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TOLEDO EDISON

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Director of Nuclear Reactor Regulation
Attn.: Mr. John F. Stolz
Operating Reactor Branch No. 4
Division of Licensing
United States Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Stolz:

By letter dated November 7, 1983 (Serial No. 1000), Toledo Edison Company submitted the Davis-Besse Nuclear Power Station, Unit No. 1 response to Generic Letter 83-28 (Log No. 1322), entitled "Required Actions Based on Generic Implications of Salem ATWS Events". Within that submittal, Toledo Edison provided detailed responses to each specific item identified in the Generic Letter 83-28.

Item 4.5.3 of the Generic Letter concerns the adequacy of testing intervals for the Reactor Trip System (RTS). Attachment 1 to this letter provides a summary of the Babcock & Wilcox (B&W) report, "Review of On-Line Test Intervals for the Reactor Trip System".

Through participation with the B&W Owners Group (BWOG), Toledo Edison has demonstrated that the current on-line test interval for the RTS is consistent with high RTS availability.

Very truly yours,

RPC:JSH:nlf
encl.
cc: DB-1 NRC Resident Inspector

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Summary

The following reports the findings of an investigation to respond to Question 4.5.3 of Enclosure A of Nuclear Regulatory Commission (NRC) letter to all Licensees, SUBJECT: Required Actions Based on Generic Implications of Salem ATWS Events (Generic Letter 83-28). Question 4.5.3 requests verification of the existing one-month Reactor Trip System (RTS) test interval and reads:

"4.5 REACTOR TRIP SYSTEM RELIABILITY (SYSTEM FUNCTIONAL TESTING)

Position

On-line functional testing of the reactor trip system, including independent testing of the diverse trip features, shall be performed on all plants.

1. . . . . .

2. . . . . .

3. Existing intervals for on-line functional testing required by Technical Specifications shall be reviewed to determine that the intervals are consistent with achieving high reactor trip system availability when accounting for considerations such as:

    1. Uncertainties in component failure rates
    2. Uncertainty in common mode failure rates
    3. Reduced redundancy during testing
    4. Operator errors during testing
    5. Component "wear-out" caused by the testing

Question 4.5 also addresses changes to the test interval:

> Changes to existing required intervals for on-line testing as well as the intervals to be determined by licensees currently not performing on-line testing shall be justified by information on the sensitivity of reactor trip system availability to parameters such as the test intervals, component failure rates, and common mode failure rates."

At this time, the purpose of the investigation is to explicitly respond to the request of 4.5.3 and provide estimates of the reliability for the existing one-month test interval.

Configuration Features of Importance

The investigation performed is generic to all plants with B&W NSS equipment, including 177 and 205 fuel assembly plants. Only two significant design configurations exist for these plants that must be accounted for by the reliability evaluation of the RTS at the one-month test interval (or for longer intervals).

Consequently, two separate models have been constructed. For this project, all 177 fuel assembly plants, except Davis-Besse, are represented by one configuration (Oconee group); Davis-Besse and Bellefonte, a 205 Fuel Assembly plant, are the other configuration (Davis-Besse group). The fundamental difference between the two configurations is:

Oconee group: Safety rods (groups 1-4) are tripped by the Control Rod Drive Control System (CRDCS) using the D.C. Shunt and A.C. undervoltage trip devices of each A.C. or D.C. breaker. Regulating rods (groups 5-7) are tripped by the electronic trip (SCR trip) portion of the CRDCS and CRDCS A.C. trip breakers using D.C. shunt and A.C. undervoltage trip devices.

Davis-Besse group: All rods are tripped by either the CRDCS using A.C. breakers or the electronic trip (SCR trip). Each breaker is tripped by D.C. shunt and A.C. undervoltage trip devices.

Both configurations offer similar diversity since the mechanical breakers are backed by the electronic trip (SCR trip). The electronic trip reduces the possibility of common mode failures.

Trip actuation features of these two groups of plants are very similar. The Reactor Protection System (RPS) and the sensor inputs are virtually the same. The evaluation also included the Anticipatory Reactor Trip System (ARTS) that senses loss of feedwater and signals reactor and turbine trip. Minor differences of the ARTS arrangement exist between the two groups of plants.

In addition to the diversity that has existed in the B&W RTS due to the electronic trip, two important equipment upgrades were implemented to reduce the potential for common mode failure of the breakers. Since these changes will be in effect for the remainder of plant life, they were included for investigation. The changes are:

1. Change of trip shaft bearing lubricant to Mobil 28 from Lubriko, the original trip shaft bearing lubricant. Accelerated aging tests by General Electric indicate that Mobil 28 has an expected lifetime in excess of approximately 1×10^6 hours (approximately

100 years), as compared to the Lubriko lifetime of 1 x 10^5 hours (approximately 10-11 years), at an expected operating temperature of 40°C. Thus, the past aging problems associated with lubricant stiffening are expected to be diminished considerably for the remainder of plant life. In particular, the common mode failure contribution to RTS unavailability that has largely been attributed to breaker shaft bearing stiffness resulting in slow response when the undervoltage device is actuated is expected to be corrected by the lubricant change. This change also includes installation of a new latch roller assembly and new trip shaft bearings.

2. Addition of an RPS trip signal to the D.C. Shunt trip device. This device operates on a different principle than the A.C. undervoltage trip device. Whereas the A.C. device is released by removal of power to the coil and uses the power stored in its spring to rotate the trip shaft, the D.C. shunt device uses the power obtained by energizing a coil to rotate the trip shaft to the "breaker open" position. The undervoltage device can apply about 24 in. oz. of torque, but the shunt device can apply approximately 200 in. oz. of torque and is able to overcome the resistance of "frozen" lubricant in the trip shaft bearings (estimated maximum resistance is approximately 110 in. oz.). Thus, the D.C. shunt trip provides a diverse mechanism from the A.C. undervoltage device and would be expected to cause shaft rotation even with frozen bearings.

Methods and Approach

The modeling methods use Reliability Block Diagrams (RBD's) for the RTS and the CRDCS breaker subsystems involved in a reactor trip. The PACRAT code was used to calculate the time dependent unavailability of equipment for the one-month on-line test intervals. The PACRAT code was developed by B&W. It is similar to FRANTIC II and has been used for other evaluations of the RPS previously submitted to the NRC (see Topical Report BAW-10085P, "Reactor Protection System", Vol. 2, Rev. 6, April, 1979).

The RBD models constructed for the Oconee and Davis-Besse groups include sensors and process equipment providing signals to the Reactor Protection System (RPS), the RPS trip module outputs, the sensors and processing equipment associated with the Anticipatory Reactor Trip System (ARTS), the ARTS outputs, the CRDCS breakers, and the CRDCS Electronic Trip (SCR trip).

The analysis addressed automatic RTS operation and omitted credit for the additional advantages of operator action for manual trips and operator action to "power drive" the rods in using the CRDCS in manual.

All of the five issues raised by Question 4.5.3 were addressed by the evaluation. Random and common mode equipment failure rates were accounted for and operating experience was used to support the evaluation wherever possible.

Data from Licensee Event Reports (LER's) was used for sensors and instrument strings and B&W operating experience data was relied upon to provide random and common mode breaker failure rates and was updated to show the effects of the lubricant changes.

Historic operating experience for B&W and Combustion Engineering (CE) plants was evaluated to obtain failure modes and frequencies for the individual breaker components. CE operating experience was used to provide failure rates for the shunt trip device and both B&W and CE experience provided data to support the undervoltage device failure rates.

Since the lubricant change will improve the reliability of undervoltage device actuation, the expected future performance was accounted for by crediting the breaker data base operating experience for those past events for which failure would not have occurred had the new lubricant been installed.

Generic data sources were used to provide failure rates for quantification for electrical components of the RTS other than the breakers, sensors, and instrument strings.

Wearout caused by test cycling and aging was evaluated for all components and emphasis was placed on the breakers since they are most affected by testing. The breakers are designed for 12,500 cycles and the lubricant change will virtually eliminate aging concerns. It was concluded that wearout is a relatively unimportant concern, however, possible effects were simulated by a sensitivity analysis using the RBD's.

The effects of testing on RTS availability included the influence of operator errors during testing and considered test and maintenance errors that could contribute to breaker failure to trip. The effect of reduced system redundancy due to channel bypass during testing was also evaluated. The tests of importance are the monthly single channel RPS and ARTS instrument string, the trip module and breaker tests.

Time dependent point estimate values for the RTS unavailability were determined using best estimate data to establish a base line and the sensitivity analysis was performed to indicate the influence of uncertainties for the five considerations of Question 4.5.3. The sensitivity analysis was based on a 95% upper bound distribution and provided insights for the effects of uncertainties.

Summary of Results and Conclusions

1. The results of the best estimate and sensitivity analyses are:

	Average System Unavailability Using Best-Estimate Data	
	Davis-Besse Class	Oconee Class
Base Case		
Best-estimate time-averaged system unavailability	6×10^{-7}/demand	6×10^{-7}/demand

	Average System Unavailability Using 95% Upper Bound Data	
	Davis-Besse Class	Oconee Class
Sensitivity to		
Uncertainties in random component failure rates	7×10^{-7}/demand (slightly sensitive)	2×10^{-6}/demand (moderately sensitive)
Uncertainties in common mode failure rates/operator errors	9×10^{-6}/demand (highly sensitive)	6×10^{-6}/demand (highly sensitive)
Reduced redundancy during test (channel bypass)	7×10^{-7}/demand (slightly sensitive)	6×10^{-7}/demand (slightly sensitive)
Breaker wearout caused by testing	(not sensitive)	(not sensitive)

2. The RTS configuration of both the Oconee and Davis-Besse groups have several features that contribute to the high reliability, such as:

   a. The Electronic Trip (SCR trip) provides a diverse method of trip actuation that is separate from the CRDCS mechanical breakers. Thus, the potential for failure to trip due to common mode failure of the breakers is significantly reduced.

b. The common mode failure potential of the breakers is considerably reduced by the addition of the shunt trip device which provides diversity from the undervoltage device. The reliability of trip actuation by the undervoltage device is improved by the lubricant change from Lubriko to Mobil 28.

c. The RPS and ARTS are configured with four channels.

3. The wearout evaluation indicated that the RTS components are not susceptible to wearout caused by testing. The breakers are the major components affected by test cycling and the GE AK-2 breaker has a design cycle objective of 12,500 cycles. Aging of the trip shaft bearing lubricant is virtually eliminated as a concern when the Mobil 28 lubricant is installed. Therefore, for the breakers, common mode failure due to wearout is not a significant source of RTS unavailability. Other components do not exhibit histories that indicate that wearout is a concern.

4. Reduced redundancy caused by testing does not significantly contribute to RTS unavailability. Reduced redundancy is primarily due to bypass testing of the RPS and ARTS sensor strings, which has the effect of reducing the trip logic from 2/4 to 2/3 for the duration of the tests. Other on-line tests (breakers, electronic trip, trip modules) are performed with the channel tripped and, therefore, in a "fail-safe" condition that does not affect unavailability.