

ANALYSIS OF THE ITER CRYOPLANT OPERATIONAL MODES

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In the framework on EFDA task, CEA is carrying out an analysis of the various ITER cryoplant operational modes. According to the Project Integration Document, ITER is designed to be operated 24 hours/day, 365 days per year in order to optimize the available time of the Tokamak. It is anticipated that operations will be carried out in long periods separated by maintenance periods (e.g. 10 days continuous operation and 1 week break) with annual or bi-annual major shutdown periods of a few months for maintenance, further installation and commissioning. For this operation schedule, auxiliary subsystems like the cryoplant and the cryodistribution have to cope with the heat loads variations which depend on the ITER operating states. The cryoplant consists of four identical 4.5 K refrigerators and two 80 K GHe loops coupled with two LN₂ modules. All of these cryogenic subsystems have to operate in parallel to remove the variable heat loads from the magnet, 80 K shields and other small users.

After a brief recall of the main particularities of a cryogenic system operating in a Tokamak environment, the first part of this study is dedicated to the assessment of the main ITER operation states with the present cryogenic Process Flow Diagram (PFD). Taking into account the heat loads related to the magnet system and the cryopump system, the relevant normal operating scenarios are checked for the typical ITER operating states like Plasma Operation State, Short Term Stand by, Short Term Maintenance, or Test and Conditioning State.

The second part of the paper is dedicated to the abnormal operating modes in order to assess the present design of the cryogenic system. This analysis distinguishes the abnormal modes coming from the magnet system from those generated by the cryoplant itself. The occurrence of a fast discharge or a quench of the magnet system generates large heat loads disturbances on the cryodistribution system and produces exceptional high mass flow rates which have to be managed by the cryoplant, while a failure of a cryogenic component induces a major disturbance on the magnet system.

Thanks to this analysis, modifications of the architecture of the present PFD are proposed to make match the technical specifications of the cryogenic system with the ITER operation requirements. In addition, this study proposes a new design of the HTS current leads refrigeration loop and a cryodistribution system which is coherent with the cryopumps operations.