The final design and manufacturing process for the ESS Monolith Vessel

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Consorcio ESS-BILBAO[1], AVS+CADINOX[2]
Bureu Veritas[3] , European Spallation Source ERIC[4]

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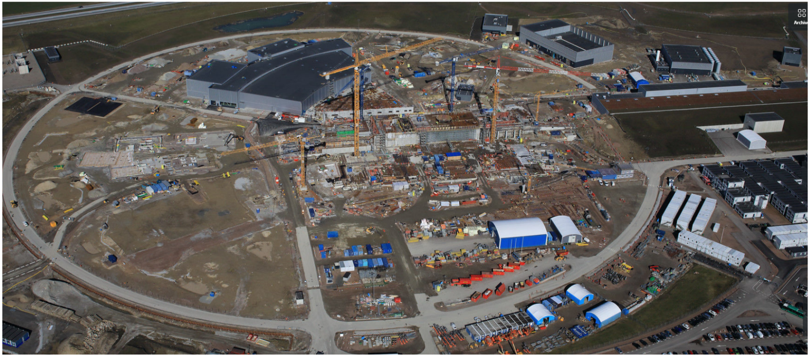
Introduction

Introduction

ESS project

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

ESS construction site (View in March 2019)



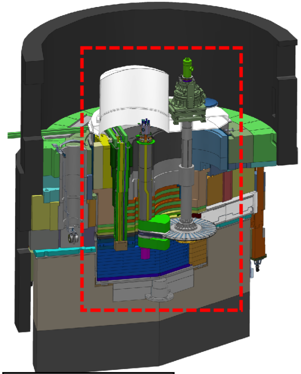
ESS-BILBAO Consortium

Role and functions

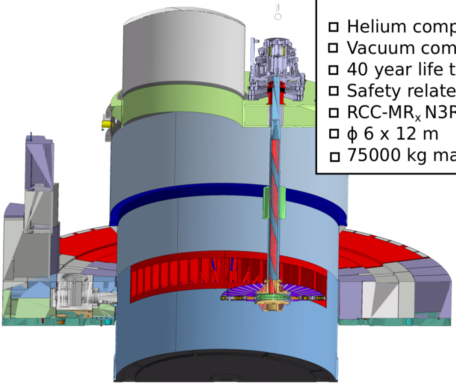
- ESS-Bilbao is public consortium between Spanish Central Government and regional goverment of Vase Country region.
- ESS-BILBAO has been nominated as Spanish representing entity for ESS operational phase.
- Staff of 50 scientists & engineers.
- The collaboration between ESS-Bilbao and IFN started on 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



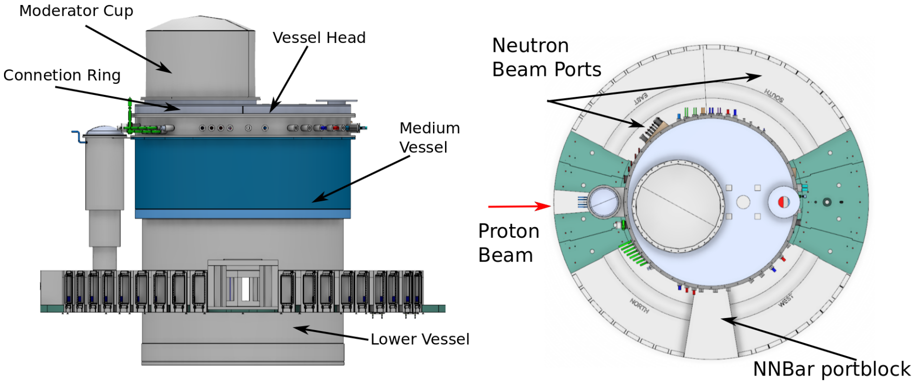
Monolith Vessel

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



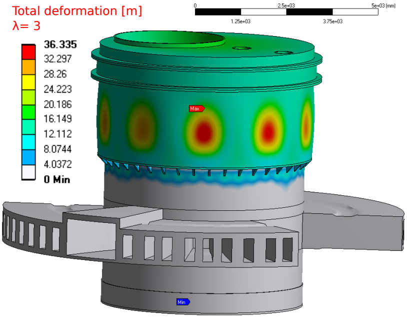
Critical design review

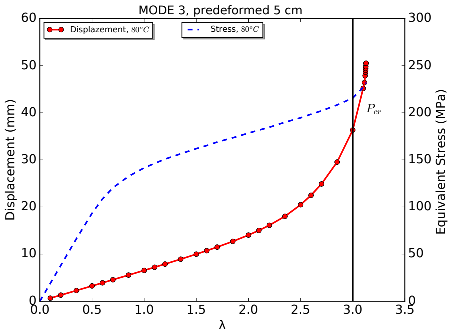
Critical design review

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





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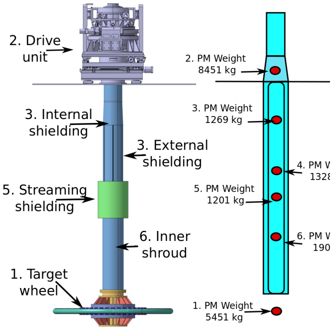
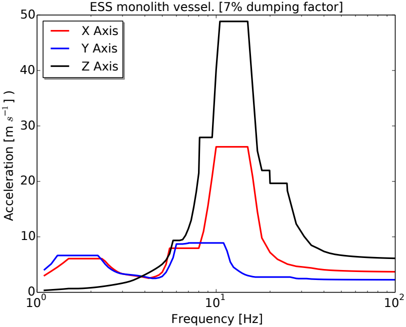
Seismic events analysis.





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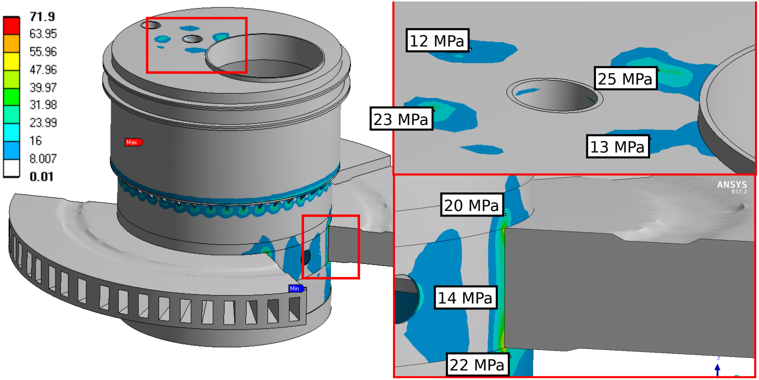
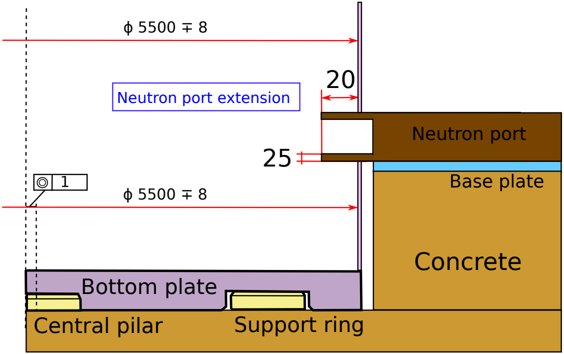


Critical design review

Manufacturing plan

The propose manufacturing plan considers to build the vessel is a single piece, cutted after the pressure test and ship to Lund in tow sections. This proposal includes significant on site work for bevel preparation and final welding.

Assembling scheme



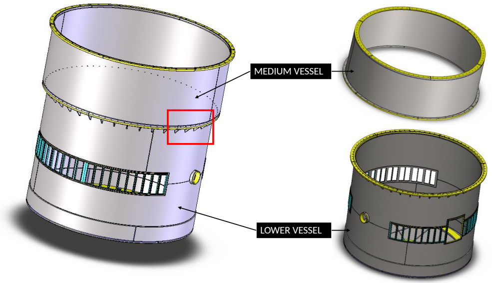
Redesign work

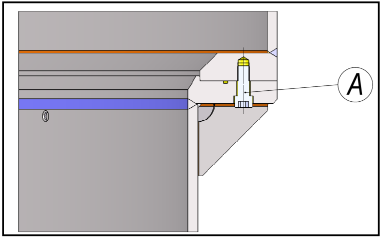
Redesign work

Contract awarded to AVS+CADINOX

On September 2018, the manufacturing contract was awarded to AVS+CADINOX. The new manufacturing team adapted the design to his technical capacities in order to minimize on site work. Its facilities has a limitation in the maximum hight of the vertical lathe and thus the vessel was split in two sections flange connected.

CADINOX vertical lathe. Maximum hight $\sim$ 3 m





Bolted connection
+ sealing weld on site

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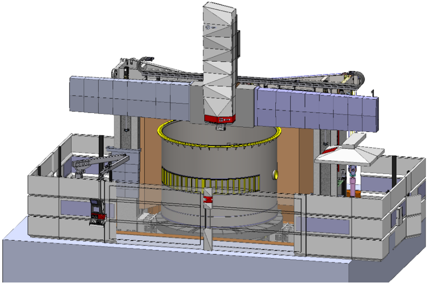
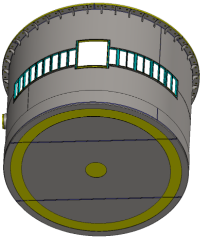


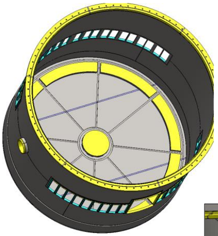
Redesign work

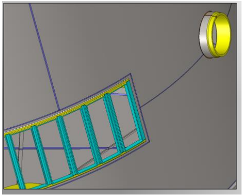
AVS+CADINOX change requested

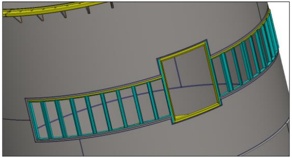
The thickness of the flanges and lateral walls were increased to withstand the loads produced in the machining process. The connection between both sections relies on bolted flange seal welded on site.

Vessel split in two sections flanged









Surfaces to be machined after welding process

Redesign work

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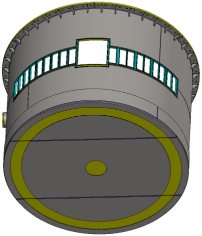

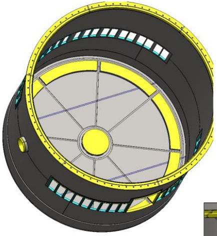

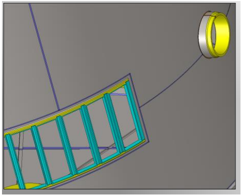

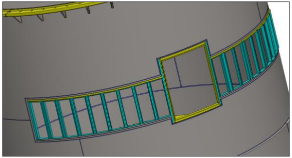

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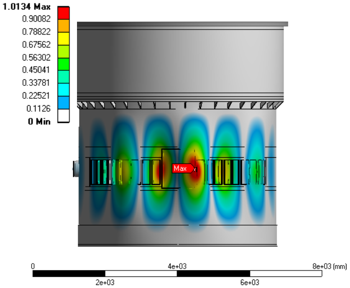

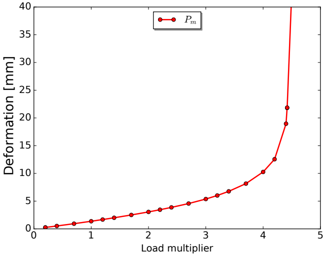

Redesign work

Welding book

The monolith have to be compatible with nuclear design rules ($RCC - MR_x$ $N3R_x$) and vacuum. This limits the welding technologies for TIG (141) which is not feasible for large components. The solution is to combine TIG (141) welding for root passes facing the vacuum and submerge arc for the bulk (121)

WPQR and welding book

ESS WPS nº	Tipo de soldadura	Material base	Proceso soldadura	Automatizacion	Espesores (mm)	
		PQR			PQR	Rango cualificacion
001	BW-chapa	X2CrNiMo17-12-2 (316L)	141 (TIG)	Manual	20	10-40
002	FW	X2CrNiMo17-12-2 (316L)	141 (TIG)	Manual	20	3-40
003	FW	X2CrNiMo17-12-2 (316L)	141 (TIG)	Manual	T1=6 / T2=25	T1=3-12 / T2=3-50
004	BW-chapa	X2CrNiMo17-12-2 (316L)	141 (TIG)	Manual	2	1-4
005	BW-tubo	X2CrNiMo17-12-2 (316L)	141 (TIG)	Manual	2,9 (D26,7)	1,45-5,8 (D≥13,35)
006	BW-tubo	X2CrNiMo17-12-2 (316L)	141 (TIG)	Manual	25 (D450)	12,5-50 (D≥225)
008	BW-chapa	X2CrNiMo17-12-2 (316L)	141 (TIG)	Manual	40	20-80
009	BW-chapa	X2CrNiMo17-12-2 (316L)	121(SAW)	Semi-automático	30	15-60
011	BW-chapa	X2CrNiMo17-12-2 (316L)	141 (TIG)	Semi-automático	40	20-80

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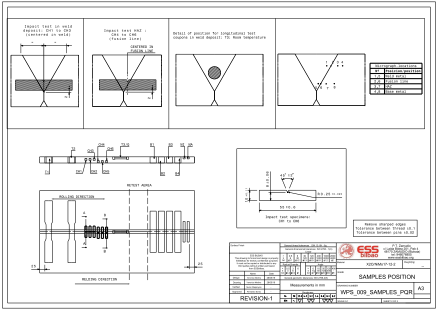

Manufacturing process

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

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Raw material and filled material (∼ 4 tones) delivery

Welding consumables

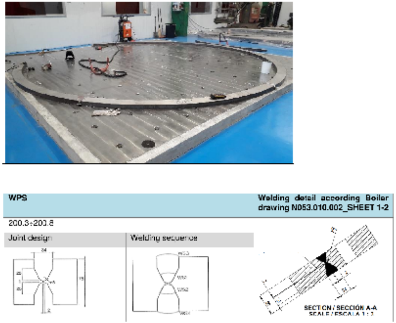
Quality labels (TIG wire)

Manufacturing process

Flanges welding

The flanges are manufacture on six sections that will be TIG welded and machined to compensate the deformations. The welding process and the NDI inspections are completed.

Flange welding completed (70 mm manual TIG (141)



Flanges assembly

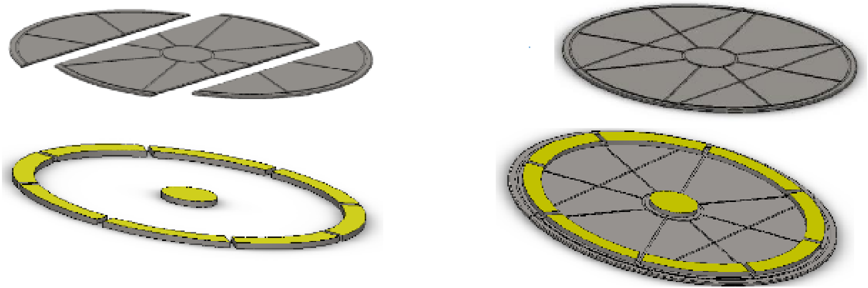
Manufal TIG (141) welding

Manufacturing process

Bottom plate

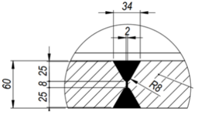
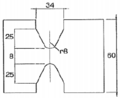
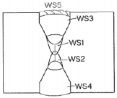
The bottom plated in assembled on three sections welded (60 mm thickness). On top of this structure the central supports are welded (filled non continuous welding).

Bottom plate (100 mm summerged arc (121) + TIG (141)

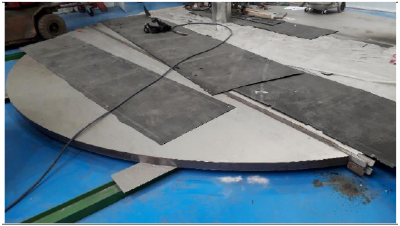


Manufacturing process

Bottom plate (100 mm 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)

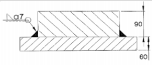


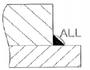
Bottom plate welding completed

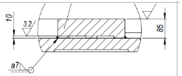
Manufacturing process

Bottom plate (100 mm summerged arc (121) + TIG (141)

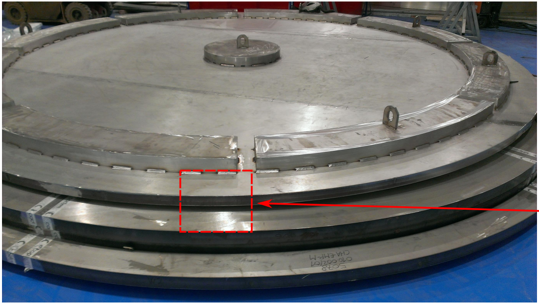
WMAP-5078/18-2	100.23	
	Joint design	Welding sequence







Support blocks

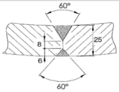


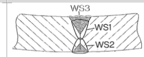
Spot TIG welding (141)

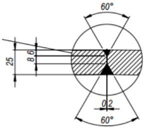
Manufacturing process

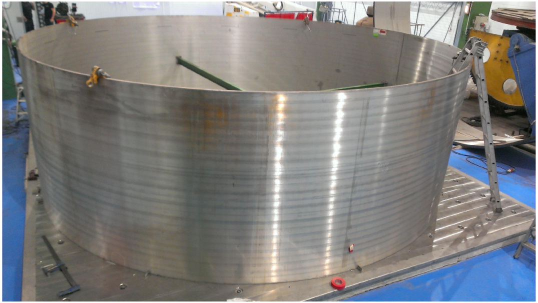
Medium vessel wall

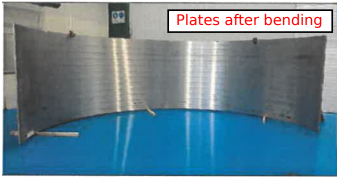
WMAP	WPS		Welding detail according Boiler drawing N053.010.002_SHEET 1-2
WMAP-5078/18-6	200.1		
	Joint design	Welding sequence	

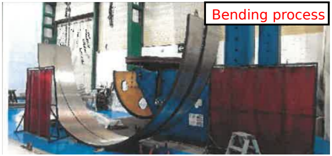









Plates after bending


Bending process

Conclusions

Conclusions

Main remarks

- The design has been adapted to suppler technical capacities.
- Raw material reception was completed in June 2019
- Welding qualification processes were completed on August 2019.
- Manufacturing is on going and the component will be delivery in Q1 2020.