The final design and manufacturing process for the ESS Monolith Vessel

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Consorcio ESS-BILBAO[1], AVS+CADINOX[2] , European Spallation Source ERIC[4]

November 1th, 2023

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Introduction

Introduction

ESS project

ESS is an going project to build a 5 MW spallation soure in Lund (Sweden) with a total budget $\sim 1800 M e$. There is 17 Eu countries that take part in the project. Spain contributes with 3% of the total construction cost.

ESS construction site

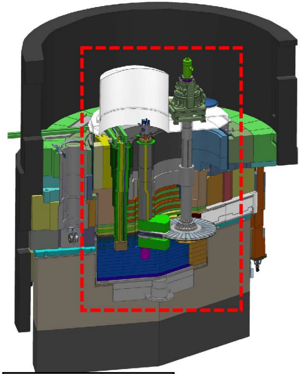
ESS-BILBAO Consortium

Role and functions

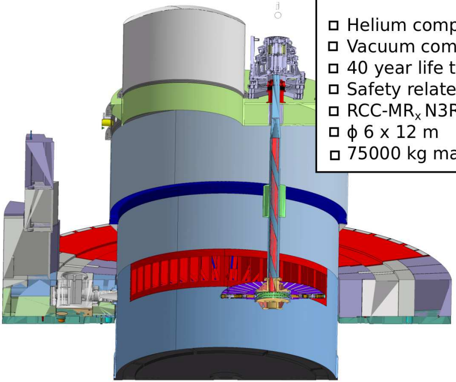
- ESS-Bilbao is public consortium between Spanish Central Government and regional goverment of Vase Country region.
- ESS-BILBAO has been nominated as Spanish representing entity for ESS operational phase.
- Staff of 50 scientists & engineers.
- The collaboration between ESS-Bilbao and IFN started on 2009. ESS-bilbao Target division is working at IFN facilities in Madrid.
- On December 2014, ESS-Bilbao was chosen as ESS partner for Monolith Vessel.
- KO meeting held on December 2015.
- On February 2017, Critical design review for the Lower and medium vessel.
- Contract for LMV manufacturing awarded on September 2018 to AVS+CADINOX.
- Manufacturing is on going.

Introduction

ESS Monoltih Vessel on ESS target station



ESS Target Station



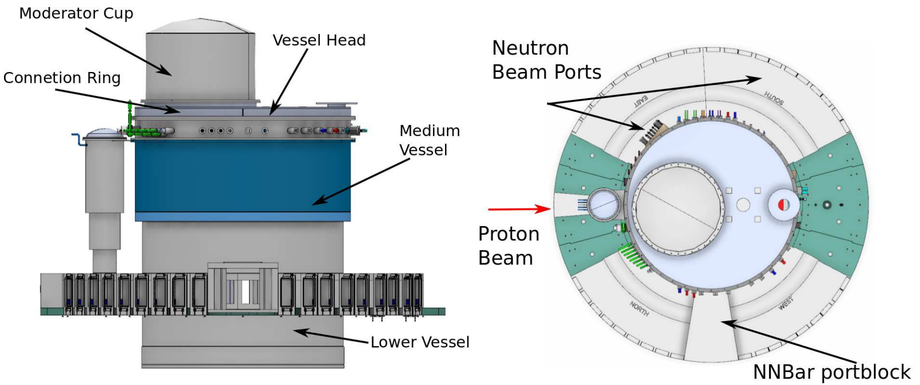
Monolith Vessel

Monoltih Vessel

- Helium compatible
- Vacuum compatible
- 40 year life time
- Safety related equipment
- RCC-MR$_x$ N3Rx
- ϕ 6 x 12 m
- 75000 kg mass

Introduction

ESS Monoltih Vessel on ESS target station



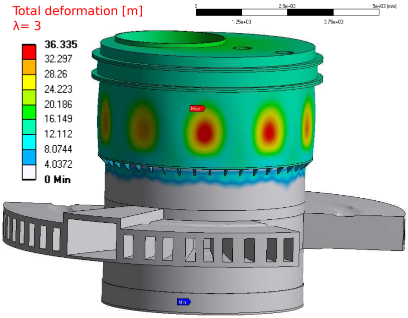
Lower and medium vessel

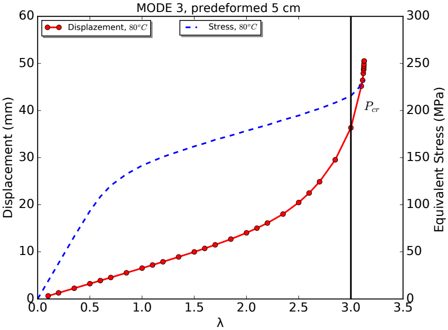
Critical design review proposal

Design analysis

The design proposed on CDR (July 2017) was optimized according to several load cases (vacuum, 2 bar overpressure, seismic events ...). The CDR was approved on late 2017 but due to admnistrative reasons the Call for tender was not published until Summer 2018.

Bluckling elastoplastic analysis for a 20 mm predeformed geometry





Manufacturing process

Raw material provided by Outokumpu

The raw material is composed by ∼ 45 tonnes of plates with thicknesses from 25 to 90 mm and more than 4 tonnes of filled material for TIG and Submerged arc welding processes. The production takes more 20 weeks an the material was delivery in July 2019.

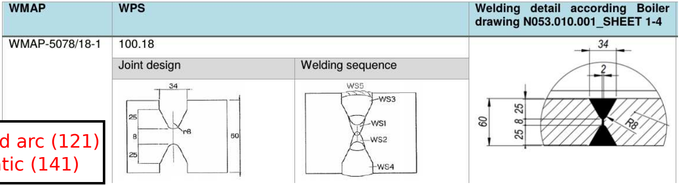
Raw material and filled material (∼ 4 tones) delivery

Plates delivery

Dimensional control

Manufacturing process Lower Vessel

Complex welding process based on summerged arc (121) + TIG (141)



WMAP	WPS		Welding detail according Boiler drawing N053.010.001_SHEET 1-4
WMAP-5078/18-1	100.18		
	Joint design	Welding sequence	

WS1-WS4 Summerged arc (121)
WS5 TIG semiautomatic (141)

Bottom plate welding completed

Manufacturing process Lower Vessel

Complex welding process based on summerged arc (121) + TIG (141)

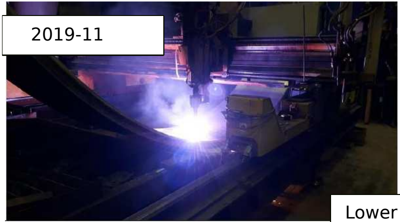
2019-11

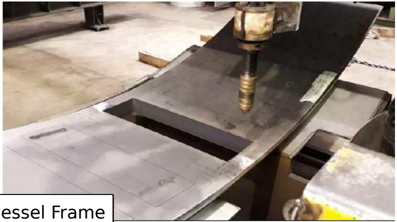
Lower vessel: Central frame

160 mm TIG welding (141)

Manufacturing process Lower Vessel

Complex welding process based on summerged arc (121) + TIG (141)





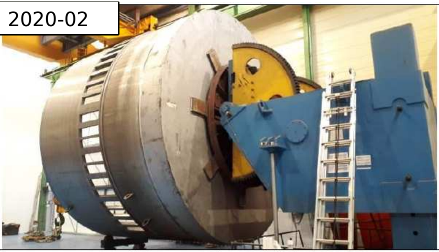
Lower body with rear window tack welded

Lower body with front window tack welded

Manufacturing process Lower Vessel

Complex welding process based on summerged arc (121) + TIG (141)

2020-02



Lower part in positioner

Inner view

Manufacturing process Lower Vessel

Complex welding process based on summerged arc (121) + TIG (141)

2020-04

Lower part with covers

Supports for dimensional control to be moved

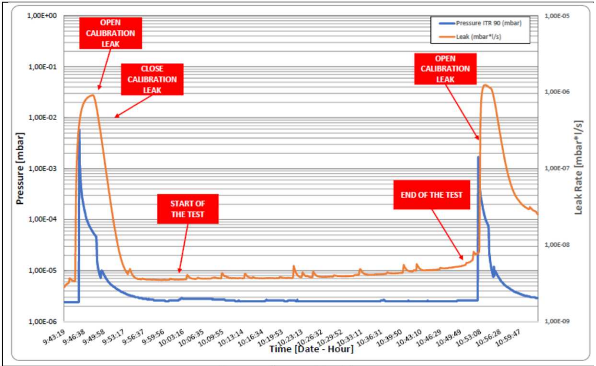
Preessure and vacumm test

Vacum test held on $May 15^{th}$, 2020

General view of vessel

Leak rate: 6.6E-9 mbar l s^{-1}

Vac. Level: 1E-6 mbar



Pressure time graphic of the test

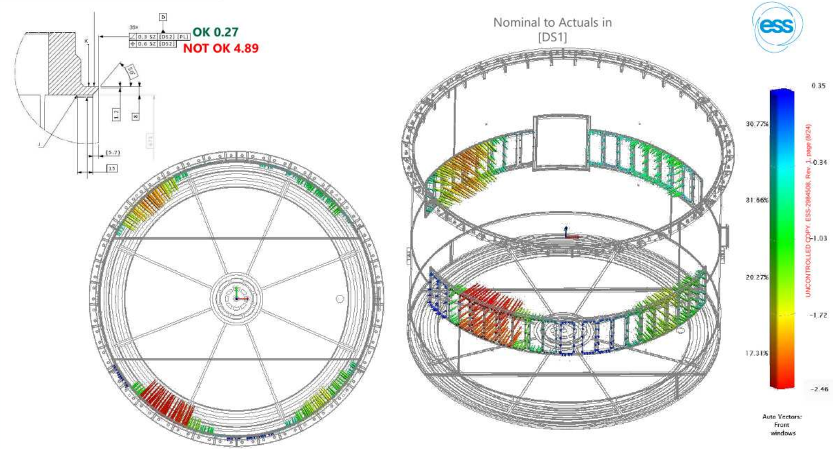
Final machining

Windows final machined extended for 2 months

Dimensional Control (ESS metrology team post process)

Final dimensional control

3 – Neutron Windows: Front side



Welding to the neutron ports

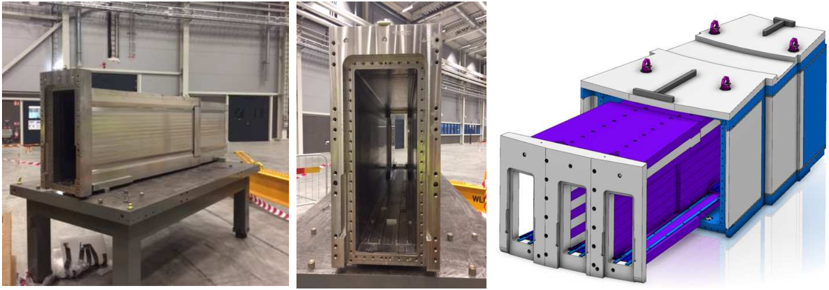
Welding to the neutron ports

Scope of the work

The LMV has be to welded to the port blocks. The ports are ESS scope (design and manufacruting). ESS awarded the contract for manufacturing to Ensa and Asturfeito. The ports are laser welded and machined thus, extremely good tolerances after alignment are expected. ESS Bilbao was responsible of the welding between the vessel and the ports.

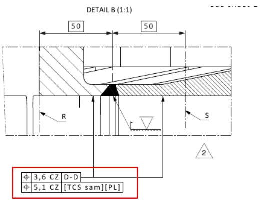
Welding to the neutron ports

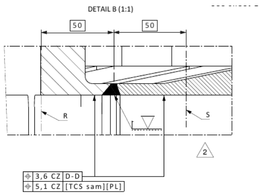
Neutron ports (ESS scope)



Welding to the neutron ports

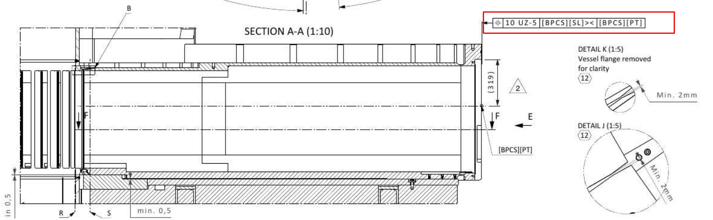
Requirements





~5 mm local shrinkage

~10 mm radial displacement



Welding to the neutron ports

Welding plan

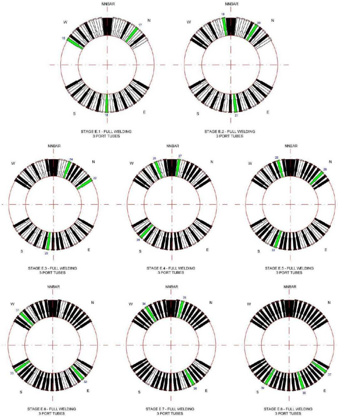
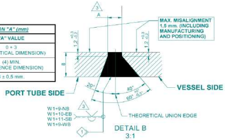
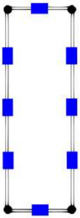


Fig. 20 – Complete weld of remaining Port Tubes.

Manuel TIG (141) in 4 layers
~8 mm thickness

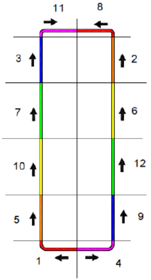
VALUES FOR DIMENSION "A" (mm)	
CONDITION	"A" VALUE
POST-WELD	0 ÷ 3 (THEORETICAL DIMENSION)
AFTER TACK-WELDING	(4) MIN. (REFERENCE DIMENSION)
AFTER ASSEMBLY	6 ± 0,5 mm.





● Tack weld 20-30 mm

■ Spacer blocks 20-30 mm.



12 SECTORS 100-150mm

Welding to the neutron ports

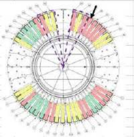
Modifications of the welding scheme on site

Welding to the neutron ports

Dimensional control during welding

N6 PT11

PORTTUBE INSTALLTION MONITORING



Porttube Position N6

Identification	#11- Type B

Dimensional monitoring according to ESS-3416994

ESS activity in red text. InKind activity in blue text

	Performed
Arrival at site	2021/09/06
Released for installtion	2021/09/16
Lifted to Monolith	2021/10/08
Aligned	2021/10/13

Dimensional monitoring before Tack-weld		Value	[Go]	[Stop]	
Dimension #01a	2021/10/13	1.10	2.75	3.70	Mandatory
Dimension #01b	2021/10/13	0.76	1.75	2.50	Mandatory
Dimension #02	2021/10/13	0.51	1.75	2.00	Mandatory
Dimension #03	2021/10/13	-1.30	0.00	4.00	Mandatory
Dimension #04	2021/10/13	11.54	15.50	17.00	Mandatory

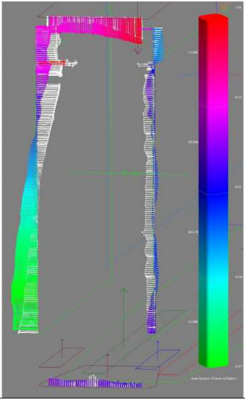
X-direction Gauge	2021/10/15	Pass
Y/Z directiont Gauge	2021/10/15	Pass
Tack-weld	2021/10/15	
Y/Z directiont Gauge	yyyy-mm-dd	Pass/Fail

Dimensional monitoring after Tack-weld		Value	[Go]	[Stop]		Change
Dimension #01a	2021/10/20	1.45	2.85	3.80	If selected	0.35
Dimension #01b	2021/10/20	0.94	1.85	2.60	If selected	0.18
Dimension #02	2021/10/20	0.78	1.85	2.10	If selected	0.27
Dimension #03	2021/10/20	0.45	1.00	5.00	If selected	1.75
Dimension #04	2021/10/20	12.38	15.50	17.00	If selected	0.84

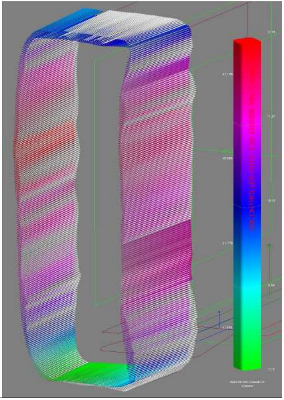
Root-weld	2021/11/16	
VT Root-weld	yyyy-mm-dd	Pass/Fail
PT Root Weld	yyyy-mm-dd	Pass/Fail
Section Gauge inspection	yyyy-mm-dd	Pass/Fail

Dimensional monitoring after Root-weld		Value	[Go]	[Stop]		Total Change	From tack Change
Dimension #01a	yyyy-mm-dd	1.00	2.95	3.90	If selected	-0.10	-0.45
Dimension #01b	yyyy-mm-dd	0.97	1.95	2.70	If selected	0.21	0.03
Dimension #02	yyyy-mm-dd	0.94	2.00	2.25	If selected	0.43	0.16
Dimension #03	yyyy-mm-dd	1.22	4.80	6.80	If selected	2.52	0.77
Dimension #04	yyyy-mm-dd	12.58	*	*	If selected	1.04	0.20

Deviation after root weld
Dim #1a #1b #2
Note: White vectors after tack weld



Deviation after root weld
Dim #4
Note: White vectors after tack weld



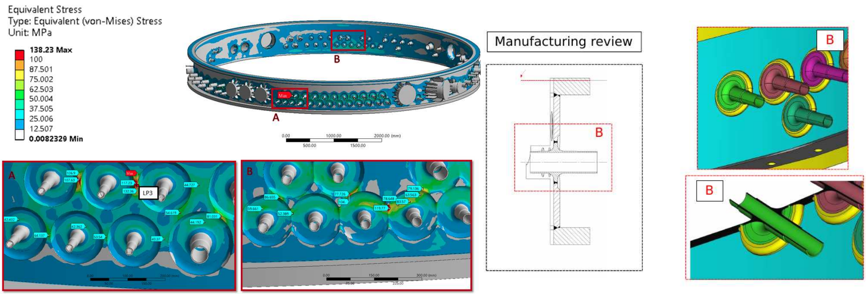
Connection Ring

Connection Ring

Design considerations

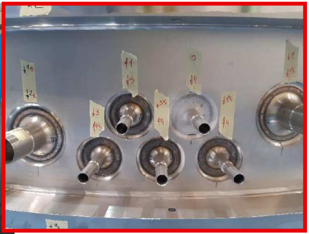
The CR is the section of the monolith vessel prepared to include all the connections of the in vessel equipment (> 100). To minimize the deformation produced by the nozzle welding, we introduce Nozzle thickness transitions to reduce the welding volume.

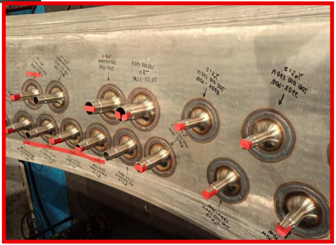
Lessons learned on the LMV applied to CR



Connection Ring

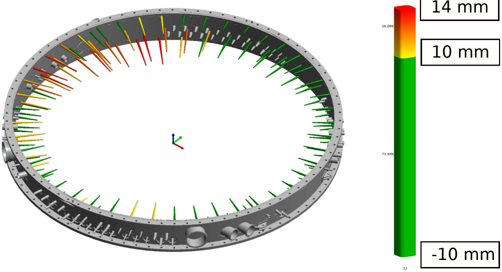
Manufacturing process completed on May 20232





Connection Ring

Pressure test, leak test and metrology completed on June-July 2022



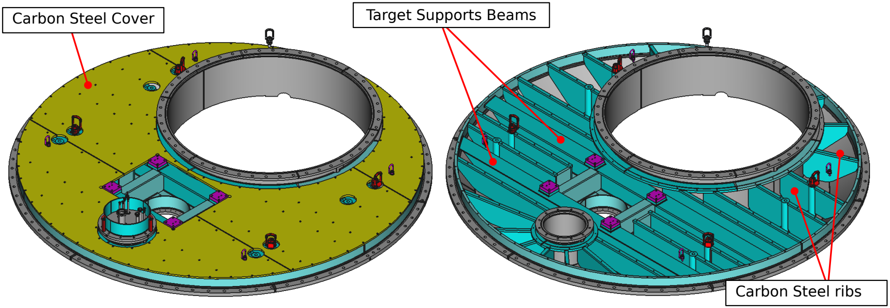
Head of the vessel

Head of the Vessel

HoV design completed and manufacturing on going

The HoV is based on stainless steel vessel and carbon steel ribs. It also includes two beams decoupled from vacuum structure to avoid target movement when vacuum is made in the monolith vessel. Also includes a layer of 25 cm of "borated concrete" to provide neutron shielding.

HoV design completed and manufacturing on going



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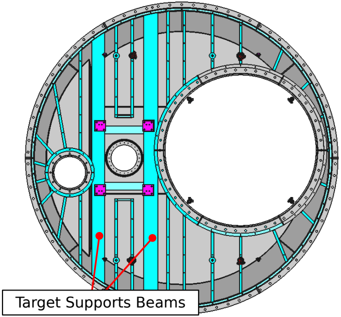
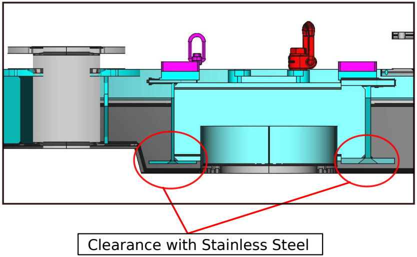
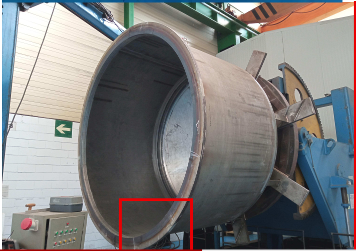




Head of the Vessel

Pressure test, leak test and metrology completed on June-July 2022

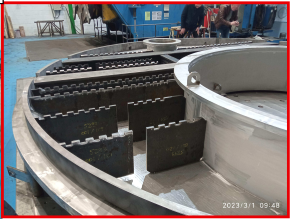
HoV welding process Q4 2022/



Head of the Vessel

Pressure test, leak test and metrology completed on June-July 2022

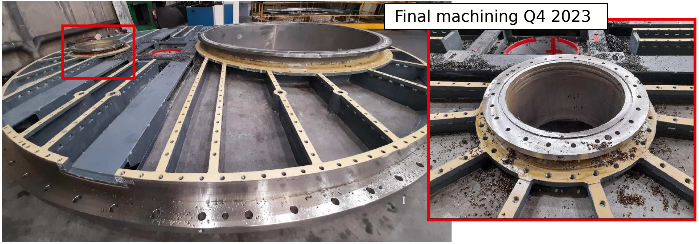
Carbon steel ribs assembly Q1 2023



Borated concrete installation Auguts 2023

Head of the Vessel

Pressure test, leak test and metrology completed on June-July 2022



Conclusions

Conclusions

Main remarks

- LMV manufacturing, FAT and SAT completed on 2020.
- Welding of the LMV to the neutron ports completed on 2022
- CR and HoV manufacturing, FAT and SAT completed on 2022
- HoV manufacturing completed, FAT and SAT schedule for Q4 2023