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Dynamic Simulation of Loss of Insulation Vacuum Event for ITER Cryodistribution System

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The Auxiliary Cold Boxes (ACBs) of the ITER cryodistribution system has multiple cryogenic process volumes as well as interfaces with cryolines with isolated vacuum spaces. The cryogenic process volumes inside a single vacuum space have different temperature level, 4 K and 80 K as well as different operating pressure, 0.5 MPa and 1.8 MPa. The cryogenic process volumes including interfacing cryolines are protected with safety relief valves (SRVs). In the event of Loss of Insulation Vacuum (LIV) of any particular vacuum space, the incidental heat load of the order of ~6.5 kW/m2 results in rapid pressurization of the cryogenic process volume and pressure must be relieved through SRV. As per the safety requirements of the ITER, the maximum helium inventory inside the tokamak building is restricted and therefore a common relief header is necessary for collecting the release of helium through SRV and carrying it outside the tokomak building. The sizing of the SRVs is performed for the various scenarios as per applicable standard; however, due to the long length of relief header, the required information regarding back pressure on the SRVs is not known in advance. The back pressure is an important parameter to be considered for the sizing and selection of SRV and is a function of geometric condition of relief header, process condition of relieving process volume and relieving mass flow rate. Estimation of back pressure considering steady state condition and maximum mass flowrate through SRV may results in a conservative and unrealistic value of back pressure. Dynamic simulation of the safety relief event along with the complete model of process volume, correct boundary conditions as well as geometric detail of relief header is developed and analyzed based on pressure flow solver model in Aspen HYSYS®. Results are presented for the most demanding scenario viz. LIV event of the largest cryoline and comparison made with the two approaches of back pressure prediction, one with steady state and the other with dynamic simulation model. Results obtained from the dynamic simulation of the entire safety relief system gave useful results at various locations; moreover, the back pressure on SRV is almost half of the back pressure resulted from the steady state approach. Certainly, the dynamic simulation provided valuable inputs for the overall system configuration.

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