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Technical Specifications (In-Cash Procurement)

Market Survey technical requirement - design and supply of EOF

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1 Purpose

The ITER organization is performing this market survey in order to identify potential suppliers for optical and electrical feedthrough, optimize its procurement strategy and identify technical challenges. This market survey is not binding nor contractual.

2 Background

The ITER project is the experimental fusion reactor aiming at being the first fusion reactor producing net energy, maintaining fusion reaction over long periods.

In order to monitor and secure the reactor, all the main components constituting the ITER reactor will be equipped with specific instrumentation sensors, surveying thermal and mechanical characteristics.

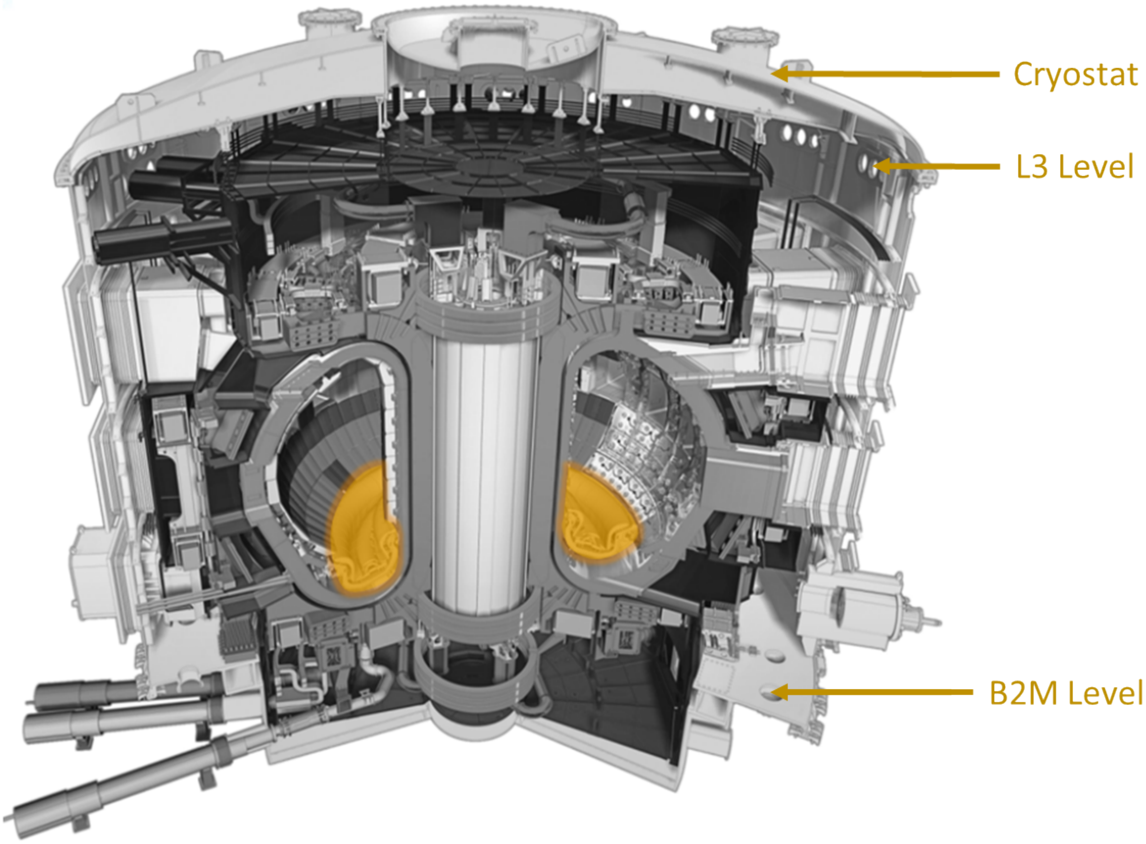


Figure 1 ITER tokamak with main components

In the following, the discussion will focus on feedthroughs, also called cryostat common feedthrough CCF, for instrumentation and cables located inside cryostat, where environmental conditions are harsh: radiation up to 5MGy, high vacuum and electro-magnetic perturbations. The CCFs are located at 2 levels inside the tokamak complex: B2M level corresponding to the lower part of the cryostat and L3 at the top of the cryostat, see figure 1.

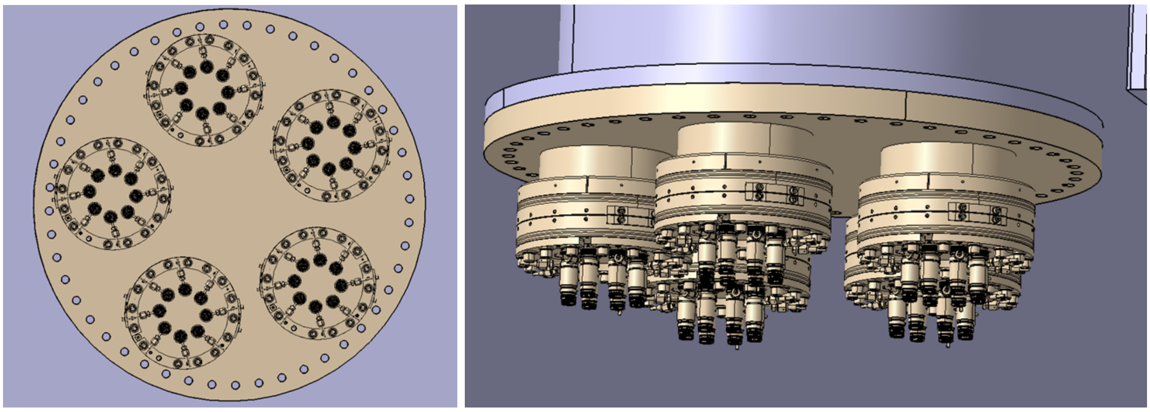


Figure 2 One of the seven Cryostat Common Feedthrough preliminary design (B2M level)

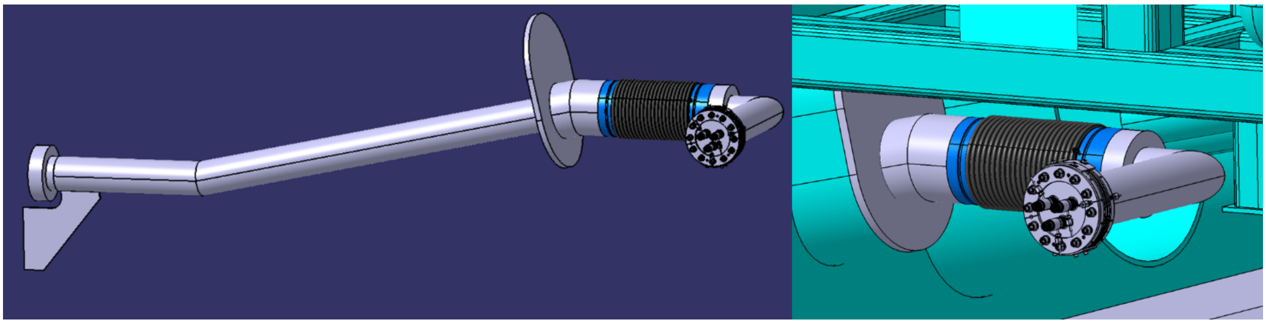


Figure 3 L3 level feedthrough made of a vacuum extension pipe see left picture. The air part is shown on the right picture.

The CCFs act as cryostat vacuum boundary. Their design shall be double vacuum barrier and shall comply to a list of technical requirements provided in chapter 4.

In addition, the CCFs are located in the tokamak building where EMC perturbations shall be considered: static magnetic field ~225mT, with transient 20mT/s.

3 Scope

The scope of this future procurement covers:

- The design
- The prototyping and qualification
- The manufacturing of the feedthrough
- The completion of factory acceptance test and delivery

The scope is limited to the feedthrough and related metal flange. The cabling, in-cryostat and ex-cryostat, is out of the scope and are already defined. The cabling datasheets are an input for the design of the feedthrough.

In-cryostat instrumentation and cables are made of:

- Type N thermocouple cables
- Signal cables for strain sensors
- Optical cables for fiber bragg gratings– single mode fiber (SM)
- Optical fiber for interferometry – multimode fiber (MM)
- Power cables – 5A – 110V – AC current

Table 1 - list of cables connecting to the Cryostat Common Feedthrough

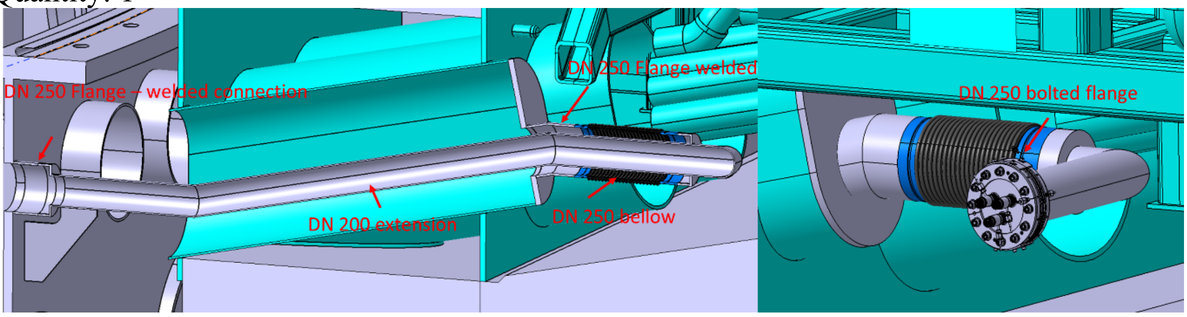
IO catalog Type *	in/out	type	wire	Metric	Imperial	Shielding	wire arrangement	wire material
FS01F9LC	in & out	optical - SM	1	9/125µm	N.A	N.A	N.A	pure silica
FM01F5LC	in & out	optical - MM	1	50/125µm	N.A	N.A	N.A	pure silica
FM08F5LN	in	optical - MM	8	50/125µm	N.A	N.A	N.A	pure silica
T20226LC	in	Electrical	2	0.16mm2	26AWG	overall shield	Twisted pairs	Copper / silver plated copper
T20426LC	in & out	Electrical	4	0.16mm2	26AWG	overall shield	Twisted pairs	Copper / silver plated copper
T20626LC	in	Electrical	6	0.16mm2	26AWG	overall shield	Twisted pairs	Copper / silver plated copper
T22822LC	in	Electrical	28	0.34mm2	22AWG	overall shield	Twisted pairs	Copper / silver plated copper
T24026LC	in & out	Electrical	40	0.16mm2	26AWG	overall shield	Twisted pairs	Copper / silver plated copper
T21817LN	in	Electrical	18	1mm2	17AWG	overall shield	Twisted pairs	Copper / silver plated copper
TN0222LC	in	Electrical	2	0.34mm2	22AWG	overall shield	Twisted pairs	Nicrosil/nisil
TN0224LC	in	Electrical	2	0.25mm2	24AWG	overall shield	Twisted pairs	Nicrosil/nisil
MS5G10LN	in	Electrical	5	6mm2	10AWG	overall shield	not twisted	Copper
TN2422LC	out	Electrical	24	0.34mm2	22AWG	overall shield	Twisted pairs	Nicrosil/nisil
TN2424LC	out	Electrical	24	0.25mm2	24AWG	overall shield	Twisted pairs	Nicrosil/nisil
FM06F5LC	out	Optical - MM	6	50/125µm	N.A	N.A	N.A	pure silica
T20822LC	out	Electrical	8	0.34mm2	22AWG	overall shield	Twisted pairs	Copper / silver plated copper

The Common cryostat feedthrough are split in 2 different design:

- L3 feedthrough, see details below for dimensions.
  The distribution of cables is given in the table below:

	In/out	T20426LC	TN0224LC	TN2422LC	T24026LC
15VVIS-EFT-0002	In	18	34	0	0
	out	0	0	3	2

  Flange dimension: DN150
  Quantity: 1



- B2M feedthrough, see details below for dimensions and cabling requirement. These feedthrough are used for optical, thermocouple, signal and power cables.
  In-cryostat cables:

	FM01F5LC	FM08F5LN	FS01F9LC	T20226LC	T20426LC	T20626LC	T20817LN	T24026LC	TN0222LC	TN0224LC	Total wires	Total optical	Total TC wires
15VVIS-EFT-0002	38	0	26	12	20	28	0	10	25	28	842	64	106
15VVIS-EFT-0003	10	0	32	0	0	52	0	0	22	0	398	42	44
15VVIS-EFT-0004	10	0	34	12	16	52	0	0	22	0	488	44	44
15VVIS-EFT-0005	40	0	36	12	16	52	0	15	39	18	1190	76	114
15VVIS-EFT-0007	18	3	2	0	4	20	3	10	0	0	604	44	0
15VVIS-EFT-0008	48	0	52	24	12	60	0	0	48	20	692	100	136
15VVIS-EFT-0009	22	0	40	12	6	52	0	0	41	0	504	62	82

Out-cryostat cables:

	FM01F5LC	FS01F9LC	T20426LC	T24026LC	TN2422LC	TN2424LC
15VVIS-EFT-0002	38	26	6	17	3	3
15VVIS-EFT-0003	10	32	0	8	3	0
15VVIS-EFT-0004	10	34	6	20	3	1
15VVIS-EFT-0005	40	36	0	26	4	2
15VVIS-EFT-0007	18	2	14	0	0	0
15VVIS-EFT-0008	48	52	12	0	5	2
15VVIS-EFT-0009	22	40	6	8	4	0

Quantity: 7

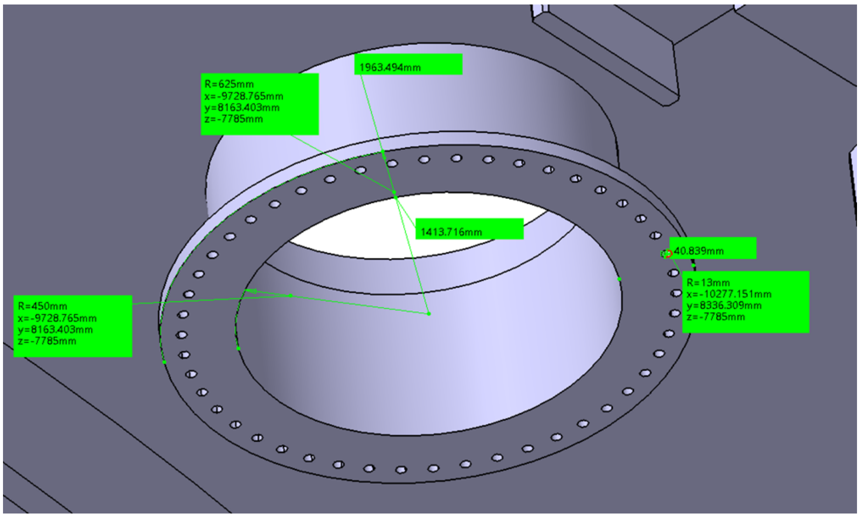


Figure 4 Cryostat Common Feedthrough preliminary design flange at B2M level, made of 304L stainless steel

4 Summary of technical requirements

This chapter is dedicated in providing the list of the main requirements applicable to the cryostat common feedthrough. This list is non-exhaustive, and the full list of requirements will be detailed in a dedicated technical specification at the time of the call for tender.

4.1 Design requirement

The design and manufacturing of the feedthrough flange shall comply with ASME VIII.

The cryostat common feedthroughs are vacuum boundaries. For this reason and to mitigate the risk of leak, the feedthrough shall be double vacuum barrier. The interspace, located between the two vacuum boundaries shall be equipped with two SVS connection flange to allow monitoring and leak detection.

The feedthroughs are cryostat boundary, the pressure and temperature conditions are given in the table below, considering normal operation and accidental events. During accidental events, the vacuum confinement shall be maintained at all time.

	Normal operation and	Accidental event	Fire event

	baking		
Temperature	Room temperature to 150°C	-100°C to 70°C	300°C for 2 hours
Pressure	IN:10^{-4}Pa / OUT: Atmospheric pressure	IN: 0.2MPa/ OUT: Atmospheric pressure	IN: 10^{-4}Pa / OUT: Atmospheric pressure

Feedthroughs are permanently installed in the cryostat. They shall survive during the whole operating life of the machine (no less than 20 years) and shall not require remote maintenance.

Wherever possible, they shall make use of modular components for easy mounting/dismounting for maintenance.

4.2 Vacuum requirements

In the ITER classification, the feedthrough are classified VQC-2A, as a consequence they shall comply to the following requirements:

- Materials shall be compatible with vacuum requirement and shall be non-magnetic.
- Materials shall have an outgassing rate lower than 10^{-7} $Pa.m^3.s^{-1}.m^{-2}$ at room temperature. If a material is selected outside of the IO recommended material a test shall be done to demonstrate vacuum compatibility.
- Materials shall have small impurity content:
  0.20 weight % Cobalt
  0.10 weight % Niobium
  0.10 weight % Tantalum
- The feedthroughs shall demonstrate leak tightness better than 10^{-9} $Pa.m^3.s^{-1}$.
- Trapped volumes are forbidden
- All welds acting as vacuum boundary shall be full penetration and 100% inspected.

4.3 Electrical and electro-magnetic requirements

Cables from instrumentation (thermocouple or signal cables) shall be segregated from power cables.

Cryostat shall be used as earthing reference. In order to minimize the inductive crosstalk inside the connectors. Also the pinout layout in the connectors shall be optimized to minimize the crosstalk between signals.

Cryostat common feedthroughs shall be either designed to withstand all electrical or magnetic fields present during ITER operation, or if sensitive to such perturbations they shall be subject to specific protection and or alternative measures.

The risk of Paschen breakdown shall be evaluated between the 2 vacuum boundaries in the interspace. As a consequence the interspace can either be continually pumped or be backfilled with a gas of accepted composition to a pressure appropriate to mitigate the risk of Paschen breakdown.

4.4 Optical requirements

The optical fiber connecting to the cryostat common feedthrough are rad-hard fiber, coated with polyimide and PEEK in order to comply with high temperature and radiation resistance.

There are two types of optical fiber passing throught the cryostat commin feedthrough:

- Single mode fiber:
- Multimode fiber

Both of them are used for customized sensors that requires insertion loss as low as possible. As a consequence the insertion loss due to the feedthrough (either connection, or feedthrough embedded fiber considering radiation loss effect) shall be below 0.5dB.

5 Qualification requirements

The prototype qualification shall be completed on prototypes representative from the final product. Any deviation from the final product shall be justified and approved.

The feedthrough shall demonstrate a successful qualification to the following tests:

- Pull test on pins and connectors
- Vibration test on the feedthrough assembly
- Fire test on the feedthrough assembly
- Leak test on the feedthrough assembly
- Insertion loss for optical
- Pressure test (pneumatic) on the feedthrough assembly
- Thermal test (cold testing) on the feedthrough assembly
- Irradiation test (if no data available) on sensitive parts

In addition to the testing listed above, material-outgassing test may be required depending on the final materials constituting the feedthrough.