



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

December 14, 1999

Mr. William T. Subalusky
Vice President and Director
Government Relations Division
Institute of Nuclear Power Operations
700 Galleria Parkway
Atlanta, GA 30339-5957

Dear Mr. Subalusky:

SUBJECT: REQUEST FOR REVIEW OF THREE REPORTS ON THE RELIABILITY OF HIGH PRESSURE INJECTION SYSTEMS IN BOILING-WATER REACTORS

Attached for your information and review are draft reports on the reliability of three high-pressure injection systems at U.S. commercial boiling-water reactors (BWR): Reliability Study Update: High-Pressure Coolant Injection (HPCI) System, 1987-1998; Reliability Study Update: High-Pressure Core Spray (HPCS) System, 1987-1998; and Reliability Study Update: Reactor Core Isolation Cooling (RCIC) System, 1987-1998.

These reports are the first update of the original reliability studies of risk-important safety systems that covered the time period from 1987 to 1993. The updated studies provide estimates of the system unreliabilities based on unplanned system demands, and quarterly and cyclic surveillance tests during the years 1987 through 1998. In addition, the reports identify dominant contributors to system unreliability, evaluate significant trends, and provide insights on failure detection methods and significant contributors to system failures.

Significant findings from these studies are as follows:

- **Overall system unreliabilities.** The industry-wide unreliabilities of the HPCI, HPCS and RCIC systems calculated from the 1987-1998 operating experience are nearly identical for all three systems--about $6E-2$ failures per demand. Recovery actions by the operator to restore the failures resulted in little improvement in these system unreliabilities. The unreliability estimates are based on failures that occurred during both unplanned demands and cyclic and quarterly surveillance tests.
- **Unreliability trends.** Estimates of system unreliability when modeled as a function of calendar year identified no statistically significant trend for any of the three systems.
- **Unplanned demand frequency trends.** Statistically significant decreasing trends were identified in the frequency of unplanned demands for all three systems when modeled as a function of calendar year. The frequency of unplanned demands decreased by about a factor of six for the HPCS system and a factor of nine for both the HPCI and RCIC systems. This is consistent with the findings presented in NUREG/CR-5750, *Rates of Initiating Events at U.S. Nuclear Power Plants, 1987-1995*.

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- *Failure frequency trends.* Statistically significant decreasing trends were identified in the frequency of failures of the HPCI and RCIC systems when modeled as a function of calendar year. The frequency of system failures decreased by about a factor of four to five for the HPCI and RCIC systems. These trending analyses included failures that were observed by all detection methods, such as all types of tests, inspections, and unplanned demands. Analysis of the HPCS system failure frequency found no statistically significant trend, mainly due to few failures of the HPCS system during the 1987-1998 time period (18 system failures from 8 plants).
- *Trends by low-power license date.* No statistically significant decreasing trends in system unreliability, unplanned demand frequency, and system failure frequency were identified for any of the three systems when modeled as a function of low-power license date. The age of the plants did not affect the unreliability or performance of any of the three systems.
- *Leading contributors to system unreliabilities.* The leading contributors to system unreliability vary for each of the three systems. The leading contributors (with recovery actions) included are:
 - HPCI system--failure of the injection valve to reopen, i.e., cycling the injection valve for subsequent reactor pressure vessel water level control (33%), failure to start of the system other than injection valve (26%), and maintenance out of service of the HPCI system (24%).
 - HPCS system--maintenance out of service of the injection train (71%) and failure to start due to the injection valve failing to initially open (22%).
 - RCIC system--failure to start of the system other than injection valve (46%) and failure to run (18%).
- *Leading component failures.* Generally, the major contributions to the unreliability of the HPCS and RCIC systems were not the result of failure of any specific component type. However, the failure of the injection valve to reopen was the major contributor to HPCI system unreliability, which contributed to 33% of the system unreliability. This contributor was due to events where the HPCI system failed as a result of thermal overload of the motor operator from repeated cycling of the injection valve during recovery from reactor trips.
- *Effectiveness of various detection methods.* Generally, testing of various types and frequencies was the most effective method in detecting failures in all three systems. Inspections (e.g., walkdowns, casual observations, plant tours) identified less than 15% of the failures of the HPCI and RCIC systems, whereas 30% of the failures of the HPCS system were identified by inspections. About one-third of the failures of the HPCI and RCIC systems were immediately identified, meaning that the failures were of the nature where plant personnel were able to respond to the failures immediately after they occurred.

The HPCI and RCIC system injection valves are tested quarterly; however, the quarterly surveillance tests of these valves are done in an environment that does not produce the same stresses on the valve that the valve would encounter in an accident environment. In addition, the injection valve is not cycled repeatedly during the quarterly test (as was the case in many unplanned demands).

- *Between-plant variations.* Statistical analysis showed plant-to-plant variations in the data of system unreliability for all three systems. However, in each case, plant-specific results of system unreliability vary little about the industry-wide average mean. The differences among plants were small and not risk-significant.
- *Comparison with PRA/IPEs.* The industry-wide average of the HPCI and RCIC system unreliabilities calculated using data (e.g., component failure probabilities, maintenance unavailability) extracted from PRA/IPEs are about a factor of three lower than the industry-wide estimate based on the 1987-1998 experience. The industry-wide average of the HPCS system unreliability based on PRA/IPE data is consistent with industry-wide estimate based on the 1987-1998 experience. The leading contributors to these unreliabilities are consistent between the PRA/IPEs and the operating experience.

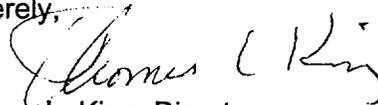
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In accordance with our peer review process we want to provide you with the opportunity to review and comment on the draft reports. We are specifically interested in your comments regarding the technical adequacy of data, specifically during the 1994-1998 update period, and the appropriateness of the findings. In order to meet our planned publication schedule, we would appreciate receiving your comments by January 28, 2000.

A copy of this draft report and letter are being placed in the Public Document Room at 2120 L Street NW, Washington, DC 20555.

If you have any questions related to this report, please contact Mr. Don Marksberry of my staff at 301-415-6378 or e-mail at dgm2@nrc.gov.

Sincerely,



Thomas L. King, Director
Division of Risk Analysis and Applications
Office of Nuclear Regulatory Research

Attachment: As stated

cc w/o att:

A. Thadani, RES
M. Federline, RES
S. Collins, NRR
R. Zimmerman, NRR
B. Sheron, NRR
J. R. Johnson, NRR



UNITED STATES
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December 14, 1999

Mr. V. K. Chexal, Director
Nuclear Safety Analysis Center
Electric Power Research Institute
P.O. Box 10412
Palo Alto, CA 94303

Dear Mr. Chexal:

SUBJECT: REQUEST FOR REVIEW OF THREE REPORTS ON THE RELIABILITY OF HIGH PRESSURE INJECTION SYSTEMS IN BOILING-WATER REACTORS

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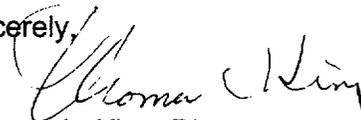
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Sincerely,



Thomas L. King, Director
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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

December 14, 1999

Mr. Ralph E. Beedle
Nuclear Energy Institute
1776 I Street N.W.
Suite 400
Washington, D.C. 20006-3708

Dear Mr. Beedle:

SUBJECT: REQUEST FOR REVIEW OF THREE REPORTS ON THE RELIABILITY OF HIGH PRESSURE INJECTION SYSTEMS IN BOILING-WATER REACTORS

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December 14, 1999

Mr. David A. Lochbaum
Union of Concerned Scientists
1616 P Street, N.W.
Suite 310
Washington, D.C. 20035-1495

Dear Mr. Lochbaum:

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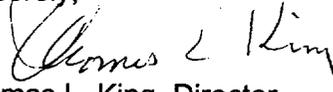
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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

December 14, 1999

Mr. Dennis Townsend
General Electric Nuclear Energy Owners Group
G.E. Nuclear Energy
175 Curtner Avenue
M/C 187
San Jose, CA 95125

Dear Mr. Townsend:

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- Leading contributors to system unreliabilities.* The leading contributors to system unreliability vary for each of the three systems. The leading contributors (with recovery actions) included are:

 - HPCI system--failure of the injection valve to reopen, i.e., cycling the injection valve for subsequent reactor pressure vessel water level control (33%), failure to start of the system other than injection valve (26%), and maintenance out of service of the HPCI system (24%).
 - HPCS system--maintenance out of service of the injection train (71%) and failure to start due to the injection valve failing to initially open (22%).
 - RCIC system--failure to start of the system other than injection valve (46%) and failure to run (18%).
- Leading component failures.* Generally, the major contributions to the unreliability of the HPCS and RCIC systems were not the result of failure of any specific component type. However, the failure of the injection valve to reopen was the major contributor to HPCI system unreliability, which contributed to 33% of the system unreliability. This contributor was due to events where the HPCI system failed as a result of thermal overload of the motor operator from repeated cycling of the injection valve during recovery from reactor trips.
- Effectiveness of various detection methods.* Generally, testing of various types and frequencies was the most effective method in detecting failures in all three systems. Inspections (e.g., walkdowns, casual observations, plant tours) identified less than 15% of the failures of the HPCI and RCIC systems, whereas 30% of the failures of the HPCS system were identified by inspections. About one-third of the failures of the HPCI and RCIC systems were immediately identified, meaning that the failures were of the nature where plant personnel were able to respond to the failures immediately after they occurred.

The HPCI and RCIC system injection valves are tested quarterly; however, the quarterly surveillance tests of these valves are done in an environment that does not produce the same stresses on the valve that the valve would encounter in an accident environment. In addition, the injection valve is not cycled repeatedly during the quarterly test (as was the case in many unplanned demands).

- *Between-plant variations.* Statistical analysis showed plant-to-plant variations in the data of system unreliability for all three systems. However, in each case, plant-specific results of system unreliability vary little about the industry-wide average mean. The differences among plants were small and not risk-significant.
- *Comparison with PRA/IPEs.* The industry-wide average of the HPCI and RCIC system unreliabilities calculated using data (e.g., component failure probabilities, maintenance unavailability) extracted from PRA/IPEs are about a factor of three lower than the industry-wide estimate based on the 1987-1998 experience. The industry-wide average of the HPCS system unreliability based on PRA/IPE data is consistent with industry-wide estimate based on the 1987-1998 experience. The leading contributors to these unreliabilities are consistent between the PRA/IPEs and the operating experience.

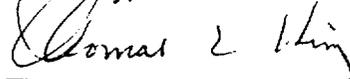
The Office of Nuclear Regulatory Research plans to update these and other related studies on a regular basis, as one part of the NRC commitment to use operating experience in risk-informed regulatory activities.

In accordance with our peer review process we want to provide you with the opportunity to review and comment on the draft reports. We are specifically interested in your comments regarding the technical adequacy of data, specifically during the 1994-1998 update period, and the appropriateness of the findings. In order to meet our planned publication schedule, we would appreciate receiving your comments by January 28, 2000.

A copy of this draft report and letter are being placed in the Public Document Room at 2120 L Street NW, Washington, DC 20555.

If you have any questions related to this report, please contact Mr. Don Marksberry of my staff at 301-415-6378 or e-mail at dgm2@nrc.gov.

Sincerely,



Thomas L. King, Director
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MEMORANDUM DATED: 12/14 /99

SUBJECT: REQUEST FOR REVIEW OF THREE REPORTS ON THE RELIABILITY OF HIGH PRESSURE INJECTION SYSTEMS IN BOILING-WATER REACTORS

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