



# Recent Progress of ITER Package in ASIPP

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The Institute of Plasma Physics, CAS  
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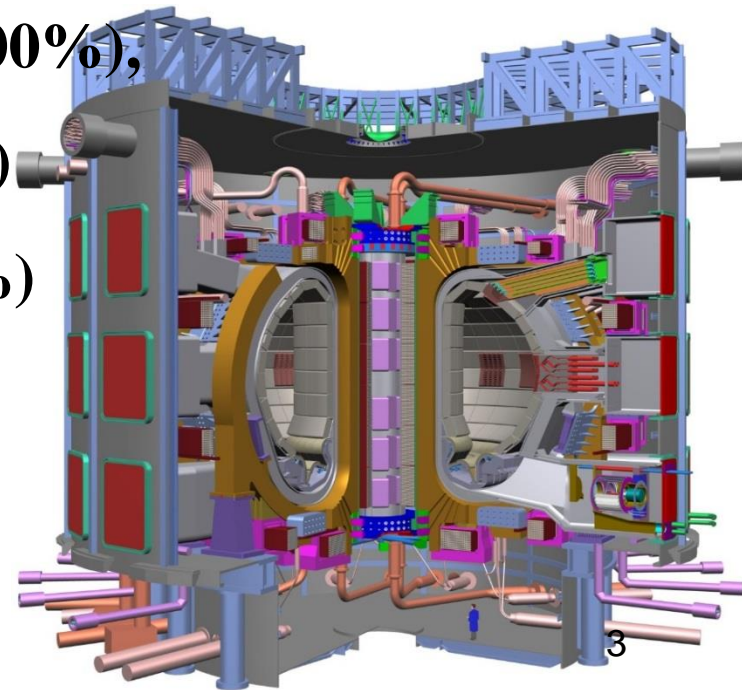


# *Content*

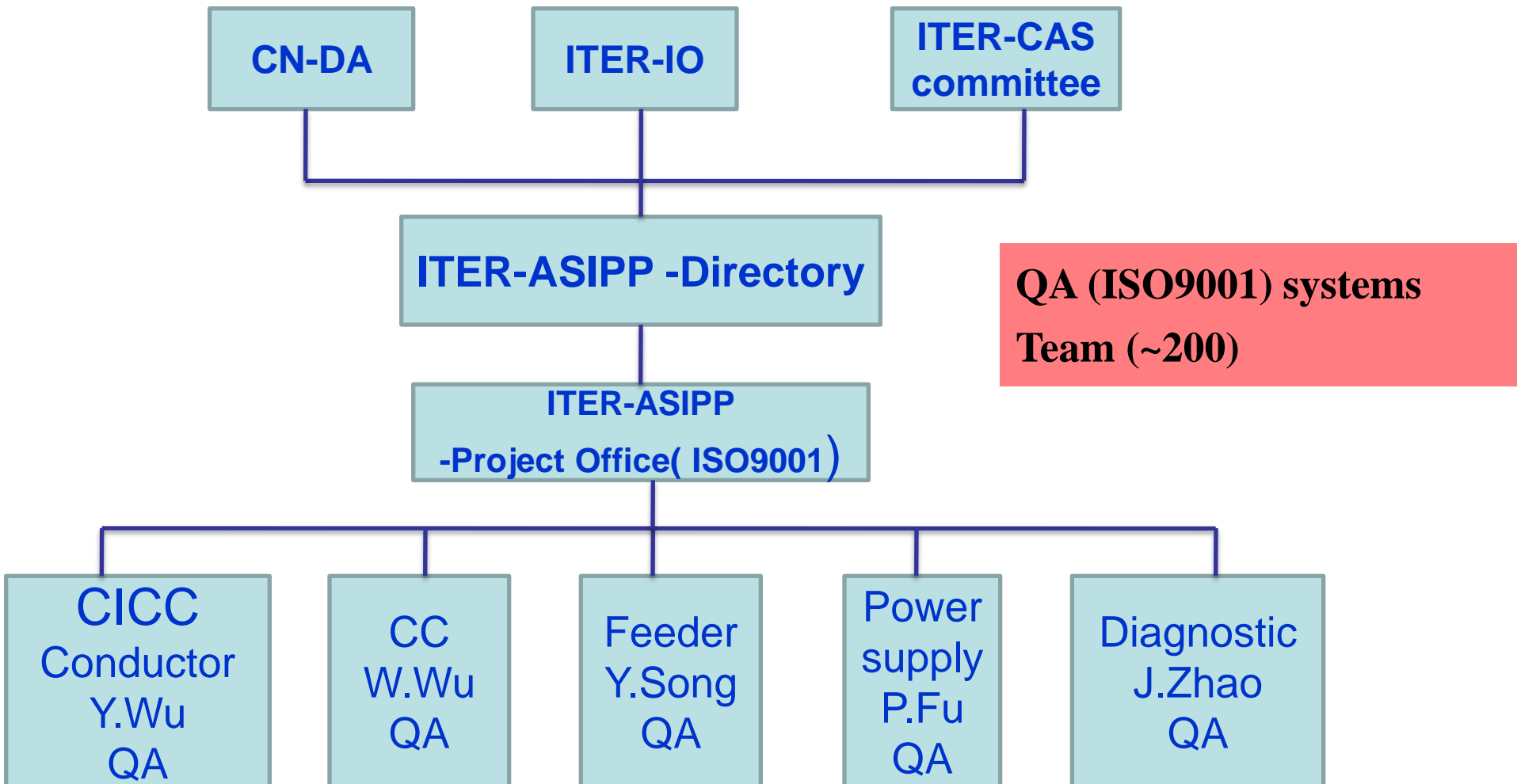
- **ITER Package introduction**
- **Main R&D activity and progress**
- **Summary**

# ASIPP Procurement Packages

- **Superconductive conductor: TF (7%) , PF (69%), CC & Feeder**
- **Feeders (100%),**
- **Correction Coils (100%),**
- **High Voltage Substation Materials (100%),**
- **AC-DC Converter (57.6%, 61.05kA)**
- **Reactive Power Compensation (100%)**
- **Diagnostics (1.6%)**



# ITER-ASIPP Management



**A successful ITER project is our first priority !**

# ITER-Conductor package

$\text{Nb}_3\text{Sn}$

7.5% TF Conductor



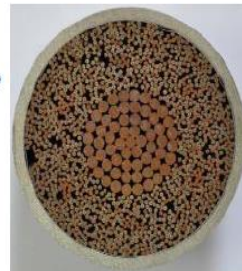
69%



PF Conductor



100%



MB Conductor

Nb-Ti

100%



CC Conductor

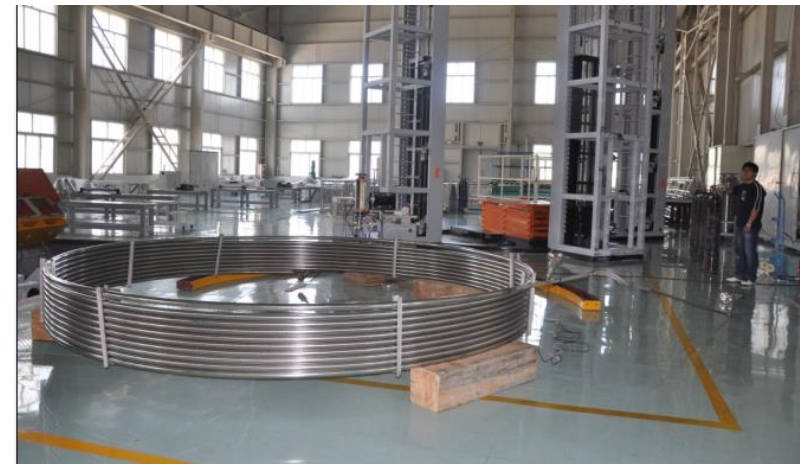
100%



(dummy)  
CB Conductor

## Package content (94):

- ◆ TF (11)
- ◆ PF2 (12), PF3 (16), PF4 (16), PF5 (16) (60)
- ◆ CC (18)
- ◆ Feeder/ MB (3), CB (2) (5)



- ✓ TF conductor 7.5%
- ✓ PF conductor 69%
- ✓ CC & Feeder conductor 100%



# ITER-Conductor production



**Conductor integration  
Workshop**

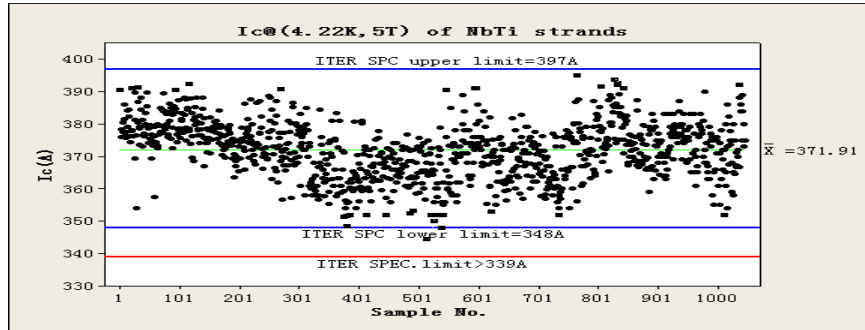


**1000m jacketing line**



**test lab**  
( Radiographic detection  
,Helium leak test, etc. )

# ITER-Conductor



## R&D activity

- ✓ Nb<sub>3</sub>Sn and NbTi strand
- ✓ Cable technology
- ✓ Jacket Section



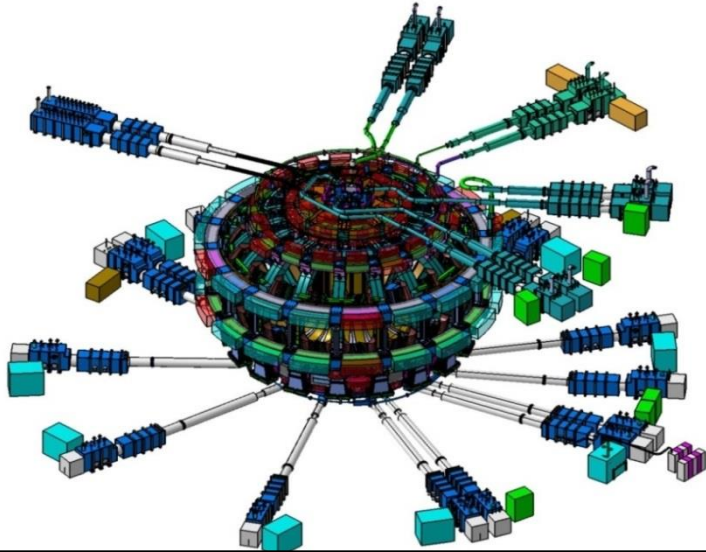
delivered to the Poloidal Field Coils Winding Building on Monday 2 June, 2012

Each conductor samples pass all test in Sultan lab, Switzerland.

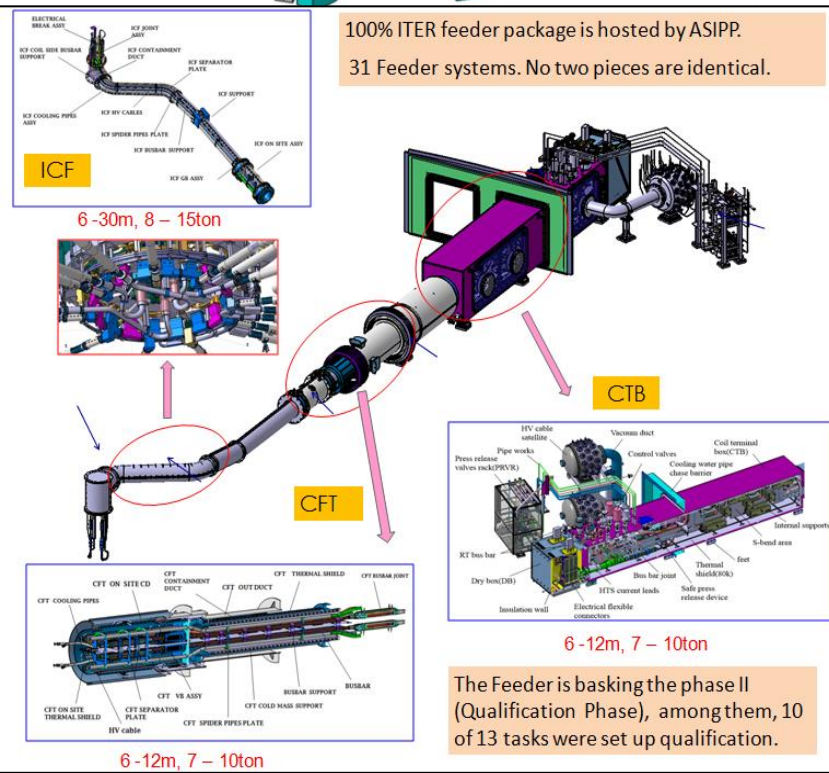
## Current status:

- ◆ total 57 conductor are completed and accepted by IO. Includes all TF, CC, and Feeder conductor, part of PF conductor.
- ◆ In addition 17 PF conductor production has been completed, and other 17 PF conductor will produced on schedule before 2018

# Feeder package



- ❑ TER feeder system transfer the electric power, cryogenic coolant and instrumentation wires to the magnets and structures.
- ❑ There are total 31 feeders that going from the outside of the cryostat to the tokamak machine center,
- ❑ It composed of Dry Box (DB), Pressure Release Valve Rack (PRVR), Coil Terminal Box and S-Bend Box (CTB&SBB), Cryostat Feed-Through (CFT) and In-Cryostat Feeder (ICF).
- ❑ Each feeder is weight about 50 ton and length 30-40 m.





# Facility preparation for Feeder package

- ✓ one 3200m<sup>2</sup> workshop for assembly including the clean room of 8 classes.
- ✓ all kind of test facility: 80kA HTSCL operation, insulation, leak check, X-ray



Main workshop



Test facilities for insulation



Main workshop



UT equipment



Workshop for assembly



Workshop (3200m<sup>2</sup>)



X-ray equipment



Workshop for test



Leak check equipment



Machining workshop



Workshop for insulation



X-ray room



Automatic welding machine

**Clean room of 8 class of  
ISO14644 for Feeder  
assembly**

Prepared facility for feeder

# Progress of Feeder PA

- Most qualification (on Phase II )work have been completed successfully.



**The qualification of  
in cryostat feeder for  
PF5 and BCC in  
2014**



**The qualification of Box in 2014**



**The qualification of 68KA/ 52KA/ 10KA  
HTSCLs in 2015**



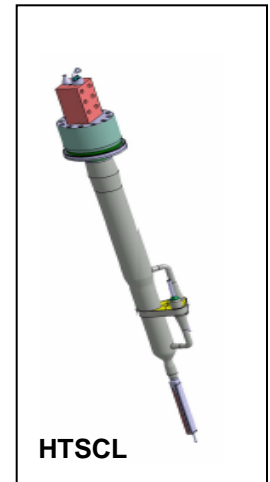
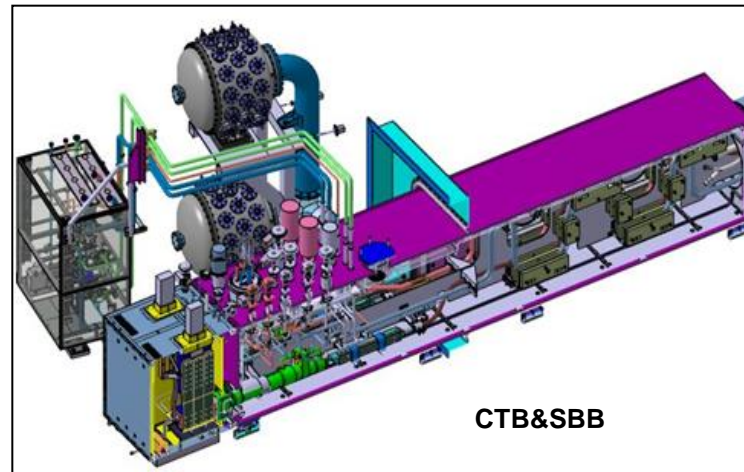
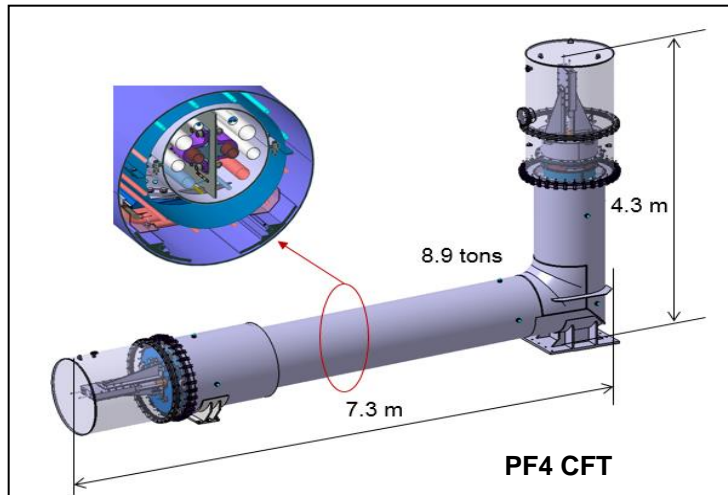
**The qualification of TF  
CFT in 2015,  
the test of mechanical  
fatigue, cold, thermal  
shock , 4k heat load**

Assembly of internal components with out vacuum duct



# Progress of Feeder PA

- ❑ The MRA meeting for PF4 cryostat feeder through in Nov 2015.
- ❑ The MRA meeting for Coil Terminal Box, S-Bend Box, Thermal shield, for cryostat feeder through Supports, for CTB Internal Element and Current Lead in 2016.



- ✓ ASIPP will finish the next six MRA meeting one by one in 2017.
- ✓ The CFT and CTB&SBB for PF4 will be delivered to ITER site in 2017 following the ITER's schedule.



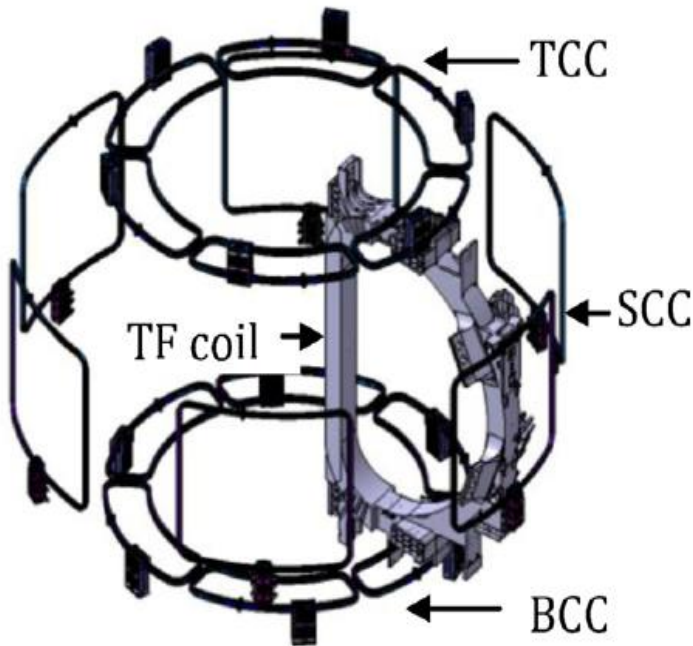
# CC coil package

## Content:

- ◆ 6 bottom correction coils (BCC)
- ◆ 6 side correction coils (SCC)
- ◆ 6 top correction coils (TCC)

## each coil need multi-dimensional wind technology

- ◆ BCC and TCC are 12 planar and arc-shaped with 7 m long and 2.8 m wide.
- ◆ 6 SCCs are three dimensional curved coils with 8.3 m length and 7.2 m width





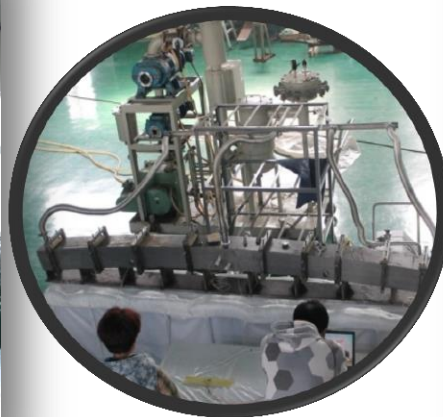
# Workshop construction for CC

workshop assembled with all kind of equipment, such as

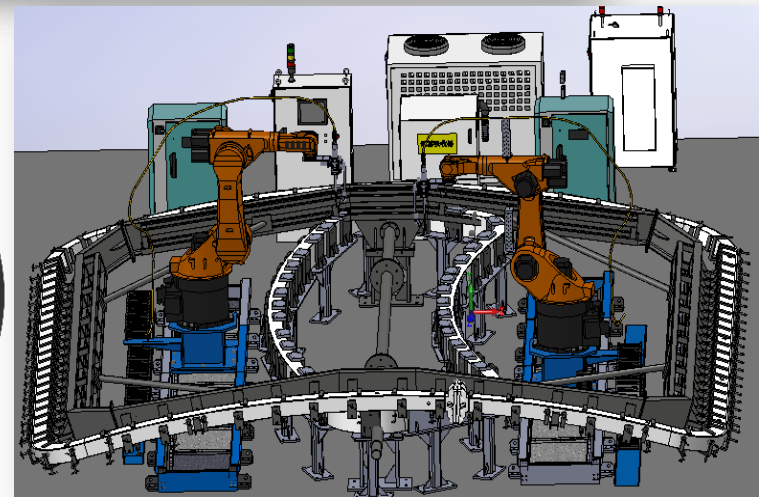
- ✓ Bending & Winding equipment,
- ✓ VPI equipment used on insulation procedure,
- ✓ the Laser Beam Welding system for case enclosure.



2

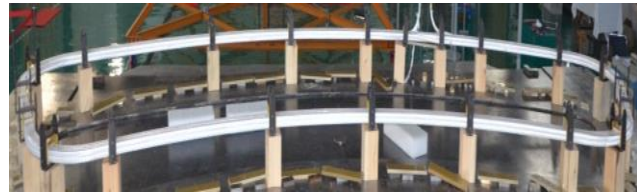
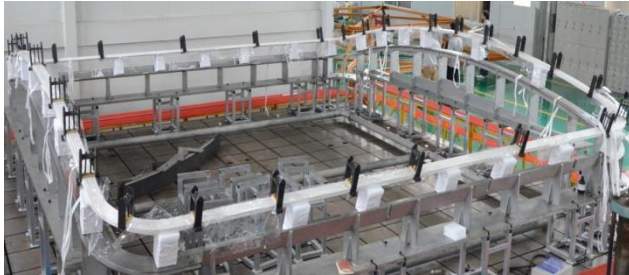


3



3<sup>rd</sup> VPI test

# Many qualification is being performed for CC



Two dummy coils of BCC and SCC were respectively made to qualify the winding process in 2013.

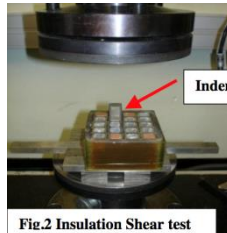
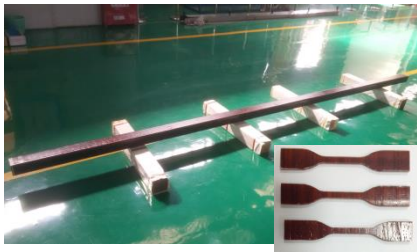
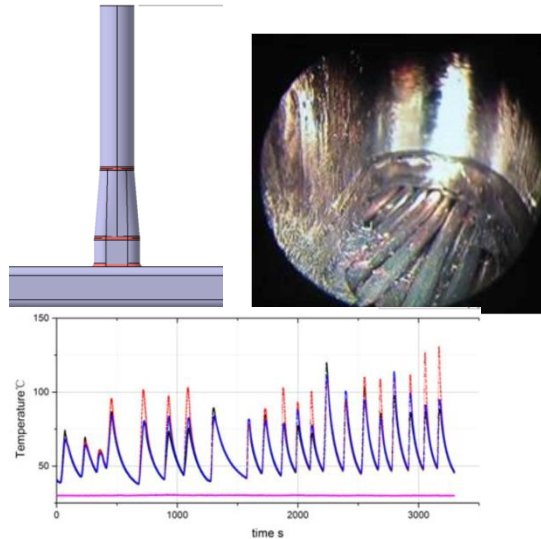


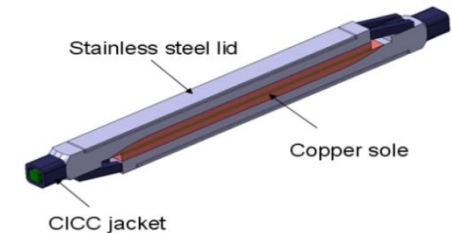
Fig.2 Insulation Shear test

Insulation system and VPI process qualification was finished in 2015.



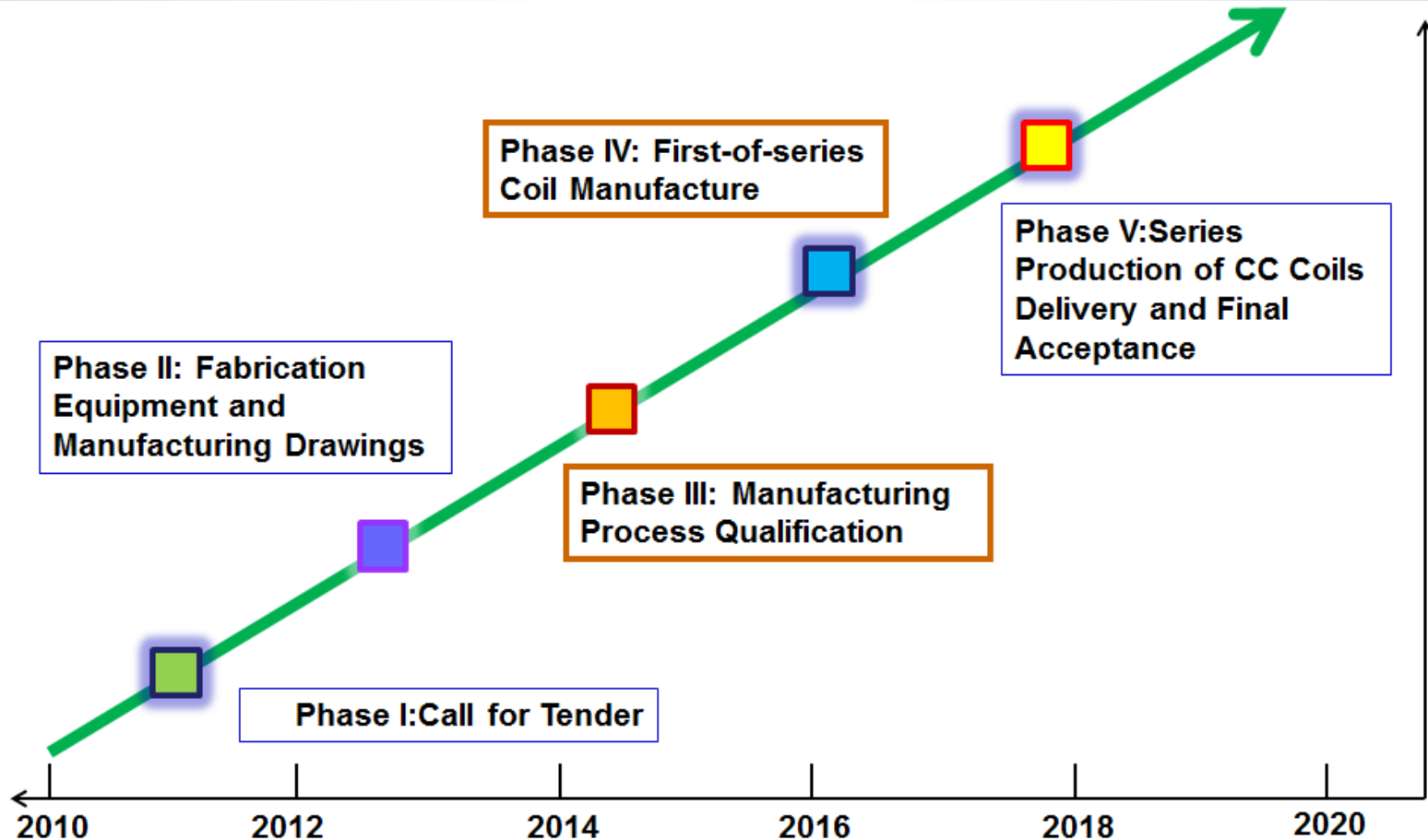
The Helium inlet/outlet welding qualification was finished in 2015.

- ✓ The terminal joint sample passed the DC and AC loss tests in Sultan facility(CRPP)
- ✓ its qualification will be finished soon.



- ✓ Case section manufacturing process qualification is on going by making two prototype.
- ✓ It will be finished at the beginning of 2017.

# CC Schedule



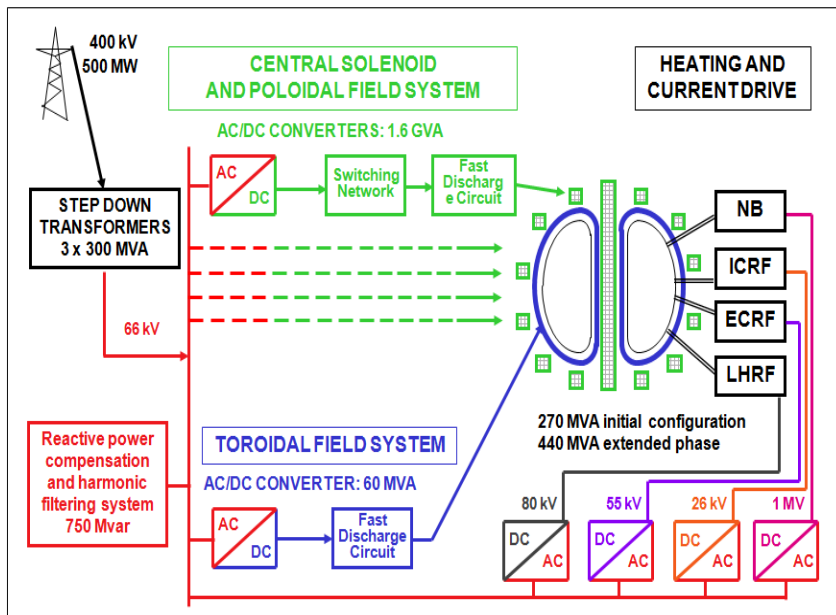
- ❑ All the technical issues for the CC PA have been solved and the qualification phase will be finished by middle of 2017.
- ❑ All the 18 coils will be delivered to ITER site before 2021.



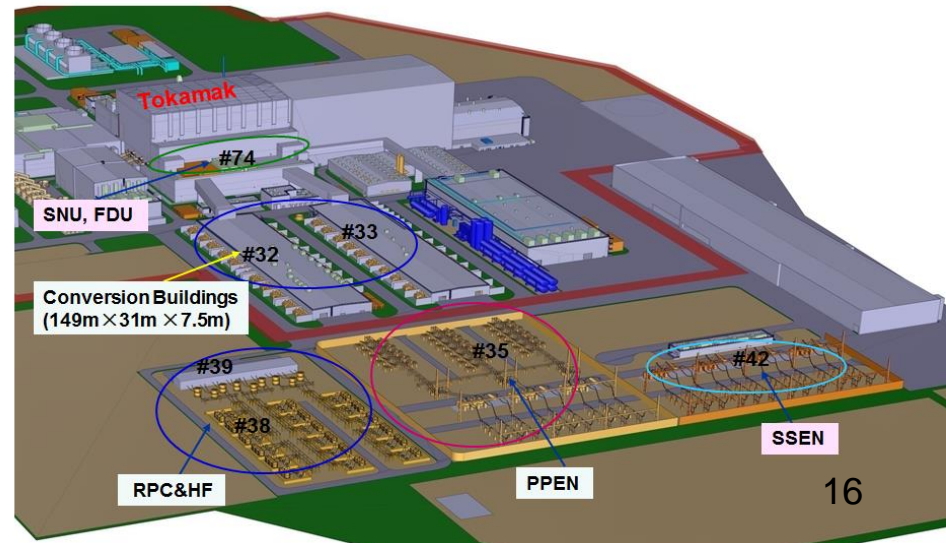
# Introduction

## ITER Magnet Power Supply :

- Pulsed power electrical network (PPEN) (CN 100%)
- AC/DC converter (CN 55%; KO 45%)
- Reactive power compensation & harmonic filter (RPC) (CN 100%)
- SNU&FDU (RU 100%)



## ITER Site Location





# ***ITER Power Supply Package***

***Can perform all ITER PS component and integration test***

## **DC Test facility**

- ★ **Max. DC current 500kA**
- ★ **Max. DC voltage 2000V**
- ★ **Out power can be adjusted**

## **AC Test facility**

- ★ **Max. AC current 450kA**
- ★ **Out power can be adjusted**

## **Converter Integration Test**

- ★ **110kV~ 10kV can be changed**
- ★ **CW 200 MVA**



# Power supply R&D

## ➤ PF Converter Components



Converter Transformer( $2 \times 41\text{MVA}$ , 66 / 1.05 kV)



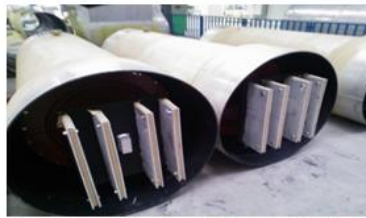
AC DS/ES (66kV/1250A)



DC Reactor (200uH / 27.5kA)



DC Disconnector (2 kV / 55 kA)



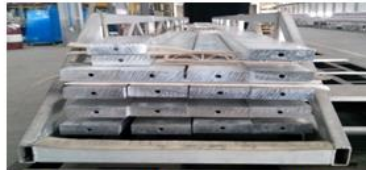
Enclosed AC Busbar (12 kV /  $2 \times 22.5$  kA)



DC Earthing Switch (12 kV)



Converter Module (1.42 kV/55 kA)



Water-cooled DC Busbar (27.5 kA)



- ★ Jul. 2012 , PDR meeting for AC/DC Converter & RPC
- ★ Sep. 2014, FDR meeting for AC/DC Converter & RPC
- ★ Mar. 2015, MRR meeting for AC/DC Converter & RPC



# ITER Power Supply Package

## Prototype test (routine test 31, type test 30)



Converter Transformer  
Short circuit AC 382kA



Converter Bridge  
Short circuit 430kA



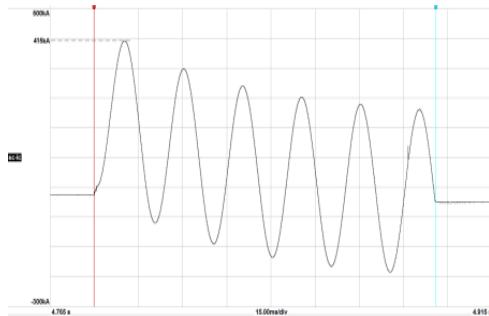
External Bypass  
Short circuit 367kA



DC Reactor  
196 kA, 28kA/4hr



Enclosed AC Busbar  
415kA, 140kA/2s



### Complete:

5 set of AC/DC converter manufacturing has been completed. And two set has passed the test. In 2017, the start delivery to IO.

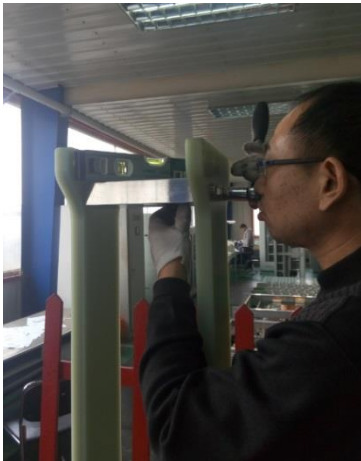
# Power Supply Package

## Current RPC Progress

- ★ one 80MVA prototype completed and tested, integration controller with ac/dc conv. was tested
- ★ first set of RPC has been completed in manufacturing, now in test state.



FAT of TCR under IO's witness



Thyristor valve assembly



Thyristor valve insulation test



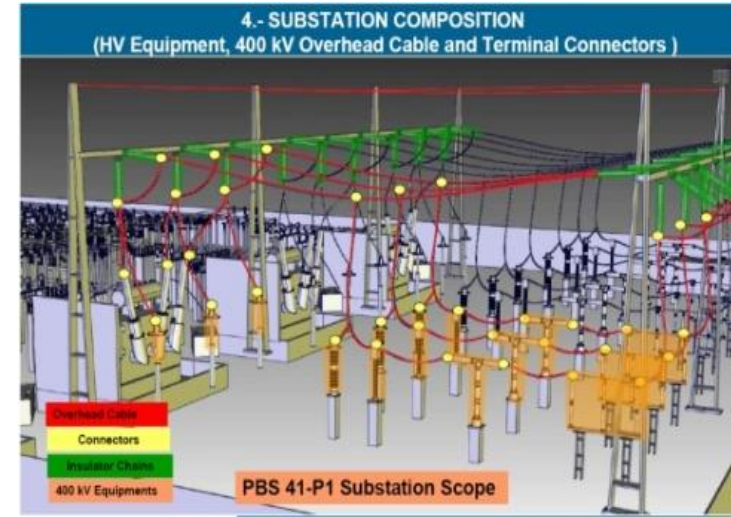
# Main Status

## 1. Current PPEN Progress

★ It is composed of 400kV, 66kV, 22kV electrical equipment with total 80 types, supplied by 28 manufacturers.

★ 70% sub-packages have been delivered to ITER site till 2016-Oct.

★ 30% sub-packages are in manufacture and test on schedule



No.	Equipment
1	ASIPP Technical Support
2	400kV & 66kV Circuit Breaker/DS/ES
3	400kV & 66kV Potential Transformer
4	400kV & 66kV Current Transformer
5	400kV & 66kV Surge Arrest
6	22kV GIS/AIS
7	LV & HV Cables and Terminals
8	Main Step-down Transformer
9	Substation Relays
	Substation Controllers
10	400kV/66kV/22kV Metallic Structure
11	E-house & UPS



Manufacturing in factory



Arrive at ITER site

## **Summary**

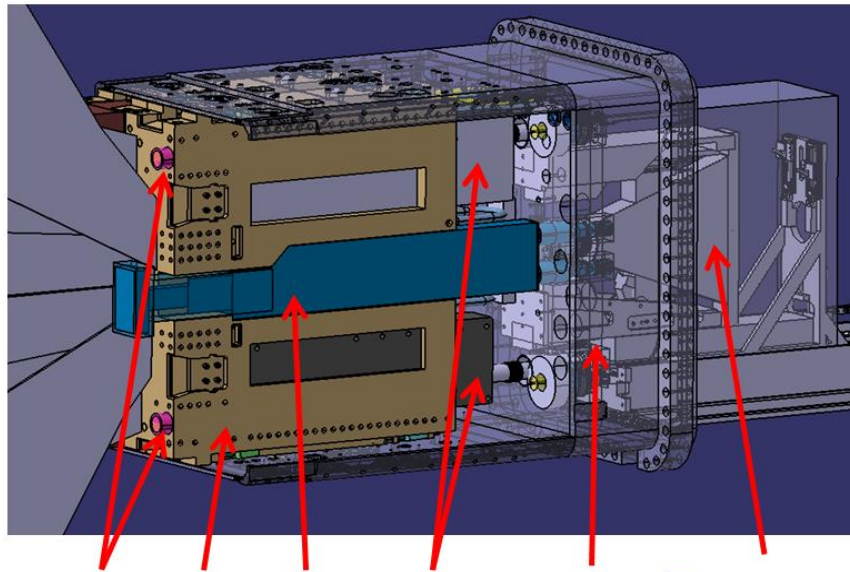
- **To complete ITER package, ASIIPP has performed a lot of R&D activity, and construct much test facility in CN DA's financial support**
- **Much equipment has been delivered and accepted by IO, also many equipment manufacturing has been completed**
- **All package meets current IO schedule.**
- **Main problem:**

**IO delay IPS, need more storage space, more human resource, more cost increase ?**



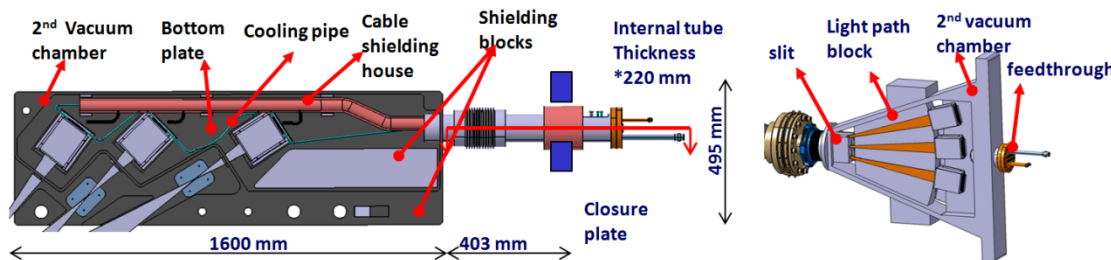
# Thanks !

# Diagnostic-Radial X-ray Camera



HXM DSM GDC In-camera Flange Ex-camera & shielding

preliminary design of RXC has been completed.  
FDR meeting can be held on time.



**Layout of internal camera and external camera**

Detail in poster, Oct. 19, by Dr. Hu



# The First Completed Task Agreement (2011-2014)

*- Final Design and Prototyping of the ITER In-vessel Coils and Feeders*

## Scope of the Tasks

- Design and analysis works by PPPL,  
in coil & feeder structural/thermal/EM \_Lead
- R&D works by ASIPP, making two prototype coils for ELM and VS
  - design optimization
  - qualification electrical and mechanical testing
  - Advanced joining studies (brazing, welding technology developing and performance inspection)
  - Coil support structure



Fabricated Mid-ELM prototype coil



Fabricated 120° VS prototype coil

# The New Task Agreement (2015)

*- Feasibility Study of a Conductor Compaction, Bending, Welding and Assembly of a Longer Conductor Length for an Alternative IVC Design with a Circular Cross-Section*

## Objectives

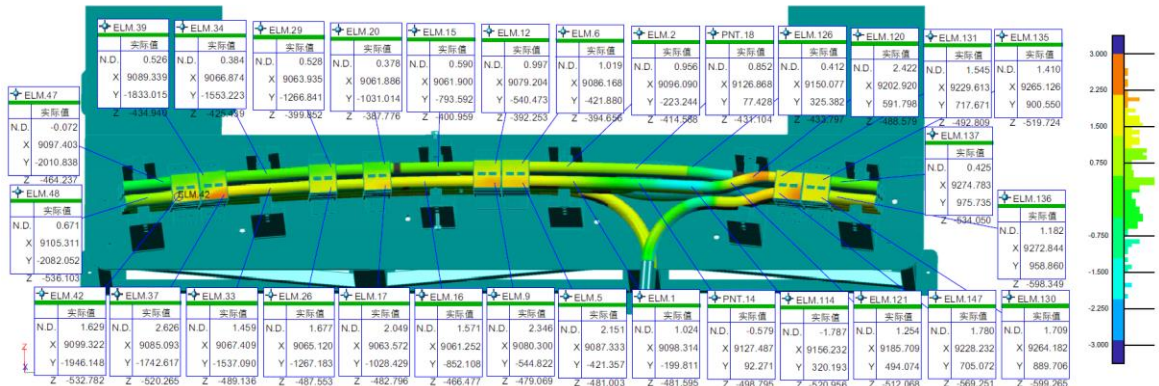
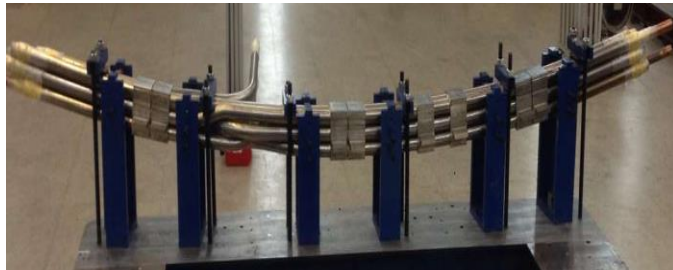
- Feasibility study of a longer conductor length for eliminating the internal joints
- Feasibility verification of the sliding brackets for reducing the thermal stress
- Performance investigation of the changed materials

## Progress of the tasks

-Finished the 40m long conductor fabrication, the required parameters and performance meet the requirements



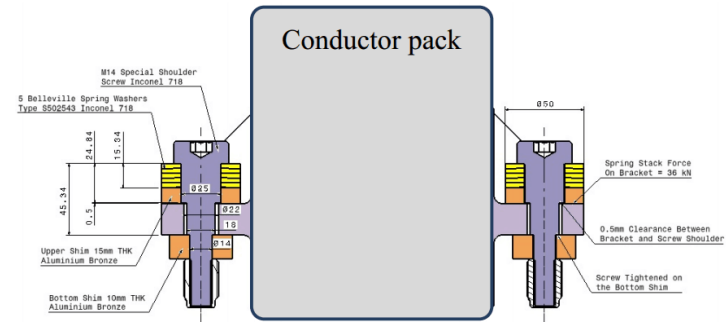
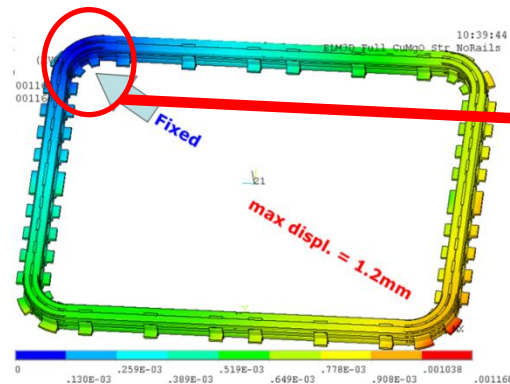
- Finished the cut-model manufacturing, the required parameters and performance meet the requirements



# The Being Planned Tests for the New TA Supplement

## 1) The bracket sliding test

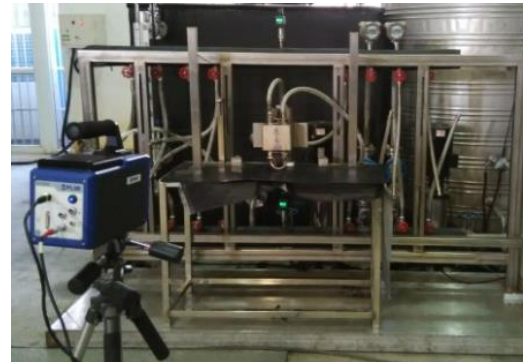
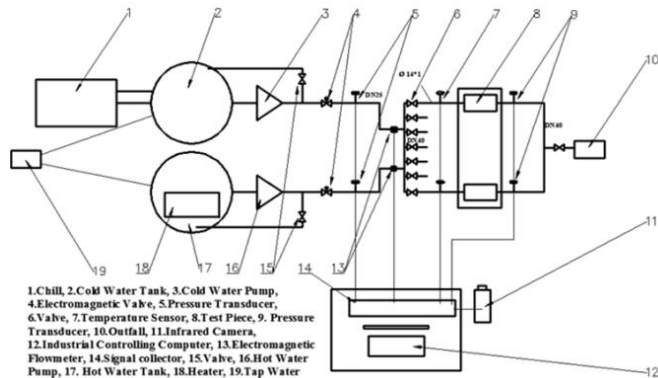
- To imitate the bracket sliding caused by thermal expansion at  $250^{\circ}\text{C}$



The designed sliding bracket

## 2) Heat transfer test for cut-model coil

- To verify whether the copper foam was fully filled and the heat transfer of the coil



Schematic diagram of heat transfer test

## 3) S-N test for the compacted Mineral-Insulated Conductor stainless steel jacket and copper tube

- to supplement fatigue parameters of the materials and verify whether it can be accepted in the operating condition or not