PBW –Vessel & Port Block manufacturing process

Consorcio ESS-BILBAO & Nortemecanica & European Spallation Source ERIC

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Material specification

General Standards

The Protom Beam Window will be manufactured on X2CrNiMo17-12-2, Grade 1. In order to fulfill the requirements in RCC-MRx section III, tome 1, subsection D (Class $N3R_X$ Section RD 2000). The raw material will have 3.1 certificate under EN 10204 standard:

- Plates: EN 10028-7
- Forgings: EN 10222-5
- Bars: EN 10272
- Tubes : En 10255

Material specification

Additional test

- Room temperature tensile test to determine Ultimate tensile strength (R_m), yield point (R_{eL} or $R_{eH)}$, Elongation (A5 or A10)
- Impact test at 0^oC according to EN ISO 148-1 and EN 10045-1 (Charpy V-notch impact test).
- Vickers Hardness test according to EN ISO 6057.
- Ultrasound inspection of 100% of the volume according to EN 10228-5. EN 10307 for Plates and EN 10228-4 for forgings.
- Ferrite content evaluation using the Pryce and Andrews diagram.
- A micrographic examination, with photographs, to be performed parallel to the main direction of extension.
- Chemical analysis including Co content
- Surface roughness test according to ASTM D7127

Material specification

Suggestted method

- Feritscope FMP30 measures ferrite content in s.s. acc. to magnetic induction method.
- Easy to mesure.
- Reading displayed and stored in instrument.

Material specification

Acceptance criteria

- Mechanical properties shall comply with table RM 3321.51
- Ferrite content: Lower than 1%
- Micrographic examination: The structure must be homogeneous. The grain size number as determined in accordance with RMC 1350, shall be greater than 2. This grain size is determined on a test sample taken close to the mechanical test specimens.
- Co content lower than 0.2 %.
- Surface roughness lower than 3,2 μm.

Assembling scheme

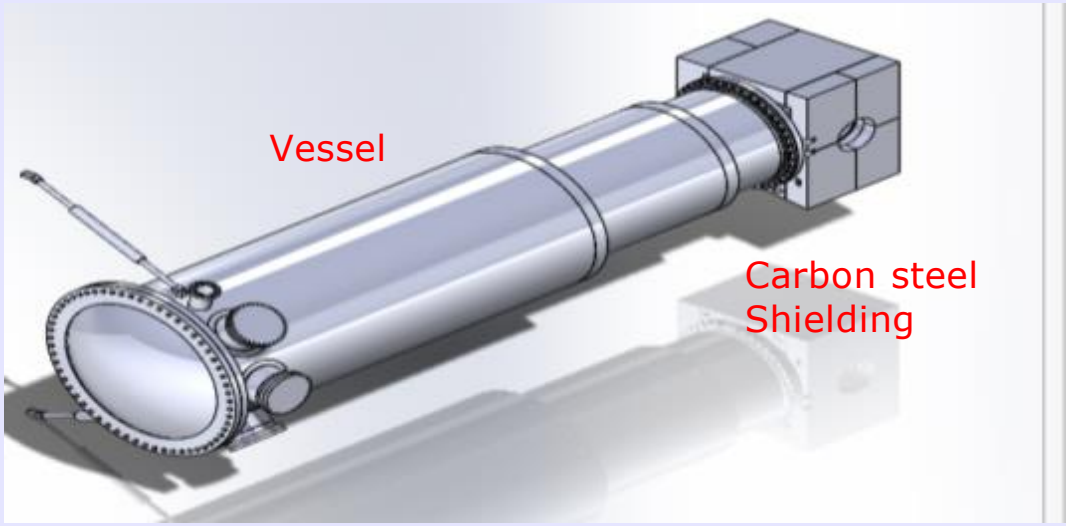
Assembling scheme

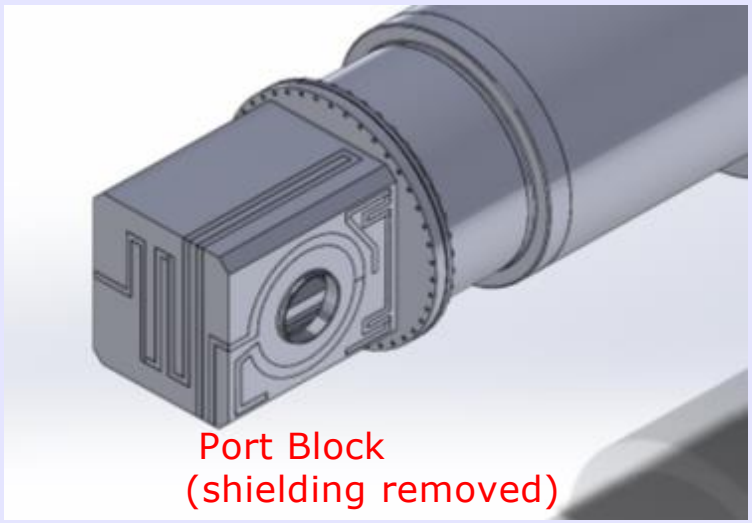
PBW- Proton Beam Window

The following pictures shows the different sections and the final PBW assembly :

- “Vessel” (2000_PBW_Vessel)
- “Port Block” (3000_PBW_PB_100)
- -“Shielding” (3000_PBW_PB_200).
- **Connecting Pipe is out of NORTEMECANICA scope of supply!**

Assembly



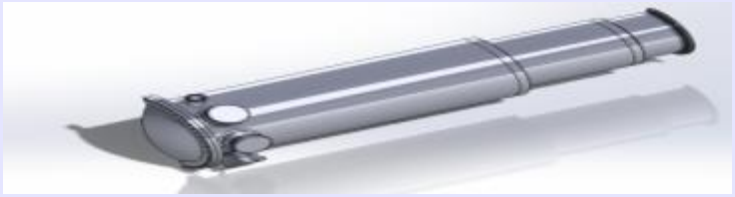


Assembling scheme

PBW- Vessel

Two components:

- Top Head : upper flange and head.
- Main body: Flanges, nozzels and shells.

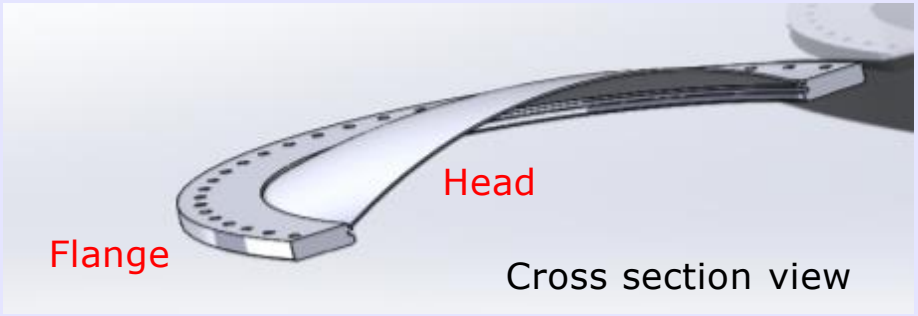


Top Head: There´re two possible options.

- Alternative #1: The top head will be made from a dished head of 5mm thickness, welded to a 75mm th. forged flange.

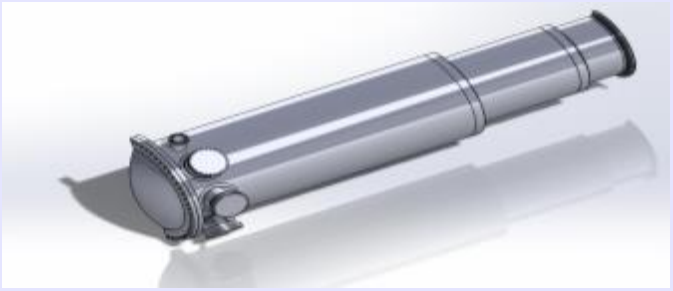
- A volumetric inspection of this weld is really a challenge,due to RT or UT are not phisically possible with this design.

Flange joint face and holes will be machined after welded, in milling machine.



Assembling scheme

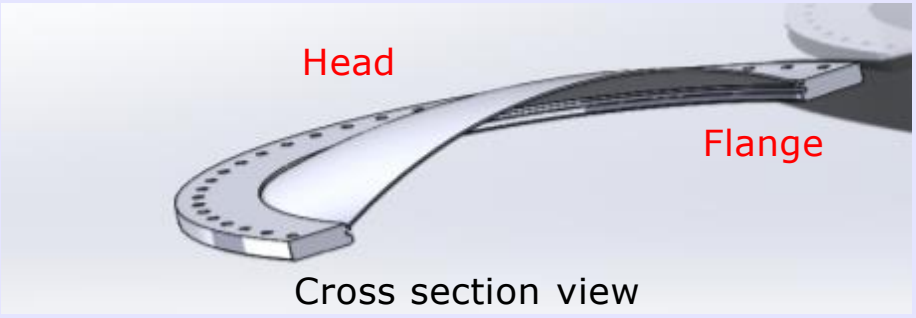
PBW- Vessel



Top Head

- Alternative #2: The top head will be made from a forged disc in a pre-machined condition.Prior to this, an UT 100% to raw material is a requirement. Final dimensions will appoached by machining on a lathe & milling machine.

Bottom view

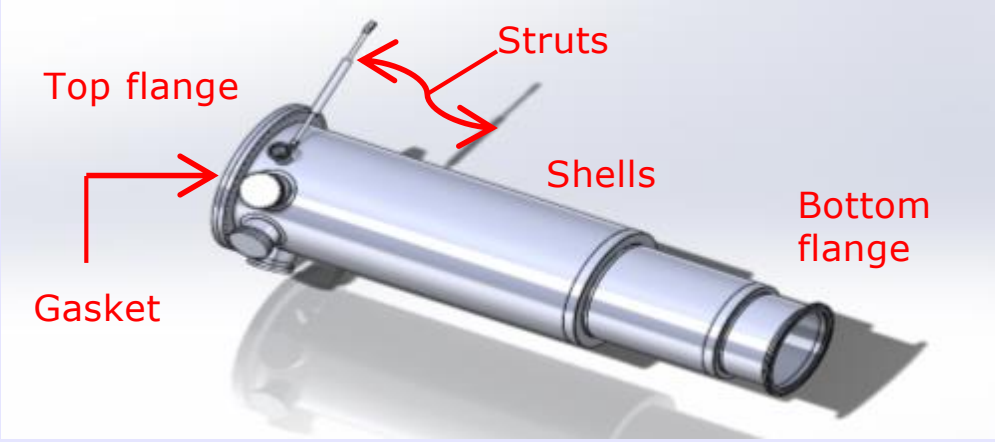


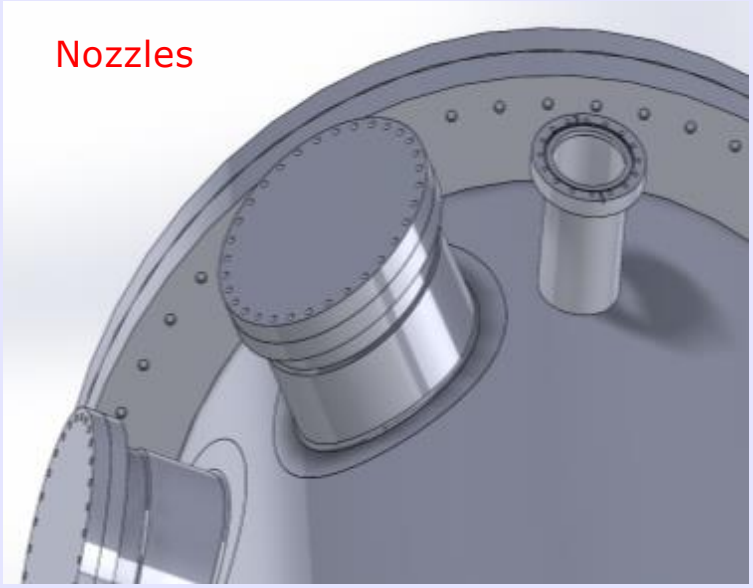
Cross section view

Assembling scheme

Main body : elements

- Threaded flange at the top.
- Three different sections: Ø1024, Ø824 & Ø714mm.
- Two rigid struts & weld-on brackets, for transmitting bidirectional loads w/Monolith Vessel.
- Five nozzles: DN50, DN100 & DN250(x3). Purposes: feed media, cabling, pressure and vacuum systems.
- Two reinforcement rings at intermediate sections.
- Drilled flange at the bottom.





Assembling scheme

Main body: manufacturing

Steps:

1) s.s. plates will be cut to the proper dimensions.
2) Machinig bevels in all sides.
3) 1st bending process for 10mm th. plates in a rolling machine.
4) Welding L.S.W. by certif. welders using a WPS (GTAW).
5) 2nd bending process to correct distorsions, for each shell separately.
6) 100% Volumetric inspection (RT and/or UT) to seam weld.

Assembling scheme

Main body: manufacturing

7) Assembly of all shells, flanges & reinforcement rings using welding rotators.

8) We´ll identified and marked the main axes.

9) Thru. holes (for nozzels) will be cut, in one side of 1st shell.

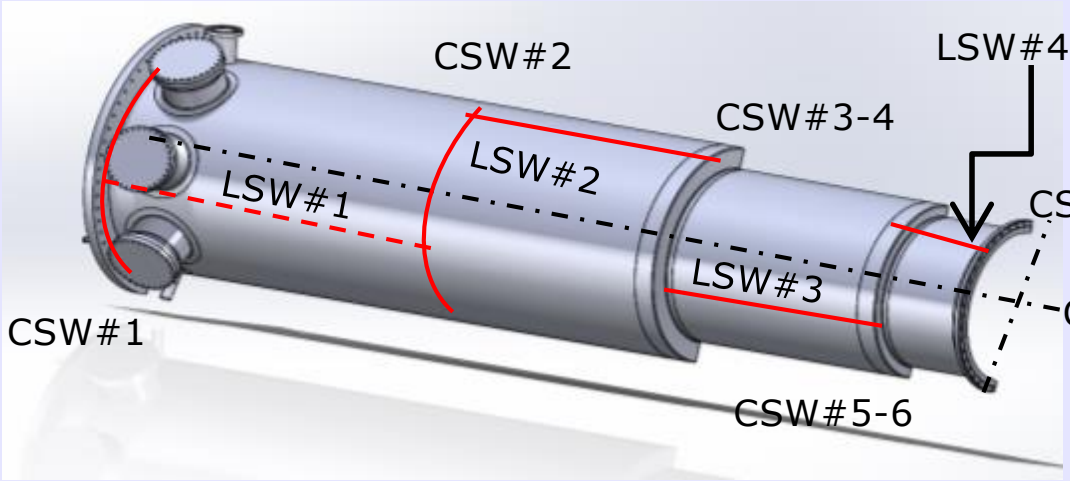
10) Welding of tubes-flanges to build the nozzles.

11) Nozzles must be welded to shell.

CSW=Circunf. Seam Weld

LSW=Long. Seam Weld

C.L. =Center line



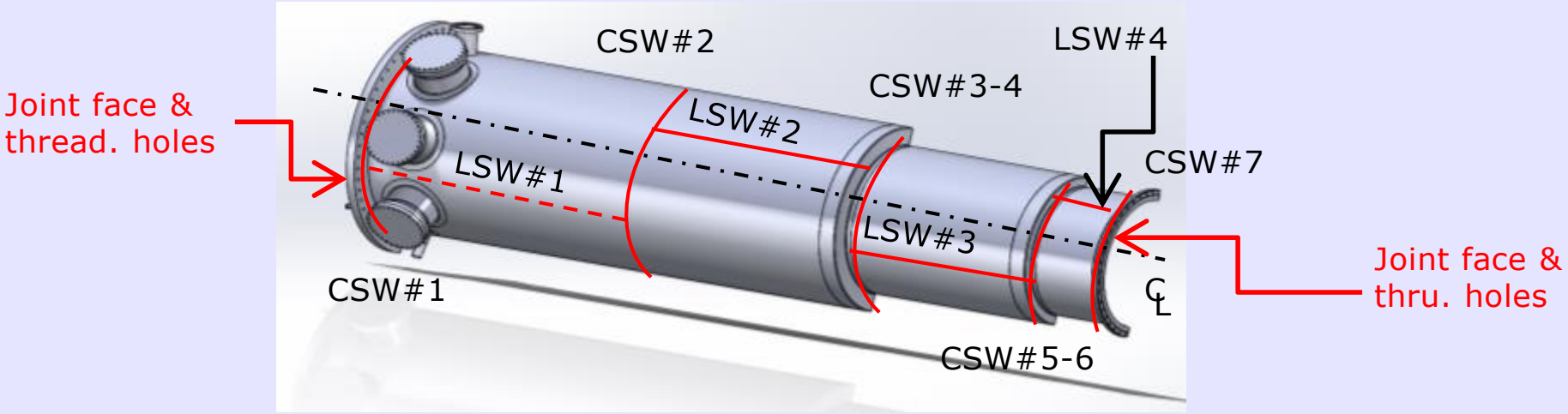
Assembling scheme

Main body: manufacturing

12) Using welding rotators, all circunf. welds will be done.

13) NDT: Volumetric(RT, UT), superficial (DPT) and VT.

14) We´ll machined upper & bottom flange (joint face and holes)
in a large boring machine.

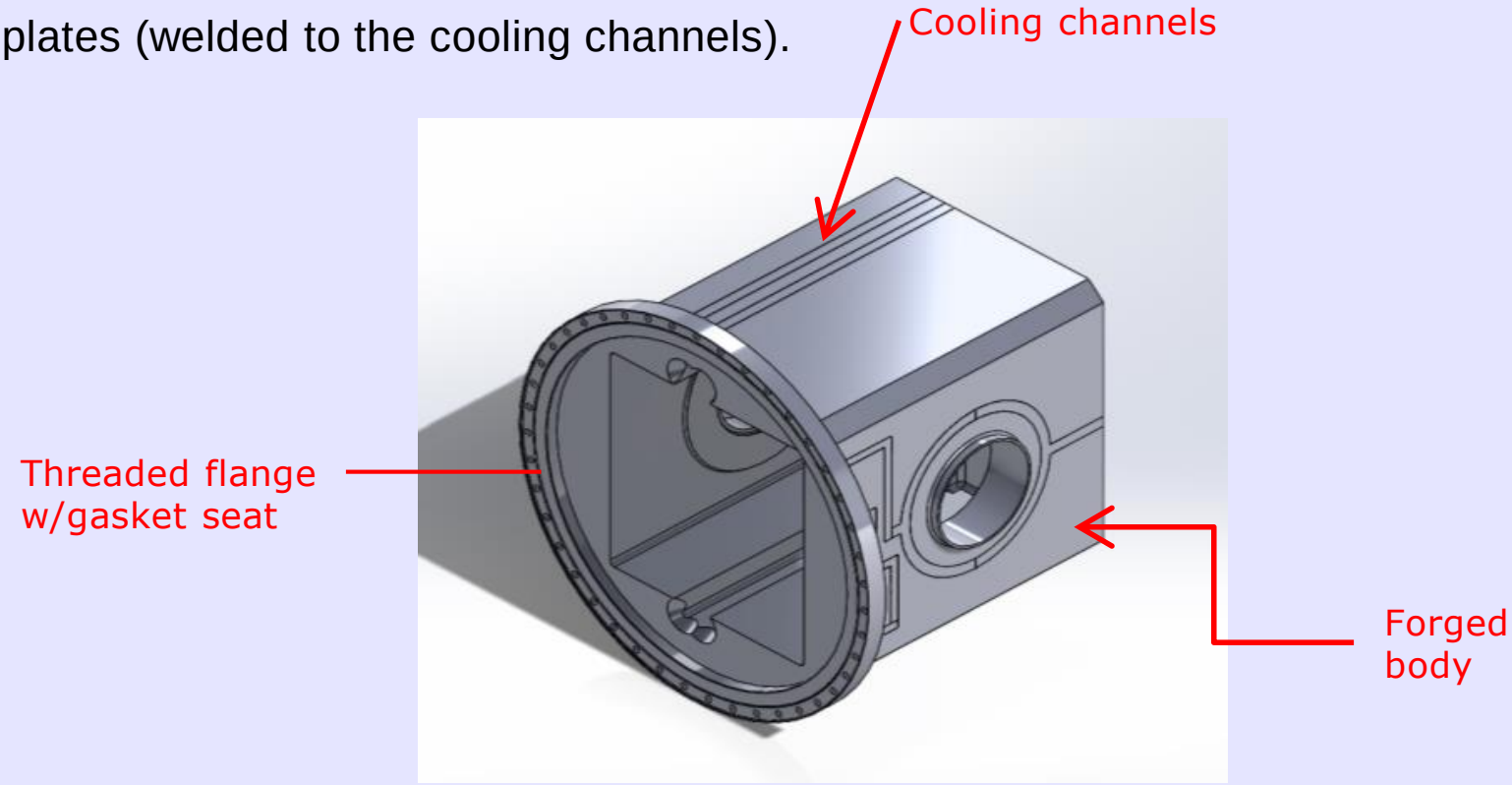


Assembling scheme

PBW-Port Block

Two components:

- Forged part.
- Cover plates (welded to the cooling channels).

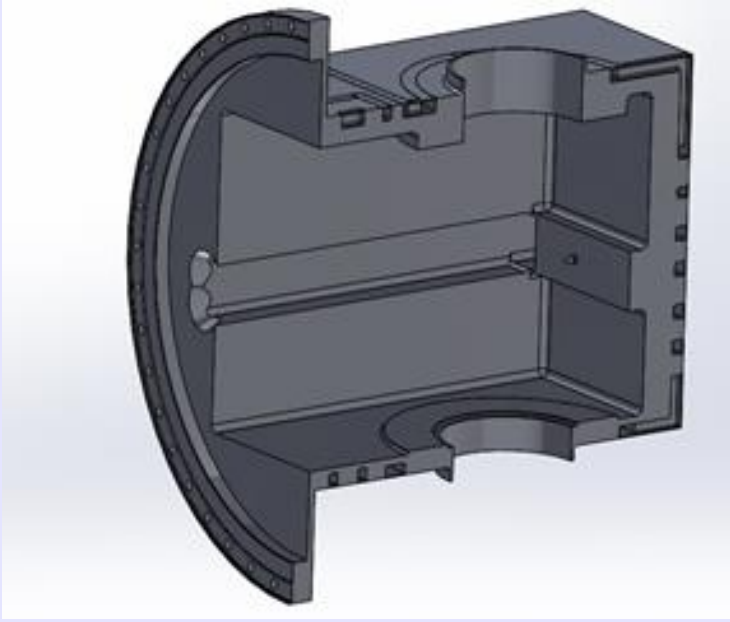


Assembling scheme

Manufacturing

1) Main body shall be purchased on a pre-machining condition and with an UT report, relative to raw material.

2) This implies that a mach. allow. (6-8mm) should be given to each side (int. & ext.) for further mach. operations.



Cross section view

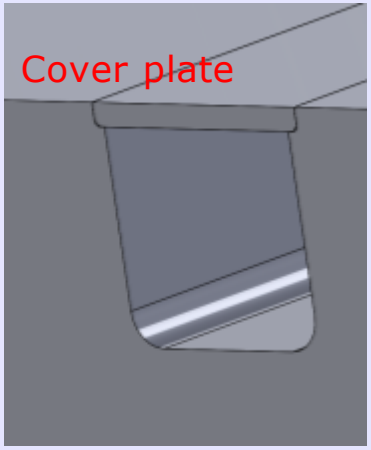
Assembling scheme

Manufacturing

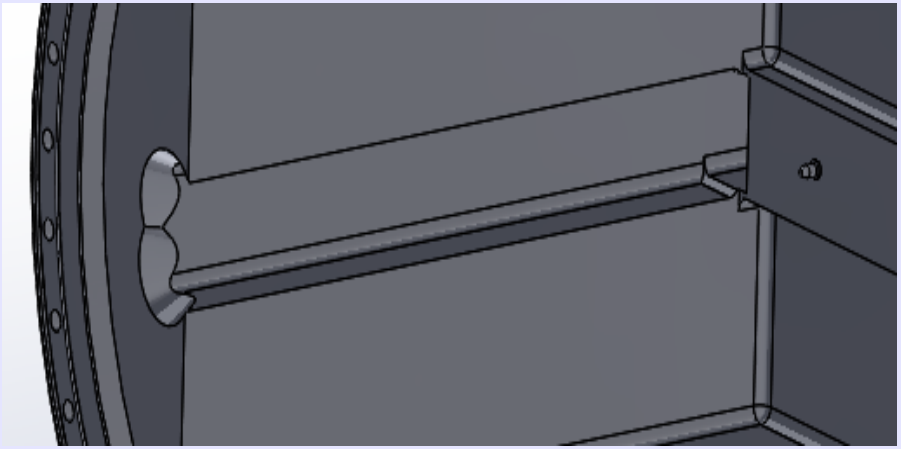
3) To minime distorsions in s.s., a rough mach. must be carried out for the cooling channels and vertical slots.

4) A intermediate mach. operation can be developed for integral pipes and all the internal-external sides.

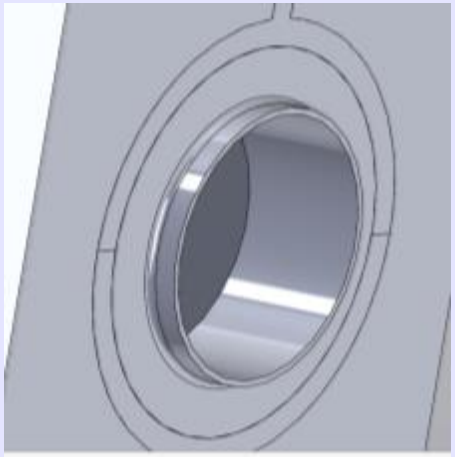
5) Welding cover plates by certif. welders using a WPS (GTAW).



Cooling channel



Vertical Slot



Integral pipes

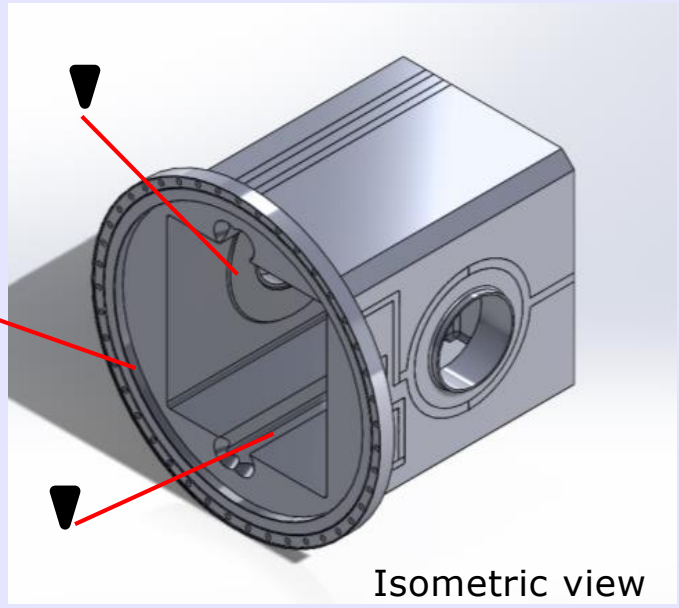
Assembling scheme

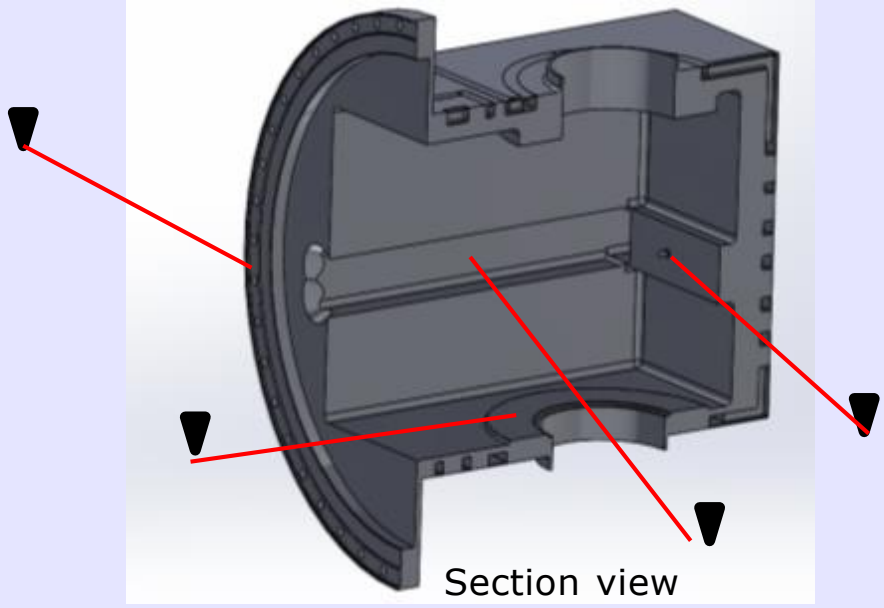
Manufacturing

6) NDT in cover plates TBD by ESS (volumetric inspection not possible with current design; DPT+boroscope inspection?).

7) Pressure test at 7.15 bar(g) to verify watertight.

8) Final machining of vert. slots, internal contact surfaces and top flange.


Isometric view


Section view

Assembling scheme

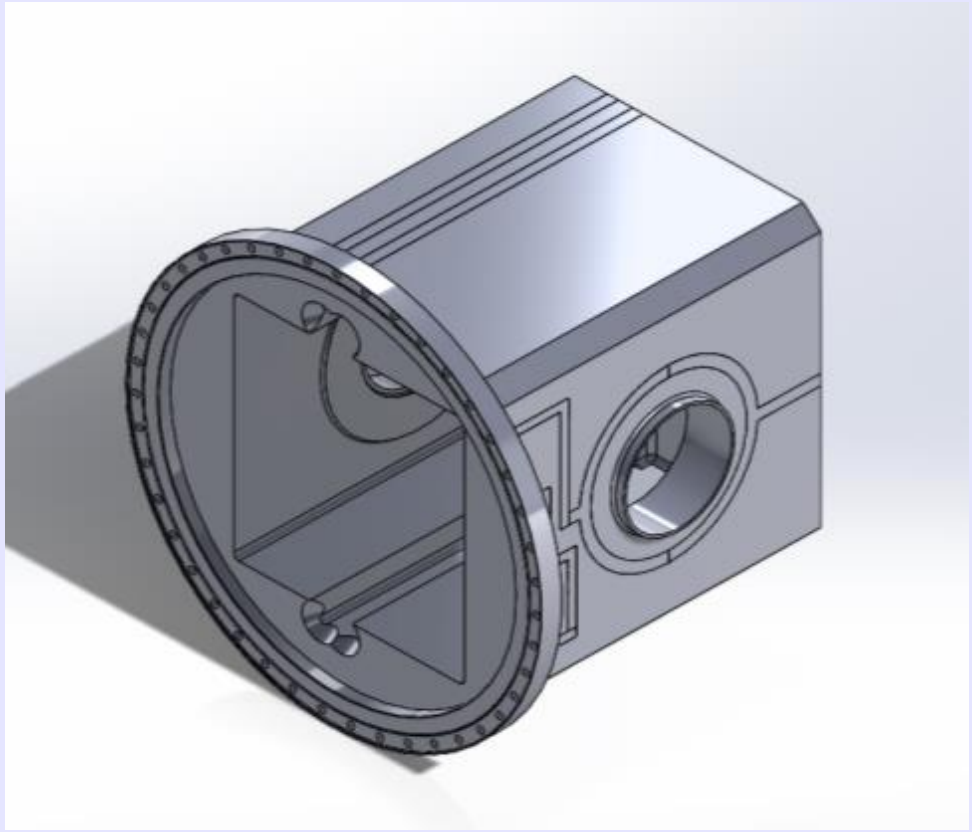
Challenge

1 -Internal machining !

- Mach. blind rectangular hole
- min. clearance piece vs machine
- Limit access for visual check
- Discontinuous ops. (in-stop-out)
- Remove chips
- Measurement operations

2 -Delivery time!

- 12÷13 weeks for forged PB (in a rough mach. condition).
- Forgings suppliers closed on August.



Assembling scheme

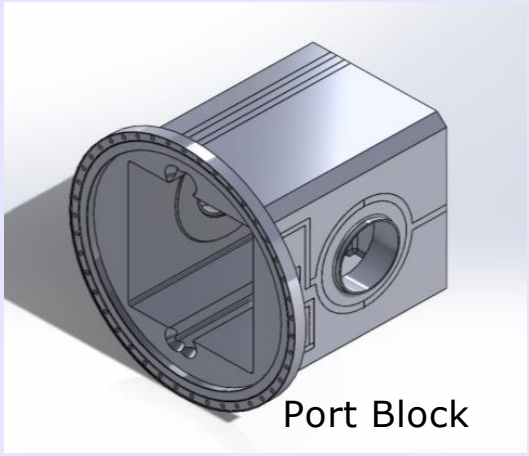
Challenge vs solution

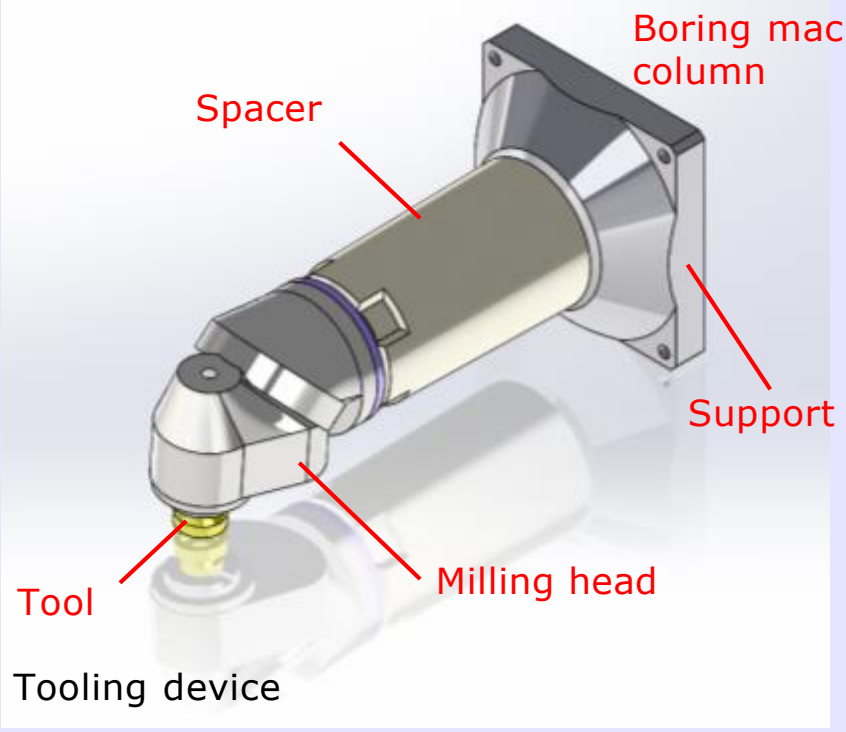
1- Internal machining !

- Design and manufacture of a tooling device.

2-Delivery time

- Dwgs valid to manufacture asap.
- 1st purchase order: Forged PB.





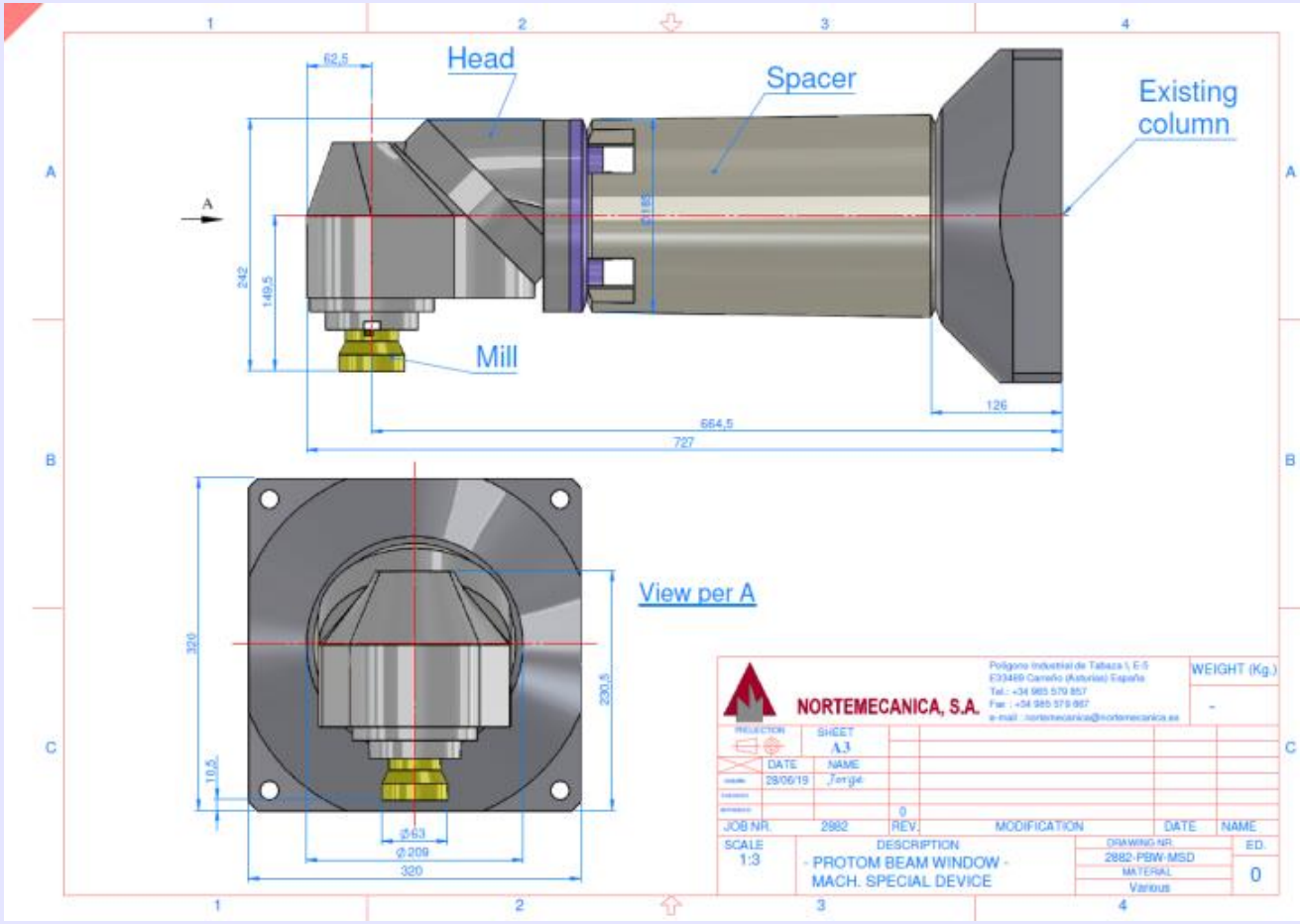
Assembling scheme

Solution

Design and manufacture a new tool that allows NM machining into a blind volume.

Maximum admisible

tool diameter = 160 mm



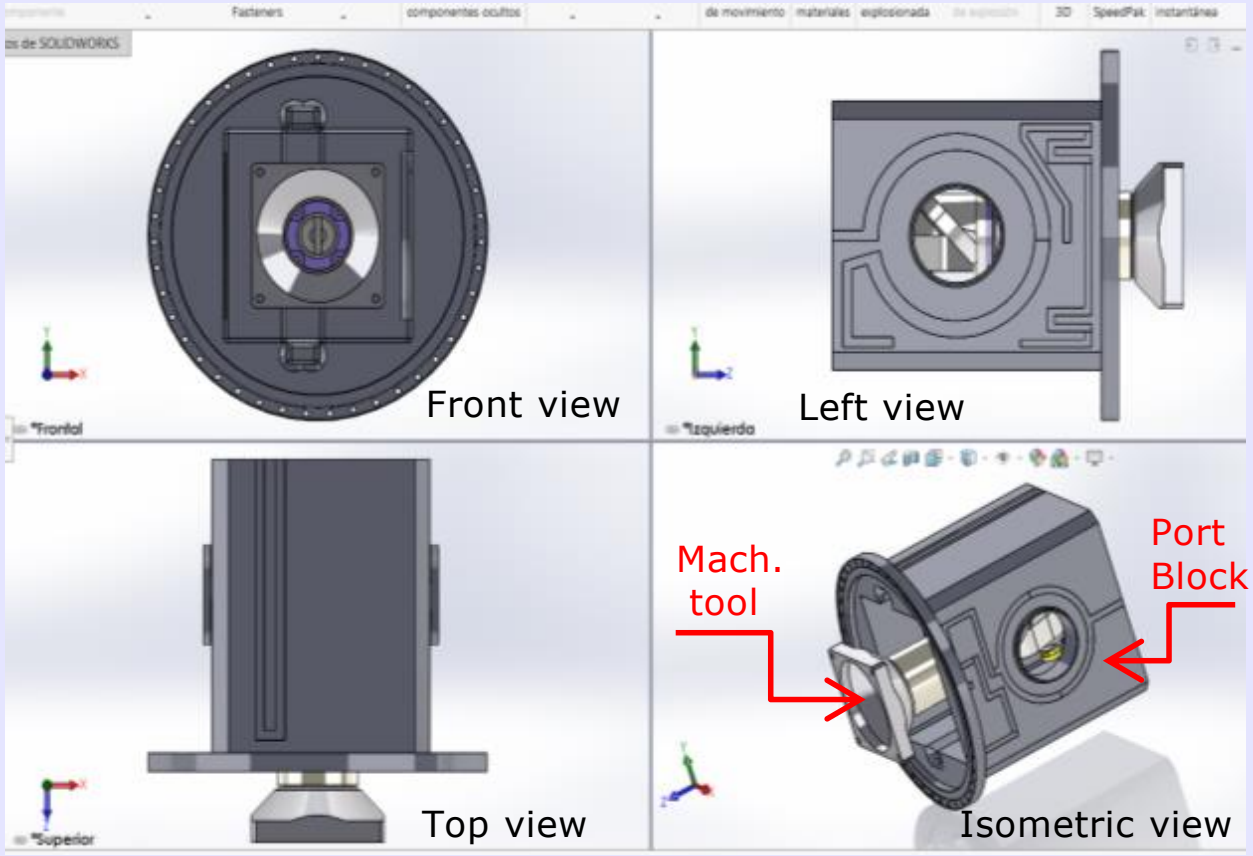
Assembling scheme

Simulation

Blind hole dimensions:
rectangle = 455x474mm
deep = 620mm

Max. tooling dimensions:
square = 320x320mm
deep = 725mm

Yes, We can!



Assembling scheme

PBW-Shielding

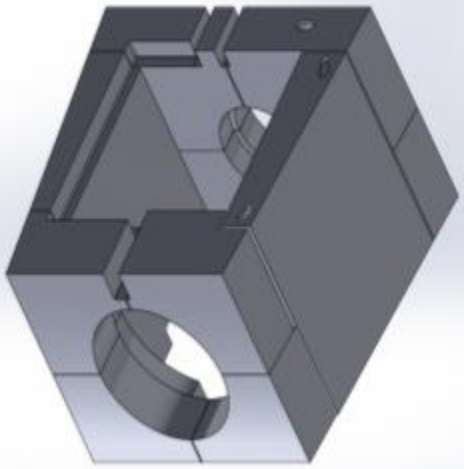
Blocks shielding will be made from carbon steel laminated plates and machined in a boring or milling machine.

PBW-Shielding

Various thicknesses: 143,153 and 208mm.

UT in steel plates prior to cutting processes.

Due to easily machined ops. no difficulties are expected.



Isometric view

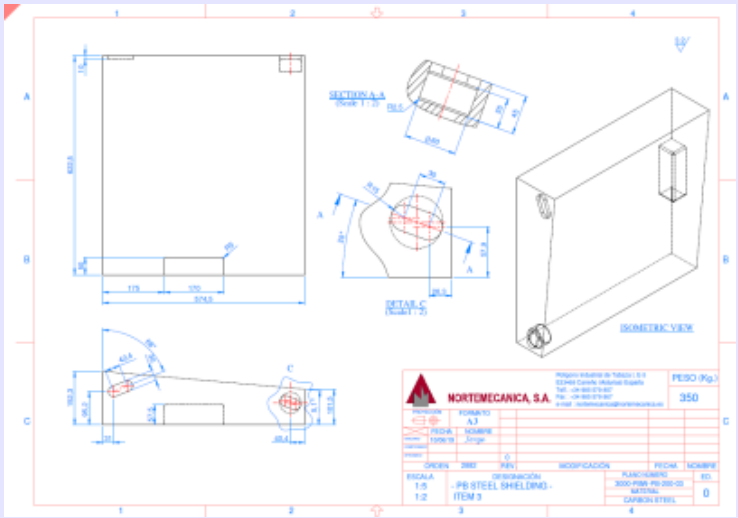
Assembling scheme

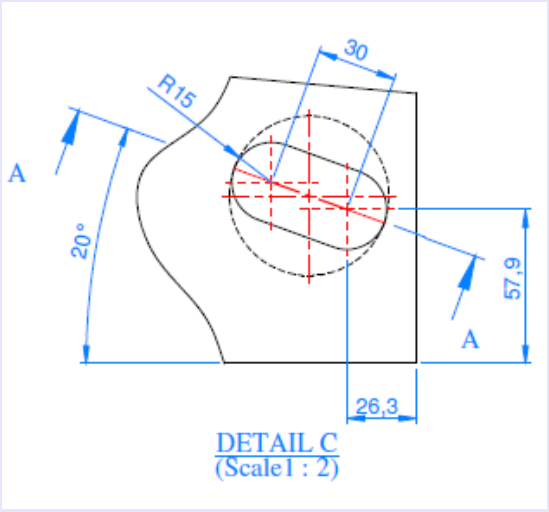
Twist lock

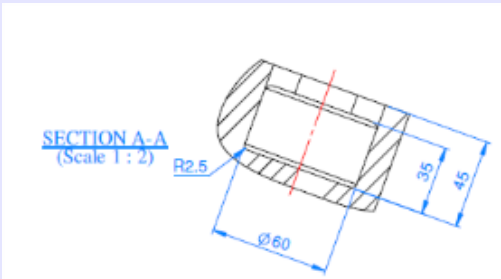
Special geometry for twist locks will be machined at the top of some plates for handling.

Slot 60x30mm, 10mm deep and blind hole Ø60x35 (milling tool "T" shaped or boring tool).

Machined holes







Final conditioning and test

Final conditioning and test: Final assembly

Complete assembly

Prior to develop the different tests, it´s necessary to proceed with the assembly of the three main componentes: Vessel, Port Block and Shielding.

This is to ensure that no interference or other undesirable situations will happen on site.

During this checking, a dimensional protocol will be fullfilled.

Preparation for test

At this point, carbon steel shielding will be dismounted for developing the pressure test.

There upon, all nozzles in PBW-Vessel are going to be closed with blind flanges, using the proper bolts, nuts, washers & gaskets.

The same procedure will be done at the top flange of the PBW-Port Block.

Two accesses (wihout flanges) are located on lateral sides of this part, it´s necessary to close these integral pipes with some nozzless by welding. After pressure & vacuum test, these nozzels will be cutted (a safety length is needed for thar purpose on these integral pipes).

Final conditioning and test: Pressure test

Hydraulic test

PBW-Vessel & Port block will be assembled together.

Then and acc. to RD5200 and REC 3257.4 an hydrostatic pressure test will be performed.

Testing pressure:

Vessel-Port Block ➡ P = 1.43x1 = 1.43 bar(g)

PB-cooling channels ➡ P = 1.43x5 = 7.15 bar(g)

Assembly for test

Nozzles to weld (for test)

Blind franges (for test)

Test assy. view

Final conditioning and test: Cleanning process

Cleanning

The cleanning process will be performed, for a cleanning class B components acc. to RF 6000

In order to remove oxides from weld processes, stainless steel brushes are going to be used.

Power brushes, abrasive papers and wheels are prohibited.

Requirements

Removal of all contaminants (dirt, grease, ...).

Use water soluble cutting oils for macihining.

Wash all parts with detergent prior to washing&rinsing with de-ionized water.

Helium leak rate: **1×10^{-6} mbar×l/s** using a mass spectrometer leak detector.

Packaged to preserve cleannig process and prevent possible contaminations, with aluminium foil or similar.

Final conditioning and test: Cleanning procedure

Chemical degreasing

Detergent NGL 17.40 spec. AL II, 10 g/l.

Temperature and time: 50÷60ºC, 30÷60 minutes.

After this process, PBW-Vessel and Port Block will be rinsed with water.

Pickling

Net inox (pure): 50% nitric acid (HNO_3) and 3% Hydroflouric acid (HF).

Temperature and time: 20ºC, 30÷90 minutes.

After this process, PBW-Vessel and Port Block will be rinsed with water.

Neutralization with detergent and ultrasonic

Detergent NGL 17.40 spec. AL II, 10 g/l.

Temperature and time: 50÷60ºC, 5÷10 minutes.

After this process, PBW-Vessel and Port Block will be rinsed with water.

Rising with demineralized water and alcohol.
Drying with clean compressed air and bake-out al 60ºC.

Final conditioning and test: Vacuum test

Vacuum test

PBW-Vessel & Port block will be separately cleaned and assembled together.

Then and acc. to RMC 7400 a vacuum test will be performed using mass spectrometer leak detector peak to a sensitive < 1×10^{-8} Pa×m^3/s

Helium leak rate ➡ 1×10^{-6} mbar×l/s.

Assembly for test

Final conditioning and test: FAT test

Final metrology

The tolerances shown on design drawings will be checked by means of a metrology test.

Pressure test

The PBW is designed to withstand up to 1 and 5 bar (g) (Design pressure). Based on that an hydrostatic pressure test will be performed at 1.43 times the design pressure (1.43 and 7.15 bars (g)) according to REC 3257.4 and RD 5200.

Vacuum test

The purpose of the leak test is to ensure the tightness of the component welds in the final stage of manufacture. The sealing of the assembly is essential for correct operation of the component. The Vacuum test will be performed acc. to ESS Vacuum Handbook.

Conclusions

Conclusions

Main remarks

-The different manufacturing steps described in the assembly process has been performed after a detailed study and according to similar jobs manufactured by our team in the past.

- All parts listed in this presentation can be manufactured successfully by NORTEMECANICA with no doubt.

- A technical solution has been identify and performed in order to machining all internal parts in PBW-Port Block.

- Critical point: Long delivery time for forged PB

- Volumetric inspections (RT and/or UT), DPT and VT will be carried out in seam welds.

- Pressure & vacuum test will be performed.

- Assembled components, as finish vacuum test, will be packaged & delivered to ESS.