Vacuum for DTL

G.Vandoni

on behalf of the TE/VSC Linac4 team

Acknowledgements

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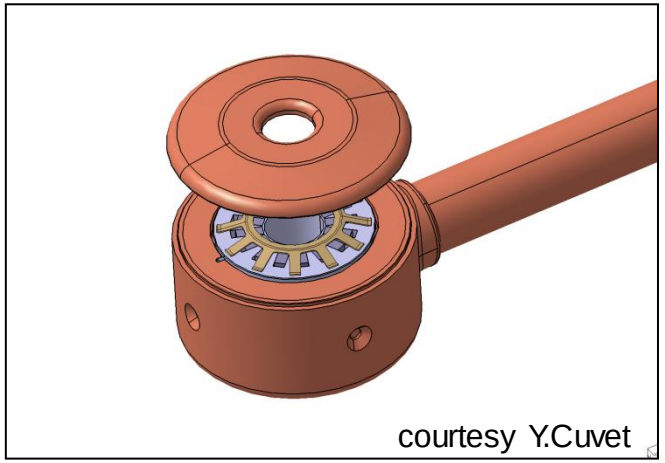
Vacuum equipment on the DTL

- Cleaning and coating for DT and DTL
- Heat treatment
- PMQ outgassing measurements
- Vacuum requirements and design
- Other vacuum tests

Drift Tube degreasing and passivation

1 Degreasing, NGL 17.40 spec. ALU III detergent in ultrasound
2 H_2O immersion and jet rinsing
3 Pickling with hydrochloric acid
4 H_2O immersion and jet rinsing
5 Passivation with chromic acid
   - A Acid dipping
   - B H_2O rinsing
   - C Passivation
   - D H_2O rinsing
6 Final ultra sound rinsing with ethylic alcohol
7 Drying (filtered air)
8 Drying (oven, 60C, 10min)
9 Packaging with tissue paper


courtesy Y.Cuvet

- Cleaning treatment of the 7 separate pieces before assembly and weld
- Assembly procedure (Y.Cuvet this morning)
- Cleaning treatment repeated on complete assembly (without magnet and cover)
- PMQ installed
- no further treatment

Cleaning and coating

Tank (proto) copper coating

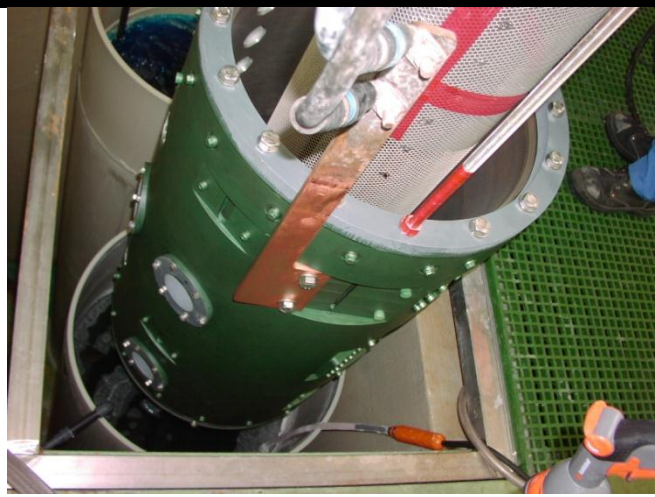
1 Degreasing, P3Almeco18 detergent in ultrasound

2 Heat treatment

Final machining

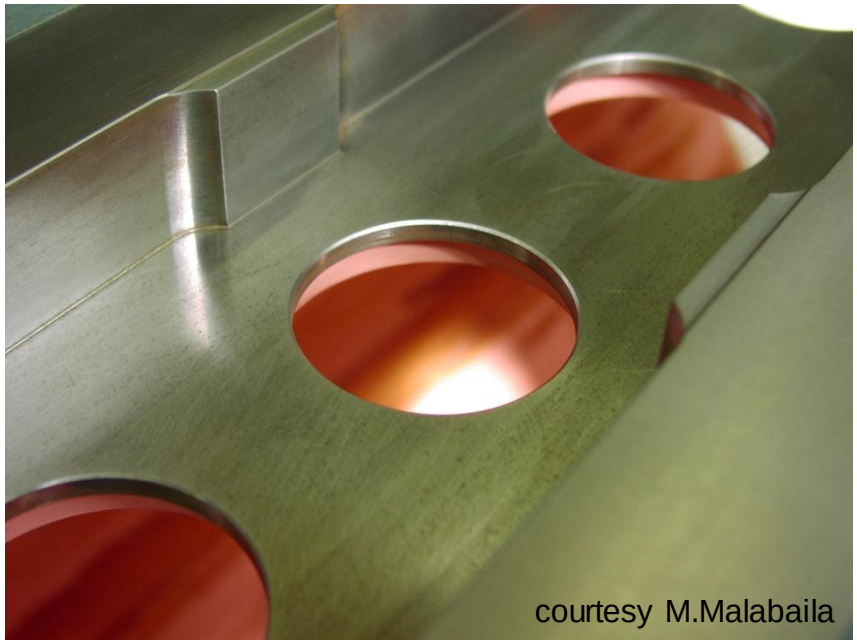
3 Degreasing

4 Electrolytic coating, 30μm



All flanges and the contact surface of the beam are protected by PVC covers, sealed with FPM o-rings

Tank proto painted to avoid corrosion



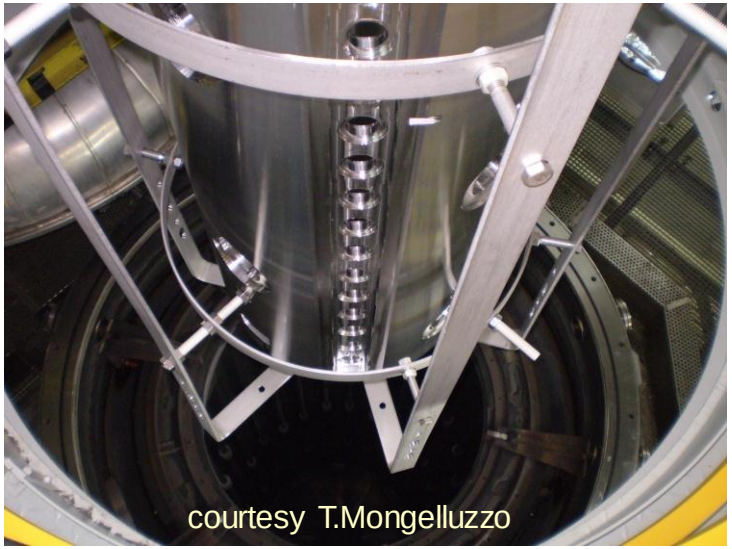
courtesy M.Malabaila

Tank 1 segment 1 DT1S1

Heat treatment parameters are defined with metallurgy (S.Sgobba), non-standard: trade-off between **stress relieving** and **corrosion risk**.

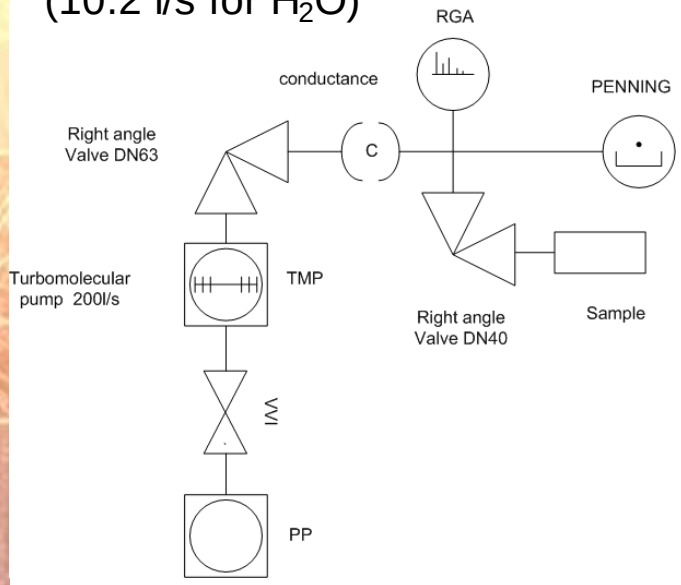
The tank is equipped with strain gauges, installed in the frame and lowered in the oven.
After 1 night, if no deformation is detected, the heat treatment is launched:
30°C/h , up to 400°C, then 8 hours of plateau, then cooldown by inertia at the same rate.

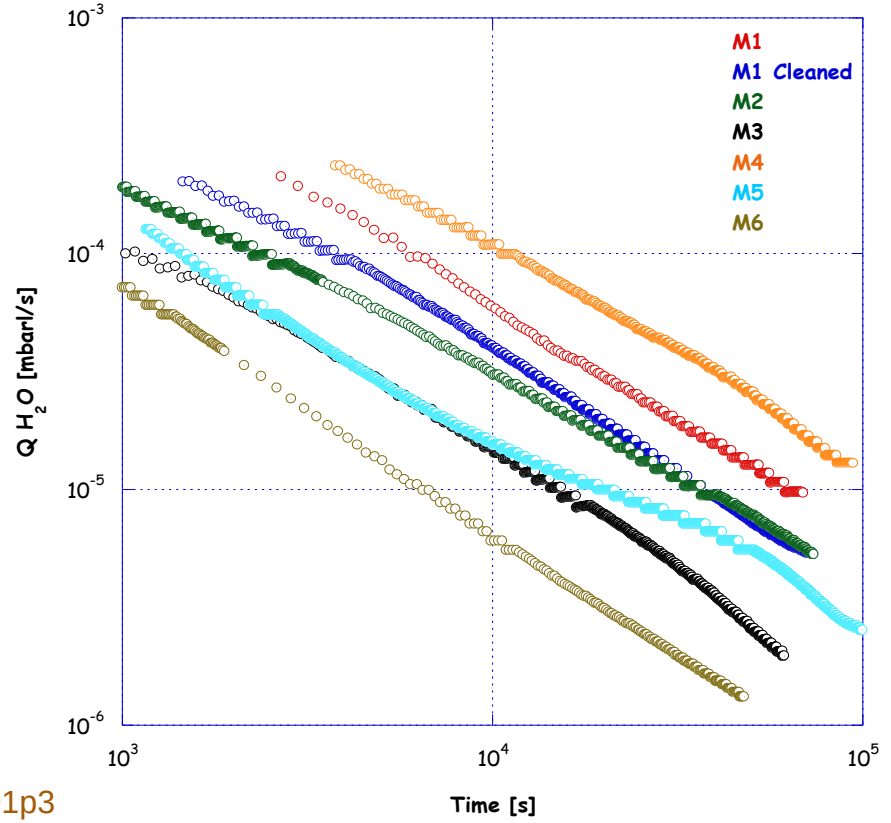
Pressure while heating is 10^{-6} mbar to $5 \cdot 10^{-7}$mbar.



PMQ Outgassing measurements

Outgassing is measured by following pressure versus time in a dome pumped down via a calibrated conductance (10.2 l/s for H_2O)





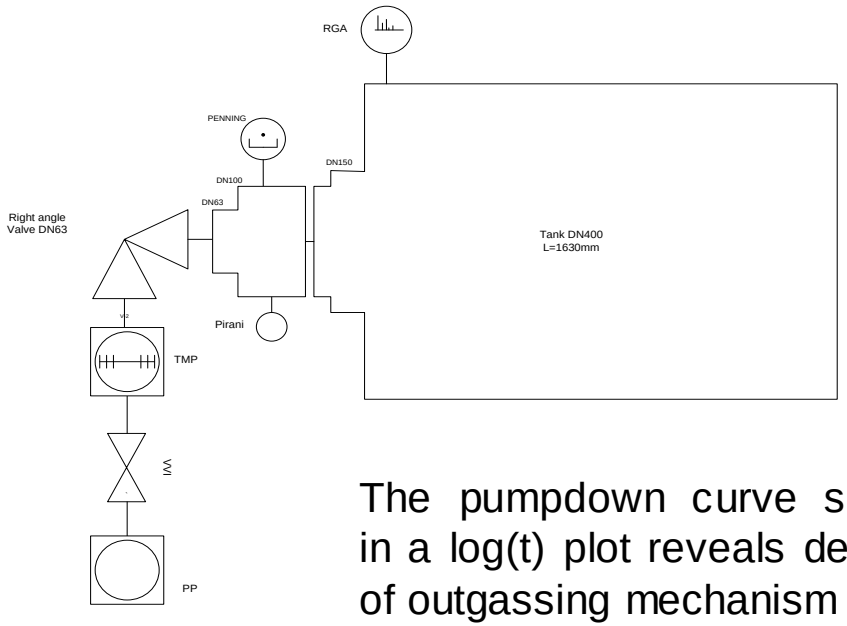
M6: Aster 103010-01p3

Outgassing of prototypes was much higher that in a 1st campaign 2008 on several prototypes .

Each PMQ was equivalent to several m^2 of austenitic stainless steel, with peak value for anodized Al casing
Tests went along with design during the whole 2010

Outgassing of series PMQs

Outgassing is measured in a large tank on batches of ~20 PMQ, then selected PMQs are measured individually in the small test-bench.

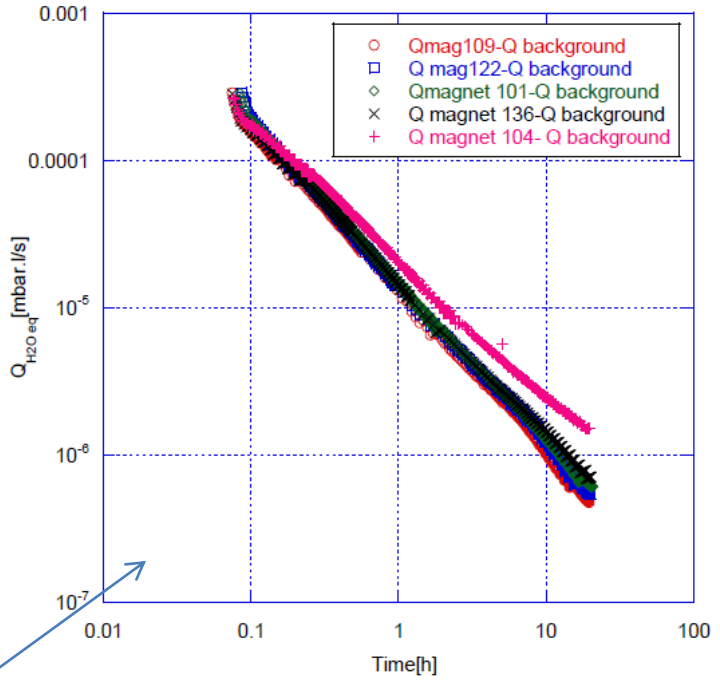


Background outgassing of the tank is determined previous to each measurement campaign and substracted.

Relevant pressure is taken after 10h pumping.

The pumpdown curve slope in a log(t) plot reveals details of outgassing mechanism

Within measurement precision, every PMQ shows an outgassing equivalent to 1m^2 of austenitic stainless steel

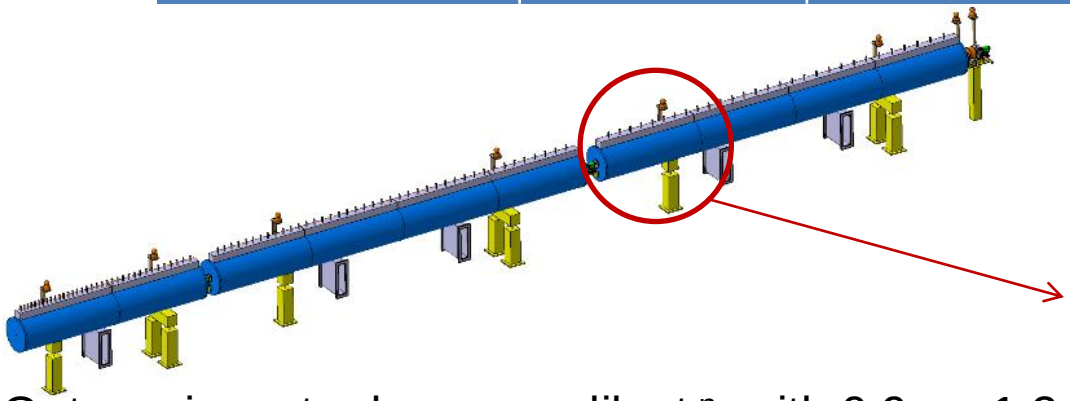


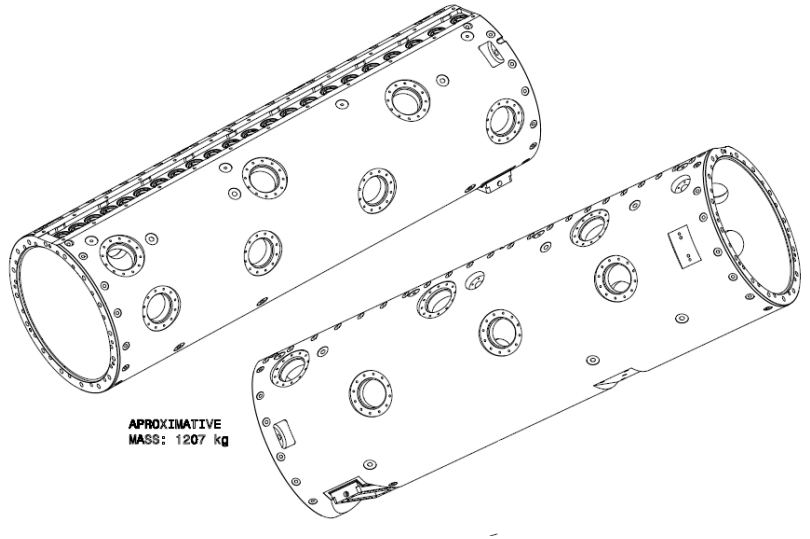
PMQ104 features 2x the batch value, with slower rate

Vacuum requirements

$2 \cdot 10^{-7}$ mbar after 10h pumpdown

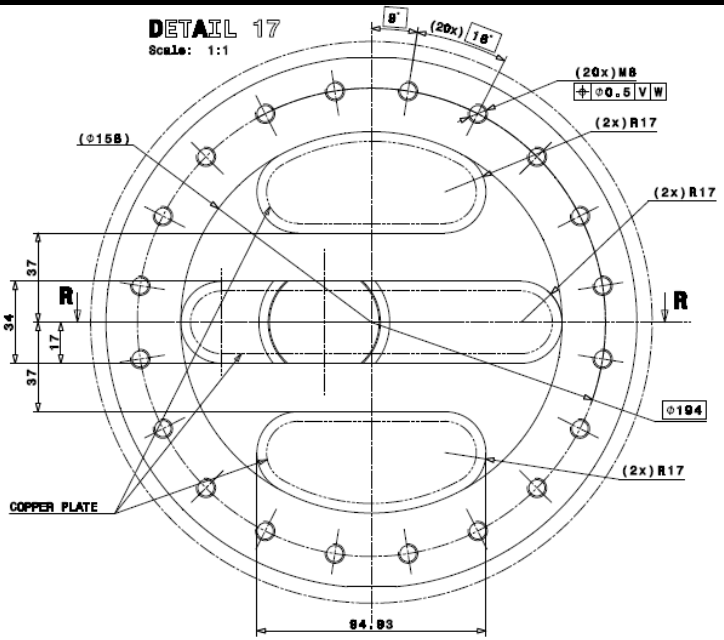
		Outgassing rate @10h [mbar l s^{-1}]	Pumping speed @ $2 \cdot 10^{-7}$mbar [l/s]
Tank, segment	7.3 m^2	$1.46 \cdot 10^{-5}$	73
PMQ, single		$1.0 \cdot 10^{-6}$	5
Tank1, total	38	$5.3 \cdot 10^{-5}$	263
Tank2, total	41	$7.0 \cdot 10^{-5}$	351
Tank3, total	29	$5.8 \cdot 10^{-5}$	291

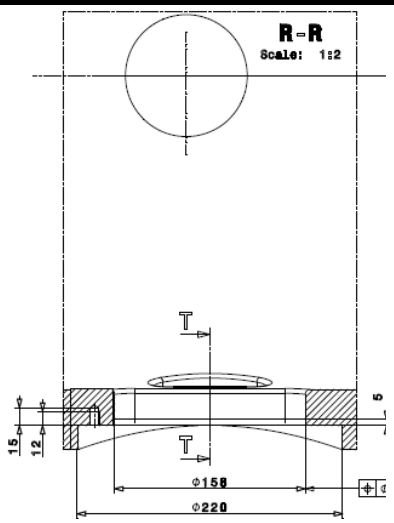




Outgassing rate decreases like t^{-n}, with $0.9<n<1.3$; with constant pumping speed the pressure follows the same law. ☞ **Contingency is given by time**

Pumping port conductance





Surface:
196 cm^2

Reduction by grid:
60.4%

Aperture conductance:
1434 l/s

Space available for vacuum conductance is a trade-off with increased RF losses

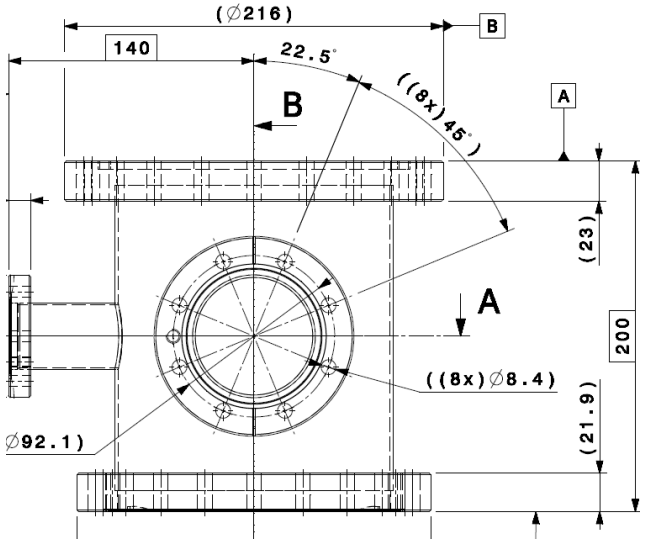
Pumping sleeve

Molecular transmission probability: 0.44

Molecular conductance for N_2 of the pumping port + sleeve:

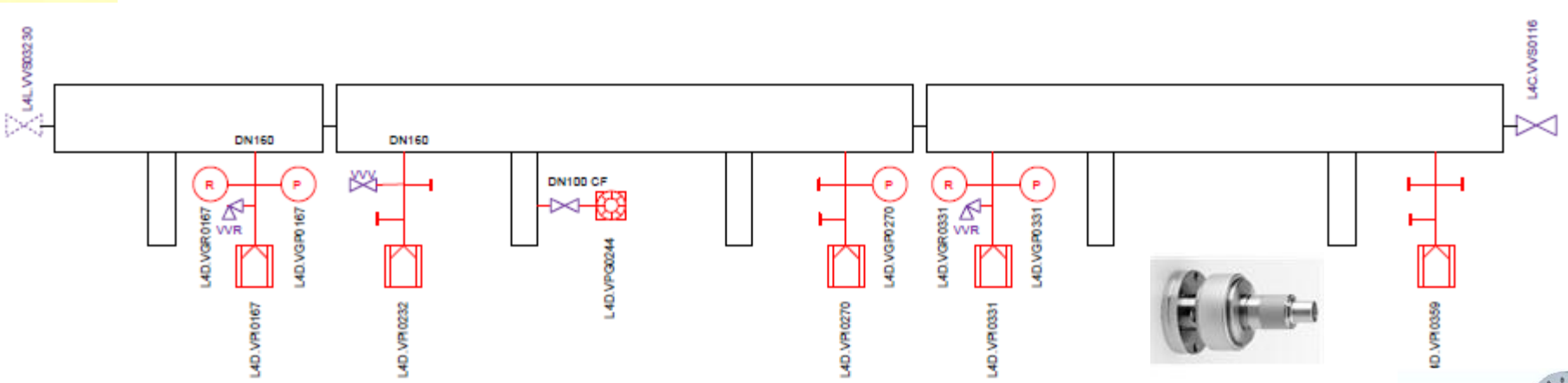
634 l/s

Gridded port

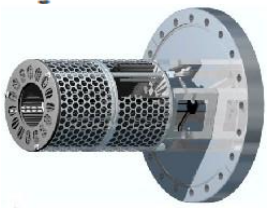


Vacuum layout

Reduction of installed pumping speed by the pumping port: **174 l/s**



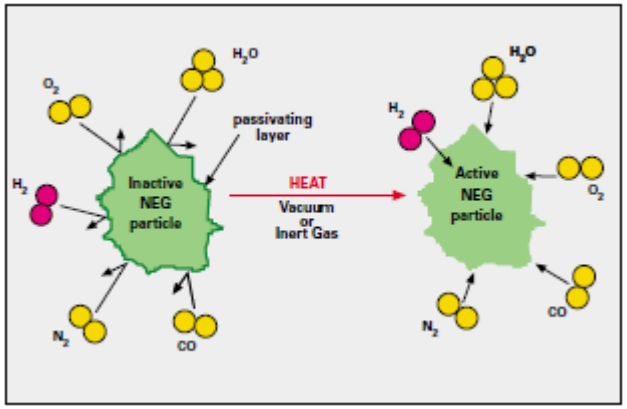
1 vacuum sector
1 Vacuum Ion Pump VPI 240l/s per segment
1 Penning gauge per tank, with ports for spare
1 fixed pumping group, 2 ports for mobile ones
Additional pumping speed with NEG pumps on waveguide

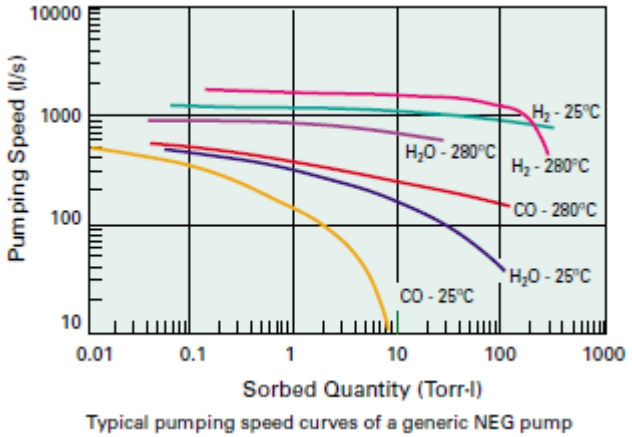


	Tank 1	Tank 2	Tank 3
installed	174 l/s	348 l/s	348 l/s
needed	**263 l/s**	351 l/s	291 l/s

NEG pumps for DTL

Non-Evaporable Getter (NEG) is a powder of Ti-Zr-Va alloys forming stable chemical compounds with active gases.
Regeneration (reactivation) is achieved by heating under vacuum, to diffuse the passive layer covering the surface the getter into the bulk.





Typical pumping speed curves of a generic NEG pump

Advantages

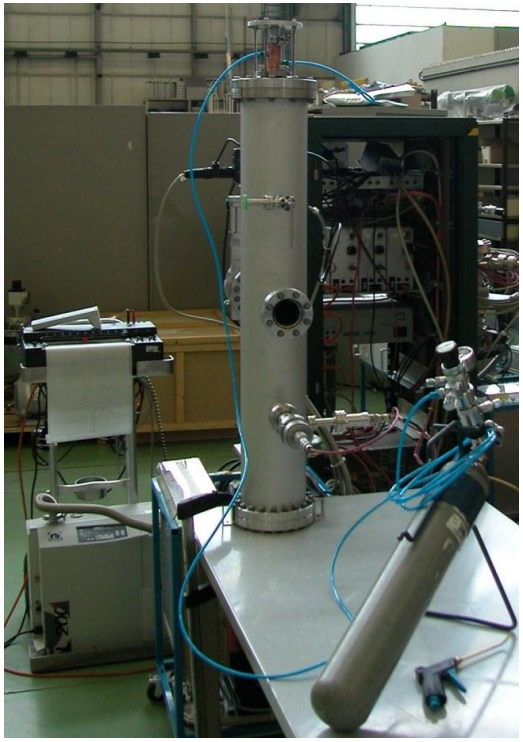
- Highest pumping speed for unit aperture area
- Very large capacity
- Remains active without electricity
- Small, lightweight

Even after reduction of conductance by the grid and the connection nipple , an additional 300l/s can be reached

✓ Non-evaporable getter pumps are being qualified for operation on the RFQ and on DTL

✓ Installation on the waveguide connection has been validated by integration

Several other vacuum tests



1. Vacuum validation of electron beam welding on DT

2. Leak test on completely assembled DT prototypes and on water cooling channel

3. Leak test on prototype tank, modification of design for individual testing of DT seals

4. Vacuum test, outgassing and chemical analysis from a DT assembled prototype: several non-conformities found (cleanliness, lubricants used), resulting in increased outgassing

Conclusions

- Cleaning, heat tratments and coating for DT and DTL are settled and are applied to the series production
- PMQ outgassing measurements follow delivery: they show that cleanliness and respect of procedures are paramount to guarantee ultimate vacuum
- Vacuum design is with small contingency, but NEG pumps will provide increased pumping speed with small integration impact
- Vacuum tests are performed all along, to qualify for installation the DTs, PMQ, tanks.

Thank you