3/4.3.8 TURBINE OVERSPEED PROTECTION SYSTEM

LIMITING CONDITION FOR OPERATION

3.3.8 At least one turbine overspeed protection system shall be OPERABLE.

APPLICABILITY: OPERATIONAL CONDITIONS 1 and 2.

ACTION:

a. With one turbine governor valve or one turbine throttle valve per steam chest inoperable and not closed, restore the inoperable valve to OPERABLE status within 72 hours, isolate the affected steam chest from the steam supply, or isolate the turbine from the steam supply within the next 6 hours.

b. With one turbine interceptor valve or one turbine reheat stop valve inoperable, restore the inoperable valve to OPERABLE status within 72 hours, or close at least one valve in the affected steam line or isolate the turbine from the steam supply within the next 6 hours.

c. With either of the the above required turbine overspeed protection systems otherwise inoperable, isolate the turbine from the steam supply within the next 6 hours.

SURVEILLANCE REQUIREMENTS

4.3.8.1 The provisions of Specification 4.0.4 are not applicable.

4.3.8.2 The above required turbine overspeed protection system shall be demonstrated OPERABLE:

a. At least once per ~~7~~ 31 days by:

Cycling each of the following valves through at least one complete cycle from the running position for the overspeed protection control system, the electrical overspeed trip system and the mechanical overspeed trip system;

1. Four high pressure turbine throttle valves,
2. Six low pressure turbine reheat stop valves,
3. Four high pressure turbine governor valves, and
4. Six low pressure turbine interceptor valves.

WARRANT No: 05872 19-2/1250

WASHINGTON PUBLIC POWER SUPPLY SYSTEM
P.O BOX 968, RICHLAND, WASHINGTON 99352

5871

PAY
NE HUNDRED FIFTY AND NO/100 DOLLARS * 02/18/86 $ ********150.00

TO THE ORDER OF • U.S. NUCLEAR REGULATORY COMM.
• COMMISSION

Washington Public Power Supply System
Payable From Any Monies in the Nuclear Project No. 2 Revenue Account

SEAFIRST BANK
1001 4TH AVENUE
SEATTLE, WA 98154

⑈005872⑈ ⑆125000024⑆ 9920 612⑈

INVOICE NO	DATE	VOUCHER	P.O. CONTRACT	GROSS AMOUNT	DISCOUNT	NET AMOUNT
			# 2	OL APPLICATION FEE		
	021586	518100		150.00		150.00

CHECK NO	DATE	VENDOR NO	VENDOR NAME	TOTAL AMOUNT
5871	021886	UU358	U.S. NUCLEAR REGULATORY COMM.	150.00

STATE OF WASHINGTON)
)
County of Benton)

Subject: Turbine Overspeed Protection System

I, R. B. Glasscock, being duly sworn, subscribe to and say that I am the Director, Licensing & Assurance for the WASHINGTON PUBLIC POWER SUPPLY SYSTEM, the applicant herein; that I have full authority to execute this oath; that I have reviewed the foregoing; and that to the best of my knowledge, information and belief the statements made in it are true.

R B Glasscock

R. B. Glasscock, Director
Licensing & Assurance

On this day personally appeared before me R. B. Glasscock to me known to be the individual who executed the foregoing instrument and acknowledge that he signed the same as his free act and deed for the uses and purposes therein mentioned.

GIVEN under my hand and seal this 18 day of August, 1986.

S.R. Murdock

Notary Public in and for the
State of Washington

Residing at Richland, Wa.
"89"

Safety Evaluation
For the Impact of Reduced Turbine Valve Testing on
the Operation of Washington
Nuclear Project - 2

INTRODUCTION

Historically, Westinghouse has recommended that turbine valves be tested periodically. A weekly test recommendation originated in the mid-1950's primarily as a result of service experience associated with fossil plant application at that time and in recognition of the importance of reliable turbine generator operation as it relates to operating personnel and equipment protection.

The importance of frequent valve testing to maintenance of the integrity of systems necessary for the safe operation of nuclear plants has never been clearly established. Nevertheless, the periodic valve testing recommendation has evolved into a license requirement for certain recent nuclear power plants by virtue of its inclusion as part of plant technical specifications. The technical specification requirement appears to be arbitrarily applied-in some cases - weekly test intervals, in others - monthly, and in still others - no requirement at all.

Based on the lack of a demonstrated safety need for frequent turbine valve testing and the inconsistency with which the requirement to test turbine valves has been applied, an evaluation to minimize turbine valve testing frequency is warranted.

In 1982 and in support of Alabama Power Company's Farley units, Westinghouse performed a probabilistic study that demonstrated that less frequent testing of turbine valves does not influence valve reliability or failure rates and from a safety point of view yearly testing is adequate. This study which is documented in WCAP-10161, "Evaluation of Impact of Reduced Testing of Turbine

Valves", is specific to Farley 1 and 2 but is generally applicable to Westinghouse nuclear turbines of the type installed at Farley (i.e., BB296 units with steam chests). Another report WSTG-3-P, "Analysis of the Probability of a Nuclear Turbine Reaching Destructive Overspeed" which was prepared by Westinghouse Steam Turbine Generator Division further documents the impact of turbine valve test frequency on turbine valve reliability. Based upon the results documented in these reports Westinghouse revised the recommended turbine valve test interval from weekly to monthly. In addition to the Farley units, the results of these studies have been successfully applied to the McGuire, Crystal River, and St. Lucie units (all BB296 turbines) to extend their turbine valve testing intervals from weekly to monthly.

SYSTEM DESCRIPTION

The main turbine is a tandem-compound unit, consistent of one double-flow high pressure turbine and three double-flow low pressure turbines, running at 1800 rpm with 44 inch last-stage blades. Exhaust steam from the high pressure turbine passes through two moisture separator/reheaters (two stage reheat) before entering the low pressure turbine inlets. The exhaust steam from the three low pressure turbines is condensed in the main condenser.

The generator has a hydrogen cooled rotor and a water cooled stator. It is a three phase, 60 cycle, 25,000 volt, 1800 rpm unit rated at 1,230,000 kVA at .975 power factor.

Steam is transported from the reactor by four main steam lines and flows through the turbine stop valves and control valves to the high pressure turbine. The steam lines are combined upstream of the stop and control valves. The turbine bypass valves are located upstream of the turbine stop valves to permit steam bypass to the main condenser during transient conditions.

The turbine generator is equipped with a digital electrohydraulic (DEH) control system. The DEH system consists of an electronic governor using solid state control in combination with a high pressure hydraulic system completely independent of the turbine lubricating system. The high pressure fluid supply is from a dual pump system in which one pump is a backup for the other. The system includes electrical control circuits for speed control, load control, and valve positioning. The turbine control system includes an overspeed trip mechanism, steam admission valves, emergency stop valves, crossover intercept valves, and an initial pressure regulator.

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

a. Governor (DEH)
b. Overspeed protection controller (OPC)
c. Mechanical overspeed trip mechanism
d. Electrical overspeed trip.

The governor, digital electrohydraulic control system maintain the turbine speed within 2-3 rpm. The speed is maintained as long as the load demand does not exceed the capability of the turbine generator unit.

The overspeed protection controller's primary function is to avoid excessive turbine overspeed such that the turbine trip is avoided. At 103% of rated speed, the OPC solenoids open, closing the governor and intercept valves to arrest the overspeed before it reaches the trip setting of 111% of rated speed. After the turbine coastdown to synchronous speed, the digital system takes control and maintains the turbine generator at synchronous speed. The turbine generator is then ready to be resynchronized.

If the turbine accelerates to 111% of rated speed, the mechanical overspeed trip mechanism trips the turbine. Tripping is accomplished by outward movement of the mechancial overspeed trip mechanism weight due to high centrifugal forces caused by excessive turbine speed. The mechanical trip mechanism causes the high pressure hydraulic trip fluid to be released to the drain. All of the

steam valves will trip closed thereby excluding all steam from entering the turbine. The turbine speed is thereby maintained below 120% of rated speed and the unit will coastdown to turning gear operation.

In addition an electrical overspeed trip, set at approximately 4 RPM higher than the mechanical overspeed will energize the solenoid trip which also dumps the high pressure hydraulic trip fluid to drain. The results are the same as the mechanical overspeed trip. This setpoint differential permits each trip device to be tested separately.

EVALUATION OF TURBINE OVERSPEED

There are three turbine overspeed cases of increasing severity which may occur as a result of equipment malfunction or failure. They are, design overspeed, intermediate overspeed and destructive overspeed. The events leading to each of the overspeed cases are described below.

Design Overspeed

The turbine speed will reach design overspeed if:

A. During normal operation load is lost, the output breakers open and a turbine trip does not occur at even onset.

B. Both the speed control and overspeed protection systems fail to close at least one or more governor valves or one or more interceptor valves.

C. The emergency trip system functions properly and interrupts the steam flow into the turbine.

Intermediate Overspeed

The conditions that lead to 130% of rated speed, given a full-load system separation are:

A. All throttle or governor valves are closed before design overspeed is reached.

B. One or more steam lines from the MSR's to the LP turbines remain open after the unit trips.

Destructive Overspeed

The turbine speed may reach the destructive overspeed if the following events occur simultaneously:

A. System separation with sufficient steam supply into the turbines, e.g., this can happen if the load is lost and the breaker opens during normal operation, and

B. A combination of failures in the overspeed protection and emergency trip systems, causing a high pressure turbine inlet to be kept open.

It should be noted that 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. Otherwise, the events which result in the occurrence of the overspeed conditions are unique. This necessitates evaluating each of the three overspeed occurrences separately.

WCAP-10161 documents a probabilistic evaluation of turbine overspeed for a BB296 unit with DEH. The methodology and the fault tree analysis and results and the data used to quantify the fault tree are directly applicable to the turbine found at Washington Nuclear Project - 2. The results documented in this report will be used to discuss design and intermediate overspeed.

WSTG-3-P documents a probabilistic evaluation of destructive overspeed for a BB296 unit with DEH. The contents of this report are directly applicable to Washington Nuclear Project - 2. The results documented in this report will be used to discuss destructive overspeed. Finally, Westinghouse Steam Turbine Generator Division has prepared a report specific to Washington Nuclear Project - 2 describing a turbine inspection program based upon turbine missile generation probabilities. The results documented in this report, "Turbine Missile Report, Results of Probability Analyses of Disc Rupture and Missile Generation", March, 1981 will be used to discuss design overspeed.

Design Overspeed Probability

WCAP-10161 documents two methods for calculating design overspeed probability. The first method utilizes a fault tree evaluation and gave consideration to the impact of varying turbine valve test intervals. This method results in a design overspeed probability, using a 95% confidence bound, of 4.7×10^{-3} and 5.3×10^{-3} per system separation for weekly and monthly turbine valve testing, respectively.

The second method of calculating the probability of design overspeed that was used, relied on operating experience. Based on operating experience Westinghouse has estimated the probability of design overspeed to be 3.2×10^{-3} per system separation using a 95 percent upper confidence bound. This calculated probability value is believed to be conservative since Westinghouse is not aware of any occurrence of a design overspeed event in a Westinghouse nuclear turbine which was caused by failure of turbine inlet valves or the control system.

Intermediate Overspeed Probability

WCAP-10161 utilized a fault tree evaluation with consideration for turbine valve test interval to determine the probability of intermediate overspeed. As

documented, the probability of intermediate overspeed using a 95% confidence bound was 5×10^{-7} and 1.1×10^{-6} per system separation for weekly and monthly turbine valve testing, respectively.

Destructive Overspeed Probability

WSTG-3-P utilized a fault tree evaluation with consideration for turbine valve test interval to determine the probability of intermediate overspeed. As documented, the probability of destructive overspeed using a 95% confidence bound was 2.8×10^{-8} and 7.8×10^{-8} per system separation for weekly and monthly turbine valve testing, respectively.

MISSILE GENERATION PROBABILITY

This section evaluates the potential for missile generation assuming a turbine overspeed has occurred. Such an assessment requires consideration not only of the likelihood of turbine overspeed, but also of the conditional probability of missile generation. The entire analytical operation can be conveniently expressed in the form of the following equation:

$$P = P_1 \times P_2$$

P_1 represents the estimated probability of turbine overspeed, P_2 represents the conditional probability of missile generation and P represents the absolute probability that a turbine missile will be generated. Missile generation probability for each overspeed event described is calculated in the following paragraphs. The sum of the three probabilities indicates the total missile generation probability per system separation.

Design Overspeed Missile Generation Probability

The report, "Turbine Missile Report, Results of Probability Analyses of Disc Rupture and Missile Generation" establishes the probabilities (P) of generating missiles at design overspeed for various low pressure turbine rotor inspection intervals. Utilizing the design overspeed missile generation probability for a five year inspection interval obtained from Table IV Output Summary, a missile generation probability (P_2) of 5.2×10^{-4} for the design overspeed case can be obtained. This value was arrived at by converting the five year probability to a yearly probability and then calculating P_2 as described in WCAP-10161.

The probability of design overspeed has been shown to be 5.3×10^{-3} utilizing the fault tree approach and assuming monthly testing. Using the P_2 value for design overspeed obtained above results in a probability of generating a missile at design overspeed of:

$$\begin{aligned} P &= P_1 \times P_2 \\ &= 5.3 \times 10^{-3} \times 5.2 \times 10^{-4} \\ &= 2.8 \times 10^{-6} \end{aligned}$$

Intermediate Overspeed Missile Generation Probability

The probability of intermediate overspeed has been shown to be 1.1×10^{-6} per system separation assuming monthly turbine valve testing. As discussed in WCAP-10161 no detailed analysis has been performed to determine the conditional probability of missile generation for the intermediate overspeed case. It is believed, however, that this condition probability is at least one order of magnitude lower than the condition probability of generating a missile at

destructive overspeed. That is, $P_2 = .1$. Therefore, the probability of generating a missile at intermediate overspeed per system seperation is:

$$P = P_1 \times P_2$$

$$= 1.1 \times 10^{-6} \times .1$$

$$= 1.1 \times 10^{-7}$$

Destructive Overspeed Missile Generation Probability

The probability of destructive overspeed has been shown to be 7.8×10^{-8} per system separation assuming monthly turbine valve testing. The conditional probability of generating a missile at destructive overspeed is assumed to be 1.0. Therefore, the probability of generating a missile at destructive overspeed per system separation is:

$$P = P_1 \times P_2$$
$$= 7.8 \times 10^{-8} \times 1.0$$
$$= 7.8 \times 10^{-8}$$

Total Missile Generation Probability

Total missile generation probability is the sum of the missile generaton probabilities for each turbine overspeed case. The total missile generation probability per system separation assuming monthly testing then is:

$$P_T = P_{DSO} + P_{IO} + P_{DO}$$

$$= 2.8 \times 10^{-6} + 1.1 \times 10^{-7} + 7.8 \times 10^{-8}$$

$$= 3 \times 10^{-6}$$

According to published NRC guidelines in Standard Review Plan Section 2.2.3 and Regulatory Guide 1.115 the probability of unacceptable damage from turbine missiles should be less than 1×10^{-7} per year. Historically, as discussed in Regulatory Guide 1.115 and in the paper, "Probability of Damage to Nuclear Components Due to Turbine Failure" by Spencer H. Bush, this value has been segregated into two probabilities with values of 1×10^{-4} and 1×10^{-3}. The value of 1×10^{-4} represents the probability of generating a missile. The value of 1×10^{-3} represents the probability of a missile striking and damaging critical components. Historically, then, acceptance criteria for the probability of generating a turbine missile is 1×10^{-4} per year. More recently the NRC has been considering limiting the probability of turbine missile generation probability to 1×10^{-5} for turbines with the rotor axis located parallel to plant structures as in the case with Washington Nuclear Project - 2 (NRC letter to R. L. Ferguson from A. Schwencer dated March 16, 1983, subject: Turbine Maintenance Commitment for WNP-2 Turbine Missile Issue).

The total turbine missile generation probability per system separation calculated above is 3×10^{-6}. To obtain the yearly turbine missile generation probability the value of 3×10^{-6} must be multiplied by the number of system separations experienced per year. WCAP-10161 assumed 3 system separations per year. Using this value, the total yearly turbine missile generation probability is 9×10^{-6}. This total yearly turbine missile generation probability is less than the historically accepted value of 1×10^{-4} per year and less than the more recent requirement of 1×10^{-5} per year. The total yearly turbine missile generation probability assuming weekly testing is 7.6×10^{-6}. The increase in turbine missile generation probability from weekly to monthly testing then is small and considred acceptable.

STATISTICAL EVALUATION OF VALVE TESTING INTERVAL AND VALVE FAILURE

WCAP-10161 and WSTG-3-P contain a statistical evaluation of valve test interval and valve failure. The statistical comparison considered valve failure rates

for different turbine valve test intervals. The conclusion reached was that statistically there can be shown no dependence of valve failure rate to the valve test interval, or, valve failure rate is independent of valve test interval. This conclusion is supportive of the same conclusion reached by evaluating valve failure mechanisms. WCAP-10161 concluded that considering known valve failure modes the required periodic testing cannot influence valve failure rates since it does not readily identify failure precursors. In summary, it is expected that less frequent turbine valve testing will not adversely impact turbine valve reliability.

CONCLUSION

As a result of the evaluations performed and documented in WCAP-10161 and WSTG-3-P Westinghouse has revised the recommended turbine valve test interval for BB296 units from weekly to monthly. Westinghouse further recommends that at a minimum plants with BB296 units revise plant technical specifications to allow monthly testing of turbine valves. This recommendation is based on the high reliability of the turbine overspeed and trip system which has been demonstrated by plant experience and which is supported by the foregoing evaluation. Additionally, it has been shown that the probability of generating a missile from turbine overspeed is acceptably low and satisfies all published acceptance criteria.

REFERENCES

1) WCAP-10161, "Evaluation of Impact of Reduced Testing of Turbine Valves", September 1982, Westinghouse NES. (Proprietary)

2) WSTG-3-P,. "Analysis of the Probability of a Nuclear Turbine Reaching Destructive Overspeed", July 1984. (Proprietary)

3) "Probability of Damage to Nuclear Components Due to Turbine Failure", by Spencer H. Bush. Taken from Nuclear Safety, Vol. 14, No. 3, May-June 1973.

4) Regulatory Guide 1.115, "Protection Against Low-Trajectory Turbine Missiles", Revision 1, July 1977.

5) Washington Nuclear Project - 2 Final Safety Analysis Report

6) "Turbine Missile Report, Results of Probability Analyses of Disc Rupture and Missile Generation", Revision 1, March, 1981, Westinghouse Steam Turbine Generator Division. (Proprietary)