Transactions, SMiRT-22
San Francisco, California, USA - August 18-23, 2013
Division VI

ITER ANTI SEISMIC BEARINGS, FACTORY PRODUCTION CONTROL, COMMISSIONING AND IN-SERVICE INSPECTION

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ABSTRACT

ITER is an international collaborative scientific project to demonstrate the feasibility of nuclear fusion power. This massive project presents huge challenges in many fields of engineering and technology. The functional requirements of the Tokamak machine and its systems require the Tokamak Complex to be protected and isolated from possible seismic hazards. Consequently the Tokamak complex has been designed and is being constructed on 493 anti-seismic bearings (Seismic Base Isolators).

INTRODUCTION

The ITER Tokamak Complex seismic isolation system consists of low damping, laminated elastomeric bearings supported on reinforced concrete pedestals. The anti-seismic bearings (ASB) are located between the Tokamak Complex raft and 1.65m high concrete pedestals as shown in Fig.1. The total permanent load on all bearings is approximately 300,000 tons.

An ASB is a square laminated elastomeric isolator, classified as “type C” in EN1337-3. The dimensions of the ASBs are 900 mm x 900 mm x 181 mm. Each ASB assembly has upper bearing plate, ASB and lower bearing plate and has overall dimensions of 1.10m x 1.10m and 285 mm as shown in Fig.2.

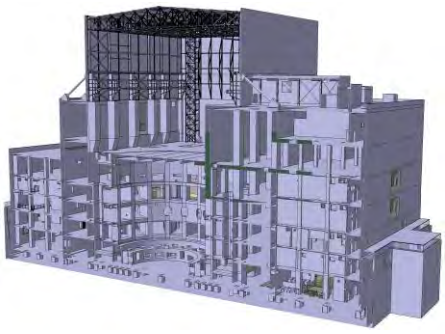

Figure1: Tokamak Complex Seismic isolation system

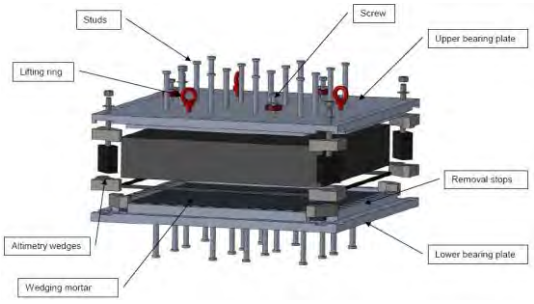

Figure 2: 3D view of ASB assembly

At SMiRT-21 a paper was presented on "The challenging requirements of the ITER anti seismic bearings" as referenced below. The paper for SMiRT-22 will present the status of the Anti-seismic bearing Factory Production Control, Commissioning and In-service inspections. Emphasis will be given on how the design criteria and technical specifications developed for the ITER Anti-seismic bearings have been or are being applied, in particular with regards to application/deviations from Euro Norms and consistency with French requirements for nuclear facilities.

FACTORY PRODUCTION CONTROL

Factory Production Control (FPC) performed is shown below in table 1. The testing plan was based upon the frequency routine test defined in EN 1337-3 (table 5 - one static compression test each 350 dm3 and one static shear test each 3500 dm3 of elastomeric rubber mixture). In addition, dynamic shear tests were performed.

The tests procedure is described in a specific procedure, and according to its program, the number of tested bearings for each test is as follows:

		FPC			
Lot	Bearings	Static Compression	Dynamic Compression	Dynamic Shear	Static Shear
Pre serie	8	2			
Lot 1	36	12	1	1	1
Lot 2	36	12			1
Lot 3	36	12	1		1
Lot 4	36	12	1	1	1
Lot 5	36	12			1
Lot 6	36	12	1	1	1
Lot 7	36	12			1
Lot 8	36	12	1	1	1
Lot 9	36	12		1	1
Lot 10	36	12	1	1	1
Lot 11	36	12			2
Lot 12	36	12	1	1	1
Lot 13	36	12			2
Lot 14	17	8	1	1	1
	493				

Table 1 Factory Production Control tests

This FPC together with the Initial Type test, Initial inspection of the factory, factory production control, and factory routine audits justified the conformity certification issued by the Manufacturer as per the following table:

MAIN STEP	Definition	Document demonstrating the compliance with the requirements (EN 15129 and ANNEX B)		
		Reference	*Doc Type*	*Title*
Initial Type Tests	*ASB mechanical characterization*	TS 10003-2	Technical specification	ASB mechanical test procedure
		TP 10003-1	Test plan	ITT specification for standard monitoring ASB
Initial inspection of the factory	*Working procedure, inspection and control , treaceability*	PAQP 10003-1	Quality and management plan	Quality and management plan
		TS 10003-1	Technical Specification	ASB supply
		PR 10003-1	Manufacturing procedure	ASB manufacturing
		ITP 10003-1	Inspection and Test Plan	ASB manufacturing
		PNG 10003-1	Drawing	Standard ASB
Factory production control	*ASB mechanical characterization*	TP 10003-2	Test plan	Factory Production Control specification for standard ASB
		TS 10003-2	Technical specification	ASB mechanical test procedure
Factory routine audit	*Working procedure, inspection and control , treaceability*	PAQP 10003-1	Quality and management plan	Quality and management plan
		PS 10003-1	Surveillance plan	Surveillance plan
		PR 10003-1	Manufacturing procedure	ASB manufacturing
		TS 10003-1	Technical Specification	ASB supply
		ITP 10003-1	Inspection and Test Plan	ASB manufacturing
Conformity certificate and identification	*Per ASB performed by the Supplier*	TS 10003-1	Technical Specification	ASB supply

Table 2 Overview tests for conformance certification

COMMISSIONING

To facilitate the commissioning or installation of ASB's on site, a pre-commissioning is performed in the workshop. The pre-commissioning results in the so-called "ASB Assembly" consisting of the upper bearing plate, the ASB and the lower bearing plate.

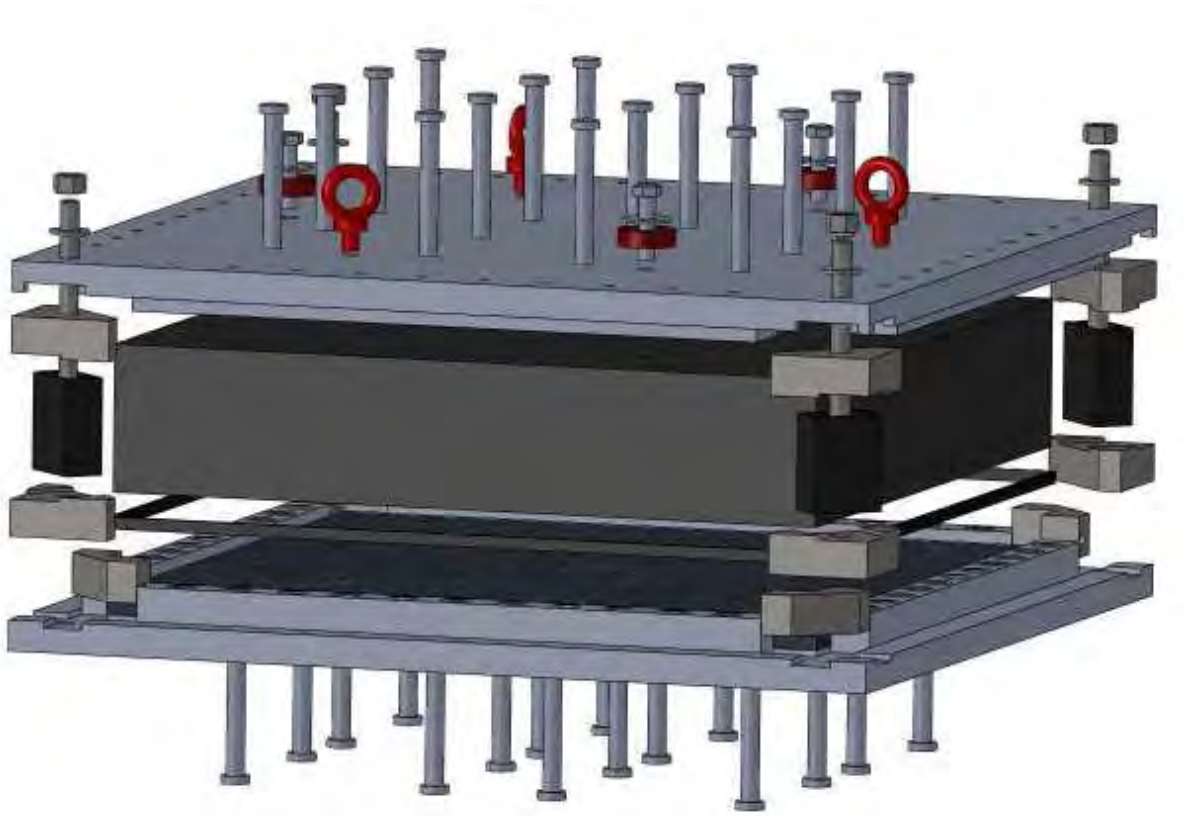

Figure 3 ASB Assembly

ASB's are delivered to the construction site, off-loaded one by one and placed in the onsite storage building. The plinths (concrete columns) on which the ASB's will be installed are executed beforehand and not all reinforcement is casted with concrete to allow the lower bearing plate studs to interface directly with the plinth reinforcement

Preparation of each plinth is necessary and particular attention is given to implement anchorages for formwork linked to the casting of self-compacting concrete and mortar layer, altitude adjustment system supports, construction joint treatment and check level of reinforcement and concrete.

The ASB assemblies, locked at its 4 corners by threaded rods and screws, are placed, adjusted and anchored to the plinth. Indicated in Figure 4 below, the first stage ASB assembly installation is to cast self-compacting concrete (shown in white).The second stage of ASB assembly installation is to cast a layer of mortar (shown in dark grey just under the lower bearing plate).

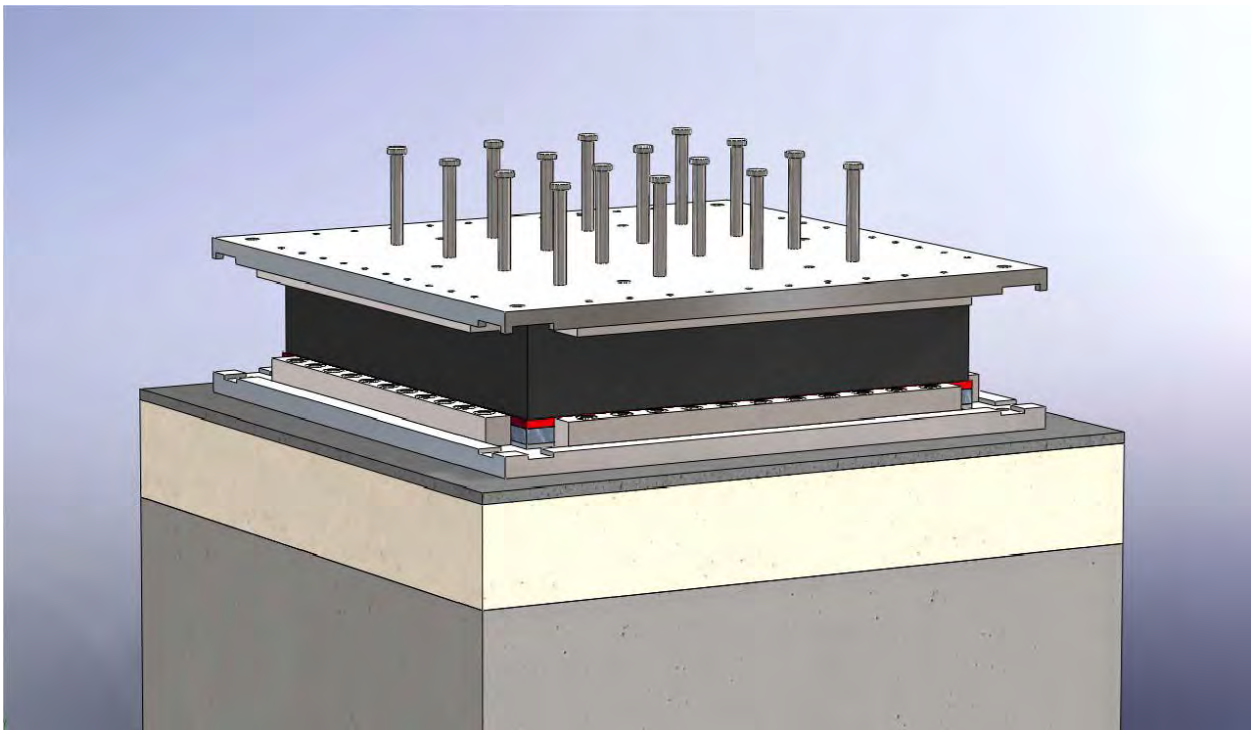

Figure 4 Installed ASB (Anti-Seismic Bearing) Assembly

The installation of 493 ASB's for the ITER project was scheduled and executed in 41 weeks. The figure below, an example of calendar week 34 2011 of the circulation plan, shows the sequencing of the installation of the ASB's. The ASB's were installed by two teams working independently, following the sequencing of the execution of the concrete foundation slab and its plinths.

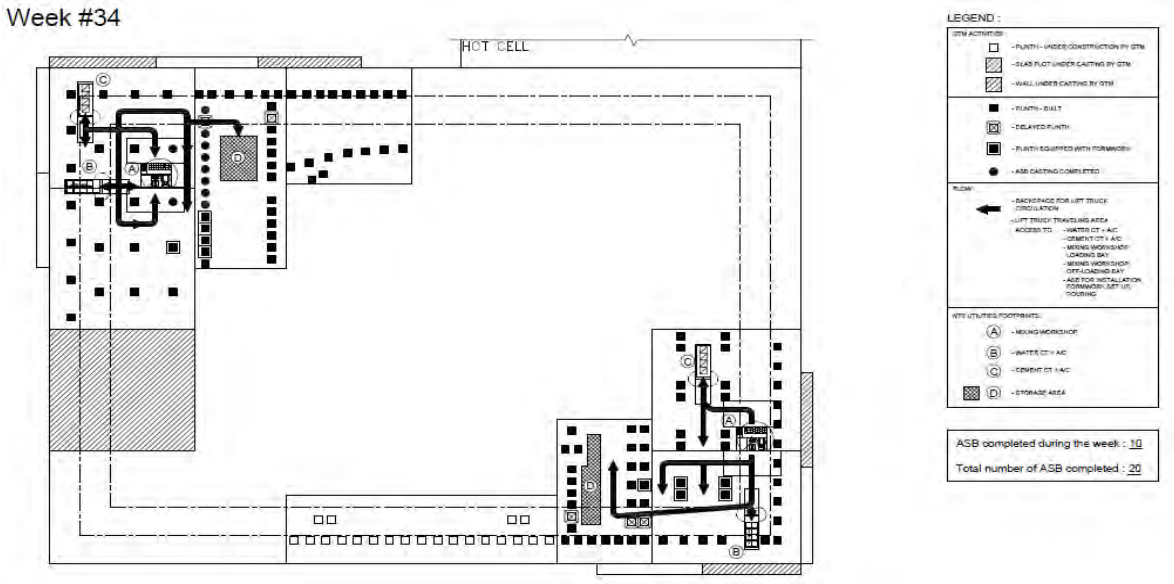

Figure 5 Example of installation plan

In April 2012 the last, 493rd, central bearing was installed (see figure below). Currently on the ITER Site the works construction works for the Tokamak Buildings slab are being implemented. Similar to the lower bearing plate, the studs are integrated in the reinforcement of the upper slab, before pouring concrete.

Figure 6 Photo of ASB's installed for ITER Tokamak Complex

IN-SERVICE INSPECTIONS

To maintain the ASB's a monitoring program is defined, based on in situ inspections on the ASB's and mechanical tests on the monitoring ASB (samples which are under same deformation compression as full scale or not loaded and extra full-scale ASB not loaded). The following ASB's are available to perform the monitoring:

Type		Number
Standard	**Extra ASB**	**3**
Samples	**Compressed samples**	**40 "Type D" + 20 "Type S"**
	Un-compressed samples	**10 "Type D" + 6 "Type S"**

Table 3 ASB's for monitoring

For the maintenance of an in-service ASB, normal or principal inspections detailed hereafter shall be periodically performed to identify defects. If necessary Mechanical tests will be performed on the extra ASB's and the monitoring samples from type I which are under compression.
Table (4) lists the various tests and associated testing procedures and table 5 shows the maintenance and inspection plan covering the first 10 years:

Test	Tested characteristics	Monitoring ASB	
		Extra ASB (Full size)	Samples
Static compression test	Static compression stiffness	X	X
Static shear test	Static shear modulus	X	X
Dynamic compression test	Dynamic compression stiffness and damping	X	X
Dynamic shear test	Dynamic shear modulus and damping	X	X

Table 4 Overview of tests to be performed

Time after t_0 (years)		0	1	2	3	4	5	6	7	8	9	10
ASB in service	**Normal inspection**	-	**X**	**X**	**X**	**X**	-	**X**	**X**	**X**	**X**	-
	Principal inspection	**X**	-	-	-	-	**X**	-	-	-	-	**X**
Assessment & monitoring	**Samples testing**	-	-	-	-	-	**X**	-	-	-	-	**X**
	Full-size ASB testing	**X**	-	-	-	-	-	-	-	-	-	**X**

O = first loading of the ASB *i.e.* construction of the upper slab ITER Tokamak Building

Table 5 Maintenance and assessment plan proposed for the first 10 years.

Although the ASB's are designed with a service life of over 70 years, if needed bearings can be replaced by installation of jacks, removing of a dedicated mortar layer between the ASB and the lower plate, installation of the new bearings and a flat jack combined with mortar.

CONCLUSION

ITER is being designed and constructed with a high level of safety as an essential requirement. In order to meet the safety and performance objectives of ITER and the French regulatory requirements, the Tokamak Complex has been isolated from the potential seismic hazard by anti-seismic bearings. The manufacturing, qualification and commissioning of ASBs have been carried out by NUVIA Travaux Speciaux with specific ITER requirements that assure that the high level of safety during construction and operation is maintained.

ACKNOWLEGMENT

This paper was prepared as an account of work by or for the ITER Organization by Nuvia Travaux Speciaux, France. Dissemination of the information in this paper is governed by the applicable terms of the ITER Joint Implementation Agreement.

DISCLAIMER

The views and opinions expressed herein do not necessarily reflect those of the ITER Organization nor any Agency thereof.

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