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

SAFETY EVALUATION REPORT
GENERIC LETTER 83-28, ITEM 4.5.3 REACTOR TRIP SYSTEM RELIABILITY FOR ALL DOMESTIC OPERATING REACTORS

1.0 INTRODUCTION

On February 25, 1983, both of the scram circuit breakers at Unit 1 of the Salem Nuclear Power Plant failed to open upon an automatic reactor trip signal from the reactor protection system (RPS). This incident was terminated manually by the operator about 30 seconds after the initiation of the automatic trip signal. The failure of the circuit breakers was determined to be related to the sticking of the undervoltage trip attachment. Prior to this incident, on February 22, 1983, at Unit 1 of the Salem Nuclear Power Plant, an automatic trip signal was generated based on steam generator low-low level during plant startup. In this case, the reactor was tripped manually by the operator almost coincidentally with the automatic trip.

Following these incidents, on February 28, 1983, the NRC Executive Director for Operations (EDO), directed the staff to investigate and report on the generic implications of these occurrences at Unit 1 of the Salem Nuclear Power Plant. The results of the staff's inquiry into the generic implications of the Salem Unit 1 incidents are reported in NUREG-1000, "Generic Implications of the ATWS Events at the Salem Nuclear Power Plant." As a result of this investigation, the Commission (NRC) requested (by Generic Letter 83-28 dated July 8, 1983) all licensees of operating reactors, applicants for an operating license, and holders of construction permits to respond to generic issues raised by the analyses of these ATWS events.

The licensees were required by Generic Letter 83-28, Item 4.5.3 to confirm that on-line functional testing of the reactor trip system (RTS), including independent testing of the diverse trip features, was being performed at all plants.

Existing intervals for on-line functional testing required by Technical Specifications were to be reviewed to determine if the test intervals were adequate for achieving high RTS availability when accounting for considerations such as: (1) uncertainties in component failure rates; (2) uncertainties in common mode failure rates; (3) reduced redundancy during testing; (4) operator error during testing; and (5) component "wear-out" caused by the testing.

2.0 DISCUSSION

The NRC's contractor, Idaho National Engineering Laboratory (INEL), reviewed the licensee Owners Group availability analyses and evaluated the adequacy of the existing test intervals, with a consideration of the above five items, for all plants. The results of this review are reported in detail in EGG-NTA 8341, "A Review of Reactor Trip System Availability Analyses for Generic Letter 83-28, Item 4.5.3 Resolution," dated March 1989 and summarized in this report. The results of our evaluation of Item 4.5.3 and our review of EGG-NTA-8341 are presented below.

The Babcock & Wilcox (B&W), Combustion Engineering (CE), General Electric (GE), and Westinghouse (W) Owners Groups have submitted topical reports either in response to GL 83-28, Item 4.5.3 or to provide a basis for requesting Technical Specification changes to extend RTS surveillance test intervals (STI). The owners groups' analyses addressed the adequacy of the existing intervals for on-line functional testing of the RTS, with the considerations required by Item 4.5.3, by quantitatively estimating the unavailability of the RTS. These analyses found that the RTS was very reliable and that the unavailability was dominated y common cause failure and human error.

The ability to accurately estimate unavailability for very reliable systems was considered extensively in NUREG-0460, "Anticipated Transients Without Scram fr Light Water Reactors", and the ATWS rulemaking. The uncertainties of such estimates are large, because the systems are highly reliable, very little experience exists to support the estimates, and common cause failure probabilities are difficult to estimate. Therefore, we believe that the RTS unavailability estimates in these studies, while useful for evaluating test intervals, must be used with caution.

NUREG-0460 also states that for systems with low failure probability, such as the RTS, common mode failures tend to predominate, and, for a number of reasons, additional testing will not appreciably low RTS unavailability. First, testing more frequently than weekly is generally impractical, and even so the increased testing could at best lower the failure probability by less than a factor of four compared to monthly testing. Secondly, increased testing could possibly of a common mode failure through increased stress on the system. Finally, not all potential failures are detectable by testing. In summary, NUREG-0460 provides additional justification to demonstrate that the current monthly test intervals are adequate to maintain high RTS availability.

3.0 CONCLUSION

All four vendors' topical reports have shown the currently configured RTS to be highly reliable with the current monthly test intervals. Our contractor has reviewed these analyses and performed independent estimates of their own which conclude that the current test intervals provide high reliability. In addition, the analyses in NUREG-0460 have shown that for a number of reasons, more frequent testing than monthly will not appreciably lower the estimates of failure probability.

Based on our review of the Owners Group topical reports, our contractor's independent analysis, and the findings noted in NUREG-0460, we conclude that the existing intervals, as recommended in the topical reports, for on-line functional testing are consistent with achieving high RTS availability that all operating reactors.

ENCLOSURE 2

EGG-NTA-8341
March 1989

Idaho
National
Engineering
Laboratory

Managed
by the U.S.
Department
of Energy

TECHNICAL EVALUATION REPORT

A REVIEW OF REACTOR TRIP SYSTEM AVAILABILITY ANALYSES FOR GENERIC LETTER 83-28, ITEM 4.5.3, RESOLUTION

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FIN D6001: Evaluation of Conformance to Generic Letter 83-28 for ORs (Project 2)

ABSTRACT

The Idaho National Engineering Laboratory (INEL) conducted a technical review of the commercial nuclear reactor licensees' responses to the requirements of the Nuclear Regulatory Commission's (NRC's) Generic Letter 83-28 (GL 83-28), Item 4.5.3. The results of this review, if all plants are shown to be covered by an adequate analysis, will provide the NRC staff with a basis to close out this issue with no further review. The licensees, as the four vendors' Owners' Groups, submitted analyses to the NRC either directly in response to GL 83-28, Item 4.5.3, or to provide a basis for requesting changes to the Technical Specifications (TS) that would extend the Reactor Protection System (RPS) surveillance test intervals (STIs). To conduct the review, the INEL defined three criteria to determine the adequacy, plant applicability, and acceptability of the results. The INEL examined the Owners Groups' reports to determine if the analyses and results met the established criteria. Fort St. Vrain's responses to Item 4.5.3 were also reviewed. The INEL review results show that all licensees of currently operating commercial nuclear reactors have adequately demonstrated that their current on-line RPS test intervals meet the requirements of GL 83-28, Item 4.5.3.

SUMMARY

The two anticipated transient without scram (ATWS) events at the Salem Nuclear Power Plant in February of 1983, focused the attention of the Nuclear Regulatory Commission (NRC) on the generic implications of ATWS events. The NRC then published Generic Letter 83-28 (GL-83-28) which listed the actions the NRC required of all licensees holding operating licenses and others with respect to assuring the reliability of the Reactor Protection System (RPS). GL 83-28, Item 4.5.3, required licensees to demonstrate by review that the current on-line functional testing intervals are consistent with achieving high reactor trip system (RTS) availability. The licensees responded to the GL 83-28, Item 4.5.3, requirements as Owners Groups with reports either in direct response to Item 4.5.3, or with a technical basis for requesting extensions to the surveillance test intervals (STIs) that generally included the Item 4.5.3 required reviews.

The NRC's Instrumentation and Control Systems Branch (ICSB), Office of Nuclear Reactor Regulation (NRR), requested the Idaho National Engineering Laboratory (INEL) to review the licensee availability analyses and evaluate the overall adequacy of the existing test intervals. INEL review results showing general compliance with Item 4.5.3 will provide the NRC with a basis to close out Item 4.5.3 without further review.

For the review, the INEL defined three acceptance criteria, reviewed the licensees topical reports, contractor review reports, and NRC safety evaluations, and determined the adequacy of the analyses and the RTS availability estimates with regard to the review criteria.

The INEL review criteria to determine the licensees' Item 4.5.3 compliance were, (1) the five areas of concern of Item 4.5.3, (2) the analyses' plant applicability, and (3) the NRC's RTS electrical unavailability base case estimates from the ATWS Rulemaking Paper, SECY-83-293.

Each Owners Groups' reports were reviewed to ensure that all five areas of concern from Item 4.5.3 were either included in the analyses or shown not to be significant with regard to RTS availability. The INEL review also ensured that the individual plants' differences from the analysis' models were taken into account and their effects were shown not to significantly affect RTS unavailability. The Fort St. Vrain responses to Item 4.5.3 were also reviewed.

The Owners Groups' RTS unavailability estimates were compared to the NRC's ATWS Rulemaking generic RTS unavailability estimates to determine the acceptability of the Owners Groups' conclusions that high RTS availability was demonstrated in the analyses.

The results of the INEL review showed that all licensees of currently operating commercial nuclear reactors have adequately demonstrated that their current on-line surveillance test intervals are consistent with achieving high RTS availability.

ACRONYMS

ATWS	Anticipated Transient Without Scram
B&W	Babcock & Wilcox
BNL	Brookhaven National Laboratory
CE	Combustion Engineering
GE	General Electric
HTGR	High-Temperature Gas-Cooled Reactor
ICSB	Instrumentation and Control Systems Branch
INEL	Idaho National Engineering Laboratory
LWR	Light Water Reactor
NFSC	Nuclear Facility Safety Committee
NRC	Nuclear Regulatory Commission
NRR	Office of Nuclear Reactor Regulation
PORC	Plant Operations Review Committee
PSC	Public Service Company of Colorado
PWR	Pressurized Water Reactor
RSSMAP	Reactor Safety Study Methodology Applications Program
RPS	Reactor Protection System
RTS	Reactor Trip System
SER	Safety Evaluation Report
STI	Surveillance Test Interval
TER	Technical Evaluation Report
W	Westinghouse

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TECHNICAL EVALUATION REPORT: A REVIEW OF REACTOR TRIP SYSTEM AVAILABILITY ANALYSES FOR GENERIC LETTER 83-28, ITEM 4.5.3 RESOLUTION

1. INTRODUCTION

1.1 Historical Background

In February of 1983, two events occurred at the Salem Nuclear Generating Station that focused Nuclear Regulatory Commission (NRC) attention on the generic implications of anticipated transient without scram (ATWS) events.

First, on February 22, during startup of Unit 1 an automatic trip signal generated as a result of a steam generator low-low level failed to cause a reactor scram. The reactor was tripped manually by an operator almost coincidentally with the automatic trip signal, so the fact that the automatic trip had failed to cause a scram went unnoticed.

Three days later on February 25, both of the scram breakers at Unit 1 failed to open on an automatic reactor protection system (RPS) scram signal. The operators took action to control this second ATWS and succeeded in terminating the incident in about 30 seconds. Subsequent investigation related the failure of the Unit 1 RPS to cause a scram to sticking of the undervoltage trip attachment in the scram circuit breakers.

As a result of these events the NRC Executive Director for Operations directed the staff to undertake three related activities: (1) an evaluation of when and under what conditions the Salem plants would be allowed to restart; (2) a fact finding report of the events at Salem 1 and the circumstances leading to them; and (3) a report on the generic implications of these events.

To address (3) above an interoffice, interdisciplinary group was formed including members from the Office of Nuclear Reactor Regulation's

(NRR's) Division of Licensing, Division of Systems Integration, Division of Human Factors Safety, Division of Engineering, Division of Safety Technology, the Office of Inspection and Enforcement, the Office for Analysis and Evaluation of Operational Data, and NRC's Region I Office. This group published NUREG-1000[1] as a result of their efforts to resolve the following questions: (1) is there a need for prompt actions to address similar equipment in other facilities; (2) are the NRC and its licensees learning the safety management lessons; and (3) how should the priority and content of the ATWS Rule be adjusted.

As a result of the NUREG-1000 findings, the NRC issued Generic Letter 83-28[2] (GL 83-28). The actions described in GL 83-28 address issues related to reactor trip system (RTS) reliability. The actions covered fall into the following four areas: (1) Post-Trip Review, (2) Equipment Classification and Vendor Interface, (3) Post-Maintenance Testing, and (4) Reactor Trip System Reliability Improvements.

Item 4, above, is aimed at assuring that vendor-recommended reactor trip breaker modifications and associated reactor protection system changes are completed in pressurized water reactors (PWRs), that a comprehensive program of preventive maintenance and surveillance testing is implemented for the reactor trip breakers in PWRs, that the shunt trip attachment activates automatically in all PWRs that use circuit breakers in their reactor trip systems, and to ensure that on-line functional testing of the reactor trip system is performed on all light water reactors (LWRs).

The specific requirements of GL 83-28, Item 4.5.3, are that existing intervals for on-line functional testing required by Technical Specifications shall be reviewed to determine if the intervals are consistent with achieving high RTS availability when accounting for considerations such as: (1) uncertainties in component failure rates; (2) uncertainties in common mode failure rates; (3) reduced redundancy during testing; (4) operator errors during testing; and (5) component "wear-out" caused by testing.

The Babcock & Wilcox (B&W), Combustion Engineering (CE), General Electric (GE), and Westinghouse (W) Owners Groups have submitted topical reports either in response to GL 83-28, Item 4.5.3,[3,4] or to provide a basis for requesting RTS surveillance test interval (STI) extensions.[5,6,7,8,9,10,11] In general, the owners groups' analyses were not done on a plant specific basis. Instead, the analyses addressed a particular class of reactor trip system and then discussed the applicability of the analysis to specific product lines. The NRC reviewed these reports for, among other things, their applicability to GL 83-28, Item 4.5.3 and summarized their findings in Safety Evaluation Reports[12,13] (SERs).

1.2 Review Purpose

This report documents a review of the Owners Groups' topical reports, the NRC SERs, and other analyses done at the Idaho National Engineering Laboratory (INEL) by personnel in the NRC Risk Analysis Unit of EG&G Idaho, Inc. The INEL conducted the review at the request of the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Instrumentation and Control Systems Branch (ICSB). The review was performed to determine if the Owners Groups' analyses demonstrated high RTS availability for the current test intervals, if the analyses included the five areas of concern from GL 83-28, and if all of the plants were covered by the analyses. The results of the review, if all plants are shown to be covered by an adequate analysis, would provide the NRC with a basis for closing out GL 83-28, Item 4.5.3, for all U.S. commercial nuclear reactors without further review.

The body of this report presents the review and its findings with regard to the stated objectives. Section 2 describes the criteria used in the review to determine the adequacy of the analyses. The review methodology is discussed in Section 3. Section 4 presents the review results. The review conclusions are given in Section 5.

2. REVIEW CRITERIA

To conduct a review, one must have criteria, or standards, on which a judgment or decisions may be based. In this section, the INEL availability analyses review criteria are presented.

GL 83-28 established the three criteria used in the INEL review. GL 83-28 stated that: (1) all licensees et al., (2) must demonstrate high RTS availability for the current test intervals by documented review when (3) accounting for such considerations as the five areas of concern listed in Section 1.1. While GL 83-28 established all three criteria, it only defined two of them--who had to do a review and what the review had to take into account. The third and most subjective criterion, "high availability", was not defined.

To establish a definition of high availability, the INEL used the electrical unavailability base case estimates presented in Table A-1 of Appendix A to SECY-83-293.[14] Unavailability is defined as 1.0 minus availability. A low unavailability is equivalent to a high availability. Most analyses calculate a system unavailability rather than an availability. Therefore, our criteria for a "high availability" will be expressed in terms of low unavailability for compatibility. These RTS unavailability estimates from Reference 14 were used for two reasons. First, they were used because they were developed by the NRC's ATWS Task Force as a reevaluation of the bases for the RTS unavailabilities used in ATWS rule value-impact evaluations. Second, as stated in Reference 14, this NRC analysis

> "...bases the RTS unavailabilities on worldwide experience to date. It is believed that this gives a reasonable estimate of RTS unavailability that includes the common cause contributions that are believed to dominate. The experience based values are distributed across the four vendor designs based on a comparative reliability analysis that evaluates the major differences among the designs."

The estimates from the NRC ATWS analysis provide a framework with which to consider the topical report analyses estimates. The numerical estimates in the SECY-83-293 for the four vendors combined with the five areas of concern from GL 83-28, Item 4.5.3, form the criteria used for this review to determine if the vendors' analyses and estimates met the requirements of Item 4.5.3.

3. REVIEW METHODOLOGY

The INEL conducted this review by examining the vendors' topical reports (References 3, 4, 5, 6, 7, 8, 9, 10, and 11), the technical evaluation reports[15,16,17,18] (TERs) done as a part of the NRC topical report review process, the NRC's SERs (References 12 and 13), and NUREG/CR-5197, Evaluation of Generic Issue 115, "Enhancement of Westinghouse Solid State Protection System."[19] This was done for three reasons. First, the reports were examined to find out whether or not the vendors' analyses addressed the areas of concern from Item 4.5.3 and reflected a high RTS availability. Second, they were examined to determine what plants were covered by the vendors' analyses. Third, the Generic Issue 115 report provided an independent, updated estimate of the availability of the W solid state RTS for comparison to the review criteria.

For the plants covered by the vendors' analyses or the NUREG/CR-5197 analysis, the appropriate analysis and availability were compared to the review criteria established in Section 2. If the analysis adequately addressed the areas of concern and demonstrated a high RTS availability, the plant was accepted as having met the requirements of GL 83-28, Item 4.5.3. The results of the comparisons for plants covered by a vendor analysis are given by vendor in Section 4.

For plants not directly covered by a vendor's analysis, an acceptable means was found to extend the analyses to cover the plants. This was done for two plants: Clinton 1 (GE) and Maine Yankee (CE). The means by which the analyses were extended to cover these two plants are also discussed by vendor in Section 4.

One plant, Fort St. Vrain, a high temperature, gas-cooled reactor (HTGR), was not covered by any of the four vendors' analyses and required special consideration. The INEL examined the responses from Fort St. Vrain required by GL 83-28, Item 4.5.3 to determine if the responses demonstrated an acceptably high RTS availability. The review of the Fort St. Vrain responses is given in Section 4.6.

4. REVIEW RESULTS

This section summarizes the results of the INEL review of the vendors' analyses with regard to the five areas of concern and plant applicability. The vendors' estimates of RTS availability are compared to the review availability criteria. Also, some insights concerning RTS availability, gained from an examination of RTS importance measures from selected PRAs, are examined.

4.1 B&W Plants

The issues of GL 83-28, Item 4.5.3, were addressed by the B&W Owners Group and the results were submitted to the NRC by the individual utilities in their responses to GL 83-28. Topical Report BAW-10167 (Reference 5) was submitted to the NRC to provide a technical basis for increasing the on-line STIs and allowed outage times (AOTs) for B&W RTS instrument strings. The analysis presented in BAW-10167 was built upon the previous analysis done to address the GL 83-28, Item 4.5.3 issues. However, some information that was resolved in the generic letter analysis was not repeated in the subsequent Topical Report because it was not relevant to the proposed Technical Specification changes. To make BAW-10167 applicable to both GL 83-28, Item 4.5.3 and STI/AOT issues, the Owners Group submitted BAW-10167, Supplement 1 (Reference 6), to the NRC. Supplement 1 completed the B&W analysis by addressing all remaining Item 4.5.3 issues. The BAW-10167 and Supplement 1 analyses included the implementation of the automatic shunt trip on the reactor trip circuit breakers as required by GL 83-28, Item 4.3.

The INEL has previously reviewed the BAW-10167 and Supplement 1 analyses and documented the review in a TER, EGG-REQ-7718 (Reference 15). For the TER, sensitivity studies which included all of the Item 4.5.3 areas of concern were conducted on the RTS models. The sensitivity study results showed the models to be insensitive to variations in the failure rates associated with the Item 4.5.3 areas of concern.

The INEL reviewed BAW-10167, BAW-10167, Supplement 1, and the TER and determined that the B&W analyses adequately covered all five areas of concern and that all currently operating B&W reactors are included.

4.2 CE Plants

Licensees with CE reactors responded to the requirements of GL 83-28, Item 4.5.3, as the CE Owners Group by submitting CE NPSD-277 (Reference 3) to the NRC. The NPSD-277 RTS availability analysis specifically included all five areas of concern and all currently operating CE reactors except Waterford 3, which was not in commercial operation until September 1985.

The CE Owners Group also submitted CEN-327 (Reference 7) to provide licensees with a basis for requesting RTS STI extensions. This later analysis expanded on the simplified models of NPSD-277 to include all RTS input parameters. All currently operating CE plants except Maine Yankee were covered in the CEN-327 analysis. The CEN-327 STI analysis specifically included the NPSD-277 analyses of the Item 4.5.3 areas of concern except component "wear-out" during testing. The CEN-327 analysis showed that the major contributors to RTS unavailability for the four plant classes are common cause failures of the trip circuit breakers which are tested on a monthly basis.

In both NPSD-277 and CEN-327, the CE RPS designs are grouped into four classes by signal processing and trip device differences, otherwise the logic and physical layouts of the RTS are the same for all RTS plant classes. In NPSD-277, Maine Yankee is included in RPS Plant Class 2. In CEN-327, Waterford 3 is included in RPS Plant Class 3. Between NPSD-277 and CEN-327, all of the CE plants are included in plant classes analyzed in CEN-327. This review considers the analysis and results in CEN-327 adequate for Item 4.5.3 resolution for all classes of CE plants.

The INEL has previously reviewed CEN-327 with regard to STI extension effects and documented the review in a TER, EGG-REQ-7768 (Reference 16). The results of sensitivity studies done for the TER show the models to be insensitive to an order of magnitude increase in the component independent failure rates. The insensitivity to increased component failure rates along with the CE analysis results showing trip circuit breaker common cause failures to be the major contributor to RTS unavailability provides a a basis for this review to conclude that RTS test-induced component wear-out is not an issue at CE reactors.

The INEL reviewed CEN-327 and the TER and determined that the CE analyses have adequately covered all five areas of concern or they have been shown not to contribute to RTS unavailability and that all currently operating CE reactors are included.

4.3 GE Plants

Licensees with GE reactors responded to the GL 83-28, Item 4.5.3 requirements as the BWR Owners' Group by submitting NECD-30844 (Reference 4) to the NRC. The RTS availability analysis specifically included the five areas of concern and covered both generic relay and solid-state RTS designs which includes all currently operating BWRs. GE stated that the relay RPS configurations for BWR plants have the same primary design features. Therefore, the generic relay RTS models used in NECD-30844 do not differ significantly from the specific BWR plants. GE used the Clinton 1 drawings for the solid-state RTS models. Since Clinton 1 is currently the only GE plant with a solid state RTS, no plant unique analysis is necessary.

The BWR Owners' Group also submitted NECD-30851P (Reference 8) to the NRC. The analysis in this second report used the base case results from NECD-30844 to establish a basis for requesting revisions to the current Technical Specifications for the RTS. The INEL had previously reviewed NECD-30844 and NECD-30851P with regard to both Item 4.5.3 and STI extension acceptability and documented the review in a TER, EGG-EA-7105 (Reference 17). Due to insufficient information, the INEL review could not complete the solid-state RTS review and accepted only the relay RTS analysis results. The NRC reviewed the topical reports and the TER and issued an SER (Reference 12). The NRC accepted the analysis results as a reference for TS changes related to the RTS and as resolution to GL 83-28, Item 4.5.3, for GE relay plants only. The INEL later completed the solid state RTS analysis review and issued Rev 1 to the TER (Reference 18), thus accepting the analyses for all classes of GE plants.

This review examined both GE analyses and the Rev 1 TER and determined that all five areas of concern are included in the analyses and that all currently operating GE reactors are included.

4.4 Westinghouse Plants

Licensees with Westinghouse reactors did not respond directly to the requirements of GL 83-28, Item 4.5.3. Prior to the Salem ATWS, they had submitted WCAP-10271 (Reference 9) to the NRC to provide a basis for requesting changes to the Technical Specifications regarding the RTS. The Westinghouse methodology attempted to balance safety and operability and was applied to a typical Westinghouse four loop reactor plant with a solid state RTS in WCAP-10271. The methodology was extended to cover RTSs for two, three, and four loop plants with either relay or solid state logic in WCAP-10271, Supplement 1 (Reference 10).

The NRC reviewed the Westinghouse topical reports with the assistance of Brookhaven National Laboratory (BNL) and issued an SER (Reference 13) limiting their acceptance to changes to only the analog channel STIs at Westinghouse plants.

The W methodology used fault trees to model the RTS. The models included the following five major contributors to RTS trip unavailability:

1. Unavailability of components due to random failures

2. Unavailability of components due to test

3. Unavailability of components due to unscheduled maintenance

4. Unavailability of components due to human error

5. Unavailability of components due to common cause failure.

While the W analysis did not directly include any sensitivity studies concerning these five areas, the component unavailabilities were increased as the test interval length increased. The STI analysis results showed a factor of 3 to 5 increase in the RTS unavailability estimates for the longer test interval. Two conservatisms exist in the models that are relevant: first, no credit was taken for early failures that would be detected and, second, no credit was taken for the diversity inherent in the W RTS design. These two conservatisms, had they been included in the model, would cause the increase in the RTS unavailability estimates to be smaller than the observed factors.

Test-induced component wear-out was not addressed in any manner in the W RTS analysis. However, the RTS analyses done by the other vendors, References 3, 4 and 6, specifically investigated the effects of this issue on RTS unavailability. Despite the differences among the other vendors' RTS designs, they all found the effects of test induced component wear-out on RTS unavailability to be insignificant. Based on the other vendors' analyses, the INEL concluded that the effects of test-induced component wear-out on W RTS unavailability would also be insignificant. Therefore, the INEL considers all W plants to be covered by adequate analyses.

4.5 Quantitative Review of Vendors' RTS Availabilities

So far, only the adequacy of the vendors' analyses has been discussed. No determination has been made of the acceptability of the numerical estimates from the various RTS availability analyses. In this section, the INEL review considers the four Owners Groups' RTS availability estimates to determine if they are indeed indicative of "high availability."

In Table 1, the four vendors' RTS unavailability estimates are compared to the review estimates of low unavailability as defined in Section 2. The B&W and GE vendors' estimates are given as an overall RTS unavailability per demand by plant model and RTS type, respectively. The CE and W vendors' estimates are given on a similar basis with an additional consideration that was not necessary for the B&W and GE analyses. In the CE and W analyses, RTS unavailability was estimated for all input parameters. For the CE and W unavailability estimates in Table 1, the INEL used the unavailability estimates for high pressurizer pressure, the parameter analyzed in Reference 19 as the limiting parameter for an ATWS in terms of the number of input channels and diversity of trip signal.

The differences in the relative values of the three PWR vendors' RTS unavailability estimates can be attributed to design differences among the RTSs. B&W and CE RTSs have four analog channel inputs for each monitored parameter with four trip logic channels while W RTSs have three or four analog channel inputs for each parameter with only two trip logic channels. The 2 of 4 analog channels for the B&W and CE RTS designs are inherently more reliable than the 2 of 3 analog channels for some parameters in the W design. Also the 2 of 4 trip logic in the B&W and CE RTSs is more reliable than the W 1 of 2 trip logic. The combination of these two design differences make the W RTS unreliability somewhat higher than the other vendors' RTS unavailabilities.

The comparison shows the B&W, CE, and GE RTS unavailability estimates are lower than the NRC's estimates while the W estimates are the same as the NRC's. The INEL review recognizes the Vendors' estimates and the NRC's estimates are influenced by a number of factors. These factors include, (1) the data uncertainties for both the NRC and Vendors analyses, (2) the scarcity of actual RTS failures world wide, (3) the modeling assumptions and simplifications used by both the NRC and the Vendors, and (4) the differing levels of model development between the NRC analysis and the Vendors' analyses and between different Vendors' analyses. These factors

TABLE 1. COMPARISON OF VENDOR AND NRC RTS UNAVAILABILITY ESTIMATES[a]

Vendor	Vendor RTS Unavailability Estimates (Failures/Demand)	NRC RTS Unavailability Estimates[b] (Failures/Demand)
B&W		
Davis Bessie Model	1E-10[c]	3E-5[d]
Oconee Class Model	1E-6[c]	3E-5[d]
CE		
Plant Class 1	2E-7[e]	2E-5
Plant Class 2	3E-6[e]	2E-5
Plant Class 3	3E-6[e]	2E-5
Plant Class 4	2E-6[e]	2E-5
GE		
Relay Plants	3E-6[f]	2E-5
Solid-state Plants	3E-6[f]	2E-5
W		
Relay Plants	5E-5[g]	5E-5[d]
Solid-state Plants	5E-5[g]	5E-5[d]

a. All estimates are rounded off to one significant digit.

b. From Reference 14, Table A-1, base case RTS electrical unavailability estimates.

c. From Reference 5, base case.

d. Includes automatic shunt trip on the reactor trip circuit breakers.

e. From Reference 7, Tables 4.1-1, 4.2-2, 4.1-3, and 4.1-4, respectively; base case test interval, high pressurizer pressure unavailability estimate.

f. From Reference 4.

g. From Reference 19, solid state RTS base case. Applied to relay-plants based on similarity of design (see Reference 11, Section 3.2.2 and 3.2.3).

help explain the differences between the Vendors' and the NRC's point estimates of RTS availability.

4.6 Fort St. Vrain

Fort St. Vrain responded to GL 83-28, Item 4.5.3 in a letter to Eisenhut dated November 4, 1983[20], stating:

> "Existing intervals for on-line functional testing required by the Technical Specifications are currently under review by Public Service Company of Colorado (PSC) and the Nuclear Regulatory Commission Region IV staff. <u>The current testing frequency at Fort St. Vrain has been dictated by the Nuclear Regulatory Commission staff</u>." (Underline added)

In response to a request for information from the NRC concerning the Fort St. Vrain responses to GL 83-28 previously sent, PSC sent the following reply to the NRC in a letter to Johnson, dated June 12, 1985[21]:

> "Existing intervals for the on-line testing required by the Technical Specifications were reviewed by Public Service Company of Colorado. A Technical Specification change to Limiting Conditions for Operation 4.4.1 (Plant Protective System) and its associated surveillance requirements (SR 5.4.1) are currently being reviewed by the Plant Operations Review Committee (PORC). This Technical Specification change is expected to be approved by the PORC and the Nuclear Facility Safety Committee (NSFC) by June 30, 1985.. As part of the development process for these proposed changes to the Technical Specifications, on-line functional testing requirements were reviewed based on past experience. Possible changes to the testing intervals in certain cases where available test data may support such changes has (sic) been discussed at length with the Nuclear Regulatory Commission staff. The Nuclear Regulatory Commission staff has informed Public Service Company of Colorado that no such changes would be acceptable at this time."

The INEL review interpreted these responses from Fort St. Vrain to mean the <u>NRC</u> has established Fort St. Vrain's RTS current test intervals, the current test intervals have been evaluated by PSC, and the NRC will not allow changes to the test intervals at this time.

From these responses, the INEL concluded that Fort St. Vrain has conducted the review required by GL 83-28, Item 4.5.3, and that the NRC considers the PSC and NRC reviews adequate to meet the Item 4.5.3 requirements.

5 REVIEW CONCLUSIONS

All four LWR vendors have submitted topical reports either in response to GL 83-28, Item 4.5.3, or to provide a basis for RTS STI extensions, or both. For the most part, these reports have addressed all of the issues in Item 4.5.3. Licensees not covered by the topical reports have submitted individual responses to Item 4.5.3.

The analyses in the topical report have shown the currently configured RTSs to be highly reliable with the current test intervals and prior to implementing some of the requirements of GL 83-28. Implementation of these additional requirements will reduce the ATWS risk even further.

The INEL has reviewed the relevant topical reports, TERs, SERs, additional analyses, and the individual licensee submittals with regard to GL 83-28, Item 4.5.3, requirements and the review criteria. Based on that review, the INEL concludes that all licensees of currently operating commercial nuclear power plants have adequately demonstrated that their current RTS test intervals are consistent with achieving high RTS availability.

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ABSTRACT (200 words or less)

The Idaho National Engineering Laboratory (INEL) conducted a technical review of the commercial nuclear reactor licensees' responses to the requirements of the Nuclear Regulatory Commission's (NRC's) Generic Letter 83-28 (GL 83-28), Item 4.5.3. The results of this review, if all plants are shown to be covered by an adequate analysis, will provide the NRC staff with a basis to close out this issue with no further review. The licensees, as the four vendors' Owners' Groups, submitted analyses to the NRC either directly in response to GL 83-28, Item 4.5.3, or to provide a basis for requesting changes to the Technical Specifications (TSs) that would extend the Reactor Protection System (RPS) surveillance test intervals (STIs). To conduct the review, the INEL defined three criteria to determine the adequacy, the plant applicability, and the acceptability of the results. The INEL examined the Owners Groups' reports to determine if the analyses and results met the established criteria. Fort St. Vrain's responses to Item 4.5.3 were also reviewed. The INEL review results show that all licensees of currently operating commercial nuclear reactors have adequately demonstrated that their current on-line RPS test intervals meet the requirements of GL 83-28, Item 4.5.3.

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