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VERSION CREATED ON / VERSION / STATUS
07 Jun 2021 / 1.1 / Approved

EXTERNAL REFERENCE / VERSION

Technical Specifications (In-Cash Procurement)

Technical Requirements of tightening tool for M110/M80 Superbolt Multi-Jackbolt Tensioner for ITER Toroidal Field Pre-Compression Ring

This document describes the technical requirements for tightening tool for M110/M80 Superbolt Multi-Jackbolt Tensioner for ITER Toroidal Field Pre-Compression Ring to survey potential supplier.
After investigation of proposals from potential supplier, detail technical specification will be prepared for further discussion.

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Technical Requirements of tightening tool for M110/M80 Superbolt Multi-Jackbolt Tensioner for ITER Toroidal Field Pre-Compression Ring

Abstract:

This document shows the technical requirement to be satisfied with when tightening M110/M80 Superbolt MJTs for ITER Toroidal Field Pre-Compression Ring Installation. IO would like to ask you to fill out our questionnaire considering demand on this document.

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1 Purpose

The ITER Organization is assessing ITER Toroidal Field (TF) Pre-Compression Ring (PCR) tightening tools that is aimed to shorten tightening duration of 72 x M110 and 72 x M80 Superbolt MJT for Upper/Lower PCRings when compared to manual torqueing. This document describes the technical requirements associated with this activity.

2 Scope

The scope of this document is to technical information and requirements that tools should satisfy.

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 two 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 mm^2 in the bulk material.

The pre-compression is progressively applied by stretching the PCRings with floating flanges (Pre-compression Counter Flange) using Superbolt MJTs as shown in Figure 3-2.

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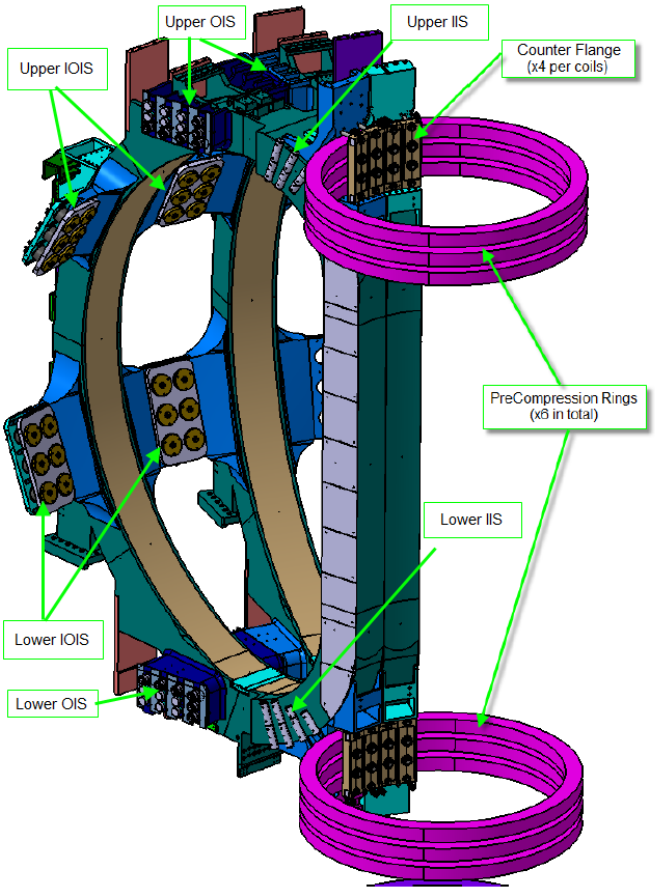

Figure 3-1: Toroidal Field Coils Sector, Pre-Compression Rings and the Inter-coil Structures

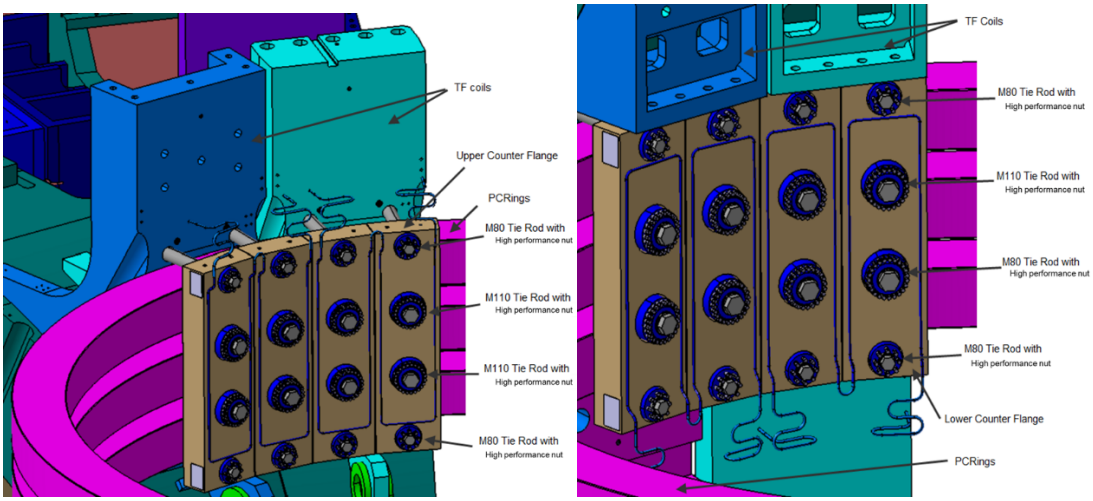

Figure 3-2: Component used on Pre-Compression system

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3.2 Pre-compression mechanism

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

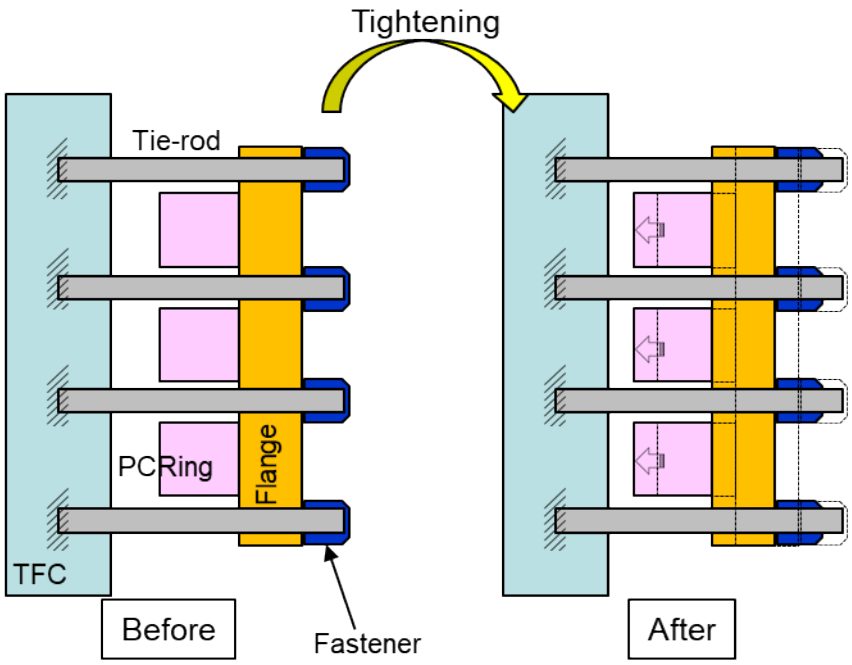

Figure 3-3: Pre-compression mechanism

3.3 M110/M80 Superbolt Multi-Jackbolt Tensioners

M110 Superbolt has 23 jackbolts in φ182mm pitch-diameter and M80 Superbolt has 8 jackbolts in φ110mm pitch-diameter. Jackbolts are arranged evenly in these pitch-diameters. The jackbolt head is HEX/SW17 for both. For detail information, refer to [4][5]. There are two type of material for jackbolt, one for assembling and another for operation.

3.4 Schedule

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

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4 Description of Tightening Requirements

4.1 Concept of tools

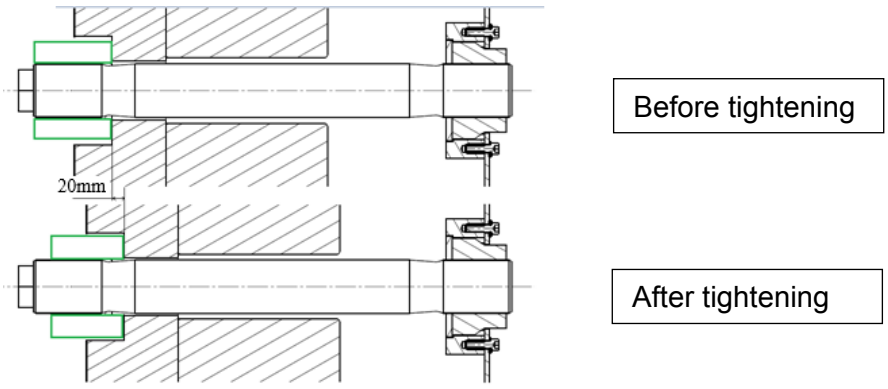
IO considers two type of tools as follows;

- Using Multi-Spindle tensioner that can tighten all or ½ or ⅓ of jackbolts simultaneously by a single tools, setting of tools onto the Superbolt MJTs is done by workers on the spot (possibly aided by rotating arms or other means),
- Using Full-Automated Robotics that tightens jackbolts one by one, works much faster and 24h/day.

If other types of solution are proposed, IO is open to discuss them.

4.2 Load, Stroke, Torque, and Others

Final load on main tie-rod, torque on each jackbolt and tightening stroke are as below.

Item	**Condition**
Number of Items	Upper : 36 Counter Flanges, 72 x M110 MJT[5] and 72 x M80 MJT[4] Lower : 36 Counter Flanges, 72 x M110 MJT[5] and 72 x M80 MJT[4]
Final Loads	M110 : 4427kN (192.5kN per jackbolt) M80 : 1548kN (193.5kN per jackbolt)
Required torque	Jackbolt of M110 : 400Nm Jackbolt of M80 : 400Nm
Tightening stroke	M110 : 20mm M80 : 20mm 
Each Step control	Screwing jackbolt process should be controlled both by angle and torque value, stopped by pre-set angle or torque limits. Angle error should be less than ±10°, torque value error should be less than ±5% of pre-set value. As for Multi-Spindle tensioner, all spindles screwing should synchronize. All spindles should stop when any one of jackbolt torque comes to pre-set limit value.

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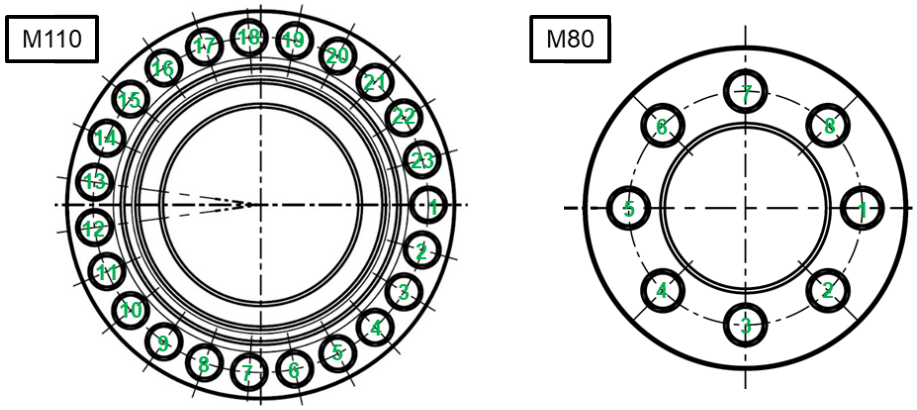
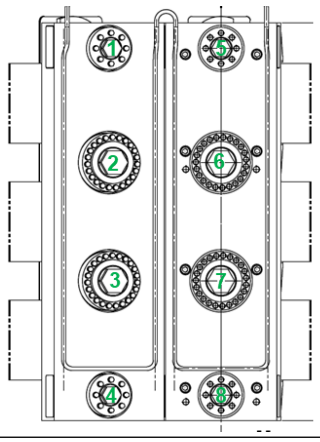
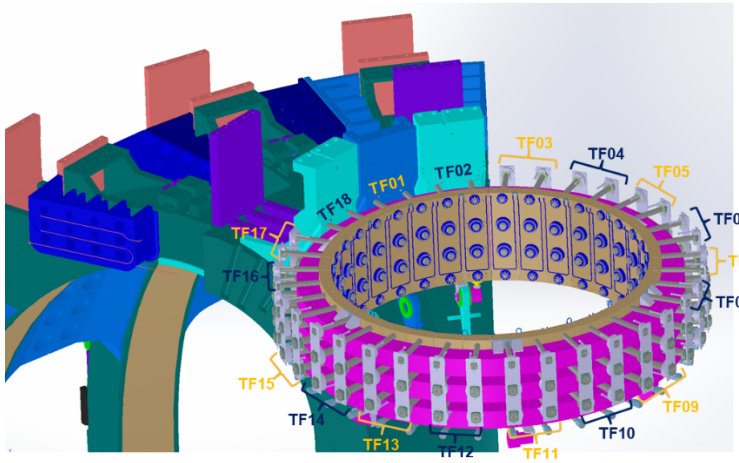
Jackbolt angle	Multi-Spindles should be inserted into jackbolts even if their angle are not aligned.

4.3 Basic Tightening Sequence

Basic tightening sequence is shown as below. In case of using multi-spindle tools or using two or three tools, tightening sequences are modified as described in section 4.4 and 4.5.

Each Superbolt	 1→13→7→19→3→15→9→21→5→17→11→23 →2→14→8→20→4→16→10→22→6→18→12 1→5→3→7→2→6→4→8
Each TFC	 2→6→3→7→1→5→4→8
For Upper/Lower PCRings	 TF01→TF07→TF13→TF03→TF09→TF15→TF05→TF11→TF17 →TF02→TF08→TF14→TF04→TF10→TF16→TF06→TF12→TF18
Number of	(This is only for full-automated robotics)

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jackbolt, Tightening steps	Number of Jackbolt : 2232 for Upper, 2232 for Lower (Tighten in parallel) Total step of screwing : 104 steps (One step is limited up to 40°, which is 0.1666mm as jackbolt stroke, and final stroke is 17.3mm) (Note) PCRings are expanded step by step so that significant stresses are not produced in the PCRings and jackbolts (shear stress in the PCRing depends on the step difference between adjacent PCCFs). Each step is limited to 40° as of jackbolt screwing angle to avoid large stress variation in jackbolts.

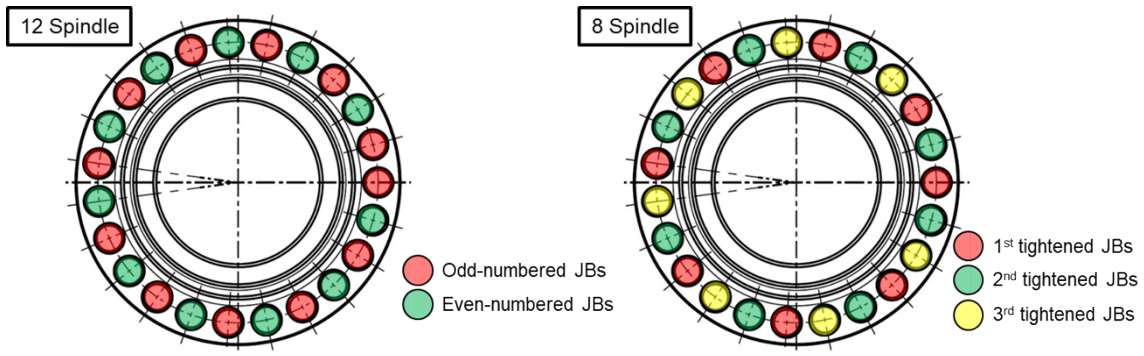
4.4 Modified Pattern for Multi-Spindle Tightening Tool

IO expects Multi-Spindle Tightening tools so that multi jackbolts of each Superbolt MJT can be screwed simultaneously. As for the tools for M80 Superbolt, the tool must have 8 spindles.

As for the tools for M110 Superbolt, either 8 spindle tool or 12 spindle tool is acceptable. For example, for the 12 spindle tool will tighten odd-numbered jackbolts at first and then tighen even-numbered ones (one spindle should be unclutched during tightening even-numbered jackbolts). The 8 spindle tool needs three times tightening for one M110 Superbolt MJTs.

It is possible to use two type of tools, 12 spindle tool + 11 spindle tool, or 8 spindle tool + 7 spindle tool instead of incorporating unclutching mechanism.

Remaining sequence is same as section 4.3.



4.5 Modified Pattern for using two or three sets of full-Automated robotics

IO targets to tighten PCRings within working 7 days (24h/day). Increasing number of tools is aimed at shortening tightening duration. In case that two or three sets of robotics are used, it is possible to work on two or three TFCs in parallel as below.

- Two sets : TF01/10→TF04/13→TF07/16→TF02/11→TF05/14→TF08/17 →TF03/12→TF06/15→TF09/18
- Three sets : TF01/07/13→TF03/09/15→TF05/11/17→TF02/08/14 →TF04/10/16→TF06/12/18

5 Reference Documents

This list contains documents for information:

[1] 1101CA_000551D - Pre-compression Counter Flange - details (24HB2M)

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[2] 12351-01_Index_102 (SZ44JR)
[3] 12353-01_Index_103 (SZAK3U)
[4] 12349-01 Index_107 (SZ4367)
[5] 12355-01 Index_109 (SZBVFC)