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TECHNICAL BASES
FOR EXTENDING
GE TURBINE VALVE SURVEILLANCE INTERVALS

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IMPORTANT NOTICE REGARDING

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ABSTRACT

This document provides the technical bases for extending surveillance test intervals for the main stop and control valves and the intermediate stop and intercept valves for GE nuclear turbines with built-up low pressure rotors employing shrunk-on wheels. The bases use NRC approved acceptance criteria and methods to establish appropriate surveillance test intervals for different turbine design configurations factoring in variations in material characteristics and condition of Low Pressure (LP) shrunk-on wheels found during periodic inspections. The analysis incorporates the latest failure rate data for the turbine valves and operating experience related to scrams that have occurred during turbine valve surveillance tests. The analysis demonstrates that for selected valve testing intervals, the NRC criterion for turbine missile generation can be met, depending on specific turbine and plant characteristics. In addition, the analysis concludes that any small incremental increase in turbine missile probability due to extended valve test intervals is offset by the decreased potential for plant scrams and pressure transients during the tests.

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1.0 SUMMARY

This report documents the bases for extending current steam valve surveillance test intervals for BWR GE turbines with shrunk-on low pressure wheels such that established NRC acceptance criteria for turbine wheel missile generation are met. Steam valves include the turbine stop valves, main control valves, and intermediate stop/intercept valves. Extending the valve test intervals has the advantage of reducing the potential for inadvertent scrams during valve testing and thereby minimizing challenges to shutdown safety systems. The report uses the results from the GE update (Reference 1) to the 1984 turbine missile analysis report. The bases allows each owner to select an appropriate valve test schedule for the individual plant's turbine design configuration factoring in variations in material characteristics and condition of Low Pressure (LP) shrunk-on wheels found during periodic inspections.

2.0 INTRODUCTION

Plant scrams during periodic turbine valve testing have been identified as a cause of inadvertent plant shutdown. As part of the continuing effort to reduce the potential for plant scrams and pressure transients, the BWR Owners' Group (BWROG) initiated a program to evaluate the frequency of required turbine valve surveillance tests and provide a basis for minimizing any unnecessary testing.

As described in Reference 1, regular surveillance tests at specified intervals have been recommended by the GE turbine manufacturer to ensure proper functioning of the main stop and control valves, and the intermediate stop and intercept valves. Proper functioning of the valves, in response to control system demand, is a key factor in limiting turbine overspeed levels during plant transients, such as load rejection. The probability of a failure to close a valve, or combination of valves, during a potential overspeed event affects the probability of generation of a turbine wheel missile.

GE nuclear turbines have not experienced a wheel burst or missile incident. However, in the early 1980's stress corrosion cracks began to be detected at the wheel bore region of some shrunk-on low pressure wheels initiating from the axial keyway. As a result of this experience, a probabilistic analysis was developed by GE and submitted to the NRC during 1984 (Reference 2). The

analysis considered the probability of unit overspeed, shrunk-on wheel material properties, in-service inspection capabilities and results, and the potential for wheel containment by stationary turbine structures. In addition, the available nuclear valve failure-to-close experience data were included in the analysis.

Since approved by NRC in 1986, the GE methodology has been applied to establish turbine LP shrunk-on wheel inspection intervals which maintain turbine missile generation probabilities within NRC criteria. The GE recommended intervals for nuclear steam valve surveillance testing, and those assumed within the wheel missile analysis, are as follows:

Type of Valves	Recommended Test Frequency
Main Stop Valves (SV)	Weekly
Main Control Valves (CV)	Monthly
Intermediate Stop Valves (ISV)	Weekly
Intercept Valves (IV)	Weekly

The Reference 1 analysis is based on the approved GE methodology and NRC acceptance criteria to evaluate increased turbine valve test intervals based on the latest nuclear turbine operating experience, specific turbine and control design, and LP turbine wheel condition. This BWR Owners' Group (BWROG) report supplements the Reference 1 analysis by providing an overall safety evaluation including identification of the potential benefits related to reduced turbine valve testing.

Section 3 provides a discussion of the Reference 1 results of the updated turbine valve failure rate for failure to close based on current operating experience. Section 4 presents operating experience data on the number of plant scrams that have occurred during turbine valve testing. In Section 5, a summary of the new recommended turbine valve test intervals is provided. A more detailed discussion of the bases for these recommended test intervals is provided in Reference 1.

3.0 UPDATED TURBINE VALVE FAILURE RATES

The BWROG, with the participation of GE, initiated a survey to gather more current nuclear field data related to turbine valve failure rates. The primary purpose of the survey was to determine if current valve performance data warrants

a modification to the valve test intervals. The survey received responses from 39 GE turbine units representing 30 BWRs and 9 PWRs. The data base represents 247.4 years of reactor/turbine operation.

An updated fail-to-close rate was calculated at the 50 % confidence level for each of the turbine valves. These updated rates are referred to as the "new rates" in this report and the previous rates referred to as "old rates". The ratios of the new rates to the old rates are as follows:

Type of Valves	Percent Change (New Rate/Old Rate) X 100
Main Stop Valves (SV)	79 %
Main Control Valves (CV)	74 %
Intermediate Stop Valves (ISV)	52 %
Intercept Valves (IV)	53 %

In all cases the new rates are lower than the old rates.

The relative effect of the newly calculated fail-to-close rates on overall unit overspeed is demonstrated in Reference 1. The new valve failure rates generally result in a slightly lower overspeed probability. These new rates were used in the updated wheel missile probabilistic analysis. The recommended turbine valve test intervals discussed in Section 5 include the new rates.

4.0 PLANT SCRAMS OCCURRING DURING TURBINE VALVE TESTING

BWR operating experience indicates there have been several incidents of plant scram during periodic turbine valve tests. A plant scram causes rapid shutdown of the reactor and can challenge safety systems and operators based on changing from a steady state operation to a pressure transient condition. An increase in unnecessary plant scrams and pressure transients contributes to an increased core damage frequency as calculated in plant Probabilistic Safety Analyses. Utilities have programs underway to identify causes of scram and take action to reduce their frequency of occurrence.

A review of BWR turbine related scrams from 1985 through August 1992 indicates there have been a total of 104 turbine system related scrams from reactor operations (post startup). Of this total, 18 scrams occurred during

periodic turbine valve surveillance tests. This represents approximately 0.1 scrams per plant-year that have occurred during valve testing. Decreasing the turbine valve test frequency can reduce this scram rate and have a positive effect on plant availability and safety by reducing the potential of unnecessary plant shutdowns and challenges to safety systems and plant operators. This effect from reduced valve testing was considered in developing recommendations discussed in Section 5. It was concluded that a decrease in the turbine valve test frequency will not significantly affect the turbine missile probability beyond the established acceptance criteria. This is based on the built-in conservatism and the very low absolute value of the NRC acceptance criteria (i.e., < 1E-04/turbine-year for a favorable turbine orientation and < 1E-05 /turbine-year for an unfavorable turbine orientation).

5.0 SUMMARY OF RECOMMENDED VALVE TEST INTERVALS

Reference 1 provides the detailed results of the updated analysis of the wheel missile probabilistic analysis. The analysis was applied to a number of typical units for the purpose of demonstrating the effect of turbine valve surveillance test intervals. Also considered were the relative differences in missile probability when the new valve failure rate information is incorporated into the analysis.

A series of graphs are presented in Reference 1 which characterize the missile probability for typical turbine units. The graphs show the yearly unit wheel missile probability versus time from the latest low pressure (LP) inspection (or from initial operation where no previous inspection has been performed) for a number of potential valve test intervals.

Based on the Reference 1 evaluation, the following observations were made:

1. For all of the above testing schemes, the test intervals for turbine stop valves and control valves are interchangeable. For example, monthly stop valve/ quarterly control valve testing is equivalent to quarterly stop valve/ monthly control valve testing.

2. The new versus old valve failure rate data have a small effect on the calculated wheel missile probabilities.

3. Variations in the calculated missile probabilities are a function of many parameters.

The overall objective in choosing an appropriate test scheme is to limit the missile generation probability to an acceptable level while minimizing the amount of turbine valve testing that could result in an inadvertent scram and pressure transient which could increase the frequency of core damage. The following are considerations that support the selection of a turbine valve test interval:

1) The turbine valve surveillance test interval should not exceed 3 months.

2) The following three standard steam valve test schedules have been selected for routine evaluation by GE.

Testing Interval = Stop Valves/Control Valves/Intermediate Stop & Intercept Valves
a) Weekly/Monthly/Weekly = Monthly/Weekly/Weekly
b) Monthly/Quarterly/Monthly = Quarterly/Monthly/Monthly
c) Quarterly/Quarterly/Quarterly

Within the bounds of a maximum 3 month interval, other testing schedules may also be evaluated on a case by case basis when required.

3) To stay within the capabilities of the wheel missile analysis, the selected valve test schedule should be in effect for the total period between LP inspections. On units with LP rotors having shrunk-on wheels, GE will provide unit-specific missile probability data for the above standard test interval schedules. Each owner has the option of switching the stop and control valve test frequencies based on individual unit considerations.

4) All other periodic turbine related operational tests should remain unchanged.

6.0 REFERENCES

1) GE Proprietary Supplementary Report, "Probability of Missile Generation in General Electric Nuclear Turbines, Steam Valve Surveillance Test Interval Extension", GET-8039, September 1993. (Non-proprietary version of report, GET-8039.1, September 1993)

2) GE Proprietary Report, "Probability of Missile Generation in General Electric Nuclear Turbines", GE Large Steam Turbine-Generator Department, January, 1984.

3) NUREG-1048, Supplement 6, "Safety Evaluation Report Related to the Operation of Hope Creek Generation Station", July 1986.

4) NRC letter from A. T. Gody, Jr. to F. A. Spangenberg, Clinton Power Station, "Amendment No. 60 to Facility Operating License No. NPF-62", Docket No. 50-461, October 9, 1991.

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Subject: Pennsylvania Power & Light, Susquehanna #1 & #2
Tbs. 170X592 & 170X593
Valve Testing Frequency for Units Having Monoblock Rotors

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The purpose of this letter is to provide information to Pennsylvania Power & Light (PP&L) to support their development of a Technical Specification change which proposes a modification to the turbine steam valve surveillance testing practice. The modification being proposed is to go to quarterly (3 months) testing for the main stop, main control, and the combined intercept valves. The current practice is to test the subject valves on a weekly/monthly/weekly basis, respectively. The proposed change is related to the fact that the subject units now have monoblock low pressure turbine rotors.

The current GE recommendations for valve testing intervals are given in GE Technical Information Letter (TIL) #969-3R1 dated December 27, 1993 (copy attached). As noted in this TIL, GE revised the recommended test intervals to include the situation in which all turbine rotors in a given unit are manufactured using the monoblock construction, meaning the turbine wheels and rotor body are integral (made from a single-piece forging). As noted in the TIL, units having all monoblock rotors may go to a valve testing schedule such that the primary turbine steam valves (main stop, main control, and combined intercept valves) may be tested (on-line functional tests) at intervals up to but not exceeding three months.

The original built-up rotor construction supplied for the Susquehanna #1 and #2 units were replaced with rotors made of the monoblock forging design. Therefore, the missile analysis that applied to the original built-up rotors is not applicable to the monoblock rotors, i.e., there is no need for making the wheel missile analysis for the monoblock rotors for the following reasons.

The Nuclear Regulatory Commission (NRC) requires that utilities in the United States consider the effects of turbine missiles as well as many other hypothetical events that might affect the operation of nuclear power plants. The utilities commonly demonstrate protection against the effects of turbine missiles by the use of probability - based analyses. The NRC has developed guidelines that limit the maximum annual probability for various hypothetical events. In the case of the Susquehanna units, the limit for the annual probability for generation of a turbine missile is $1X10^{-5}$. Analyses by GE have shown that this probability limit can be exceeded for units that have the built-up rotor construction with separate wheels shrunk on a shaft and have axial keyways in the wheels. Experience has shown that stress corrosion cracks (SCC) can initiate and grow with time in the wheel axial keyways. If such cracking is allowed to continue, a wheel burst may occur, presenting the potential for a wheel missile to exit the turbine. Thus, GE developed a missile probability calculation procedure for calculating unit missile probabilities for the units having the built-up rotor construction. The acceptance of this procedure by the NRC is discussed in the NRC's NUREG-1048, Supplement No. 6 (July 1986).

For the Susquehanna units, the maximum attainable speed is 215-218% if the single-admission operating mode is used and 218-222% if the partial arc admission operating mode is used. The minimum speed capability of the monoblock rotors, assuming all buckets remain attached to the rotor, is 219-225%. This range is based on the minimum specification tensile strength value. Using a more typical tensile strength value, the speed capability is increased to 230-235%. Therefore, based on a conservative evaluation, the speed capability of the monoblock rotors is considerably higher than the shrunk-on design and in excess of the maximum speed capability of the involved units.

A complete failure of the control system is required to achieve the above overspeeds. The annual probability of this complete failure is in the range of 10^{-3}.

In conclusion, the possibility of turbine wheel missiles being generated due to stress corrosion cracking in wheel bores is no longer present with use of the monoblock rotors. It is therefore concluded the Susquehanna units can implement the extended valve test intervals as discussed in the GE TIL-969-3R1.

Please transmit the contents of this letter to Mr. Terry Bannon of PP&L.

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