

Technical Specifications (In-Cash Procurement)

Technical Requirements of Large-Scale M110/M80 Fasteners and Associated Tooling for ITER Toroidal Field Pre-Compression Ring Installation

This document describes the technical requirements for large-scale M110 and M80 Fasteners and Associated toolings of ITER TF pre-compression rings to survey potential supplier. After investigation of proposals from potential supplier, detail technical specification will be prepared for further discussion.

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Abstract:

This document defines the technical requirements of M110/M80 Fasteners used for ITER Toroidal Field Pre-Compression Ring Installation.

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1 Purpose

The ITER Organization, is assessing the M110 and M80 fastener solutions which would allow to achieve for ITER Toroidal Field (TF)Pre-Compression Ring (PCR) tightening. This document describes the technical requirements associated with this activity.

2 Scope

The scope of this document is the definition of technical requirement that M110 and M80 fasteners and tightening tools shall comply with, these requirements include dimensional restriction, service load, and material properties.

3 Presentation of TF Pre-Compression system

3.1 Context

ITER Tokamak magnet system has 18 Toroidal Field (TF) Coils that are arranged as a torus. Figure 3-1 shows one TF Coils with Pre-Compression Rings and TF Inter-Coil Structures.

In the inboard curved region of each TF Coil, the overall radial expansion of the TF Coils during energization results in the opening of toroidal gaps between adjacent TF Coils. The radial movement would be sufficient to create a toroidal gap of approximately 0.3 mm between the poloidal shear key and the key slot (IIS). During plasma operation, the shear loads acting on the keys increase this gap to more than 1mm. In order to suppress this undesirable “breathing” effect and ensure that the keys do not become loose in their slots, each TFC is put under a centripetal load of approximately 39MN (19.5 MN at the top and bottom curved regions) at operating conditions by two sets of pre-compression rings (PCRings). This pre-compression substantially reduces the toroidal loads in the intermediate Inter-coil connections (IOIS), thus increasing the machine fatigue life significantly beyond the 60000 design cycles with an allowable defect size of 100 mm² in the bulk material.

The pre-compression is progressively applied by stretching the PCRings with floating flanges (PCCF) using one of the solutions proposed through this solicitation.

The PCRings and components are shown in Figure 3-2. The current design uses Inconel 718 Superbolts®.

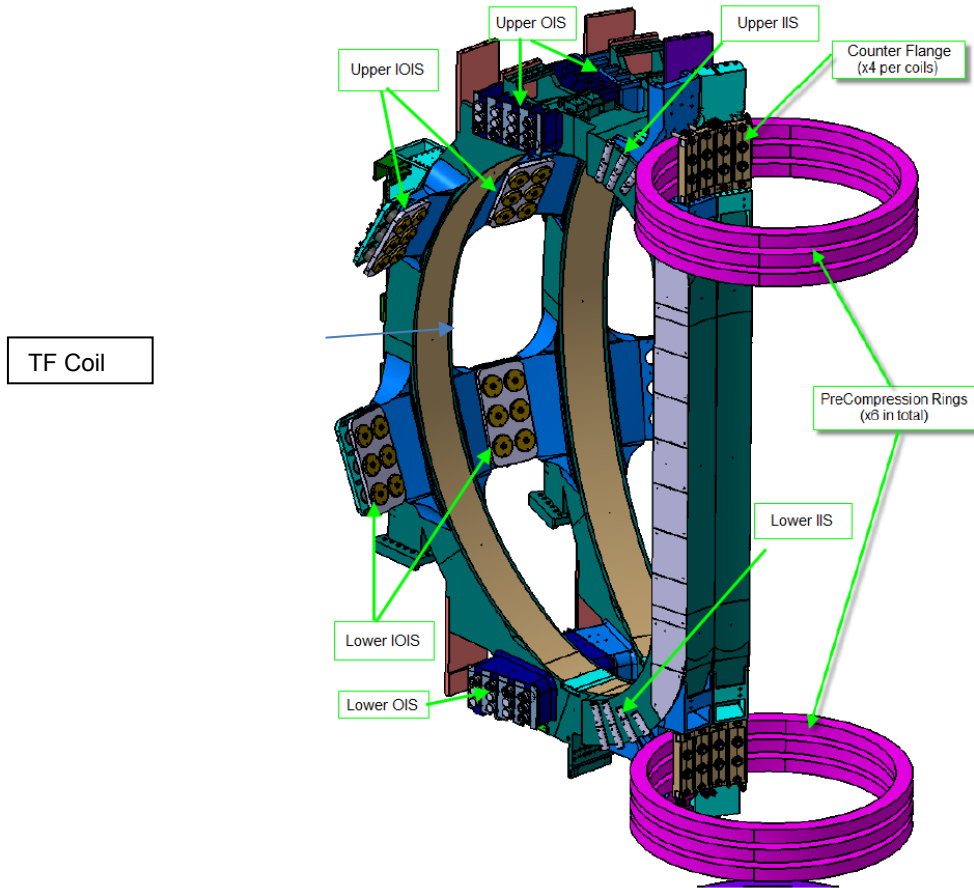


Figure 3-1: Toroidal Field Coils Sector, Pre-Compression Rings and the Inter-coil Structures

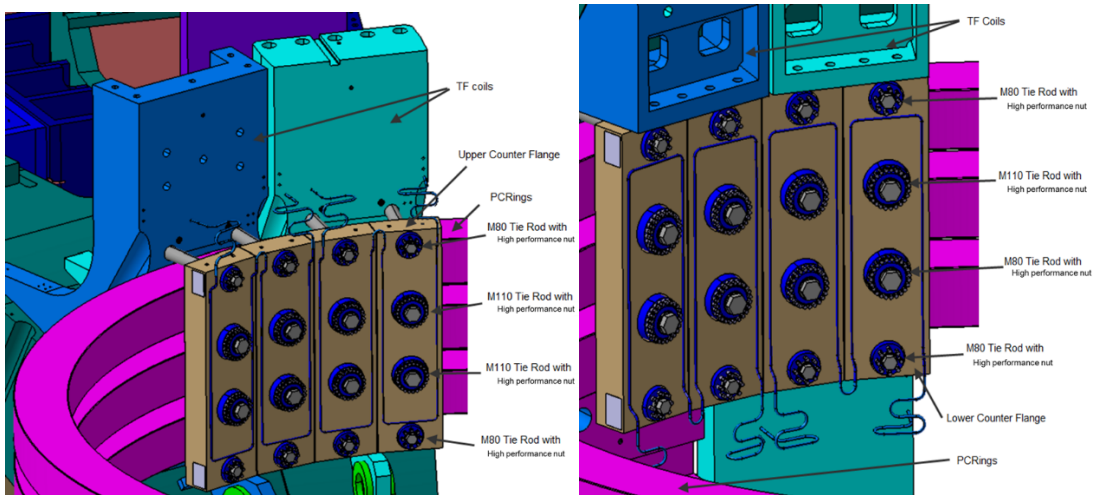


Figure 3-2: Component used on Pre-Compression system

3.2 Pre-compression mechanism

Component names are shown in Figure 3-2. After assembly all 18 TF Coils, the Pre-Compression Rings are installed on the flanges and M110/M80 Tie rods (Studs). Tie rods (Studs) are screwed into TF Coils. PCR's dead weight is temporarily supported from Counter Flanges, after pre-compression, they are kept by friction between Counter Flanges (PCCF). By tightening fasteners on Tie rods (Studs), Counter Flanges are pushed onto PCR that expand radially accordingly. Hoop stress in PCR works on TF Coils via Tie rods (Studs). This force works as centripetal load on TF Coils. This mechanism is shown schematically in Fig. 3-3.

Fasteners (Nuts or alternative locking fasteners) stay in-situ as a key-shims to maintain tension on the PCR.

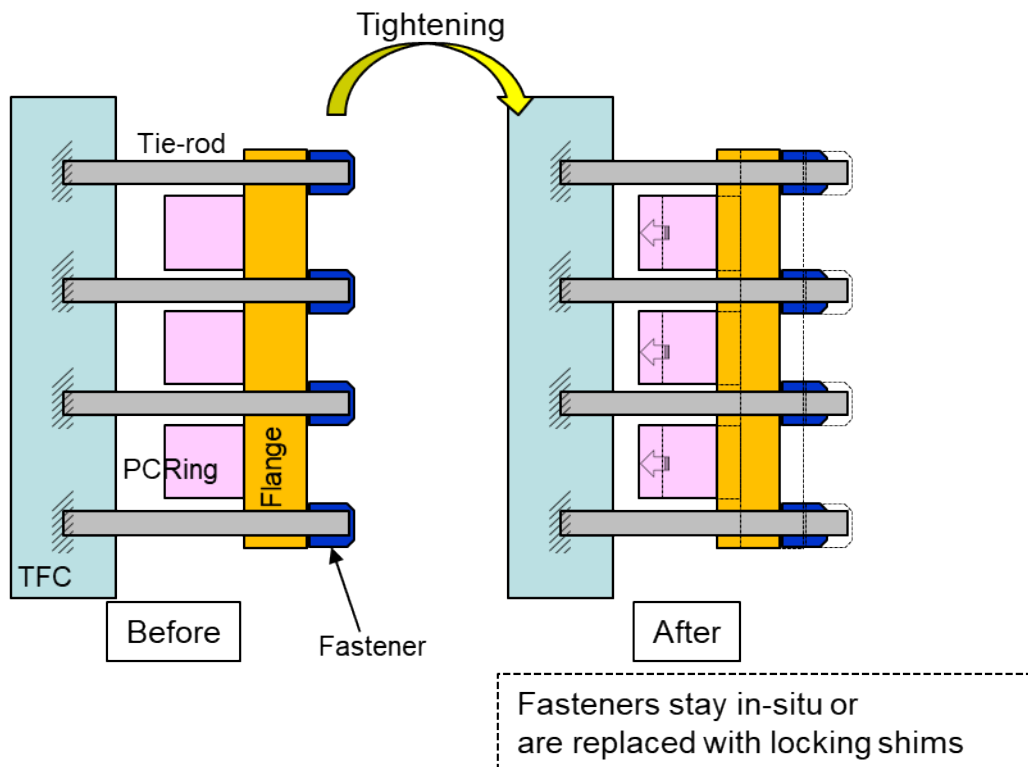


Figure 3-3: Pre-compression mechanism

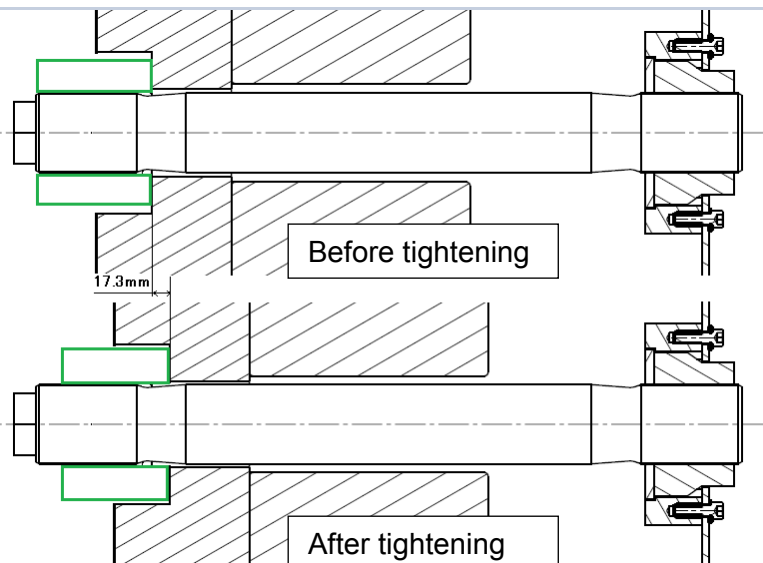
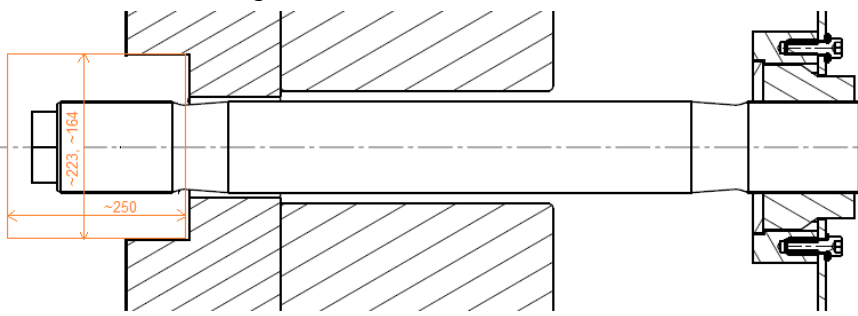
3.3 Schedule

The ITER assembly schedule shows a planned start date of October 2023 for TF Pre-Compression Ring tightening activity in October 2023. As such all qualification tests, series manufacturing, commissioning of tools and delivery to the IO must be complete by this date.

4 Description of Requirements

4.1 M110 / M80 Fasteners

As described in 3.2, tie rods shall be pulled by reaction force on PCCF. It is possible to separate locking structure and tightening tools. Locking structure, working as a key-shim, shall comply below requirements.

Item	Condition
Load after tightening	M110 : 4427kN M80 : 1548kN
Tightening stroke	M110 : 17.3mm (Max. 20mm) M80 : 17.3mm (Max. 20mm) <div style="text-align: center;">  </div>
Dimension	M110 : Proposed system to fit within cylinder of outer diameter of less than 223mm, height shall be less than 250mm including washer. Tie rods thread is M110 x 4 -6g (max. 140mm) M80 : Proposed system to fit within cylinder of outer diameter of less than 164mm, height shall be less than 250mm including washer. Tie rods thread is M80 x 4 -6g (max. 105mm) Note) If propose product with non-cylindrical shape, please provide IO of its shape and dimension to check interference. <div style="text-align: center;">  </div> Refer to [1][2][3]

Material	Material shall be composed of austenitic structure so as to have non-magnetic properties. (Only for items stay in-situ as during operation. Tools used for tightening are not covered by this requirement)
Special requirement	Torsion and bending causing loosening of the tightening force shall be avoided. Even if friction coefficient of sliding surface becomes 1/10 or less, the nut shall not loosen due to torsion or bending.

4.2 Tightening tools and auxiliaries

Tightening tools shall achieve the load after tightening described in 4.1. The drive source shall be manual, hydraulic, electric, etc. Do not use explosives or flammable materials. All materials must be vacuum compatible.

Tightening will be done in a work space with a diameter of approximately 4.5 m surrounded by PCCF as shown in Figure 4-1. Tools shall be arranged within this environment. Considering this space limitation, tools need to be arranged within a 10 degree sector per tool as shown in Figure 4-2 or not over 20 degrees for two adjacent tools.

The reaction force of the tightening must act on the PCCF that is coupled to the Tie rod. Floors and walls cannot receive reaction force. As IO provides working floors for upper/lower PCR, workers' weight or tools weight can be used to receive reaction force.

The working floor design condition considers weight of workers and general tools. If some heavy tools are proposed, please include their quantity, size and weight in your proposal.

All PCCFs move about 15 mm in the radial direction by tightening. Therefore, tools shall not interfere the movement of the adjacent PCCFs.

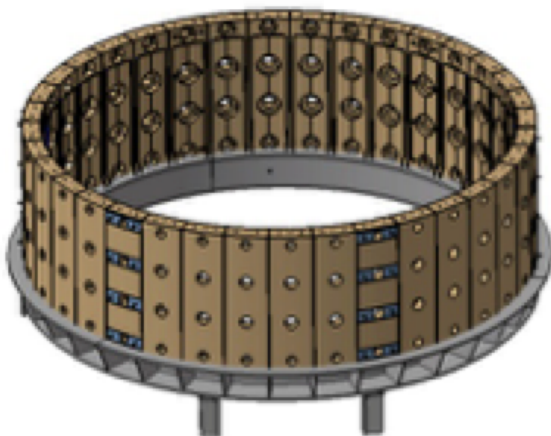


Figure 4-1: PCCF arrangement

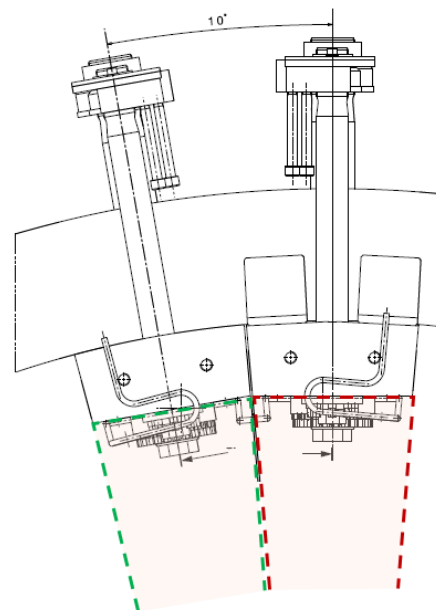


Figure 4-2 Dimension restriction of tools

5 Reference Documents

This list contains documents for information:

- [1] [1101CA_000551D - Pre-compression Counter Flange - details \(24HB2M\)](#)
- [2] [12351-01_Index_102 \(SZ44JR\)](#)
- [3] [12353-01_Index_103 \(SZAK3U\)](#)

Acronyms

IO	ITER Organization
ISO	International Organization for Standardization
PCCF	Pre Compression Counter Flange
PCR	Pre Compression Rings

Appendix

This appendix details what would be the scope of supply, should a suitable solution be proposed meeting the specified technical requirements.

A.1 Scope of Supply

The supplier shall supply IO of following items;

- Sample products of M110 fasteners & associated tooling
- 144 x M110 fasteners, 144 x M80 fasteners
- Associated tools including auxiliaires

A.2 Design and Related Activities

The supplier shall propose fasteners to comply with in-service conditions and requirements described in section 4.1. Design calculation report and product specification shall be provided and reviewed and approved by the IO before starting sample product manufacturing..

A.3 Supply of Documentation

The supplier shall provide IO with the documents and data defined in the table A1 of this Technical Specification (List of Deliverables).

Table A1 List of Deliverables

No.	Name	Note
A1-1	Quality Plan	
A1-2	Manufacturing and Inspection Plan	
A1-3	<i>Drawing and Cad model of fasteners and tools</i>	Include 3D models
A1-4	Fabrication Report (Material, Fabrication Inspection records)	
A1-5	Monthly progress report	
A1-6	User manual	
A1-7	Release Note	
A1-8	Delivery Readiness Review	
A1-9	Delivery of the products at IO site	Refer to A.1