February 8, 2000

MEMORANDUM TO: Ashok C. Thadani, Director
Office of Nuclear Regulatory Research

FROM: Samuel J. Collins, Director ***/ra/***
Office of Nuclear Reactor Regulation

SUBJECT: USER NEED REQUEST RELATED TO STEAM GENERATOR SEVERE ACCIDENT RESPONSE AND TESTING OF STEAM GENERATOR TUBES DURING SEVERE ACCIDENT CONDITIONS

This memorandum requests that the Office of Nuclear Regulatory Research (RES) develop a confirmatory research program to address two areas associated with steam generator tube integrity during postulated severe-accidents in pressurized-water reactors (PWRs). Although the two areas that confirmatory research is being requested in are closely related, the Office of Nuclear Reactor Regulation (NRR) has divided this user need request into two areas since the lead for these areas are in different organizational divisions, both in NRR and RES. Both requests are considered high priority in that the information is important to confirm the robustness of risk-informed licensing decisions and to provide reduced uncertainty and improved technical bases for expected future licensing requests. The confirmatory research will support the agency's efforts to maintain safety while reducing unnecessary regulatory burden through more realistic assessments. The confirmatory research will improve the agency's knowledge where uncertainties in our technical understanding exist and where safety margins are not well characterized. Internal efficiencies will be gained with use of the models developed. The improved understanding of margins that result from this research should improve public confidence. The schedule for each request is discussed in the two attachments.

Attachment 1 is a request for RES to develop and provide us with models and/or methods capable of investigating thermal hydraulic and dose consequences associated with steam generator tube integrity during postulated severe accidents in PWRs. The Division of Systems Safety and Analysis (DSSA) has the lead in NRR for this area. Attachment 2 is a request for RES to provide us with models and/or methods capable of investigating steam generator tube structural behavior under postulated severe accident conditions. The Division of Engineering (DE) has the lead in NRR for this area. Both NRR divisions have already had very constructive discussions with your staff about some of the key issues identified in the attachments. We look forward to continued close cooperation with your staff to develop the research program in these areas.

Attachments: As stated

CONTACTS: Walton Jensen, SRXB/DSSA
415-2856

James Andersen, EMCB/DE
415-1437

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DIVISION OF SYSTEMS SAFETY AND ANALYSIS (DSSA)

OFFICE OF NUCLEAR REACTOR REGULATION

USER NEED REQUEST RELATED TO

STEAM GENERATOR SEVERE ACCIDENT RESPONSE

This attachment requests that the Office of Nuclear Regulatory Research (RES) develop a plan to investigate severe-accident behavior in pressurized-water reactors as it relates to steam generator tube integrity. Issues raised by both NRR and RES staff members during the recent review of the electrosleeve steam generator tube repair process at Callaway have indicated a need for improvement in our understanding in this area. These issues relate to uncertainties in the analysis of time to failure of reactor coolant pressure boundary components during a postulated severe accident and specifically the items listed below. Our objective is to reduce uncertainties and, therefore, improve our ability to assess the likelihood of steam generator tube failures in such accidents. These accidents, when accompanied by SG tube failures, will likely result in containment bypass and release of radioactive materials to the environment. The plan should focus on issues associated with assuring acceptable modeling of the high-temperature and high-pressure thermal-hydraulic conditions within the primary system and the mechanical response of the structures and components that make up this system during severe- accident scenarios. NRR would like the following information in areas that play a significant role in understanding and modeling these types of events:

(1) Identification of accident scenarios that lead to high-temperature and high-pressure conditions within the reactor coolant system that have a high likelihood of challenging the integrity of the reactor coolant pressure boundary;

(2) Models and/or methods that provide improved understanding of time-dependent thermal-hydraulic conditions in the hot leg, surge line, steam generator tubes, and other critical systems, structures, and components (SSCs) in the scenarios of interest, leading to a reduction in uncertainties in modeling and assessment of these events;

(3) Models and/or methods for predicting the response of the SSCs identified in Item (2) resulting from exposure to those thermal-hydraulic conditions, to improve prediction of reactor coolant pressure boundary failure locations and modes (the materials response aspects of this subtask are within the purview of the Division of Engineering (DE) and interactions on this should be with DE);

(4) An assessment of the effect, if any, each SSC failure has on the potential for containment bypass and steam generator tube failures;

(5) Models and/or methods for predicting system interaction effects and associated risk implications as a function of steam generator tube crack size

(6) Improved methods and/or models to evaluate the offsite dose consequences from a tube rupture by attenuation of fission product releases through transport and deposition mechanisms in the secondary system;

(7) Improvement of probabilistic safety assessment modeling of these scenarios, including the effects of operator actions.

Per the September 19, 1995, Memorandum of Understanding on RES and NRR Interactions (D. L. Morrison to W. T. Russell), NRR staff from DSSA and DE will work with RES staff to develop RES' Program Plan for the steam generator severe-accident program.

Schedule

We request that you provide a plan to address the needs identified by Items 1 through 7 by June 15, 2000. We would like test results from supporting experimental facilities provided by January 2001 and reports supplying the requested evaluations should be provided by the summer of 2001. However, we will work with your staff to find mutually agreed upon delivery dates for each of the products requested.

Priority

These requests should be considered high priority in that the information is important to confirm the robustness of risk-informed licensing decisions and to provide reduced uncertainty and improved technical bases for expected future licensing requests.

Future Discussions

In addition to the work specified above, NRR would like to begin discussions with RES concerning assistance in the review of MAAP, which has been used to support risk-informed licensing submittals, particularly with regard to beyond-design-basis and severe-accident analyses performed to justify or support proposed licensee actions. Specific areas of concern include success criteria, end states, timing, and system thermodynamic responses associated with these analyses. We would also like to discuss the level of guidance that should be incorporated in the Probabilistic Risk Assessment (PRA) Standard with regard to these key analytical areas.

Following these discussions, we will provide you with an additional user request for any additional work that is concluded to be necessary in this area.

DIVISION OF ENGINEERING

OFFICE OF NUCLEAR REACTOR REGULATION

USER NEED REQUEST RELATED TO TESTING OF

STEAM GENERATOR TUBES DURING SEVERE ACCIDENT CONDITIONS

Background

In considering the issues involving severe accidents and risk, the staff concludes that core damage conditions, particularly those associated with high primary pressure, dry steam generator secondary side events, have the potential to cause failure of degraded steam generator tubes and subsequent containment bypass under the high temperatures associated with these events. The staff considered high temperature effects in its risk assessment work (refer to NUREG-1570, "Risk Assessment of Severe Accident Induced Steam Generator Tube Rupture") that supported the draft steam generator rule and assessed the potential for plant-specific vulnerabilities due to particular forms of steam generator tube degradation. Uncertainties exist in our understanding of various forms of steam generator tube degradation, in particular, degraded tube behavior under severe accident conditions. We recognized and accounted for this uncertainty by taking a risk-informed approach to reviewing and approving recent alternate repair criteria and methods for degraded steam generator tubes. Nevertheless, we believe it would be beneficial to obtain additional information on degraded steam generator tube performance to reduce current uncertainties.

Technical Issue

Additional information is desired regarding the behavior of cracks in steam generator tubes under pressure differentials and elevated temperatures associated with the "high-dry" severe accident sequences. Based on available data and analyses, through-wall cracks as long as 0.4 inches are not expected to rupture under these conditions, but are expected to open significantly. Leakage of superheated steam through the opening would create a jet that would impinge on adjacent tubes. A concern has been raised that the impinging jet could cut open the neighboring tube during the course of the accident. This could alter the course of the accident so that containment would be bypassed. Staff risk evaluations have assumed that this effect would occur for cracks that are long enough to produce substantial leakage, but the staff would like additional information to better define the appropriate crack length threshold to apply to this assumption. Below some length, the staff expects the leakage to be too small to produce a steam jet that will cause gross tubing failure in the time available during the accident sequence.

In order to better address this issue, the staff would like to be able to predict the opening of subcritical through-wall cracks under severe accident conditions and to predict the cutting rate, if any, of gas jets emanating from such cracks. In particular, the staff is interested in evaluating the possibility that a jet of superheated steam, hydrogen, and entrained particles emanating from a cracked tube may penetrate the neighboring tube during severe-accident transients. In addition, the staff would like the ability to calculate the leak rate from tubes with through-wall cracks of various lengths under severe-accident conditions. The staff is interested in knowing if (and how) creep and creep crack growth play a role in the crack opening areas developed under the time/temperature/pressure exposures during severe accidents. Also, information is desired on whether the fluid escaping the crack will cause erosion of the crack walls, thereby increasing the crack opening areas.

Regulatory Application

Licensees are expected to continue to submit a number of licensing action requests pertaining to steam generator tube repair criteria and methods over the next several years. These licensing action requests may be risk-informed or may have potential risk implications. A better understanding of the phenomena and materials behavior should lead to reduced uncertainties and a more robust and accurate assessment of risk. The results from the RES work will allow the staff to make better risk-informed decisions regarding these matters.

Products

This attachment to the user need memorandum requests RES to conduct analysis, testing and modeling to determine (1) the effects of jet impingement on neighboring steam generator tubes during severe-accident transients, (2) the crack opening area, which will be used to calculate leak rate from steam generator tubes with through-wall cracks of various lengths under severe-accident conditions, (3) the critical flow through cracks in steam generator tubes, (4) if (and how) creep and creep crack growth play a role in the crack opening areas developed under severe-accident conditions, and (5) whether the fluid escaping the crack will cause erosion of the crack wall, thereby increasing the crack opening areas. Finally, the data and modeling developed above for evaluating jet impingement and leak rates from cracked tubes may need to be validated by testing of cracked tubes under simulated severe accident conditions. A decision point on the need for this type of integrated testing should be included in the RES program plan.

Schedule

As discussed in a meeting with members of your staff in November 1999, the arrangement and actual conduct of the tests to support an initial assessment for items (1) and (2) were thought to be relatively straightforward. We would like to receive the results of these tests in the fourth quarter of fiscal year 2000. Validation of results, including considerations of items (3) and (4), is requested by the fourth quarter of fiscal year 2001. We will work with your staff to ensure these are achievable schedules.

Priority

High Priority - The requested information is important to confirm the robustness of risk-informed licensing decisions and to provide reduced uncertainty and improved technical bases for expected future licensing requests.