ANALYZING AND MODELLING NATURAL CIRCULATION PHENOMENA IN A CANDU 6[1]

by

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SUMMARY

Postulated accidents in CANDU reactors assume that forced circulation eventually becomes unavailable due to either manual or automatic trip of the pumps or loss of Class IV power. At the end of pump rundown, the fission decay heat is transported to the steam generators by natural circulation. This natural circulation is driven by density difference of the coolant in the cold and hot vertical piping in the respective inlet and outlet sides of the reactor core. For certain postulated loss of coolant accidents concurrent with loss of forced coolant circulation, the coolant can be a two-phase mixture in certain portions of the circuit.

To develop a better understanding of natural circulation behaviour under two-phase conditions and obtain experimental data for code development and validation, a number of experiments were conducted in the multi-channel RD-14M test facility. These experiments indicated that, for certain conditions, two-phase natural circulation flow was oscillatory. Under these conditions, the flow reversed in direction in some of the simulated fuel channel assemblies. (A channel assembly consists of inlet and outlet feeders and end fittings and a heated channel.) After this flow reversal, vapour began to

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accumulate in the initially liquid-filled outlet feeder pipe. This vapour caused the flow in the fuel channel to decrease and the fuel element simulators to heat up.

This paper discusses these multi-channel flow phenomena and presents theories to explain them and models to predict their consequences in a CANDU 6. A multi-channel linear model (named MMOSS-I, Reference 1) was developed to predict the heat transport system conditions under which the two-phase coolant flow is oscillatory. It is postulated that vapour in the reverse-flowing outlet feeder results from entrainment of vapour bubbles in the outlet header due to oscillatory flow in the header and feeders. It is further postulated that these bubbles in the header are supplied by the forward-flowing feeders which are located in the same feeder bank as the reverse-flowing outlet feeder. A model (named BENDORY, References 2 and 3) was developed to compute the flow and void fraction in the reverse-flowing feeder and the connected channel. Another model (named AMPTRACT, Reference 4) developed previously is used to predict the fuel temperature under stratified flow conditions.

It is shown that vapour entrainment is self-limiting and, as a consequence, the fuel does not heat up excessively (as supported by evidence from more recent experiments) and the fuel and fuel sheath remain intact under these postulated accident conditions.

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