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August 23, 1985
5211-85-2135
RFW-0591

Office of Nuclear Reactor Regulation
Attn: John F. Stolz, Chief
Operating Reactors Branch No. 4
Washington, D. C. 20555

Dear Mr. Stolz:

Three Mile Island Nuclear Station Unit 1 (TMI-1)
Operating License No. DPR-50
Docket No. 50-289
Response to NRC Request for Additional Information
Generic Letter 83-28, Item 4.5.3

On November 8, 1983, GPUN provided a response to Generic Letter 83-28, "Required Actions Based on Generic Implications of Salem/ATWS Events," defining the degree of TMI-1 conformance as well as plans and schedules for upgrades to conform with the positions of the Generic Letter. On April 3, 1985, the NRC requested additional information on Items 2.1, 2.2 and 4.5 of the Generic Letter. GPUN provided information on Items 2.1 and 2.2 on August 5, 1985. This letter provides information on Item 4.5 and completes our response to the NRC's request for additional information.

Item 4.5.3 concerns the reliability of the Reactor Trip System (RTS) based upon the current Technical Specification required on-line functional testing interval. As indicated in our November 8, 1983 response, GPUN was participating in the Babcock & Wilcox Owners Group (BWOG) program to demonstrate that the current on-line test interval for the RTS is consistent with high RTS availability. The NRC requested a description of the program, a discussion of the results and plant specific information regarding how the results will be implemented at TMI-1.

The BWOG has completed its program and evaluation and concludes that the current one month surveillance test interval is consistent with high reliability. The evaluation (Attachment 1) was submitted to the NRC on

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April 8, 1985. Section 4.5, Reactor Trip System Reliability (System Functional Testing), provides the information requested by the NRC. GPUN has reviewed the evaluation and concurs. Note the two equipment upgrades discussed in the section Configuration Features of Importance have been implemented at TMI-1.

Sincerely,

R. F. Wilson
Director Technical Functions

RFW:gpa
2231f/001-2
Attachment

cc: R. Conte
T. Murley
J. Thoma

04850073

THE B&W OWNERS GROUP

Arkansas Power & Light Company ANO-1
Duke Power Company Oconee 1, 2, 3
Florida Power Corporation Crystal River 3
GPU Nuclear Corporation TMI-1
Sacramento Municipal Utility District Rancho Seco

Toledo Edison Company Davis Besse
Tennessee Valley Authority Bellefonte 1, 2
Washington Public Power Supply System WNP 1
Babcock & Wilcox Company

Working Together to Economically Provide Reliable and Safe Electrical Power

April 8, 1985

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Mr. Thompson
Division of Licensing
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, DC 20555

SUBJECT: B&W Owners Group - ATWS Committee
Amended Response to GL 83-28

Gentlemen:

Attached is Amendment 1 to the B&W Owners Group response to Generic Letter 83-28 dated November 5, 1983.

This Amendment addresses Items 4.1, 4.2, and 4.5.3 documenting our completed actions to date and future activities relative to these items.

The information contained herein has been for the most part, previously discussed with your staff during recent meetings. There has been significant interaction with your staff during the formulation and implementation of these resolutions. We believe this was most helpful in the development of sound and thorough resolutions.

Should you have questions with regard to the Owners Group activities, please contact me.

Very truly yours,

J. Ted Enos

J. Ted Enos, Chairman
BWOG ATWS Committee

JTE:ds

cc: BWOG ATWS Committee
E. C. Simpson FPC
J. H. Taylor B&W

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4.1 REACTOR TRIP SYSTEM RELIABILITY (VENDOR-RELATED MODIFICATIONS)

The original response to this Item (November 1983) indicated that no Vendor related modification had been recommended for the GE AK Reactor Trip Breakers (RTB).

In February 1984, the B&W Owners Group (BWOG) undertook a program to determine long term actions to improve reliability of the RTBs, in particular the Undervoltage (UV) trip device. This program was discussed with the NRC during a meeting on April 1984 and in detail during presentations by the BWOG to the NRC on June 21, 1984 and October 10, 1984.

The long term Improvement Program evaluated two general types of improvements:

Replace GE AK Breakers with a different device; and

Modify existing GE AK Breakers.

A number of alternatives were identified in each category as follows:

<u>Replacement Alternatives</u>

<u>W</u> DS-206 Breaker with UV and shunt

<u>W</u> DS-416 Breaker with UV and shunt

ITE K600 Breaker with UV and shunt

ITE K1600 Breaker with UV and shunt

Contactor/Molded Case Breaker combination

Solid State Device

<u>Modification Alternative</u>

Replacement of bearings with Mobil 28 lubricated bearings and shunt trip.

Replacement of front frames and a shunt trip

Replacement of bearings with Mobil 28 lubricated bearings and a boosted UV device and a shunt trip

Replacement of bearings with Mobil 28 lubricated bearings and 2 shunt trips.

It was recognized that many parameters and concerns existed which must be evaluated against each option to determine the one that best improved long term performance in a reasonable and economic manner. As such, the Kepner-Tregor Decision Analysis technique was applied to assist in determining the best alternative. This technique is a systematic process for thorough consideration of objectives, alternatives, and risks in selection of a course of action and it proved very valuable in our application.

To accomplish the review, a comprehensive list of system "Requirements" and "Desirables" were established. An alternative had to meet all Requirements to be considered acceptable. Following this, the Desirables were "weighted" by relative importance and each alternative was assigned a numerical score based on its capability to meet the Desirable. The final result was a numerical rating of each alternative which represented its ranking as an alternative. Attachment 1 and 2 are listings of the Requirements and Desirables.

The first round KT evaluation clearly indicated that Modification alternatives were superior to Replacement Alternatives.

A second KT evaluation was conducted on the Replacement alternatives. This evaluation focused on Desirables (the alternatives had already met all the Requirements) in an effort to fine tune the evaluation and more clearly distinguish between the alternatives.

The entire program was oriented toward identifying the root cause of previous UV performance problems and identifying the most cost effective resolution of those problems. A substantial amount of data was gathered and evaluated which indicated conclusively that the root cause was two fold:

Improper Maintenance Practices; and

Aging of bearing lubricant.

This, combined with the results of the evaluation program lead conclusively to the following necessary modifications to resolve long term reliability concerns.

Improved Maintenance and Surveillance Practices

Incorporation of Screening and Operability Criterion

Installation of DC shunt trip

Replacement of Trip Shaft bearings with Mobil 28 lubricated bearings

Followup effort to verify fix.

This solution was chosen by the BWOG for the following reasons.

It meets all of the evaluation requirements.

The results of maintenance improvements made in 1983 were very positive.

It results in a breaker unreliability rate of less than 10E-3 per demand.

The overall Reactor Trip System Unreliability (failure to trip) is extremely small.

The shunt trip to be added has a proven high reliability.

GE lubrication testing indicated approximately a factor of 10 increase in life with Mobil 28 lubricant as compared to the old lubricant.

It is a cost effective solution that technically resolves the concerns.

The BWOG has recommended that all applicable GE and B&W service-advisories for RTB Maintenance be incorporated into the individual plant procedures. As some of this guidance has been changed and/or superceded during the evolution of this issue, the BWOG has directed B&W to provide a Comprehensive Service Advisory which encompasses all currently valid advisory information and supercedes all previous advisories. Upon completion of this work, the advisory will be provided to the individual utilities.

The BWOG has recommended that each utility incorporate a screening and operability criterion in its maintenance/surveillance procedure(s). The Screening Criterion (nominally 50 msec) is a measure of RTB response time which indicates the RTB may be in need of maintenance but at a point where the RTB is still operable. The Operability Criterion (nominally 100 msec) is a measure of RTB response time (based on Safety Analysis) beyond which the RTB is not Operable.

The BWOG has recommended that each utility install a DC shunt trip on existing GE AK RTBs.

The BWOG has recommended that each utility adopt the 12 month preventative maintenance interval recommended by GE and B&W.

The BWOG has recommended that each utility replace trip shaft and latch roller bearings (in existing RTBs) with bearings lubricated with Mobil 28. In addition, the BWOG has recommended Mobil 28 lubricated bearings be used exclusively in GE AK RTBs.

The BWOG has implemented a data gathering effort to evaluate the effectiveness of these modifications. This program is expected to continue for approximately 2 years. (See Amendment 1 response to Item 4.2 for further details.)

EVALUATION CRITERIA

ALL OPTIONS

REQUIREMENTS

- o Capability to Interrupt 22KA @ 600V
- o Trip Capability from RPS
- o Reliability Greater than 10 E-3
- o 500 Amp Continuous Current Rating
- o Response Time Less than 80 msec
- o Seismic Qualification (IEEE 344)
- o Compliance with GDCs
- o Diverse From SCRs (ATWS Rule)

EVALUATION CRITERIA

ALL OPTIONS

DESIRABLES

- Minimize Response Time
- 2/1 Trip Force Over Required
- Parts Available Thru 2006
- Minimize Maintenance Required
- Minimize Cost
- Maximize Expected Life
- Maximize Maintenance Interval
- Minimize Implementation Schedule
- Capability To Provide Trip Confirm

4.2 Reactor Trip System Reliability (Preventive Maintenance and Surveillance Program for Reactor Trip Breakers).

Item 1: A Planned Program of periodic maintenance, including lubrication, housekeeping, and other items recommended by the equipment supplier.

Our Amendment 1 response to Item 4.1 describes the BWOG recommendations for periodic maintenance.

Item 2: Trending of parameters affecting operation and measured during testing to forecast degradation of operability.

Our November 3, 1983 response described in some detail a proposed program for trending RTB performance to forecast degradation. This program was originally proposed at a time (1983) when actual performance degradation of RTB performance was being observed over a relatively short time. As such, it was expected that a trending program could predict a need for maintenance over a short period (e.g. months).

The degradation in performance is now understood and attributed to aging problems with the lubricant used in the RTB bearings. As discussed in our Amendment 1 response to Item 4.1, the BWOG has recommended that the RTB bearings be replaced with bearings lubricated with Mobil 28 lubricant. Extensive testing by General Electric has indicated that a similar aging problem with Mobil 28 should not occur for well in excess of 40 years. This testing is substantiated by the fact that the test data predicted aging problems with the old lubricant at a time very consistent with field data. With a change to bearings lubricated with Mobil 28, short term performance degradation is not expected.

Given this, the monitoring program has been reoriented to provide a "proof of fix." The program collects data from the B&W Operating Owners on key performance parameters notably UV response time, trip shaft torque, and UV device pick-up and drop out voltage. As the program is oriented toward breaker performance, non-performance related maintenance parameters (e.g., insulation resistance, etc.) are not being collected.

Data from these performance parameters is provided to the BWOG Availability Committee for trending and analysis. Provided no unexpected results are obtained, we anticipate this program to complete in approximately two years.

In addition to the lubrication change, the BWOG has recommended the incorporation of screening criteria in the maintenance/surveillance procedure(s), which would result in RTB maintenance prior to exceeding an Operability limit.

The BWOG has recommended that Preventative Maintenance be performed on GE RTB's, at a 12 month interval. Field experience with Mobil 28 lubricated bearings, to date, has shown essentially no RTB performance degradation between maintenance intervals.

Item 3: Life testing of the breakers (including the trip attachments), on an acceptable sample size.

The BWOG has evaluated this concern and the circumstances surrounding the Westinghouse RTBs at Salem, which prompted the concern. Substantial input has been obtained from General Electric and B&W in the course of this evaluation as well as the field experience of the RTB users.

It is the conclusion of the BWOG that the design of the GE AK RTBs is such that the breaker and its tripping devices are not susceptible to a wear related failure as are the Westinghouse RTBs. GE does not recommend replacement of any trip related parts (due to wear related concerns) for the life of the breaker. Breaker life is defined by GE in years and number of trips both of which are beyond actual service projected to be seen in actual RTB service.

As such the BWOG has concluded that life cycle testing of a GE RTB would produce no useful information to predict wear related failures as there are no mechanistic means for wear to produce a failure. The BWOG therefore, does not recommend performance of a life cycle test.

Please refer to the BWOG Amendment 1 response to Item 4.5.3 for further analysis of breaker wear.

Item 4: Periodic replacement of breakers or components consistent with demonstrated life cycles.

The BWOG recommends that GE RTBs be maintained and/or replaced consistent with existing General Electric and B&W guidance.

4.5 REACTOR TRIP SYSTEM RELIABILITY (System Functional Testing)

Item 4.5.3

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"

Licensing currently not performing periodic on-line testing shall determine appropriate test intervals as described above. 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.

Our November 3, 1983, response indicated that the BWOG had an evaluation underway to address this item. That evaluation has been completed and the results demonstrate the current one month surveillance test interval for the Reactor Trip System is consistent with high reliability.

The following is a summary of the evaluation and conclusions.

<u>Configuration Features of Importance</u>

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's) portion of the CRDCS and the 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 are now in progress (or have been completed) to reduce the potential for common mode failure of the breakers. As it is anticipated these changes will be incorporated at all plants, they were assumed to exist for the purpose of this evaluation.

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 (~100 years) as compared to the Lubriko lifetime of 1×10^5 hours (~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. The BWOG has recommended each utility change existing RTB bearings to bearings lubricated with Mobil 28 lubricant (see Amendment 1 to Item 4.1).

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 30 oz. in of torque, but the shunt device can apply approximately 200 oz. in of torque. 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 reactor trip. The PACRAT code (developed by B&W was used to calculate the time dependent unavailability of equipment for the one-month on-line test intervals. 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 the Anticipatory Reactor Trip System (ARTS), the ARTS outputs, the control Rod Drive Control System (CRDCS) breakers, and the CRDCS Electronic Trip (SCR's). 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 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 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 U.V. device failure rates. Since the lubricant change will improve the reliability of the U.V. 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-average system	6×10^{-7}/demand	6×10^{-7}/demand

	Average System unavailability using best-estimate 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)	9×10^{-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 Bessee 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 12,400 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.

5. The evaluation of the RTS reliability and demonstration that high reliability is achieved with the current 1 month testing frequency addresses the concerns of Generic Letter 83-28 Item 4.5.3. The necessity of further evaluation to determine a different surveillance interval has been referred to the BWOG Tech Spec Task Force to be incorporated in their overall evaluation of Tech Specs.