PARTICLE EXHAUST CHARACTERIZATION OF THE DIII–D CRYOPUMP FOR NEON GAS*

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The particle exhaust characteristics of an in-vessel cryogenic condensation pump [1] in the DIII–D tokamak have been measured for neon, both as a pure gas and as a minority gas with a deuterium majority gas (the situation in DIII–D plasma discharges). By injecting discrete puffs of neon gas into the vacuum vessel, the effective neon pumping speed is measured by analyzing the exponential decay of the pressure in the pump plenum; the pumping speed at the cryopump is then calculated based on the steady-state ratio of the main chamber and pump plenum pressures, measured by two absolutely calibrated capacitance manometers. The measured pure neon pumping speed is pressure independent: S ~ 13.5 kl/s . In the presence of a deuterium majority gas, the pumping speed of neon is found to be enhanced and increases with the deuterium pressure, suggesting that the flow to the pumping surface is in the transition regime between molecular and Poiseiulle flow [2]. In this case, the measured neon pumping speed is given by: S (kl/s) = 13.5 + 4.54*Pd, where Pd is the deuterium pressure in mtorr. The deuterium pumping speed was also re-characterized and agrees reasonably well with a previously published calibration [2]: S (kl/s) = 29.4 + 0.66*Pd, where Pd is the deuterium plenum pressure in mtorr. These pumping speeds are used to compute the exhaust rate for neon (and deuterium) gas during tokamak discharges.

During some plasma discharges, neon is injected via fast time-response piezo-electric gas injectors to increase the radiated power and reduce the divertor heat flux; the absolute injection rate is determined from an in-situ calibration. For these discharges, the particle balance of neon gas in the vessel is given by: $dN_{ne}/dt = S_{ne} – Q_{ne}$ where N_{ne} is the vessel inventory, S_{ne} is the injection rate, and Q_{ne} is the exhaust rate. The inventory of neon gas in the main chamber is obtained from an absolutely calibrated charge exchange-recombination spectroscopy system [3], and the pressure of neon gas in the pump plenum is measured by a "modified Penning gauge" [4], which was recently further modified to allow absolute measurement of the neon gas partial pressure. With these measurements, the particle balance for injected neon gas is estimated during plasma discharges with trace neon injection ($N_{neon\ core}/N_{electron}$ ~ 1%), both with and without additional deuterium gas injection. Results of the particle balance during discharges with an active cryopump indicate good neon particle accountability, i.e. most of the injected neon is exhausted by the end of the discharge. These characterization data will be used to interpret the effectiveness of the divertor in compressing neon gas in the divertor volume, the purpose of which is to maximize the divertor-to-core neon inventory ratio and the divertor-to-core radiated power ratio.

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*Work supported by the U.S. Department of Energy under Contract Nos. DE-AC03-89ER51114 and DE-AC05 - 96OR22464.

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Subject Category: <u>12. Plasma Fueling and Particle Control</u>

Preference: ❏ Oral ☒ Poster