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Investigation on the thermal equilibrium around a cryogenic accidental event and the impact on the possibly enclosed surrounding environment

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Complex and large cryogenic distribution systems are an integral part of a fusion machine having superconducting magnets, cryopumps etc. The various equipment of the cryogenic distribution system are interconnected via notably large cryogenic transfer lines (CTL) to distribute the cold helium to the end users. During the nominal operation of the fusion machine, the helium inventory in the CTLs could be in the order of several tons. In the worst possible accidental scenario, the cold helium present in CTLs could be released in the surrounding volume due to complete breakage of process pipe and outer vacuum jacket. This disruption can significantly reduce the temperature of the ambient including the equipment/systems existing in the area of vicinity of ruptured CTLs. Such a study on thermal equilibrium between the process fluid of CTLs and finite surrounding, possibly enclosed volume in case of accidental scenario is necessary considering the safety aspects of a fusion plant.
The simulation study of such a scenario has been performed for two possible practical cases; (i) effect on temperature of outer vacuum jacket due to loss of insulation vacuum (ii) effect on temperature of the ambient including surrounding systems due to rupture of process pipe as well as breakage of outer vacuum jacket of CTLs. A detailed mathematical model has been developed to evaluate the propagation of the thermal wave train between the process fluid of CTLs and the surrounding environment. The present analysis, based on certain assumptions, aims to estimate the lowest possible temperature in the surrounding environment due to the possible accidental scenario. A test plan in the simulated condition also has been conceptualized. The paper will describe the simulation results and basis of the test plan to obtain the near possible realization.

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