Target Design progress

Consorcio ESS-BILBAO & Instituto de Fusión Nuclear & ESS-AB

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December 17^{th}, 2015

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Introduction

ESS-BILBAO Consortium

Role and functions

- The Spanish Government has taken the decision to make ESS-BILBAO the only contractor from Spain to ESS project.
- Staff of 65 scientists & engineers and the possibility to hire extra staff.
- ESS-BILBAO has been nominated as Spanish representing entity for ESS operational phase.
- ESS-BILBAO is a private entity, so we have a large flexibility to employ and subcontract.
- On November 2014, ESS-Bilbao was chosen as ESS partner for Target Wheel, shaft and drive unit.
- On December 2014, ESS-Bilbao was chosen as ESS partner for Beam Dump, Proton Beam Entrance Window and Monolith Vessel.
- On September 2015, ESS-Bilbao was chossen as ESS partner for the Neutron Beam windows.

ESS-BILBAO Consortium Contribution to Target Station

On going work

WP	Name	KO meeting	Status
WP 12.2.2	Target Wheel	January 30, 2015	"2 months delay"
WP 12.2.3	Target Drive and Shaft	January 30, 2015	On time
WP 12.4.5	Tunning Beam Dump	April 10, 2015	On time
WP 13.4.3.1	Proton Beam Entrance Window	April 10, 2015	On time
WP 12.4	Monolith Vessel	September 2015	-
WP 12.4.2.2	Proton Beam instrumentation Plug	-	-
WP 12.4.6	Neutron Windows	-	-

Staff modifications

- Angelo Ghiglino is leaving the ESS-BILBAO
- 4 new positions for ESS-BILBAO Target Division. The new staff will be incorporated in February.

Vessel & Spallation Material

Vessel & Spallation Material

Target Review panel

A review panel for the evaluation of the Target was organized on October 13rd in Lund. The panel reviews in detail all the work develop in the target design. This review was planed in our schedule by February 2016 so, we did with a few months in advance.

Panel composition

- Jose Manuel Perlado (IFN)
- Phillip D Ferguson (ONL)
- Michael Butzek (FZJ)
- Masatoshi Futakawa (JPARC)
- Michael Wohlmuther (PSI)
- David Jenkins (ISIS)
- Knud Thomsen (PSI)
- Matt Fletcher (Chairman,ISIS)
- Bernie Riemer (SNS by skype connection)

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Main question to the panel

- Is the proposed concept mature enough to proceed with detailed design and analysis?
- Yes, but abrasion testing / proving is critical to conclude as the mounting technique will determine many detail design features.
- Some areas are well advanced, other areas need to keep pace
  - Hazard analysis
  - Assurance that abrasion is not an issue.
  - Weld inspection methods that assure robust joints under steady and cyclic loads.

ESS-BILBAO on going work

Based on the panel comments we are planing to perform several abrasion (already contracted with Technalia) and vibration test. Regarding the Hazard Analysis the work is ongoing. Finally, regarding the welding inspections we have award a contract to ENWESA to define the welding procedure and the inspection techniques for the critical welding areas of the target.

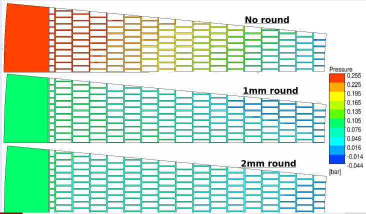
CFD Tungsten Bricks Optimization

Rounded Corners

In this table some results are shown, comparing different round radius with sharp corner solution. It can be observed that with rounded corners, the pressure drop is highly reduced down to **0.1 bar** because the boundary layer is not detached. This means that the maximum velocity is also reduced and thus, maximum temperature is higher. A radius with 1 mm seems a good choice.

TH Properties	No rounded corners	2 mm round radius	1 mm round radius
Max. Vel (m/s)	101	68.5	81
ΔP (bar)	0.3	0.085	0.1
Max. Temp (^{o}C)	351	445.5	410

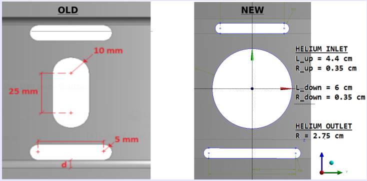
CFD 2D optimization



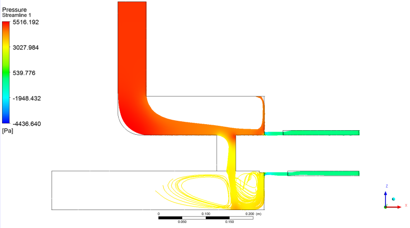
CFD holes optimization

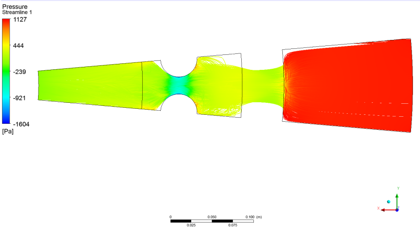
Geometry

The geometry of the inlet and outlet holes in the cylinder has been modified in order to reduce the pressure drop which is produced when the helium flow trough. The area of the holes has been increased as much as the mechanical limits of the shaft could allow.



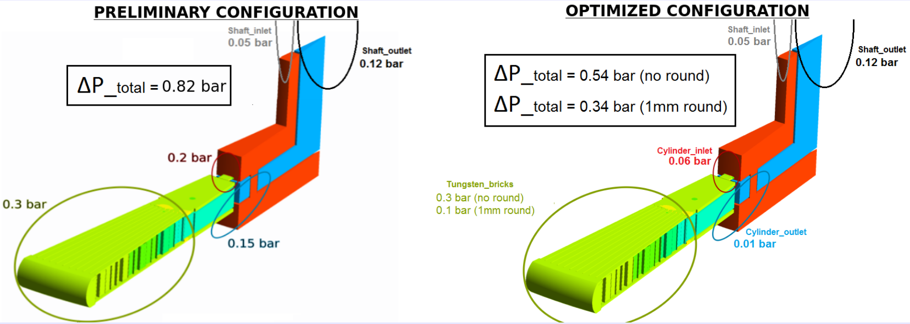
Pressure Drop: He inlet = 0.06 bar; He outlet = 0.01 bar





Wheel and Shaft pressure drop reduction

Total pressure drop



- A roughness of 5 μm has been used for the calculations.
- The pressure drop in the rotating seal has not been included

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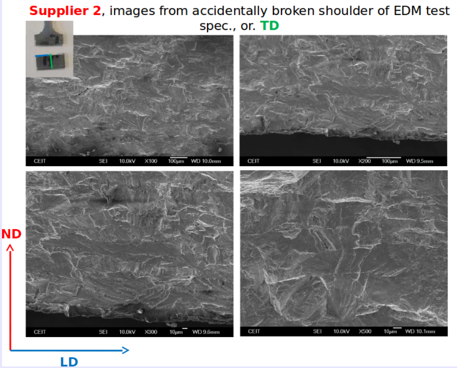
QA analysis of different W suppliers

Our industrial partner (CEIT) has almost completed the evaluation of the 6 different tungsten suppliers. 3 of them will continue in the next phase of the analysis after discussion with ESS materials group. The call for tender to supplier the W bricks is planed for the next summer.

Example of surface characterization (Supplier 2)



Vessel & Spallation Material

QA analysis of different W suppliers (EDM

W supplier	Visual inspection	Density, ρ ($g\ cm^{-3}$) Geom. ± assoc. error	Density, ρ ($g\ cm^{-3}$) Water displ. ± sd	*E*, Young modulus, RPN (GPa) ± assoc. error	*HV* (1 kg) RP ($Kg\ mm^{-2}$) ± 95% cl	Res. stresses, surface (MPa) ± sd σ_{11} (LD)	Res. stresses, surface (MPa) ± sd σ_{22} (TD)	Fractography	Chemical composition Impurities above threshold
1	Grey spots (oxide) on surface	**19.22** ±0.03	**18.95** ±0.22	**403.9** ±0.7	**423.7** ±25.7	**-1276** ±9	-1074 ±13		-
2	Thin continuous (oxide) layer on surface	**19.16** ±0.03	**19.21** ±0.03	**405.9** ±0.8	**496.5** ±9.5	**-789** ± 11	-1088 ± 9	Brittle, transgranular, distorted cleavage , oriented facets Minor intergranular fraction	-
3	Damaged edges. Scratches on surface, slightly oxidized (finger prints).	**18.27** ±0.03	**17.69** ±0.03	**364.9** ±0.7	**355** ±6	**-956** ± 20	-1166 ± 8	Brittle, intergranular fracture, equiaxed grains, porosity Some precs. at grain edges	-
4	Bright smooth surface, free from oxides	**19.24** ±0.03	**19.20** ±0.03	**408.1** ±0.8	**496** ±6.0	**-225** ± 27	-1113 ± 11		-
5	Brightest, smoothest surface. Free from oxides	**19.22** ±0.03	**19.23** ±0.01	**406.4** ±0.8	**412** ±16	**-230** ±24	-247 ±26		>30 ppm O
6	Rough surface, free from oxides. Bricks slightly shorter?	**19.26** ±0.03	**19.15** ±0.05	**391.4** ±0.7	**470** ±5.0	**-709** ± 18	-1055 ± 7		-

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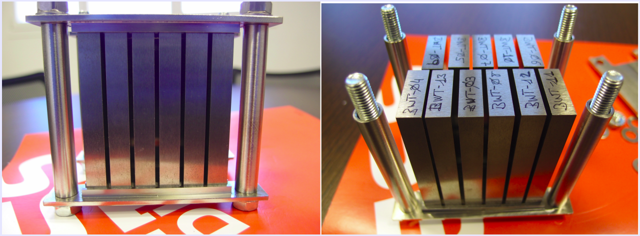
Prototype to evaluate the assembling conditions

The prototype showed on the last Technical Board was focus on the tolerances for the manufacturing process, however, the assembling process for the $\sim$ 200 bicks was defined. A new prototype of 11 bricks focused on the assembling concept has been completed (including the W bricks and top 30^o chamfer).

Based on the conclusions of the assembling prototype a final version of the cassette will be manufacture by the end of February.

Assembling prototype for 11 bricks



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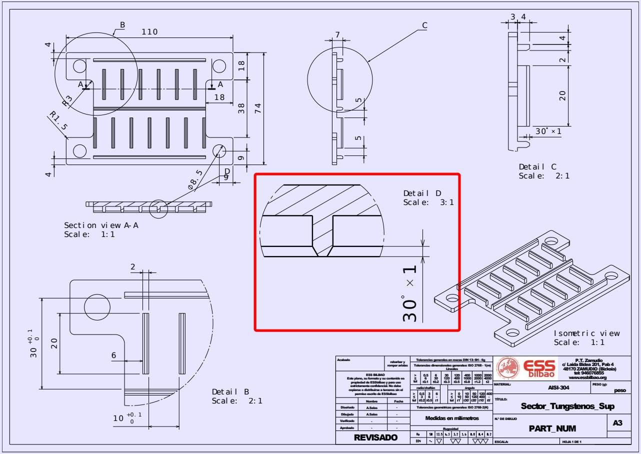
Assembling prototype for 11 bricks (top cover)



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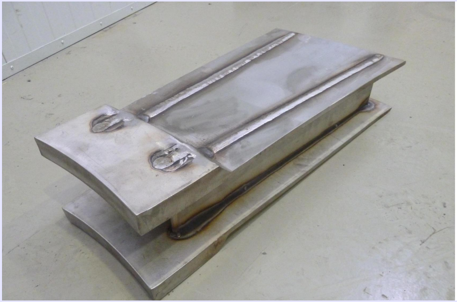
Welding prototype

The prototype is almost completed including metrology before and after the welding process. The analysis shows significant deformation ($\sim 700\ \mu m$) so machining after welding will be needed to achieve the flatness required.

A contract to ENWESA has been award to evaluate different alternatives of welding process to minimize the deformation.

On going work



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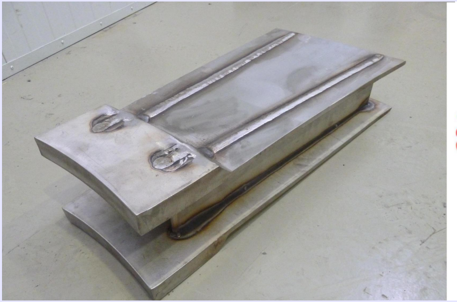
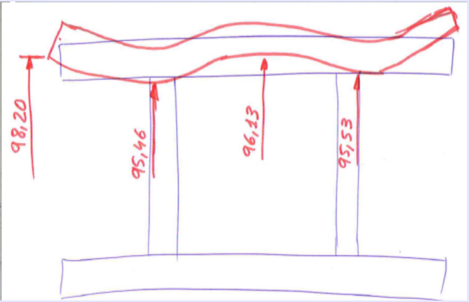




WP Drive Unit

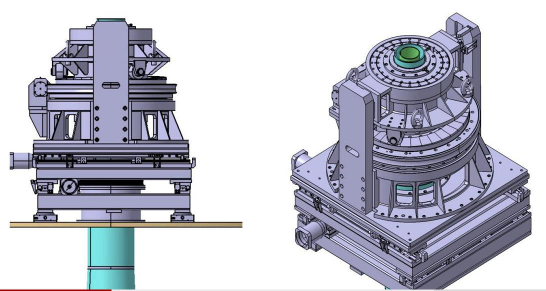
Drive Unit

Preliminary proposal completed

A.V.S (ESS-Bilbao partner for the drive unit) has completed the preliminary design of the drive unit. The selection of the main bearing an the movement system has been agreed with ESS, however some additional discussion is still needed for the motor and the control system.

All the information needed for the final drive unit call for tender has been produced (waiting for the ESS control team).It is schedule for the first trimester of 2016.

Drive Unit



Drive Unit

Bearing selection for 200.000 h of operation (Schaeffer)

2.2.7. Bearing behavior (ISO/TS16281)

Des	Lhmr h	Lhr h	Lnr 10^6 U	Lnmr/Lnr	n 1/min
718/630-MPB	924397	265176	413.7	3.49	26.0
718/630-MPB	> 1000000	> 1000000	> 1000000.0	-	26.0
NNU4952-S-K-M-SP	> 1000000	> 1000000	> 1000000.0	-	26.0

Table Explanations:
Des: Designation
Lhmr: Modified reference rating life
Lhr: Nominal reference rating life
Lnr: Nominal reference rating life
Lnmr/Lnr: Life factor
n: Equivalent speed

2.2.8. Bearing behavior (Catalog)

Des	Lh10 (xy) h	L10 (xy) 10^6 U	S0_xy_min	n 1/min
718/630-MPB	171514	267.6	33.600	26.0
718/630-MPB	> 1000000	> 1000000.0	> 100.000	26.0
NNU4952-S-K-M-SP	> 1000000	> 1000000.0	> 100.000	26.0

Table Explanations:
Des: Designation
Lh10 (xy): Catalog rating life to DIN ISO 281
L10 (xy): Catalog rating life to DIN ISO 281
S0_xy_min: Static load safety factor (Catalog)
n: Equivalent speed

Conclusions

Summary

- The target project is average on schedule.
- First Review was organized 3 months in advance. No mayor issues were shown by the panel.
- Final CFD & FEM modeling is on going.
- The focus of the next months will be the W supply process and the cassette manufacturing.
- Target wheel Welding process seams to be challenging so additional prototyping activities are needed.
- Drive Unit ready for call for tender.