*.
   b. CuCrZr and CuCrZr
2) The surface of 7000 mm² shall be bolted by one single bolt preloaded at 100kN
3) The bolt preload shall be controlled before and after each test (by means of bolt elongation, torque measurement…) with an uncertainty better than ±5%.
4) Bolt and nuts could be re-used in case of no failure.
5) Contact surfaces shall be with roughness of Ra3.2 and flatness of 0.05.
6) Current: DC or AC with effective current of 137 kA
7) Pulse duration shall be 300 ms
8) 10 current pulses for each set-up shall be performed (60 pulses in total)
9) The current/voltage measurement system shall be able to measure the current flowing through the test mock-up and the voltage drop on both contact interfaces.

The Contractor is responsible for all activities of this task including:

- Design of the component and of the testing equipment,
- Provision of manufacturing drawings for mock-up and test jig/fixtures,
- Provision of the manufacturing and inspection plan.

Dimensional inspection of the entire set of components shall be reported according to a protocol based on ISO/TC 213 - Dimensional and geometrical product specifications and verification.

Deliverable 1:

- Protocol for testing performed in phase 3, and
- Manufacturing and Inspection Plan of parts/jigs.

The start of manufacturing is subject to the IO approval of these deliverables

5.2 Phase 2 – Manufacturing and Inspection

Based on geometries, drawings, and inspection plan agreed during Phase 1, the contractor shall perform manufacturing of all required parts.

The contractor is responsible for all activities of this task including:

- Purchasing of material,
- Provision of the material certificates,
- Provision of dimension control and inspection reports.

Deliverable 2:
A manufacturing report for IO approval that includes MIP, material certificates, and inspection reports.

5.3 Phase 3 – Testing and Reporting

The contractor shall implement the test program as defined and agreed in Phase 1. The scope is anticipated to include:

- Calibration and validation of the bolt pre-load,
- Data gathering and storage,
- Assessment of the results,
- Production of a test report and final presentation.

The test report shall include:

- Measurement of current passed through the mock-up and voltage drop on two contact interfaces, all with digital recording,
- Visual observation during the pulse and photographs taken after dis-assembly of tested mock-up to characterize the contact surface conditions,
- Bolt preload (elongation) measurements before and after testing.

Deliverable 3:
A complete test report.
All tested samples shall be shipped to IO at the end of the task.
All measured data shall be presented in the final report.

5.4 Phase 4 (Optional)

In order to have better understanding of the limit of the joint design, additional test could be done only changing the bolt preload (and therefore average pressure).
Depending on result obtained at phase 3, the exact same test shall be repeated and reported with this sole parameter variation (increase or decrease of preload to be agreed if option is released).

In case ES mock-up surfaces been damaged during phase 3, surfaces shall be re-machined to initial requirements (flatness, roughness).

6 Estimated Duration

The contractor shall propose a detailed schedule of work, considering at least the scope and deliverables of work. If any mandatory information is required, the contractor, as an expert in the field, must identify and include this in the planning.

7 Input data from IO

The IO will provide all drawings and models of blanket ES assembly.

The format of the models is CATIA v5R19, but they can also be supplied in IGES or STEP upon request.

The contractor will be requested to provide a detailed list of additional input data required to complete the tasks in order to allow the IO to prepare the input data for the kick off meeting. If any requested additional input data cannot be provided by IO, then the contractor will make clearly identified assumptions to be agreed with IO.

8 List of deliverables and due dates

The deliverables and timescales for the scope of supply shall be as described below.

Deliverables	**Description**	**Target Timescales**	**Acceptance**
1	Presentation of Test Program: Phase 1	T0 + 2 month	Protocol and MIP approved by IO TRO
2	Presentation of Phase 2 activities results	T0 + 6 months	Manufacturing report approved to IO TRO
3	Presentation of Phase 3 activities results and Final Report	T0 + 8 months	Test Report approved by IO TRO
4	Presentation of Phase 3 activities results and supplementary report	T1 + 2 months	Test report approved by IO TRO

Where:

- T0 : date of kick-off meeting
- T1 : signature of option release

At the end of the study a detailed report of the work will be produced and a presentation will be given to the IO.

All the technical data and components produced or gathered during this contract will be transferred to the IO at the end of the work.

9 Deliverable Acceptance Criteria

The reports shall be prepared and submitted to the IO by the dates outlined above. It is understood that the report is expected to be prepared in Microsoft Word format, however; an alternative format may be used subject to the prior written approval of the IO.

The Final Report shall also be sent in PDF format. In case of discrepancy with the Microsoft Word format version, the PDF version is considered as the official deliverable of the contract.

The presentations and the Final Report shall be reviewed by the IO TRO who shall inform the contractor in writing of its approval or disapproval within 20 working days after the receipt of each report. In case of disapproval, the IO TRO shall provide a justification to the contractor and necessary measures for improvement shall be taken by the supplier without delay.

10 Responsibilities

1. The contractor shall be responsible for implementation and coordination of all activities required to support this task. Ensuring suitably qualified staff and available resources to complete tasks in the proposed timescales.
2. IO TRO shall be responsible for technical input and technical support for the scope identified.

11 Work Monitoring

Regular (typically monthly) video-conference shall be used to enable supplier and IO to discuss on progress and issues. These will be arranged between respective responsible officers.

The following meetings can be anticipated.

Meeting	Topic	Anticipated Date	Location
1	Kick-off meeting	T0	Contractor or IO / VC
2	Presentation of Task 2	T0 + 6 Months	Contractor or IO / VC
3	Final presentation	T0 + 8 Months	IO
4	Optional test presentation	T1 + 2 months	Contractor or IO / VC

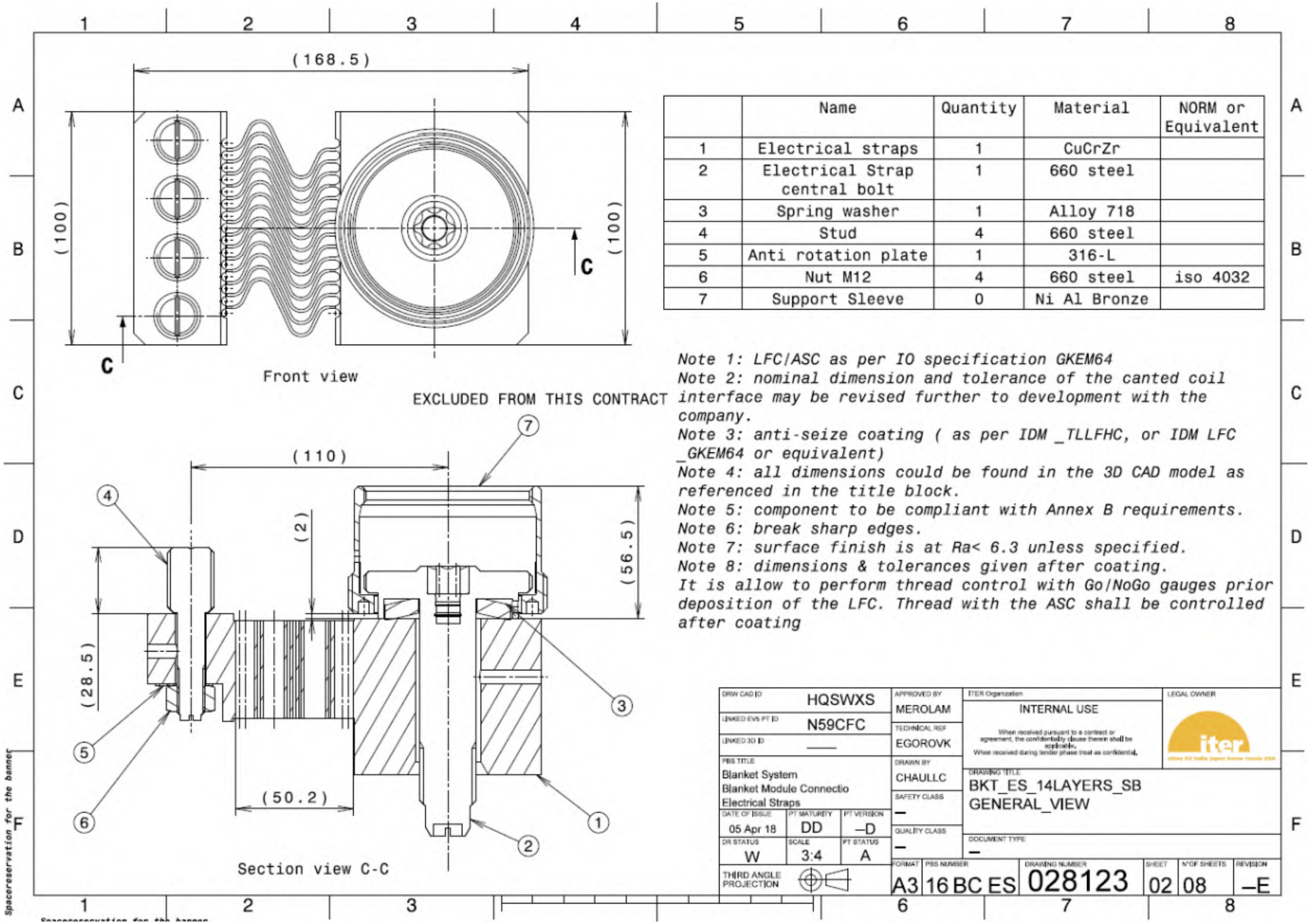
12 Quality Assurance (QA) requirements

The organisation conducting these activities should have an ITER approved QA Programme or an ISO 9001 accredited quality system.
The general requirements are detailed in ITER document ITER Procurement Quality Requirements (ITER_D_22MFG4).
Prior to commencement of the task, a Quality Plan (ITER_D_22MFMW) 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.
Manufacturing and Inspection Plan (or Inspection Plan) should be implemented to monitor quality control and acceptance test. The contractor are subject to Requirements for Producing an Inspection Plan (ITER_D_22MDZD).
All requirements of this Technical Specification and subsequent changes proposed by the Contractor during the execution of the Contract are subject to the Deviation Request process described in Procedure for the management of Deviation Request (ITER_D_2LZJHB). When a non-conformance is identified, the contractor are subject to the Non-conformance Report

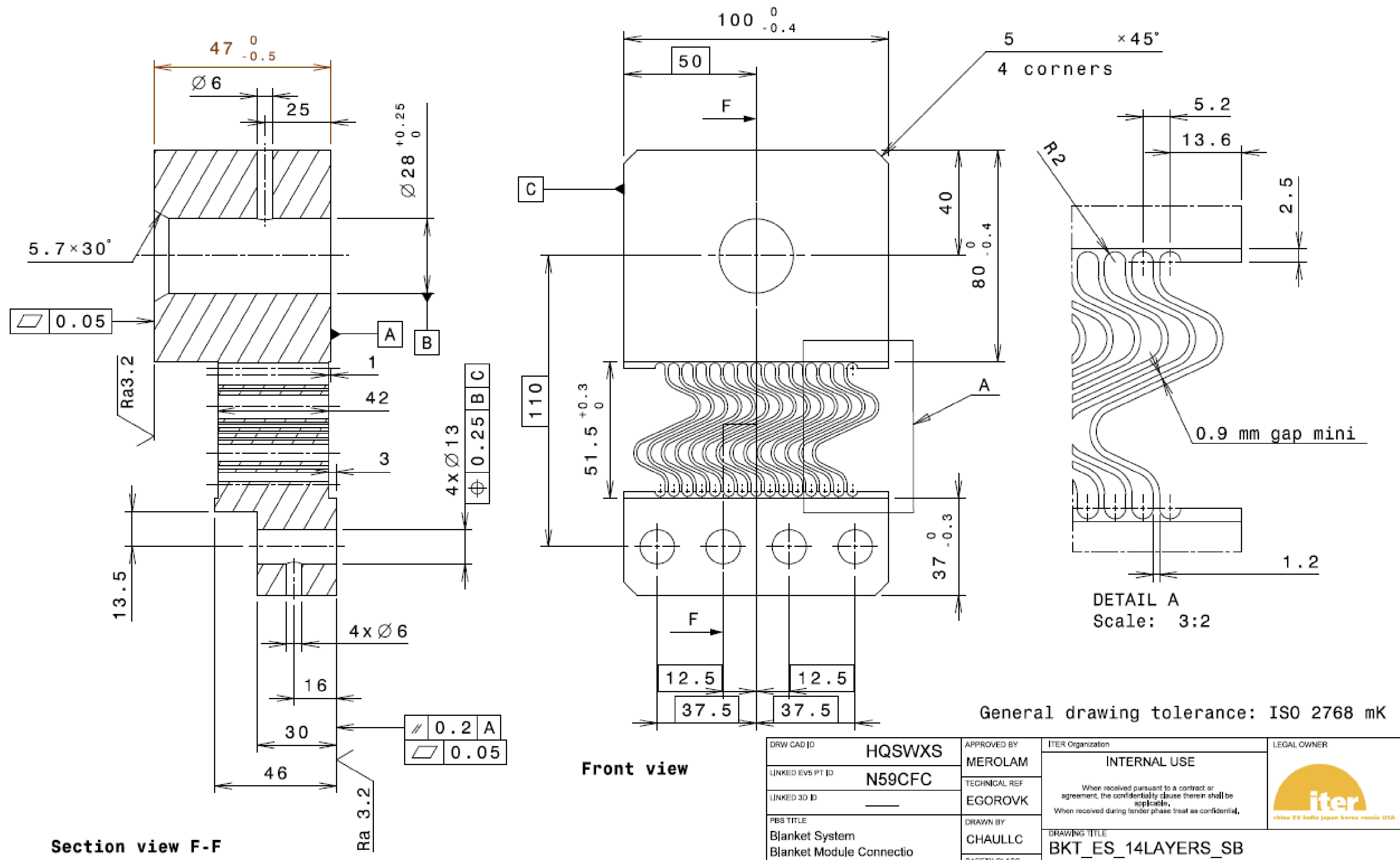
process describe in Procedure for management of Nonconformities (ITER_D_22F53X).
Documentation developed as the result of the contract should be retained by the performer for a minimum of 5 years and then may be discarded at the direction of the IO

13 Annexes

13.1 Annex 1 – Electrical Straps drawings



	Name	Quantity	Material	NORM or Equivalent
1	Electrical straps	1	CuCrZr	
2	Electrical Strap central bolt	1	660 steel	
3	Spring washer	1	Alloy 718	
4	Stud	4	660 steel	
5	Anti rotation plate	1	316-L	
6	Nut M12	4	660 steel	iso 4032
7	Support Sleeve	0	Ni Al Bronze	



General drawing tolerance: ISO 2768 mK

DRW CAD ID: HQSWXS	APPROVED BY: MEROLAM	ITER Organization: INTERNAL USE	LEGAL OWNER: iter china EU india japan korea russia USA		
LINKED EVS PT ID: N59CFC	TECHNICAL REF: EGOROVK	When received pursuant to a contract or agreement, the confidentiality clause therein shall be applicable. When received during tender phase treat as confidential.			
LINKED 3D ID: —					
PBS TITLE: Blanket System Blanket Module Connectio Electrical Straps	DRAWN BY: CHAULLC	DRAWING TITLE: BKT_ES_14LAYERS_SB BEAM_14L			
	SAFETY CLASS: —				
DATE OF ISSUE: 05 Apr 18 / PT MATURITY: DD / PT VERSION: –D	QUALITY CLASS: —	DOCUMENT TYPE: —			
DR STATUS: W / SCALE: 3:4 / PT STATUS: A					
THIRD ANGLE PROJECTION	FORMAT: A3 / PBS NUMBER: 16 BC ES	DRAWING NUMBER: 028123	SHEET: 04	N°OF SHEETS: 08	REVISION: –E

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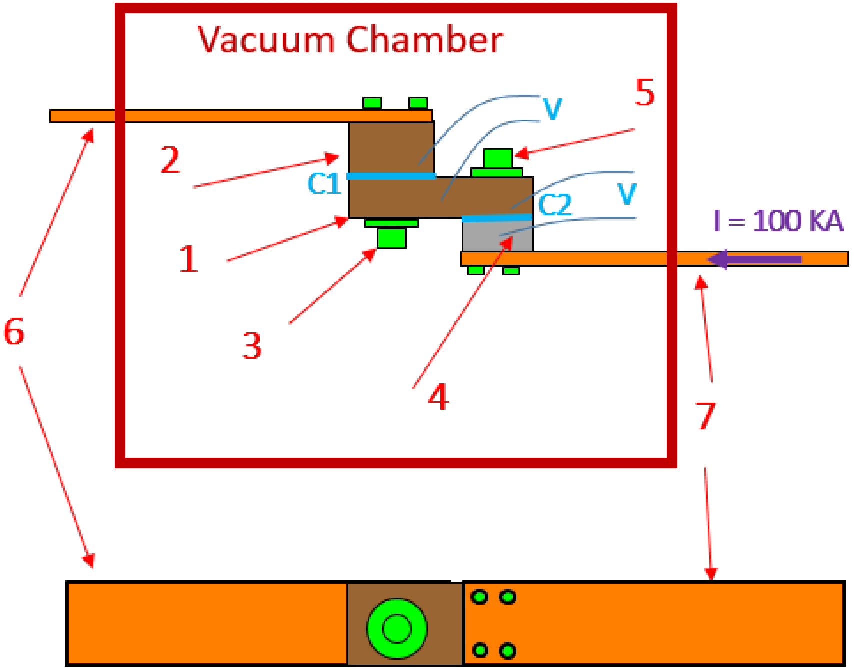
13.2 Annex 2 – Proposed Test set-up



1. Test mock-up (1) made of CuCrZr is bolted to the CuCrZr plate/block (2) by Bolt (3) and to SS316 plate/block (4) by bolt (5).
2. The bus bar (6) are attached to the plate/block (2) and bus bar (7) are attached to the plate/block (4) allow to pass high current (up to 100 kA)
3. Voltage drop measurement are performed for contact C1 and C2