INFORMATION ONLY

ORIGINAL DRAFT RAIs

REGARDING LICENSEE DEBRIS GENERATION

ASSUMPTIONS FOR GSI-191 RELATED TO INFORMATION CONTAINED IN

TECHNICAL REPORTS WCAP-16710 AND WCAP 16851

PRESSURIZED WATER REACTOR OWNERS GROUP

PROJECT NO. 694

1. Although the American National Standard Institute/American Nuclear Society (ANSI/ANS) standard predicts higher jet centerline stagnation pressures associated with higher levels of subcooling, it is not intuitive that this would necessarily correspond to a generally conservative debris generation result. Justify the initial debris generation test temperature and pressure with respect to the plant specific reactor coolant system conditions, specifically the plant hot and cold leg operating conditions. If zone of influence (ZOI) reductions are also being applied to lines connecting to the pressurizer, then please also discuss the temperature and pressure conditions in these lines. Were any tests conducted at alternate temperatures and pressures to assess the variance in the destructiveness of the test jet to the initial test condition specifications? If so, provide that assessment.

2. Describe the jacketing/insulation systems used in the plant for which the testing was conducted and compare those systems to the jacketing/insulation systems tested. Demonstrate that the tested jacketing/insulation system adequately represented the plant jacketing/insulation system. The description should include differences in the jacketing and banding systems used for piping and other components for which the test results are applied, potentially including steam generators, pressurizers, reactor coolant pumps, etc. At a minimum, the following areas should be addressed:

    a. How did the characteristic failure dimensions of the tested jacketing/insulation compare with the effective diameter of the jet at the axial placement of the target? The characteristic failure dimensions are based on the primary failure mechanisms of the jacketing system, e.g., for a stainless steel jacket held in place by three latches where all three latches must fail for the jacket to fail, then all three latches must be effectively impacted by the pressure for which the ZOI is calculated. Applying test results to a ZOI based on a centerline pressure for relatively low L/D nozzle to target spacing would be non-conservative with respect to impacting the entire target with the calculated pressure.

    b. Was the insulation and jacketing system used in the testing of the same general manufacture and manufacturing process as the insulation used in the plant? If not, what steps were taken to ensure that the general strength of the insulation system tested was conservative with respect to the plant insulation? For example, it is known that there were generally two very different processes used to manufacture calcium silicate whereby one type readily dissolved in water but the other type dissolves much more slowly. Such manufacturing differences could also become apparent in debris generation testing, as well.

c. The information provided should also include an evaluation of scaling the strength of the jacketing or encapsulation systems to the tests. For example, a latching system on a 30 inch pipe within a ZOI could be stressed much more than a latching system on a 10 inch pipe in a scaled ZOI test. If the latches used in the testing and the plants are the same, the latches in the testing could be significantly under-stressed. If a prototypically sized target were impacted by an undersized jet it would similarly be under-stressed. Evaluations of banding, jacketing, rivets, screws, etc., should be made. For example, scaling the strength of the jacketing was discussed in the OPG report on calcium silicate debris generation testing.

3. There are relatively large uncertainties associated with calculating jet stagnation pressures and ZOIs for both the test and the plant conditions based on the models used in the WCAP technical reports. What steps were taken to ensure that the calculations resulted in conservative estimates of these values? Please provide the inputs for these calculations and the sources of the inputs.

4. Technical report WCAP-16710-P discussed the direct impingement of a jet on a woven fiberglass blanket that did not result in the failure of the cloth covered blanket material. Later discussions with Westinghouse Electric Company (Westinghouse) determined that all tests included stainless steel jacketing covering the fiberglass blankets. Apparently the 5 pipe diameter (5D) ZOI test resulted in the removal of the steel jacket without significant damage to the fiberglass blanket underneath. The claim that the 5D ZOI jet did not damage an unjacketed blanket is questionable since the test started with a jacketed sample and it is unknown when the jacket was removed from the test sample. Based on the test data, the jet pressure was likely reduced from the initial pressure by the time the blanket was subjected to the jet without the protection of the jacket. Explain how it was determined that direct impingement at 5D ZOI equivalent would not fail a woven fiberglass blanket. What was the jet pressure that the blanket was subjected to after the jacket was removed? What would be the equivalent ZOI be for this condition?

5. Describe the procedure and assumptions for using the ANSI/ANS-58-2-1988 standard to calculate the test jet stagnation pressures at specific locations downrange from the test nozzle.

a. In technical report WCAP-16710-P, why was the analysis based on the initial condition of 530°F whereas the initial test temperature was specified as 550°F?

b. Was the water subcooling used in the analysis that of the initial tank temperature or was it the temperature of the water in the pipe next to the rupture disk? Test data indicated that the water in the piping had cooled below that of the test tank.

c. The break mass flow rate is a key input to the ANSI/ANS-58-2-1988 standard. How was the associated debris generation test mass flow rate determined? If the experimental volumetric flow was used, then explain how the mass flow was calculated from the volumetric flow given the considerations of potential two-phase flow and temperature dependent water and vapor densities? If the mass flow was analytically determined, then describe the analytical method used to calculate the mass flow rate.

d. Noting the extremely rapid decrease in nozzle pressure and flow rate illustrated in the test plots in the first tenths of a second, how was the transient behavior considered in the application of the ANSI/ANS-58-2-1988 standard? Specifically, did the inputs to the standard represent the initial conditions or the conditions after the first extremely rapid transient, e.g., say at one tenth of a second?

e. Given the extreme initial transient behavior of the jet, justify the use of the steady state ANSI/ANS-58-2-1988 standard jet expansion model to determine the jet centerline stagnation pressures rather than experimentally measuring the pressures.

6. Describe the procedure used to calculate the isobar volumes used in determining the equivalent spherical ZOI radii using the ANSI/ANS-58-2-1988 standard.

a. What were the assumed plant-specific RCS temperatures and pressures and break sizes used in the calculation? Note that the isobar volumes would be different for a hot leg break than for a cold leg break since the degrees of subcooling is a direct input to the ANSI/ANS-58-2-1988 standard and which affects the diameter of the jet. Note that an under calculated isobar volume would result in an under calculated ZOI radius.

b. What was the calculational method used to estimate the plant-specific and break-specific mass flow rate for the postulated plant loss of coolant accident (LOCA), which was used as input to the standard for calculating isobar volumes?

c. Given that the degree of subcooling is an input parameter to the ANSI/ANS-58-2-1988 standard and that this parameter affects the pressure isobar volumes, what steps were taken to ensure that the isobar volumes conservatively match the plant-specific postulated LOCA degree of subcooling for the plant debris generation break selections? Were multiple break conditions calculated to ensure a conservative specification of the ZOI radii?

7. Provide a detailed description of the test apparatus specifically including the piping from the pressurized test tank to the exit nozzle including the rupture disk system.

a. Based on the temperature traces in the test reports it is apparent that the fluid near the nozzle was colder than the bulk test temperature. How was the fact that the fluid near the nozzle was colder than the bulk fluid accounted for in the evaluations?

b. How was the hydraulic resistance of the test piping which affected the test flow characteristics evaluated with respect to a postulated plant specific LOCA break flow where such piping flow resistance would not be present?

c. What was the specified rupture differential pressure of the rupture disks?

8. Technical report WCAP-16710-P discusses the shock wave resulting from the instantaneous rupture of piping.

a. Was any analysis or parametric testing conducted to get an idea of the sensitivity of the potential to form a shock wave at different thermal-hydraulic conditions? Were temperatures and pressures prototypical of PWR hot legs considered?

b. Was the initial lower temperature of the fluid near the test nozzle taken into consideration in the evaluation? Specifically, was the damage potential assessed as a function of the degree of subcooling in the test initial conditions?

c. What is the basis for scaling a shock wave from the reduced-scale nozzle opening area tested to the break opening area for a limiting rupture in the actual plant piping?

d. How is the effect of a shock wave scaled with distance for both the test nozzle and plant condition?

9. Please provide the basis for concluding that a jet impact on piping insulation with a 45° seam orientation is a limiting condition for the destruction of insulation installed on steam generators, pressurizers, reactor coolant pumps, and other non-piping components in the containment. For instance, considering a break near the steam generator nozzle, once insulation panels on the steam generator directly adjacent to the break are destroyed, the LOCA jet could impact additional insulation panels on the generator from an exposed end, potentially causing damage at significantly larger distances than for the insulation configuration on piping that was tested. Furthermore, it is not clear that the banding and latching mechanisms of the insulation panels on a steam generator or other RCS components provide the same measure of protection against a LOCA jet as those of the piping insulation that was tested. Although technical report WCAP-16710-P asserts that a jet at Wolf Creek Generating Station or Callaway Nuclear Plant cannot directly impact the steam generator (SG), but will flow parallel to it, it seems that some damage to the SG insulation could occur near the break, with the parallel flow then jetting under the surviving insulation, perhaps to a much greater extent than predicted by the testing. Similar damage could occur to other component insulation. Please provide a technical basis to demonstrate that the test results for piping insulation are prototypical or conservative of the degree of

damage that would occur to insulation on steam generators and other non-piping components in the containment.

10. Some piping oriented axially with respect to the break location (including the ruptured pipe itself) could have insulation stripped off near the break. Once this insulation is stripped away, succeeding segments of insulation will have one open end exposed directly to the LOCA jet, which appears to be a more vulnerable configuration than the configuration tested by Westinghouse. As a result, damage would seemingly be capable of propagating along an axially oriented pipe significantly beyond the distances calculated by Westinghouse. Please provide a technical basis to demonstrate that the reduced ZOIs calculated for the piping configuration tested are prototypical or conservative of the degree of damage that would occur to insulation on piping lines oriented axially with respect to the break location.

11. Technical report WCAP-16710-P noted damage to the cloth blankets that cover the fiberglass insulation in some cases resulting in the release of fiberglass. The tears in the cloth covering were attributed to the steel jacket or the test fixture and not the steam jet. It seems that any damage that occurs to the target during the test would be likely to occur in the plant. Was the potential for damage to plant insulation from similar conditions considered? For example, the test fixture could represent a piping component or support, or other nearby structural member. The insulation jacketing is obviously representative of itself. What is the basis for the statement in the WCAP technical report that damage similar to that which occurred to the end pieces is not expected to occur in the plant? It is likely that a break in the plant will result in a much more chaotic condition than that which occurred in testing. Therefore, it would be more likely for the insulation to be damaged by either the jacketing or other objects nearby.

12. For the Min-K panel testing, one specimen was ejected from the test fixture and impacted a tree some 150 ft away. This impact resulted in minor damage to the encapsulation. Was the potential for a similar occurrence in the plant evaluated? What would be the result if the panel impacted an object much closer than 150 ft? Would this impact be more severe? What would be the result if the panel lodged within the jet ZOI? Could the encapsulating material fatigue, fail, and allow the insulating material to be released?