AREVA

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U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Response to a Request for Additional Information Regarding ANP-10286P, "U.S. EPR Rod Ejection Accident Methodology Topical Report"

Ref. 1: Letter, Ronnie L. Gardner (AREVA NP Inc.) to Document Control Desk (NRC), "Request for Review and Approval of ANP-10286P, 'U.S. EPR Rod Ejection Accident Methodology Topical Report'," NRC:07:065, November 20, 2007.

Ref. 2: Letter, Getachew Tesfaye (NRC) to Ronnie L. Gardner (AREVA NP Inc.), "Third Request for Additional Information Regarding ANP-10286P, 'U.S. EPR Rod Ejection Accident Methodology Topical Report'," February 27, 2009.

Ref. 3: Letter, Ronnie L. Gardner (AREVA NP Inc.) to Document Control Desk (NRC), "Response to a Third Request for Additional Information Regarding ANP-10286P, 'U.S. EPR Rod Ejection Accident Methodology Topical Report'," NRC:09:021, March 24, 2009.

AREVA NP Inc. (AREVA NP) requested the NRC's review and approval of topical report ANP-10286P, "U.S. EPR Rod Ejection Accident Methodology Topical Report" in Reference 1. The NRC provided a third Request for Additional Information (RAI) regarding this topical report in Reference 2. The responses to all but one of the questions in this RAI were provided in Reference 3. The response to the final question, RAI-36, is enclosed with this letter, ANP-10286Q4P, "Response to a Request for Additional Information – ANP-10286P, 'U.S. EPR Rod Ejection Accident Methodology Topical Report'."

If you have any questions related to this submittal, please contact Ms. Sandra M. Sloan, Regulatory Affairs Manager for New Plants. She may be reached by telephone at 434-832-2369 or by e-mail at sandra.sloan@areva.com.

Sincerely,

Alan B Meginnis
for

Ronnie L. Gardner, Manager
Corporate Regulatory Affairs
AREVA NP Inc.

Enclosures

cc: G. Tesfaye
Docket No. 52-020

D077
NRO

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RAI-36. *In order to assess the NEMO-K/LYNX-T Computational Engine reactivity insertion accident analyses, we request that AREVA perform comparison analyses of reactor excursion tests performed during the mid-1960s at the National Reactor Testing Station. These data were taken during the E-Core campaign as part of the Special Power Reactor Test III (SPERT) program. This comparison analysis will assist the verification of compliance of the rod ejection analysis with the Standard Review Plan (SRP), Section 15.4.8.*

Response to RAI-36:

Two of the SPERT III–E facility (Reference 1) rod ejection experiments were selected for evaluation against the test results provided in Reference 2. Test 60 was selected for a hot zero power (HZP) condition and Test 86 for a hot full power (HFP) condition. These are simulated with NEMO-K using cross-sections and delayed neutron precursor data provided by the NRC. The cross-sections are converted to NEMO-K cross-section tables. The SPERT III-E experiments do not require the use of LYNXT to simulate the experiment. The majority of the remaining information is obtained from References 1 and 2, or as noted in the text. Assumptions are made where the information is not readily available. Several model assumptions are required to perform these benchmarks due to the difficulty of finding applicable reference information for modeling. A number of the key modeling assumptions are listed below.

- The cross-sections and neutron precursor data provided by the NRC are used as provided.
- The regulating control rod fuel follower is not modeled in the lower reflector region.
- The axial reflectors are modeled with a standard PWR model since it represents a similar metal to water ratio for the SPERT III-E core.
- The regulating control rod position is adjusted until the NEMO-K initial K-effective is 1.0 prior to the ejection of the transient control rod. The initial transient control rod is positioned so that it yields the measured ejected control rod worth or is within the uncertainty quoted for the test.
- The control rod ejection begins to move at zero seconds. Note that the ascension to full power and the start of the ejection for test 86 is not described in enough detail to determine whether the core is in thermal equilibrium with the power or whether significant xenon is produced. Zero xenon is assumed.
- The direct energy deposition into the coolant is based on a PWR value of 2.7 percent of the total energy produced.
- The power density in the fuel rod model for each assembly is scaled by the number of fuel rods in the assembly to obtain an accurate nodal average fuel temperature.
- The number of fuel rods per assembly and flow areas for the 5x5 fuel assembly are used for all assemblies for the hydraulic calculations. This assumption should cause an overprediction of the Moderator Temperature Coefficient (MTC) feedback in the 4x4 assemblies.
- The gap conductance for HZP and HFP are assumed constant and are 1.3042 and 2.0000 W/cm^2K, respectively (as provided by the NRC).

The base neutronic model is validated with two static comparisons. First, the hot zero power (HZP) static control rod worths at 500°F versus the initial position are calculated and compared in Figure 36-1 to the measured test results from Reference 2. Second, the calculated moderator temperature coefficient (MTC) is -3.8¢/°F and the measured MTC is listed as -4.0¢/°F. The agreement with the measured results is good (within 5%) and indicates that the assumptions made are reasonable.

Test 60 - HZP

Test 60 is an ejected control rod test initiated from a core power of 50 watts at 500 °F. In Test 60 the initial transient control rod position is set to yield a worth of 1.23$ when ejected (which is equal to the measured worth).

The mean generation time, which is controlled by the thermal neutron velocity in a 3-D kinetics code, is not directly measurable. However, if the ejected control rod worth and the beta-effective are known, then the mean generation time can be estimated from the measured reactor period. The thermal neutron velocity is adjusted to yield a reactor period of 9.6 milliseconds which is approximately equivalent to the measured reactor period of 9.7 milliseconds for Test 60. The value used for the thermal neutron velocity is within 3 percent of the values used for the U.S. EPR NEMO-K model at BOC and EOC.

The Test 60 power versus time results, as measured and calculated, are shown in Figure 36-2. The calculated peak power is 439 MW and the measured is reported as 410 ±41 MW. The calculated integrated power at the peak is 8.6 MW-sec and the measured is reported as 8.5 ±1.1 MW-sec. Both of these calculated values are within the measurement uncertainty of the test.

Test 86 - HFP

Test 86 is a prompt critical ejected control rod test initiated from a core power of 19 MW with a measured ejected rod worth of 1.17±.05$. Test 86 is simulated with an ejected control rod worth of 1.22$. This value is equal to the measured worth at the high end of its uncertainty (4.3 percent higher than the reported measured value). Reference 2 states that the ejected control rod worth can not be measured directly at power and its uncertainty is higher because the feedback is immediate and a stable reactor period was not established. The difference in control rod position between a 1.17$ and a 1.22$ ejected control rod worth is less than one-quarter inch, which highlights the sensitivity of this small core to the initial control rod position. Also, a PWR typically has to eject a full length control rod which is at least 10 feet in length to become prompt critical whereas the SPERT III-E core becomes prompt critical with less than 8.5 inches of control rod movement. This sensitivity indicates that the experimental uncertainty for control rod worth is larger than 4.3 percent, the difference between the reported worth and the worth used in the NEMO-K calculations.

The same thermal neutron velocity derived for Test 60 is used for modelling Test 86.

The Test 86 power versus time results, measured and calculated, are shown in Figure 36-3. The calculated peak power response is in agreement with the measured response yielding a calculated peak power of 604 MW compared to a measured value of 610 ±60 MW. The calculated time integrated power at the peak is 13.7 MW-sec and the measured is reported as 17 ±2 MW-sec.

The calculated result for the integrated power for this test is outside of the quoted measured uncertainty. As stated in the Table VII of Reference 2, the definition of this result is the time integrated power above the initial power. The possible causes of the difference between the measured and calculated integrated power for Test 86 could be a higher uncertainty in the measured results attributed to the "at power" conditions or a lack of refinement in the model to represent the small SPERT III-E core configuration which is not typical of a PWR. Neither of these conditions affects the ability of NEMO-K to calculate at-power ejected rod transients in PWRs as evidenced by the benchmarks included in NEMO-K topical report BAW-10221PA (Reference 3).

Conclusion

NEMO-K has been benchmarked against the SPERT III-E tests reported above and against a set of international standard problems reported in the NEMO-K topical report BAW-10221PA (Reference 3). These results demonstrate the adequacy of NEMO-K to simulate a control rod ejection transient.

References for RAI 36:

1. J. Dugone, "SPERT III Reactor Facility, E-Core Revision," IDO-17036, U.S. Atomic Energy Commission, November 1965.

2. "Reactivity Accident Test Results and Analyses for the SPERT III E-Core—A Small, Oxide-Fueled, Pressurized Water Reactor," IDO-17281, U.S. Atomic Energy Commission, March 1969.

3. BAW-10221PA, "NEMO-K a Kinetics Solution in NEMO," September 1998.

Figure 36-1—SPERT III-E Test 60 Ejected Control Rod Worths

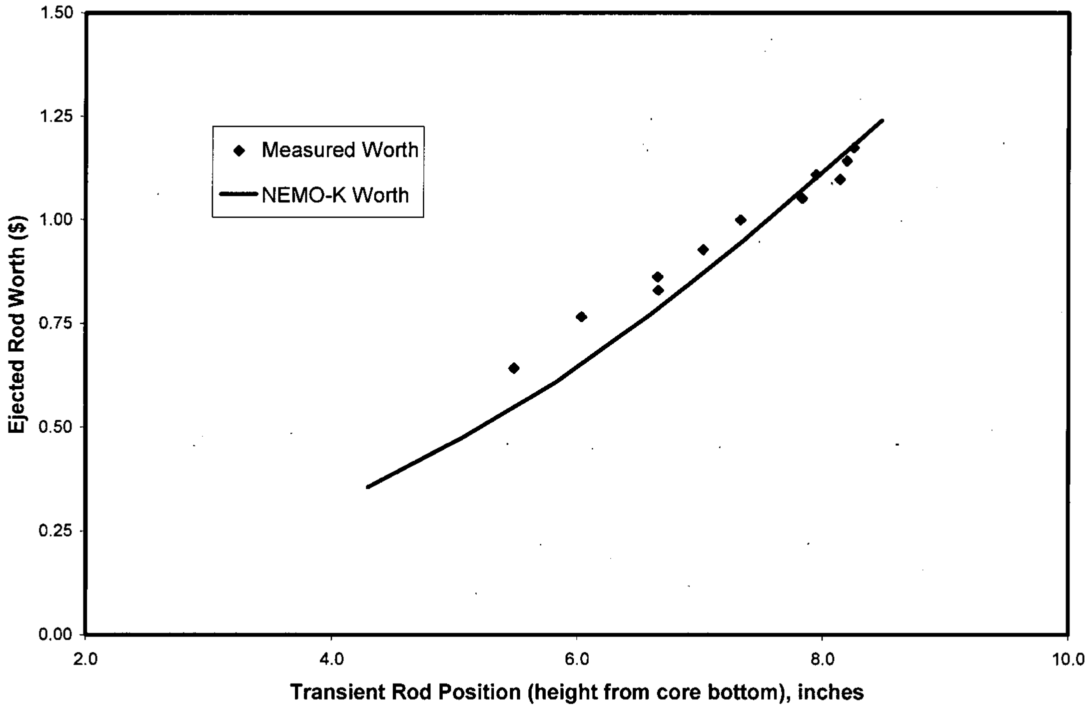

Figure 36-2—SPERT III-E Test 60 Power Response

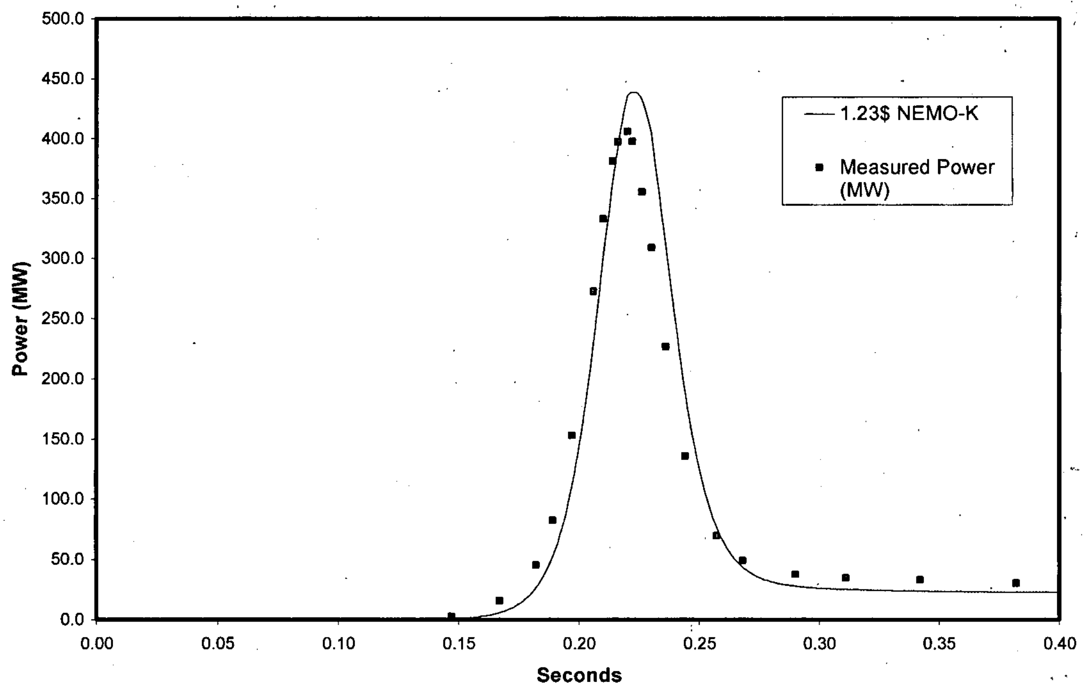

Figure 36-3—SPERT III-E Test 86 Power Response