SPACE NUCLEAR REACTOR CONCEPTS FOR AVOIDANCE OF A SINGLE POINT FAILURE

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ABSTRACT

This paper presents three space nuclear reactor concepts for future exploration missions requiring electrical power of 10's to 100's kW, for 7-10 years. These concepts avoid a single point failure in reactor cooling; and they could be used with a host of energy conversion technologies. The first is lithium or sodium heat pipes cooled reactor. The heat pipes operate at a fraction of their prevailing capillary or sonic limit. Thus, when a number of heat pipes fail, those in the adjacent modules remove their heat load, maintaining reactor core adequately cooled. The second is a reactor with a circulating liquid metal coolant. The reactor core is divided into six identical sectors, each with a separate energy conversion loop. The sectors in the reactor core are neurotically coupled, but hydraulically decoupled. Thus, when a sector experiences a loss of coolant, the fission power generated in it will be removed by the circulating coolant in the adjacent sectors. In this case, however, the reactor fission power would have to decrease to avoid exceeding the design temperature limits in the sector with a failed loop. These two reactor concepts are used with energy conversion technologies, such as advanced Thermoelectric (TE), Free Piston Stirling Engines (FPSE), and Alkali Metal Thermal-to- Electric Conversion (AMTEC). Gas cooled reactors are a better choice to use with Closed Brayton Cycle engines, such as the third reactor concept to be presented in the paper. It has a sectored core that is cooled with a binary mixture of He-Xe (40 gm/mole). Each of the three sectors in the reactor has its own CBC and neutronically, but not hydraulically, coupled to the other sectors.