

ENEKUY

## Completion and test of the first ITER TF coil winding pack by Europe

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### The TF coils: main parameters

Number of TF coils	18
Magnetic energy in TF coils (GJ)	~ 41
Maximum field in TF coils (T)	11.8
Centering force per TF coil (MN)	403
Vertical force half TF coil (MN)	202
TF discharge time constant (s)	11
Total weight of TF coils system	~6540t
TF cases	~190t
TF WP	~110t
Pre-compression system, keys and bolts	~60 t

Weight (no precom.): 300t/coil

#### Peak field 11.8T

**Constant Current 68KA** 





# The ITER TF coils







#### FUSION The biggest challenge: to transfer FOR ENERGY the conductor into radial plate groove



Winding of double pancake according to nominal trajectory

Heat Treatment causes a length change  $\Delta L$ 

The conductor is inserted inside the radial plate grooves along its trajectory 750m long



Machining of the radial plate grooves according to a nominal trajectory



#### THE INSERTION OPERATION



The trajectory of the conductor and of the radial plate groove MUST STAY within +/-100ppm of the nominal trajectory along the 700m long groove !



# Status of the production



#### The 70 Radial plates: the main manufacturing steps



6 segments of ITER grade 316LN are forged for each RP (Tcourtes by hyssen)



Forged segments are pre-machined (5mm over metal) at CNM



Forged segments are butt-welded (NG GTAW or LV EB) in larger sectors at SIMIC



Final machining with portal machine on nominal trajectory at 20+/-1C (at CNIM) Sectors are welding by NG GTAW or LV EB (in photo GTAW welding-

SIMIC))



The Manufacture of the Radial Plates by SIMIC and CNIM

# All 70 RP have been successfully completed and delivered !



Celebration for the completion of last RP with representatives of companies involved.

- Achieved average flatness = 0.9mm with  $\sigma$  = 0.2mm
- Achieved average accuracy on groove length 12ppm with  $\sigma$ =19ppm
- Considering the dimensions 12mx9m and 700m long groove, quite a good result !





- Average accuracy on conductor trajectory length of 700m:
  - DP after winding = 11ppm with  $\sigma$ =7ppm
  - DP after heat treatment = 21ppm with  $\sigma$ =15ppm



• An outstanding result considering the dimensions and length of the DP conductor !

#### FUSION Steps of the WP construction at ASG (with Elytt FOR ENERGY and Iberdrola contribution)

#### 4 units completed



#### 2 units completed



Application of semiconducting painting

#### 4 units completed



Application of ground insulation

#### 2 units completed



#### 1<sup>st</sup> WP completed and 2<sup>nd</sup> manufactured and to be completed in September!



**FUSION** 

FOR



# Insertion on the WP inside the TF coil cases

 Once the winding pack arrives to SIMIC in Porto Marghera (It) it will be cooled down the WP to 80 K and HV and leak test before, during and after the thermal cycle will be carried out.



• Cryo-plant and cryostats are installed at SIMIC.



#### The WP insertion ...

• The insertion of the WP inside the cold case and the welding of the coil case will be carried out in horizontal position is order to minimize distortions of the WP due to gravity and to facilitate welding.



- During the insertion the coil cases shells slowly move toward the winding pack.
- At the end of the process the WP will be totally engaged inside the coil case.



#### The coil case closure welding

# Finally the closure welding of the coil case will be carried out with automated welding robots





#### The insertion facility at SIMIC



The insertion facility is being installed and it will be commissioned by September, ready for the coil case will be delivered by Japan which should arrive in November....



## Conclusions

- 100% RP have been successfully produced
- 63% DP have been completed
- 2 WP have been manufactured
- This has been hard work and many tough challenges had to be tackled ...
- More than 600 people and more than 25 organizations from around Europe have been involved ....
- Main recipe for the success so far has been a strong and constructive international collaboration ....
- Hopefully a good example in a time where confrontation is more common than collaboration....

# The 1<sup>st</sup> WP has been the results of more than 600 workers activity ...



**FUSION** 

ENERGY

FOR

#### FUSION The 1<sup>st</sup> WP has been the results of more than 25 ENERGY organizations activities ....

ASG

IBERDROLA

ELYTT ENERGY

Icas SIMIC 

ΞM

WORKING TOGETHER

OR THE MAGNETS

THAT WILL DELIVE THE ENERGY

OF THE FUTURE

Celebration for the completion of the 1<sup>st</sup> WP with the representatives of the main organizations which contributed to its construction

ooter (e.g. date, name of speaker, name of presentation...)



# Thank you