Monte Carlo approach to define the refrigerator capacities for JT-60SA

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The cryogenic system of JT-60SA shall provide refrigeration at different temperature levels to keep the toroidal and poloidal field coils, their structures and feeders at 4.4 K; deliver a flow of helium at 50 K for the current leads; allow operating the divertor cryo-pumps at 3.7 K; and keep various thermal shields at temperatures between 80 K and 100 K. The transient operation of the JT-60SA tokamak with large heat load variations between plasma pulses and intermediate recovery periods asks for a plant with an equivalent capacity at 4.5 K of 8 kW.

The total heat load for the plant comes from many different sources. The magnitude of the heat load from each source is estimated or calculated in different ways and may include uncertainties. Moreover, the parameters defining the different contributions may differ from their design value or degrade during operation of the cryogenic system. Hence it is common to add contingencies on the capacity requirement for a refrigeration plant. Heat loads are typically multiplied by a constant factor to provide this margin. For systems where the heat load comes from several independent sources, this procedure may overestimate the margin, since it is very unlikely that all contributions adopt their most unfavourable value simultaneously.

For this reason a Monte Carlo approach will be adopted to define the design requirements of the cryogenic system of JT-60SA. With this approach individual contingencies and distribution probability functions are attributed to the independent design variables. By statistically varying the parameters and adding the resulting heat loads a distribution function of heat loads is created for each temperature level. The refrigeration contingency for a given temperature may then be defined by the load which will not be exceeded with 95 % probability.

The presentation will detail the different heat load contributions from JT-60SA and describe the Monte Carlo method as it is applied to the design of the JT-60SA refrigeration system in detail.