OPENING AND EXTENSION OF CIRCUMFERENTIAL CRACKS IN A PIPE SUBJECT TO DYNAMIC LOADS

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SUMMARY

Nuclear power plants are presently designed to withstand instantaneous pipe severance in combination with the maximum seismic loads. The hypothetical combination of these two unlikely events leads to system designs which are very expensive and require dynamic event devices such as pipe whip restraints which have the potential for deleterious interaction with the piping system during normal operations. These present pipe rupture criteria are based on the a priori hypothesis that the instantaneous guillotine pipe break is possible, rather than from a consideration of the manner in which cracks might open or extend in a real piping system. The objective of this study is to help establish the basis for understanding how cracks which might exist in the primary piping of a pressurized water reactor (PWR) would open and extend so that new criteria can be developed based on this information.

One of the regions where loss of pressure boundary integrity must be postulated is the weld between the reactor vessel inlet nozzle and the cold leg pipe. This region (including the effects of the reactor vessel and the primary pump) is modeled for analysis with the MARC general purpose finite element program. A crack, one half circumference long, is considered to suddenly occur centered at one of the four compass points around the pipe weld when the pipe is at normal operating pressure. The most severe part of the safe shutdown earthquake (SSE) loading transient is applied simultaneously with the initiation of the crack.

The plastic dynamic analysis of the crack opening of each of the four cases is performed using the MARC program until the maximum opening occurs. The J-integral plastic crack extension criterion is computed for all times during the transient. The results indicate that none of the cracks will extend significantly and that the opening areas are small fractions of the flow area of the pipe.