Warsaw University of Technology
EURATOM-IPPLM Association

24th Symposium on Fusion Technology

11 - 15 September 2006 - Palace of Culture and Science, Warsaw, Poland

TOPIC: A - Experimental Fusion Devices
(P1-A-562)

DESIGN STATUS OF THE ITER CRYOSTAT HIGH VACUUM PUMPING SYSTEM

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The superconducting magnets and structures of ITER are enveloped by the cryostat vessel which, during normal operation, is evacuated to 0.1 mPa to limit the gas conduction heat load to the cold components to an acceptable level. When the magnets are cold all gases except helium (and to an extent protium) are pumped by the cold magnet surfaces; the former gas arises from leaks in helium bearing pipework inside the cryostat while protium outgases from the warm metallic surfaces facing the cryostat vacuum. Neutron irradiation of epoxy can result in evolution of protium and alkanes. Prior to magnet cool-down, the cryostat has to be pumped down from the crossover pressure of 10 Pa (reached using the mechanical rough pumps) to the nominal operating pressure of 0.1 mPa by the cryostat high vacuum cryopumps. In this operation mode the gas load comprises mainly air and water, the latter outgassing from the ~ 1300 m2 of vacuum facing epoxy of the poloidal field coils. In order to pump protium and helium at 5 K, the pumping mechanism is cryo-sorption. The sorbent panels have provision for regeneration at three temperature levels, 100 K for helium and protium regeneration, 300 K for regeneration of air-likes and to 475 K for regeneration of water-likes. The last two mentioned have an influence on the sorbent at increasing dose while the amount of helium that can be pumped without regeneration is limited by the sorbent helium capacity. Protium accumulation is limited by the safety requirement to keep the peak regenerated concentration below 1.5 mole/m3, corresponding to a peak deflagration pressure of 0.2 MPa in the event of an air leak into the closed pump prior to or during regeneration.

For the cryostat cryopump, adequate total pumping speeds are required for the timely evacuation of water and air during the transient pump-down. Likewise a good helium pumping speed is needed for pumping helium coolant leaks into cryostat vacuum and to obtain an acceptable response time during helium leak testing of the cryostat vacuum boundary and internal components. To provide pumping continuity during regeneration, two cryostat cryopumps are used. To minimize procurement cost, the cryostat cryopumps are of virtually identical design to the torus cryopumps. Thus these cryopumps must meet the all design requirements for both the cryostat and torus exhaust operation modes.

The cryostat cryopumps play a safety role by pumping air leaks in the cryostat vacuum envelope. Such leaks could engender an ozone hazard if excessive amounts of air were to freeze out on the 5 K structures and be subsequently irradiated beyond a critical dose. Since the cryopumps act as a leak integrator, air leak levels well below the safety threshold are detectable.

The paper describes the design basis of the cryostat cryopumps, including all operating modes and the current design status.