

Design of a Cryogenic Distillation Column for JET Water Detritiation System for **Tritium Recovery**

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* See the Appendix of F. Romanelli et al., Proceedings of the 25th IAEA Fusion Energy Conference 2014, Saint Petersburg, Russia

Q = 112 W

Top product (distillate):

H₂, 200 mol/h

Aims:

Water Detritiation Facility

- Process tritiated water produced by the Exhaust Detritiation System (EDS) of JET Active Gas Handling Facility (AGHS)
- Combination of filtration, electrolysis, permeation and cryogenic distillation processes
- Recovers tritium from water with average activity of 1.9 GBq/L, able to process water with activities of 85 GBq/L (and higher)
- Continuous operation, up to 120 standard litre per minute (300 mol/h) of hydrogen species



Cryogenic Distillation (CD) Columns

- Two CD columns that will operate in parallel or series as per water activity
- Remove protium from the stream and perform tritium pre-enrichment before final recycling process in AGHS

Operating parameters:

- Operating temperatures: 20 25 K temperature defines the composition
- Operating pressure: ~105 kPa
- Column tritium inventory limit: 60 TBq (0.169 g T_2) / column for unmanned operation.
- Flexible to operate at low and potentially high tritium content (Table 1)
- Number of theoretical plates per column 100

	30 ppb	2000 ppb	3000 ppb	6500 ppb
H ₂	0.9996	0.9996	0.9996	0.9996
HD	0.0004	0.0004	0.0004	0.0004
HT	3.00E-08	2.00E-07	3.00E-06	6.50E-06
D_2	4.91E-08	4.91E-08	4.91E-08	4.91E-08
DT	8.09E-12	5.39E-11	8.09E-10	1.75E-09
T ₂	3.49E-16	1.55E-14	3.49E-12	1.64E-11

Table 1: Q₂ speciation as a function of the atomic tritium ratio (atomic deuterium content = 400ppm).

Top column section

- Diameter: 60 mm
- Structured Packing: Sulzer EX packing, 20 – 30 mm HETP (height equivalent to a

Species	Feed	Distillate	Product
H ₂	0.9996	0.9996	4.70E-11
HD	0.0004	3.98E-04	0.9515
HT	3.00E-08	2.06E-23	0.0192
D ₂	4.91E-08	6.62E-30	0.0293
DT	8.09E-12	0	4.91E-06
T ₂	3.49E-16	1.03E-29	2.15E-10

able 2: Design simulation, atomic D = 400 ppm, atomic =32 ppb); Feed flow: 300mol/h. Bottom flow: 0.5mmol/h = 21.2K, P = 105kPa (ProSimPlus simulation)





Figure 3: Detritiation factor as a function of the reflux ratio (Feed = 300 mol/h, Bottom = 0.5 mmol/h, T = 21.2K. ProSim Simulation



- The CD column system aims to process tritiated streams from EDS as a tritium pre-concentration stage prior to its recovery in one of the isotope separation systems in AGHS
- Designed to operate continuously 200 days/ year for low concentration of tritium or very high activities
- System limited to 300 mol/h by the electrolyser capacity
- CD columns designed to process up to 200 mol/h
- Tritium inventory limited by the intermediate reboilers (~100W), reduces flowrate, diameter of bottom section of the column

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