UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

AEOD/E002

MAY 23 1980

MEMORANDUM FOR: Harold R. Denton, Director
Office of Nuclear Reactor Regulation

FROM: Carl Michelson, Director
Office for Analysis and Evaluation of
Operational Data

SUBJECT: BWR JET PUMP INTEGRITY

Since the beginning of February of this year, NRR, IE, and AEOD have been investigating the causes and evaluating the consequences and immediate corrective actions required as a result of the jet pump failure at Dresden Unit 3, LER No. 80-4/03L-0, Docket No. 050-249. The failure was determined to be caused by progressive intergranular stress corrosion cracking of the jet pump Inconel X-750 hold down beam. The deepening crack eventually led to hydrodynamically induced overloading and breakage of the remaining ligament at the root of the crack. This recent Dresden 3 experience, together with other previous jet pump integrity-related problems at the Dresden and Quad Cities units, has prompted AEOD to also review, in more general terms, the BWR jet pump mechanical design and its related design basis. Our review examined the DBA-LOCA blowdown and ECCS mechanical loadings which have been considered by GE and evaluated by the staff. The AEOD analysis and evaluation of these operating experiences and design bases, thus far, have resulted in the formulation of the following recommendations which we are now asking you to consider. Additional experience may give rise to further recommendations.

1. AEOD recommends that GE and/or the affected BWR licensees be requested to submit and commit to a schedule for replacement of all hold down beams with an improved design, and that said schedule call for implementation beginning no later than the Spring, 1981 refueling outages.

   To date, for the most part, vendor, licensee, and NRC staff discussions, evaluations, and actions have been appropriately directed toward the immediate safe operation of currently operating BWR jet pump plants. We agree that the specific concerns and issues that were addressed are consistent with current regulatory needs and requirements. Furthermore, we agree that the actions being taken by licensees provide reasonable assurance of safe plant operation in the short-term. At the same time, however, AEOD considers the jet pump integrity analyses and evaluations that were performed and the actions taken to be adequate for only a relatively brief interim period until such a time when an improved jet pump hold down component(s) can be designed, developed, and implemented. In this regard, during a meeting with the staff on April 16, 1980, GE indicated its intentions to begin work on such a long-term fix. However, GE's representatives were not prepared to commit to a specific schedule for this work, nor has GE formally done so to date. Since the current remedial licensee actions will still allow plant operation with an indeterminate number of potentially partially degraded (cracked) hold down beams (with reliance on daily jet pump operability surveillance to detect impending jet pump failure), we recommend that GE and/or the affected BWR licensees promptly be requested to submit and commit to a schedule for modifying the beam design to correct the identified shortcomings. We further recommend that their schedule call for implementation beginning no later than the Spring, 1981 refueling outages.

2. AEOD recommends that steps be taken to evaluate the potential for, and magnitude of, water hammer type loads on jet pump integrity.

   We have found from our review that the potential for, and magnitude of, water hammer type loads on the jet pump 180° elbow (and hold down beam), which might occur during the initial phase of LPCI injection (when the recirculation system piping may be filled with steam), have not been considered. Such water hammer impact loads on the elbow (beam) may be momentarily higher than the blowdown and quasi steady-state hydrodynamic LPCI injection loads already considered in the jet pump design and beam failure analysis. A load pulse could be postulated to occur as a result of the liquid water slug initially moving at a higher velocity in a steam filled piping than it would subsequently when the piping is completely filled with liquid. In this regard, plants still using LPCI loop selection logic (e.g., Dresden 3) would be of greatest interest since they would involve the largest LPCI induced dynamic forces. Accordingly, we recommend that steps be taken to evaluate the potential for, and magnitude of, water hammer type loads on jet pump integrity.

3. AEOD recommends that appropriate steps be taken to evaluate the potential for damaging jet pump vibration and fatigue failure during the initial LPCI injection or subsequent long-term cooling modes.

   Our general examination of jet pump design/analysis and testing has resulted in the finding that no analyses or tests have been performed to determine the vibrational characteristics of BWR jet pumps during the initial LPCI injection or subsequent long-term cooling modes. That is, no quantitative assessment of the susceptibility of jet pumps to damaging flow induced vibrations has been undertaken for jet pump operation in a steam or vapor surrounded environment, which would exist for large recirculation line pipe breaks. Under such circumstances, the potential exists for vapor entrainment and subsequent collapse of vapor bubbles causing excessive vibration and subsequent damage or failure of one or more jet pumps while operating in the initial or latter stages of emergency core cooling. Additionally, backflow would occur in the idle loops which could result in damaging vibrations. Accordingly, we recommend that appropriate steps be taken to evaluate the potential for damaging jet pump vibration and fatigue failure for the aforementioned conditions, since BWR operating experience has shown the tendency of jet pumps to experience higher amplitudes of vibration during off-normal (e.g., single loop operation) conditions.

We believe the above recommendations, which are intended to assure the integrity of BWR jet pumps, are consistent with NRC staff actions taken in connection with other similar operating experience prompted issues which involve LOCA potential and ECCS performance. Such issues include BWR Nozzle Cracking, BWR Core Spray Sparger Cracking, and PWR Steam Generator Tube Integrity.

In the case of BWR jet pump plants with core spray sparger cracking, for example, the staff has reviewed licensing analyses which give no credit for core spray (CS) heat transfer function even though stress-deflection analyses support the conclusion that cracked spargers will retain their structural integrity during a DBA. Thus, even though structural analyses show the sparger would be expected to remain intact following a LOCA/core spray injection, significant staff uncertainty exists as to its capability to perform its spray function as designed. This position has been taken despite CS system redundancy. Conversely, with regard to the jet pump hold down beam cracking problem, a ratio of LOCA blowdown loads to normal loads also supports the conclusion that a cracked beam will withstand the blowdown without failure. In this case, however, the staff has not required that one or more failed jet pumps be assumed for ECCS performance analysis purposes. This comparison is not intended to illustrate any inconsistency in staff actions which relate to the potential for LOCA/ECCS induced mechanical failures resulting in the loss of safety function of important safety equipment in the BWR system. The two are contrasted instead in order to substantiate our belief that there is a need to develop and document a comparatively higher degree of assurance than presently exists (via additional analysis/testing) that jet pumps will remain intact to perform their intended safety functions if such credit is to be given in the long-term. The need for this assurance appears to be especially true in the case of BWR jet pumps which potentially could be susceptible to common cause/common mode failure mechanisms such as has been discussed above.

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