PRELIMINARY DESIGN OF A CONTAINMENT TO WITHSTAND CORE MELT FOR A 1,100 MWE LWR SYSTEM

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SUMMARY

The joint probability of loss of coolant accident which would lead to a core melt and subsequent vessel rupture and containment failure based on current containment designs has generally been estimated at less than 10^{-8} per reactor year, which would appear well within the bounds of required safety. However, increasing demand for metropolitan siting in time may generate a need for a containment system capable of handling massive core melt and secondary system blowdown. In addition, cost trade-offs between a decrease in emergency core cooling system requirements and reduced costs associated with the restraint and supports of the nuclear steam supply system components and the higher cost of a containment system to accommodate core melt and secondary system blowdown may yield an alternative to current designs based on highly reliable operation of emergency core cooling systems which would result in the same overall probability of radioactivity release to the environment at comparable costs.

In this paper the current literature relative to the effects of a reactor core melt in a 1,100 MWe light water reactor and its subsequent effect on the breach of the containment system are reviewed.

Sources of energy release to the containment are identified, reviewed, and quantified to include an attempt to develop pressure and temperature transients used to define containment design parameters. Included in this energy release evaluation would be the effect of secondary as well as primary system blowdown, metal water reaction, steam generation as a result of coolant contact with the molten core, and the vaporization of water of crystallization and other materials making up the structural barrier when in contact with the molten core. From the containment pressure and temperature transients developed from the various energy release to the containment design pressures and temperatures are defined and the structure sized and costed in accordance with current ACI-ASME Code design requirements.

Additional design features discussed will include a large ablative heat sink or melting bed forming part of the containment base mat, minimizing the amount of carbonate material of relatively low vaporation temperature, limiting the quantity of reactor coolant in contact with the molten core to reduce containment design pressure and potential for missile generation and the design of the containment structure for a high pressure design. The requirements for forced containment cooling to maintain containment design pressures and temperatures are also evaluated.

The net effect of such a passive containment system designed in effect to accept the consequences of a complete disruption of the nuclear steam supply system, including major component failure could be to reduce the need of the emergency core cooling systems and component support systems to meet balanced economic rather than safety considerations. Net savings in the emergency core cooling and component support systems could then be used to offset the increased containment structures cost.