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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

SUPPORTING AMENDMENT NO. 34 TO FACILITY OPERATING LICENSE NO. NPF-21

WASHINGTON PUBLIC POWER SUPPLY SYSTEM

WPPSS NUCLEAR PROJECT NO. 2

DOCKET NO. 50-397

1.0 INTRODUCTION

Although large steam turbines and their auxiliaries are not safety-related systems as defined by NRC regulations, failures that occur in these turbines can produce large, high energy missiles. If such missiles were to strike and damage plant safety-related structures, systems, and components, they could render them unavailable to perform their safety functions. Consequently, General Design Criterion 4, "Environmental and Missile Design Bases," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," requires, in part, that structures, systems, and components important to safety be appropriately protected against the effects of missiles that might result from such failures. The specific guidelines involving evaluation of the effects of turbine failure on the public health and safety follow Regulatory Guide 1.115, "Protection Against Low-Trajectory Turbine Missiles," and three essentially independent Standard Review Plan (SRP) Sections 10.2 "Turbine Generator," 10.2.3 "Turbine Disk Integrity," 3.5.1.3 "Turbine Missiles," and 2.2.3 "Evaluation of Potential Accidents."

In a letter dated August 18, 1986, Washington Public Power Supply System (the licensee) requested a license amendment to the WNP-2 Technical Specifications. Specifically, the licensee requested that the turbine valve test interval as specified in 3/4.3.8 be revised from weekly to monthly.

The turbine valves of the turbine overspeed protection system are tested periodically to ensure their reliability and functionality in case of a turbine overspeed event. A turbine overspeed event may lead to fracture of the turbine disc and, thus, missile generation. In WNP-2, there are four high pressure turbine throttle valves and governor valves, six low pressure turbine reheat stop valves and interceptor valves. The standard Westinghouse Technical Specifications recommend that these valves be tested weekly. The weekly test was based on historical experience in the fossil plant turbines, and its importance to the safety of turbine operation has never been clearly defined. Since implementation of the historic recommended test interval, improved valve design and an increase in the knowledge concerning turbine valve reliability mitigated the original reasons for frequent valve testing. For these reasons, in 1982, Westinghouse conducted a study (WCAP-10161) to determine the impact of extending the testing interval of turbine valves for the Farley Nuclear Power Station. The study showed that the impact of a monthly testing interval will not significantly increase the probability of turbine missile generation, and that the acceptance criteria would be met with less frequent testing.

2.0 DISCUSSION

The licensee used the Westinghouse report, WCAP-10161, as a primary reference in the submittal of WNP-2. The staff reviewed methodology and results of the report as a primary source to determine the acceptability of the extended valve testing interval. WNP-2, a boiling water reactor, uses a Westinghouse turbine generator which consists of one high pressure turbine and three low pressure turbines.

There are four methods of turbine overspeed protection. They are:

- The digital electrohydraulic (DEH) control system (governor)
- The overspeed protection controller
- Electrical overspeed trip
- Mechanical overspeed trip

The DEH system maintains the turbine speed within 2-3 rpm of the rated speed and it consists of an electronic governor using solid state control combining with a high pressure hydraulic system. The system includes electrical control circuits for speed control, load control, and turbine valve positioning. The control system includes an overspeed trip mechanism, steam admission valves, emergency stop valves, crossover intercept valves, and an initial pressure regulator.

At 103 percent of rated speed, the overspeed protection controller activates the solenoids and closes the governor and intercept valves to arrest the overspeed before the turbine reaches the maximum trip setting. The mechanical overspeed trip mechanism trips the turbine prior to 111 percent of rated speed. The mechanism will trip all steam valves thereby excluding all steam from entering the turbine. The electrical overspeed trip, which is set at about 4 rpm lower than the mechanical overspeed trip setting, will energize the solenoid trip which in turn closes all steam valves.

Probabilistic Evaluation

The probability of turbine missile generation (P) due to a turbine overspeed event is calculated by multiplying the probability of turbine overspeed (P_1) by the conditional probability of turbine missile generation (P_2), given a turbine overspeed event.

Three cases of turbine overspeed event that could generate turbine missiles were considered: design overspeed, intermediate overspeed and destructive overspeed. The total probability of turbine missile generation (P_t) is the sum of the probability of missile generation in each of the overspeed events; therefore, P_t is the sum of P_1P_2 at design overspeed, P_1P_2 at intermediate overspeed, and P_1P_2 at destructive overspeed. In WCAP-10161, the staff evaluated the fault tree construction, fault tree quantification, and derivation of missile generation probability.

Calculation Of Turbine Overspeed Probability

The turbine overspeed probability was calculated based on a fault tree analysis of the turbine overspeed protection system logic. The primary failure modes of the system were the failures of electrical and mechanical control components, trip circuitries and valves. Three fault trees were constructed for each of the three turbine overspeed conditions discussed above. Three valve testing intervals were considered in the computation: yearly, monthly, and weekly. To account for uncertainties, two sensitivity calculations were made using 50 percent and 95 percent confidence limits for each of the test intervals. Hence, the fault tree for each of the overspeed events was quantified six times.

The fault trees were not modeled as detailed as that of a full-scale probabilistic risk assessment study. For example, the basic event, "servo circuitry failure", was not further expanded to include the failure of components such as relays, switches, and contacts. The failure modes of some basic events could have been expanded to include more failure conditions. For example, the failure modes of valves did not include the operator failure to return the valves to original position after maintenance. In fact, human error was not included in any of the failure modes in the fault trees. However, the staff believes that the fault tree construction, in general, is sufficiently detailed in the context of this analysis.

System separation with sufficient steam supply is a precondition for any overspeed event. This is represented in the fault trees by an "and" gate under the top event, and the trees have been quantified for three separations per year. For any overspeed event to occur, a system separation is necessary, that is, loss of load accompanied by or due to opening of the generator output breaker.

To quantify the fault trees, the licensee used the component failure rates from different sources: (1) field incident report; (2) outage data system; (3) previous reports and service histories of turbines; (4) a panel of five engineers; (5) 1982 survey of owners of operating Westinghouse nuclear turbines; and (6) summary of a Westinghouse Generic reliability data bank search. This search included sources from IEEE-500, WASH-1400, and NUREG reports on LERs. Based on these sources, the staff believes that the licensee has adequately quantified the fault trees.

The result shows that the design overspeed probability, using a 95 percent confidence bound, is 4.7×10^{-3} and 5.3×10^{-3} per demand, per system separation for weekly and monthly valve testing intervals respectively. The intermediate overspeed probability is 5×10^{-7} and 1.1×10^{-6} per year for weekly and monthly valve testing intervals, respectively. The destructive overspeed probability is 2.8×10^{-8} and 7.8×10^{-8} per year for weekly and monthly valve testing intervals, respectively.

Calculation of Conditional Missile Generation Probability

The conditional probability of missile generation was calculated for each of the overspeed cases. The licensee assumed that a destructive overspeed event will always result in missile generation. Thus, the conditional probability of missile generation due to destructive overspeed is 1. Hence the probability of missile generation due to destructive overspeed is 7.8×10^{-8} per year.

The licensee assumed that the conditional missile generation probability due to intermediate overspeed will be at least one order of magnitude lower than that of the destructive overspeed event, i.e., 10^{-1} per year. The staff judges that the intermediate overspeed probability would lie between 1 and 10^{-1} per year and that 10^{-1} per year would fall within the uncertainty limits. Hence, the probability of missile generation of 1.1×10^{-7} per year is acceptable.

The licensee calculated the conditional probability of missile generation given a design overspeed event assuming a 5-year inspection interval of low pressure turbine discs. The conditional probability was calculated to be 5.2×10^{-4} per year. The probability of missile generation due to design overspeed is 2.8×10^{-6} per year.

Total Probability of Turbine Missile Generation

Adding the probability of missile generation in all three overspeed events, the total probability is about 3×10^{-6} per year assuming the monthly testing of turbine valves, three system separations per year, and 95 percent confidence limit. The three system separations give a total turbine missile generation probability of 9×10^{-6} per year.

Regulatory Guide 1.115 specifies that the probability of unacceptable damage from turbine missiles should be less than 1×10^{-7} per year. This probability is the product of three probabilities: a) missile generation, b) missile striking safety equipment and structures, and c) damaged equipment failing to perform their safety function. Historically, analyses assumed the missile generation probability to be about 10^{-4} per year. The missile strike probability was estimated on the basis of postulated missile sites, shapes, and energies, and on plant specific information such as turbine orientation and target geometry. The damage probability was generally assumed to be 1.0; therefore, it necessitated that strike probability be made less than or equal to 10^{-3} per year so that the unacceptable damage probability would be within 10^{-7} per year. However, the strike probability calculation involves numerous modeling approximations and simplifying assumptions that are required to incorporate available data

into acceptable models. This has become an academic exercise rather than a practical engineering analysis. Also, operating experience shows that nuclear turbine disc cracking, turbine stop and control valves failure, and disc rupture are the primary causes in the generation of missiles.

Therefore, in view of operating experience and NRC staff objectives, the staff has shifted emphasis in the reviews of the turbine missile issue from the strike and damage probability to the missile generation probability. (Ref: Safety Evaluation Report related to the operation of Hope Creek Generating Station, Supplement No. 6, Appendix U, NUREG-1048). The staff believes that maintaining an initial small value of missile generation probability through turbine testing and inspection is a reliable means of ensuring that the objectives precluding turbine missiles and unacccept-able damage to safety-related structures, systems, and components can be met. The staff has limited the missile generation probability to 1×10^{-5} per year for turbines with the rotor axis located parallel to plant structures as in the case of WNP-2. The turbine missile generation probability at WNP-2, 9×10^{-6} per year, is within the limit; therefore, monthly valve testing is acceptable on the basis of the probabilistic evaluation.

3.0 ENVIRONMENTAL CONSIDERATION

This amendment involves a change in the installation and use of a facility component located within the restricted area as defined in 10 CFR Part 20 and changes in surveillance requirements. The staff has determined that this amendment involves no significant increase in the amounts, and no significant change in the types, of any effluents that may be released offsite, and that there is no significant increase in individual or cumulative occupational radiation exposure. The Commission has previously issued a proposed finding that this amendment involves no significant hazards consideration and there has been no public comment on such finding. Accordingly, this amendment meets the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the issuance of this amendment.

4.0 CONCLUSION

The Commission made a proposed determination that the amendment involves no significant hazards consideration which was published in the Federal Register (51 FR 33960) on September 24, 1986, and consulted with the state of Washington. No public comments were received, and the state of Washington did not have any comments.

We have concluded, based on the considerations discussed above, that: (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, and (2) such activities will be conducted in compliance with the Commission's regulations and the issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public.

Principal Contributor: J. Tsao, NRR

Dated: December 11, 1986

AMENDMENT NO. 34 TO FACILITY OPERATING LICENSE NO. NPF-21
WPPSS NUCLEAR POJECT NO. 2

DISTRIBUTION:

Docket No. 50-397
NRC PDR
Local PDR
PRC System
NSIC
BWD-3 r/f
JBradfute (2)
EHylton (1)
EAdensam
Attorney, OELD
CMiles
RDiggs
JPartlow
EJordan
BGrimes
LHarmon
TBarnhart (4)
EButcher