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TOPIC: G - Vessel/Vessel-in Engineering and Remote Handling

Structural Analysis for an Upper Port of the ITER Vacuum Vessel (P2-G-141)

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The ITER vacuum vessel (VV) has numerous openings for the port structures including upper, equatorial, and lower ports used for equipment installation, utility feedthrough, vacuum pumping, and access into the vessel for maintenance. Every upper port, slanted upward slightly, has a trapezoidal/rectangular cross-section and consists of a port stub, a stub extension and a port extension with a connecting duct. To investigate the structural integrity and to increase the structural reliability of the VV and ports, the structural analyses of the upper port structure have been performed.

The global structural analysis of the upper port with the in-port components has been carried out. The local analyses of a tangential key, an upper port flange, a connecting duct and a sealing unit have been performed. The design loads are dead weight, normal and abnormal pressure load, electromagnetic load, and seismic load in consideration of the dynamic amplification factors. The stress analyses were performed in a nonlinear elastic approach taking into account the contact surface between port extension flange and port plug flange. Two advanced designs from the ITER international team have been reviewed. To verify the strength of the reinforcing ribs for the connecting duct and of the fastening/sealing units, the local analyses utilizing the sub-modeling technique have been performed.

The ASME code and the ITER design criteria were applied for the evaluation of the structural analysis results from the global and local analyses. The clearance between a port and a plug to accommodate the plug deformation has been assessed. The upper port flange based on the original design could withstand design loads, but there could be a gap on the flange surface under the design condition. The modified flange design, which is under the bolt friction only without tangential key was proposed. The deflection of the plug for an advanced design with a removable flange is higher than that for the original design since the stiffness of a port and a plug is reduced by the continuous groove for the nuts. The other advanced design using large superbolts is very acceptable in the structural design point of view. From the local analyses for a connecting duct and a fastening/sealing unit, it is expected that the stresses be less than the allowable values.