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SUMMARY

Call for Nominations

IO/16/CFT/13145/JTR

Contract for
The provision of a Test Facility for the Full Size Pre-Compression Rings

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1 Purpose and Background

The purpose of this contract is the preparation and operation of a mechanical test facility capable of proof testing all the ITER pre-compression rings to beyond their operating conditions before their installation in the machine.

2 Scope of the Contract

The Supply consists of 3 main items

1) Design finalization and procurement of the mechanical parts of the test facility from industrial companies. Integration of the various components to the extent required by the industrial procurement strategy.
2) Construction or adaption of the infrastructure (building and other civil engineering works) associated with the facility, and installation of the mechanical parts
3) Operation of the facility and execution of the test programme defined by the IO. The operational phase of the facility is anticipated to last for 2-3 years but the facility must be maintained in a stand-by mode until all the pre-compression rings have been successfully installed in ITER. Operation of the facility will include transport of the rings (point of origin to be considered as the ITER site) and their return to the IO.

3 Procurement Strategy

IO will be fully responsible for this procurement. A single contract will be placed covering all 3 main items of the supply. Tenderers will provide prices separately for each item. The pre-qualification questionnaire and the tenderers ITT documents shall be submitted together in separate packages. The PQQs will be opened and evaluated first. Only successful PQQ applications will be considered for the final tender evaluation.

The IO will provide a conceptual design report (attached as an Annex to this Call for Nominations). The contractor will be responsible for the final design and performance confirmation, and the manufacturing design. The contractor, in the tender submission, may propose alternative designs, in particular those that involve the use or adaption of existing equipment. The final design/analysis reports must be approved by IO before manufacturing is started.

The contractor may utilise subcontractors for parts of the supply. The procurement strategy for mechanical equipment, hydraulic systems and control systems will be provided with the tender. The tender must also explain how multiple sub-contractors will be integrated. All subcontracts are subject to IO approval in advance.

A baseline test programme is outlined in section 8. This is expected to last for 2 years, after which the facility will be put in a standby status. The contract will contain options to allow further tests to be made at any time during the standby period.

At the end of the contract, ownership of the 'movable' parts of the facility (instrumentation, electronics, control systems, hydraulics and cylinders) if procured under the contract will remain with the IO who may choose to remove them. The cost of dismantling and packing these components will be included as an option in the contract. Transport will be paid by the IO.

Alternatively the IO may decide to relinquish ownership to the supplier. In this case the IO will not retain any responsibility for removal or disposal of any part of the facility.

In the case of existing components adapted by the supplier, ownership will remain with the supplier.

4 Procurement Time table

A tentative time table is outlined as follows:

Call for Nomination (CFN)	2nd Aug 2016
ITT including Pre-Qualification Questionnaire	16th Sept 2016
Deadline for receipt of Tender including PQQ docs	28th Oct 2016
Estimated Contract Award	December 2016
Estimated Contract Signature	February 2017

5 Definitions

PCR	Pre-Compression Rings OR (according to context) Project Change Request
PCR-TF	Pre-Compression Ring Test Facility
TF	Toroidal Field (coils) or Test Facility according to context
IIS	Inner Intercoil Structure
UOIS, LOIS	Upper, Lower Outer Intercoil Structure
UIOIS, LIOIS	Upper, Lower Intermediate Outer Intercoil Structure
AFP	Advanced Fibre Placement
F4E	Fusion for Energy
UTS	Ultimate Tensile Test

6 Pre-Compression Rings

The pre-compression ring baseline design consists of 3 glass-fibre reinforced composite rings placed at the top and bottom of the TF coils, Fig 1. In addition to these 6 rings, a further 3 are stored permanently as spares below the TF coils since there is no access to replace the lower rings once the TF coils are installed. The rings are attached to each TF coil through 36 counter flanges placed inside the rings. The counter flanges press on the inner bore of the set of 3 rings and are attached by studs to the TF coil flanges.

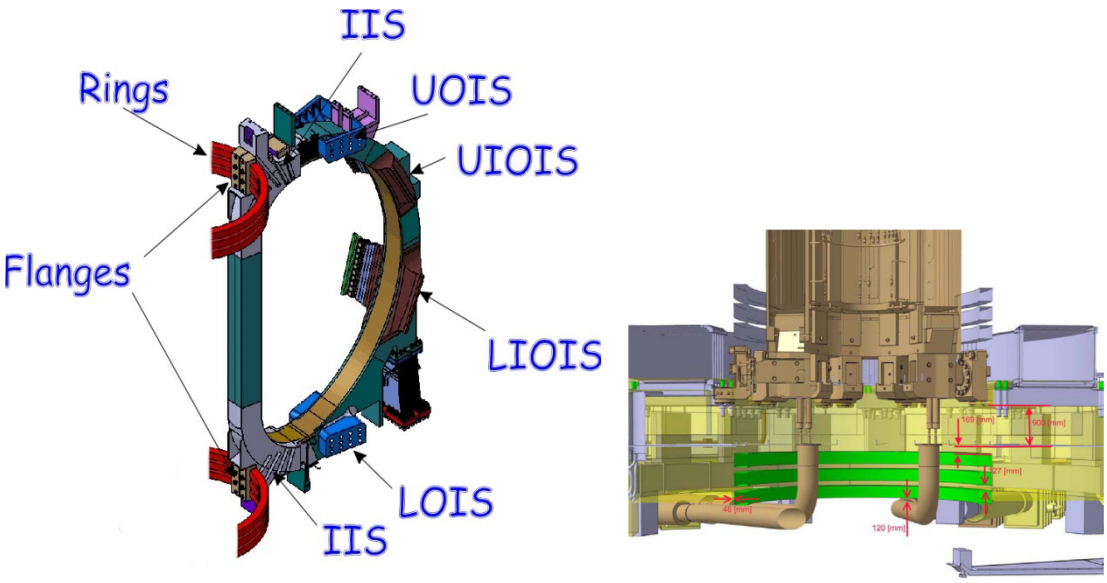

Fig 1: Location of the Pre-Compression Rings

The rings are pre-tensioned during assembly using sets of superbolts that tension the studs linking the counter flanges to the TF coil flanges, Fig 2. The pre-tensioning process involves extending the ring radius by up to 25mm and one of the requirements on the rings, to maintain consistency with the 29mm stroke of the jackbolts on the superbolts, is that the overall elastic modulus of the rings is such that the required force on the TF coil flange is provided by this 25mm extension.

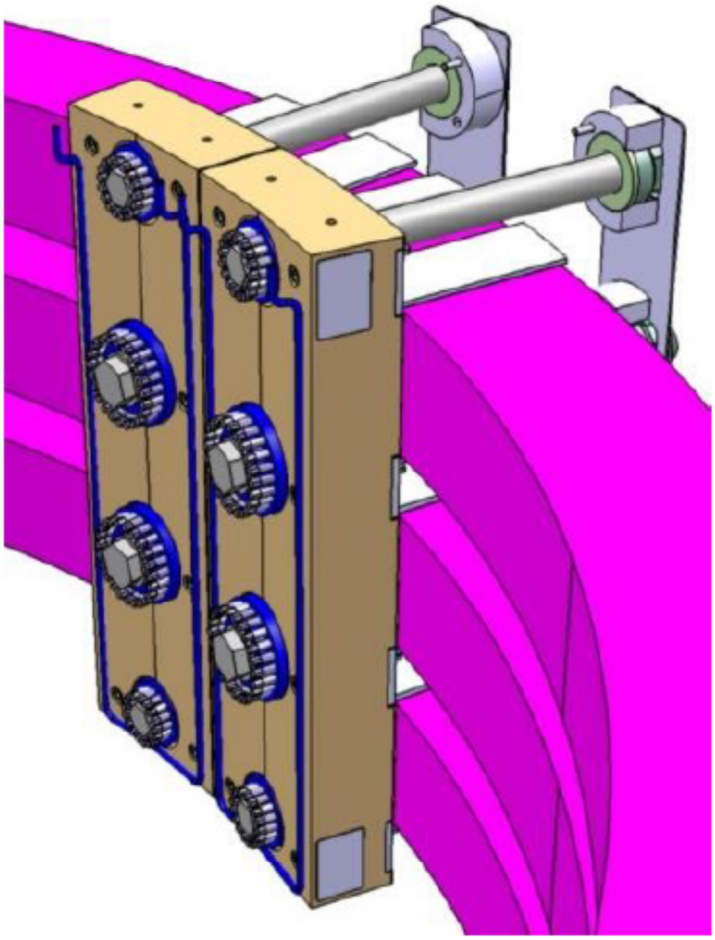

Fig 2: Superbolt/counter flange system

The material for the rings was originally selected as uni-axial glass – resin, based on an extensive development of 1/5 scale rings in the period 2003-2010.

One important advantage of the glass-resin is the low modulus and high strength, which allows a large (0.5% strain) extension. This effectively decouples loads applied by the rings (and the loads on the superbolts and connecting studs) from the TF coil movement during a plasma pulse, suppressing fatigue. The large extension also makes the pre-compression system insensitive to any permanent settlement of the TF coils after the first few energisations.

Tests on the 1/5 scale rings wound with uniaxial fibre confirmed that with S-glass fibres (with a single strand strength of >3000MPa), a ring ultimate tensile strength of >1500MPa could be obtained with an overall elastic modulus of 60GPa (consistent with providing a force of 10MN/ring/TF coil, with 3 rings and an overall extension (on the radius) of about 28mm.

A ring fabrication contract was placed by the EUDA F4E using the AFP method, a standard aerospace manufacturing method. This uses a lay-up of a 2D pre-impregnated glass mat tows (pre-impregnated flat strips of glass fibre about 0.2mm thick and 6mm wide) in the radial-toroidal plane. The large steering radius of the full size rings allows the tows to be curved so

that the warp fibres are always toroidal. Each ring is made by stacking (and bonding) a set of 3 slices. Once the tows have been placed, the ring slice is cured.

There have been some issues with long wave ripples around the circumference, probably due to the inward movement of the fibres during the curing and prototype rings have exhibited a wedge shape. The mechanical properties measured on samples extracted from different regions of the slice indicate a marginal performance of the full ring.

A back-up plan is being implemented using pre-cured uniaxial glass strip made in a standard industrial process known as pultrusion. This strip is then wound and bonded.

A full size test facility for the rings will now be constructed through this contract, to address the following issues:

- Although we are confident that one of the glass-fibre options will be successful, there are still doubts about the stability of the manufacturing route, particularly for the AFP option.
- Relying on data from sub-size rings is inadequate for either of the proposed manufacturing routes, because of the increased bending radius and the different specification of the raw material between full and sub size. Cutting samples from full size rings creates difficulties in applying loads and a geometry correction factor has to be applied because of the curvature.
- Performance prediction of the finished rings in uncertain. We do not have a property database for a reasonable production sample (i.e. of several rings)
- Quality inspection of the finished rings is uncertain. NDT techniques are available but the impact of defects is unknown which makes setting thresholds arbitrary (and a subject for dispute with manufacturers)
- There are health and safety concerns with workers in close proximity to the rings when carrying out the pre-tensioning operation, due to the high stored elastic energy in a ring being released if it fractures

7 Description of the Pre-Compression Ring Test Facility

The test facility will be used to:

- Test 1/3 slice of ring (full inner radius and height but 1/3 thickness) up to ultimate conditions
- Proof test all rings up to 1.5 operating loads before installation
- Carry out stress relaxation tests on ring slices

A conceptual design of a facility has been produced by F4E and analysed by IO https://user.iter.org/?uid=T6V6HA attached as Annex A. The main features of this are shown in Fig 5 and the main parameters in Table 1.

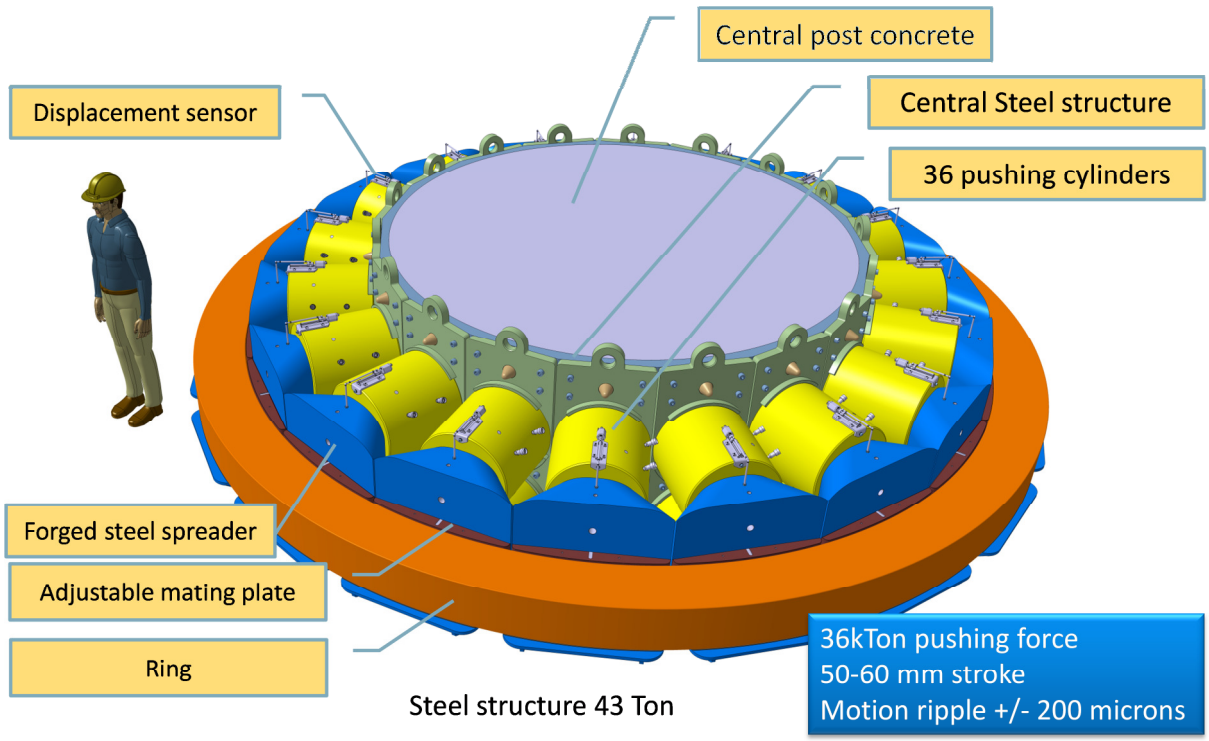

Fig 5: Concept of the PCR Test Facility

The facility uses 36 hydraulic cylinders to press on the inner surface of the ring through 18 curved interface plates. The hydraulic cylinder forces are reacted by a central structure consisting of steel load spreading plates and a central concrete core.

Table 1: PCR Test Machine Main Parameters

Parameter	**Value**	**Comment**
Radial built	6 m	Approximate diameter
Height	2 m	
Overall weight	200 ton	Including concrete
Heaviest part	50 ton	Without concrete
Concrete cast weight	30 ton	Reinforced cast
Number of actuators	36	
Maximum thrust per actuator	1000 ton	
Maximum operating pressure	700 bar	
Maximum actuating speed	1mm/min	extension
Maximum return speed	10 mm/min	retraction
Maximum cylinder stroke	75 mm	
Installation free play	5mm	on the radius
Maximum ring expansion	70 mm	on the radius
Maximum displacement ripple	+/- 0.1 mm	Actuator to actuator value
Minimum actuating step	0.1 mm	radially

Duty cycle	10%	
Type of machine	Hydraulic synchronized	
Test nominal temperature	20 C	Room conditions
Hydraulic fluid max temp	150 C	
Type of circuit	sealed	To avoid contamination
Type of control	displacement closed loop	
Control	each cylinder	Individual
Data acquisition system frequency	2 Hertz to 1 kHertz	Parameter sensitive
Electrical power	15 kW	Continuous operation

8 Infrastructure

The test facility will be housed in a suitable facility. This must provide a controlled environment for the rings (in particular cleanliness, moisture and temperature) while they are installed on the machine. An appropriate crane has to be made available to install and remove the ring under test.

During ultimate strength tests, and possibly during proof tests, rings may fail. The failure is associated with a considerable release of mechanical energy and possibly shrapnel as the ring disintegrates. The supplier will be fully and solely responsible for providing personal and equipment protection, probably through walls or by placing the facility in a pit.

9 Test Programme

The machine will be commissioned using a 1/3 ring slice in an UTS test

Following this the baseline programme will contain, over a period of three years

- 3 Ultimate Tensile Tests of Ring Slices
- One of these UTS tests may be associated with fatigue loading, up to 1000 cycles
- One stress relaxation test
- 12 Proof Tests of full sized rings
- 2 of these Proof Tests with a limited cyclic loading (3 cycles)

The supplier will quote for optional additional tests for any of the items in the base programme, to be carried at any time during the stand-by period of the machine.

Maintain the facility in a standby state until the pre-compression rings are installed on the machine

10 Transportation and Storage of Rings

The supplier will be responsible for transport of the rings from the ITER site, their safe storage in controlled environmental conditions and their return to the ITER site. The IO will provide the rings packed, with transport frames and the supplier will return the tested rings packed in a similar way.

11 Schedule

The main dates are summarised in Table 2. The schedule is tight and keeping to it will be a key condition of the contract.

Table 2. Schedule for Construction and Operation of PCR-TF

Activities	**Schedule**
Call for Nominations,	August 2016
Pre-Qualification of Companies	September 2016
Call for Tender and submission of bids	October 2016
Tender evaluations	February 2017
Contract signature	March 2017
Commissioning of Facility	No more than 18 months from contract signature
Duration of Ultimate or Proof Test (including installation and removal of ring)	Less than 4 weeks/test
End of standby phase	December 2024

Ring transport methods are up to the contractor but the overall duration of the transport in one direction must not exceed 3 weeks.

12 Experience requirements

The ITER Organization is looking for Contractors with experience and knowledge in the following areas

- Proven mechanical design and analysis capability
- Demonstrated ability to host and operate a large mechanical test facility
- Experience in mechanical instrumentation (strain gauges, displacement sensors etc) operating under dynamic conditions
- Proven experience to integrate multiple supply contracts
- Proven experience with the manufacture of large hydraulic cylinders
- Proven experience with the manufacture of hydraulic circuits working at pressure exceeding 700 bar.

- Proven experience with the design and manufacture of hydraulic systems with actuators actively synchronized to an accuracy better than 0.1 mm (each actuator shall not deviate more than +/- 0.1 mm from the nominal requested position)
- Defined transport arrangements for the rings to and from the facility

This experience may be provided by named subcontractors or by members of a consortium.

13 Candidature

Candidature is open to all companies participating either individually or in a grouping (a consortium or any legally-established entity) which is settled in an ITER Member State.. All members of a consortium (i.e. the leader and all other members) are jointly and severally liable to the ITER Organization for the entire scope of the Contract .

The consortia or groupings shall be presented at the pre-qualification submission stage. The consortium cannot be modified later without prior approval of the ITER Organization.

14 Annex A: Pre-compression Ring Test Machine Conceptual Design