May 22, 2006

MEMORANDUM TO: Michael J. Case, Director
Division of Inspection and Regional Support
Office of Nuclear Reactor Regulation

FROM: James W. Andersen, Chief ***/RA/***
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SUBJECT: EVALUATION OF THE ADEQUACY AND READINESS OF THE MITIGATING SYSTEMS PERFORMANCE INDEX (MSPI)

Since 2002, the Office of Nuclear Reactor Regulation (NRR) has been working with the Office of Research (RES), the regions, the Nuclear Energy Institute (NEI), industry representatives, and other stakeholders to improve and risk-inform the Safety System Unavailability (SSU) performance indicator (PI) of the Reactor Oversight Process (ROP). Representatives from these groups formed the ROP Working Group subcommittee and developed a Mitigating Systems Performance Index (MSPI), a risk-informed PI, as a replacement to the SSU PI. The MSPI was trial tested in a pilot program that was conducted from August 2002 to September 2003 with nine licensees and 20 plants participating from the four regions. The bench marking analysis and comparison studies performed by RES on the results of the MSPI pilot were completed in January 2004 and culminated in issuance of NUREG-1816, "Independent Verification of the Mitigating Systems Performance Index (MSPI) Results for the Pilot Plants," dated February 2005.

The staff has long recognized the importance of PRA quality to the integrity of MSPI. Consequently, the staff and industry formed a MSPI PRA Quality Task Group to ascertain the level of PRA quality necessary to maintain the accuracy and integrity of MSPI. It should be noted that at the beginning of the ROP, the PI program was not made mandatory by rulemaking, but rather was voluntarily agreed to by the industry. Similarly, there are no regulatory requirements concerning the scope and quality of licensees' PRAs. Recognizing these facts, the staff/industry MSPI PRA Quality Task Group issued their report in December 2004, and it contained a number of recommendations that were fully endorsed by the staff and industry. However, three months later, NEI and the industry proposed an alternate method to satisfy PRA quality for MSPI. This alternate method was to perform a monitored component comparison study of risk coefficients (Birnbaum) grouped by accounting for similar plant attributes and plant vintage and design.

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The purpose of this memorandum and evaluation is to document the staff's initial review of the readiness of the MSPI to be implemented into the ROP and to evaluate industry's alternative method to satisfy PRA quality for MSPI. The review was conducted from September through November, 2005. The industry's proposal, and the staff's assessment of it, is discussed in the enclosed attachment, as well as the results of the staff review of the industry's MSPI basis documents. As noted in the attachment, the MSPI and its supporting PRA quality requirements were considered a Phase 2 PRA application under the Commission's phased approach to PRA quality. As such, the staff's assessment and conclusion concerning the adequacy of PRA quality for MSPI are not applicable to any other regulatory application or purpose. As a result of the aforementioned review of the industry MSPI basis documents, the staff concluded the industry was not ready to implement MSPI by the proposed target date of January, 2006. This conclusion was based on the number of issues and discrepancies identified by the staff during its review of the industry's comparison study and MSPI basis documents. The industry acknowledged these issues and worked with the staff to resolve the issues discussed in the enclosed attachment. Both the staff and industry agreed to delay implementation until these issues were addressed and resolved.

Since the attached report was completed, industry has resolved the significant staff issues, and MSPI was implemented as of April 1, 2006. Since the report was written prior to implementation, it does not reflect the resolution of issues and was written as of November 2005. No effort was expended to bring this snap-shot of MSPI to the current time period.

If you have any questions concerning the evaluation, please contact myself or John Thompson.

Attachment: As Stated

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If you have any questions concerning the evaluation, please contact myself or John Thompson.

Attachment: As Stated

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Attachment

Evaluation of the Adequacy and Readiness of the Mitigating Systems Performance Index

(as of November 2005)

Table of Contents

Executive Summary

The staff has completed its initial review of the readiness of the Mitigating Systems Performance Index (MSPI) to be implemented into the reactor oversight process (ROP). The objective of this review was to assess the adequacy of PRA quality as it applies to the MSPI and to ensure that the MSPI implementation guidance (Appendices F and G of NEI 99-02, Revision 4) is clear in its meaning, addresses all known identified issues, and is adhered to by the industry before implementation into the ROP. The purpose of this paper is to document the staff's evaluation of the MSPI as of November 2005.

Part I of this evaluation consists of an assessment and review of the industry's alternate approach to PRA quality for MSPI. That is, a review and assessment of the industry's component comparison study to ensure the adequacy of PRA quality required for MSPI implementation. It should be noted that at the beginning of the ROP, the PI program was not made mandatory by rulemaking, but rather was voluntarily agreed to by the industry. Similarly, there are no regulatory requirements concerning the scope and quality of licensee's PRAs. The industry comparison study was a study conducted by the Westinghouse Owners Group for the operating pressurized water reactors (PWRs), except for the Babcox and Wilcox (B&W) designed plants, and a similar study conducted by the General Electric (GE) Owners Group for the boiling water reactor (BWR) designed plants. Although the industry comparison studies appeared to be a valid and reasonable method to meet PRA quality requirements, the variation in execution of these studies between the two owner's groups, as well as the timeliness of the products, made it difficult to compare and draw conclusions. Therefore, the staff performed its own parallel component comparison study. The staff's component comparison study used industry plant data from licensee PRAs. This data was inserted into the Standardized Plant Analysis Risk (SPAR) models and the results were compared to SPAR results obtained using the more generic plant data already contained within the SPAR models. The staff's review resulted in the identification of approximately 266 "candidate" component outliers. These candidate outliers were components (or components identified within PRA basic events) that had significant variations in values between the values derived from SPAR and the values derived from plant PRAs. In a majority of cases, the differences were due to lack of modeling detail associated with the SPAR models. However, in about 40 cases, the bonafide (i.e., verified) component outliers resulted from differences attributed to licensee PRA modeling or assumptions. These issues will need to be addressed and resolved prior to MSPI implementation.

Part II was a review of the draft basis documents conducted by MSPI regional review teams during the time period of September through November 2005. The staff performed a 100 percent review of the four front line systems for each licensee, as well as an audit of the support cooling water systems at selected facilities. These reviews ensured that licensees compiled their draft basis documents in accordance with the guidance contained in Appendix F, "Methodologies For Computing the Unavailability Index, the Unreliability Index and Component Performance Limits," of NEI 99-02, "Regulatory Assessment Performance Indicator Guideline." The results of the reviews indicated that the draft basis documents were in many instances, out of date when reviewed against current MSPI Appendix G guidance (MSPI Basis Document

Development), and were incomplete in some areas, contained mathematical errors and misinterpretations of the guidance, and lacked appropriate detail. The NRC teams also identified several generic issues that could be linked to areas of the guidance (Appendix F) that needed additional clarity, revision, or further discussion. Two of the more significant generic issues were truncation and convergence relative to the overall plant core damage frequency (CDF) and calculated component Birnbaum risk value, as well as an unexpected number of unaddressed facts and observations (F&Os) from the licensee conducted PRA peer reviews that had significance and impact to MSPI. These issues will need to be addressed and resolved prior to MSPI implementation. In summary, the NRC teams concluded that the draft MSPI basis documents in the form reviewed were incomplete and not adequate for MSPI implementation.

Part I

Assessment of Adequacy of Probabilistic Risk Assessment (PRA) Quality for MSPI Implementation

The MSPI is a risk-informed PI that relies heavily on information contained within PRAs. In order to ensure that the MSPI will be reasonably accurate in its characterization of risk, the staff determined that an assessment of PRA quality suitable for MSPI implementation was appropriate. The assessment of PRA quality was conducted by an industry-staff MSPI PRA Quality Task Group and was convened to resolve issues related to the quality required of a PRA for implementation of the MSPI. The Task Group consisted of representatives from industry and the staff with PRA expertise. Their report was issued on December 16, 2004 and included the following recommendations:

1. The MSPI application was considered a Phase 2 application under the Commission's phased approach to PRA quality. The MSPI is an index that is based on an internal initiating events, full-power PRA, for which the ASME Standard has been written. The ASME Standard has been endorsed by the staff in Regulatory Guide (RG) 1.200, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," which has been issued for trial use.

2. Licensees should assure that their PRA is of sufficient technical adequacy to support the MSPI application by:

    - resolving the peer review Facts and Observations (F&Os) that are classified as being in category A or B (those that can have an impact on the PRA results), or demonstrate that not resolving them will not have an impact on the MSPI,
    - performing a self assessment using the NEI-00-02 process as endorsed by Appendix B of RG 1.200 for the ASME PRA Standard supporting level requirements (SRs) listed in Table 1 of the Task Group report.

3. Licensees should document their demonstration of their assurance of technical adequacy by including in the MSPI basis document:

    - the results of, and resolution of any findings from, the self-assessment performed for the SRs identified in Table 1 of the Task Group report, taking into consideration Appendix B of RG 1.200, with particular attention to the notes in the table,
    - for those significant F&Os not resolved, a justification for why not resolving them has no impact on the efficacy of the MSPI,

    and, in the archival documentation:

    - a description of the resolution of the significant, i.e., the A and B category, F&Os identified by the peer review team.
    - a description of the methods and data used to address the issues identified in Section 2 of Part B of the December 2004 MSPI PRA Task Group report.

4. When a licensee's PRA is modified, those SRs that are affected should be subjected to a further self-assessment to assure that the technical adequacy is maintained.

5. If there is an indication that the importance measures used as a basis for the MSPI may be outliers, the staff should review or audit a licensee's PRA, focusing on those SRs in Table 1 of the Task Group report.

6. A process should be developed for the identification of outliers, that recognizes that variability can exist from modeling approaches as well as from plant design. Some guidance is provided in Section 7 of Part B of the Task Group report. Development of this process should use the results of a cross-comparison of licensee importance measures, and the results of a comparison of SPAR model importance measures, for plants of similar design.

Although both industry and staff agreed with the findings of the MSPI PRA Task Group report, the industry, by letter dated July 27, 2005, proposed an alternative approach to address MSPI PRA quality that relied upon a cross-comparison of Birnbaum risk importance measures for most of the monitored components in the MSPI. This cross-comparison would be performed in lieu of the recommendations of the MSPI PRA Task Group. The cross-comparison process had the following basic steps:

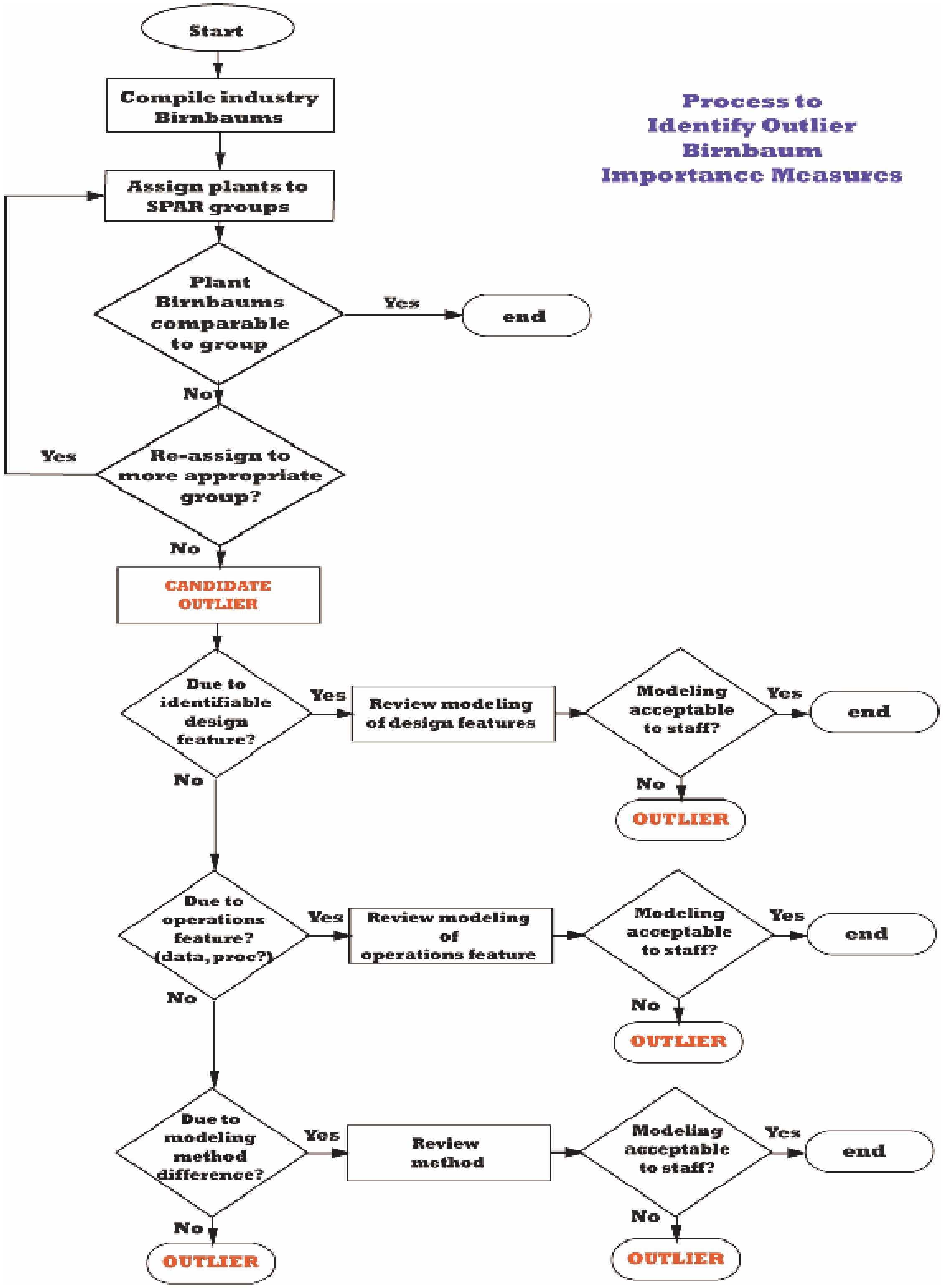
- comparing component importance measures rather than train importance measures,
- grouping plants based on the one or two most important plant attributes that affect the importance of that system,
- comparing Birnbaum values for similar components within each group, and
- identifying candidate outliers with Birnbaum values much higher or much lower than other Birnbaum values within the same group.

Candidate component outliers that were not satisfactorily resolved would be subject to an adjustment to the corresponding Fussell-Vesely risk coefficient values that are input into the MSPI program.

Although the staff agreed to the proposed alternative approach, additional review and oversight was necessary because the alternate approach did not provide a level of assurance of PRA quality commensurate with the recommendations contained with the December 2004 MSPI PRA Task Group report. As a result, the staff performed an independent component cross-comparison effort as confirmation of the industry results. This process is described below.

General Process

The important elements of the process for performing the MSPI Outlier reviews are summarized below and also depicted in a flow chart, "Process to Identify Outlier Birnbaum Importance Measures," provided below.


Start
Compile industry Birnbaums
Assign plants to SPAR groups
Process to Identify Outlier Birnbaum Importance Measures
Plant Birnbaums comparable to group
Yes
end
No
Yes
Re-assign to more appropriate group?
No
CANDIDATE OUTLIER
Due to identifiable design feature?
Yes
Review modeling of design features
Modeling acceptable to staff?
Yes
end
No
No
OUTLIER
Due to operations feature? (data, proc?)
Yes
Review modeling of operations feature
Modeling acceptable to staff?
Yes
end
No
No
OUTLIER
Due to modeling method difference?
Yes
Review method
Modeling acceptable to staff?
Yes
end
No
OUTLIER
No
OUTLIER

Industry Birnbaums, at the basic event level, were obtained mainly from the draft MSPI basis documents provided by licensees. Major in-scope components for each plant were assigned to SPAR groups based on specific design characteristics. Valves and circuit breakers were not considered. A list of the different SPAR groups containing a description of the group is provided in Table 1.

Plant Birnbaums were then compared to the Birnbaums of the SPAR group. If the Birnbaums were comparable, based on a decile score within the group distribution of less than four, the plant component basic event was eliminated from further review. Otherwise, the basic event became a candidate outlier which was then re-evaluated to determine if the basic event was in the appropriate group. Basic events were re-assigned as appropriate and the process repeated. The remaining plant component basic events were then evaluated against the following three criteria:

- Was the Birnbaum different due to an identifiable design feature?
- Was the Birnbaum different due to an identifiable operations feature (data, procedure)?
- Was the Birnbaum different due to an identifiable modeling method difference?

Design features, operations features or modeling methods, as appropriate, were reviewed. If the difference could be explained by a plant-specific design feature and/or a modeling method acceptable to the staff, the basic event was eliminated as a candidate outlier. During this review, numerous sources were used including the basis documents, the Owner's Groups cross-comparison reports, the SDP Phase II notebooks, IPEs, FSARs, and SPAR model descriptions. If the information available to the reviewers was not adequate for an understanding of the outlier issue, the utility was contacted in an effort to resolve the model differences. The candidate outliers that remain unresolved at this point have been characterized as outliers in this report. The list of outliers has been provided to industry and the process of resolving outliers continues. The staff welcomes feedback from licensees in an effort to resolve the remaining concerns.

Table 2 provides the MSPI Unresolved PRA Outliers along with the list of Generic PRA Issues as of November 2005.

Summaries of MSPI PRA issues and MSPI Generic SPAR Issues are provided below.

C Open A&B Facts and Observations possibly affecting MSPI	16
C Model truncation & convergence issues	14
C Low loss of offsite power frequency issues	9
C Low loss of service water frequency issues	5
C Missing support system adjustment contribution to FV	5
C BWR 5/6 credit for RPV injection after containment failure	5
C Station Blackout mitigation strategies issues	4
C Offsite power recovery issues (after battery depletion, etc)	4
C Unexplained model asymmetry issues	3
C Common cause factor analysis issues	2
C Control of turbine-driven pump without DC power	2
C Low loss of DC bus initiator frequency	1
C Missing test & maintenance basic event for EDGs	1

The first two items do not represent outlier issues *per se*. Excluding these first two items, there are approximately 40 items summarizing the Birnbaum outliers for all plants. Since one item may impact the Birnbaum values for more than one component (e.g., A & B pumps) and one failure mode (e.g., fail-to-start, fail-to-run), in fact there are approximately 90 components equating to about 180 basic events that are represented here. This is compared to some 5000 in-scope components across the industry.

Summary of MSPI Generic SPAR Issues

- Loss of emergency AC power bus initiator frequency about an order of magnitude higher than industry average.
- Pressurizer PORV success criterion for feed and bleed is assumed to be two irrespective of plant design and analysis.
- Modeling asymmetries (e.g., loss of DC bus on only one division).
- Single value loss of service water frequency irrespective of plant site and design.
- Higher failure probability for local, manual control of turbine-driven AFW pump.
- Old RCP seal LOCA model for B&W plants.
- Small-LOCA frequency is lower than industry norm by nearly an order of magnitude because it does not include lower end of spectrum (e.g., small-small LOCAs).
- Instances where SPAR did not model T&M.

These issues are being addressed as part of the enhanced Rev 3 SPAR models.

Generic Issues

In addition to the PRA issues discussed above, there were four Generic Issues identified during the MSPI Basis Document review. Those issues are described below.

1. Convergence (truncation)

During the MSPI Basis Document review it was determined that truncation limits of five orders of magnitude were insufficient in all cases to demonstrate that the overall model results converged. An agreement between industry and Staff was reached at the November 16, 2005 MSPI Public Meeting to resolve this issue. In general, the model was to be quantified at 7 orders of magnitude below the CDF results. If this could not be accomplished, each applicable basic event Birnbaum value would have to be calculated independently, or the licensee demonstrate that the Birnbaum was low enough not to impact the MSPI.

2. Facts and Observations (F&Os)

Facts and Observation issues fall into two generic categories. The first is unresolved Facts and Observations that could have an influence on MSPI values. These were identified during the outlier reviews. The second category is one of non-compliance with Appendix F and Appendix G guidance concerning documentation of Facts and Observations. The table of the current MSPI Unresolved PRA Outliers and the table containing Generic PRA Issues are listed in Table 1.

3. Adjustment for Support System Initiator

Several basis documents do not indicate how the adjustment for support system initiator was performed. The method from Appendix F, as well as, the computation, should be provided in the basis document. The industry was made aware of the issue at the November 16, 2005 MSPI Public meeting. The industry peers are communicating with the utilities and providing guidance to resolve.

4. Failure to Run for UAI

Using Failure to Run for Unavailability (max FV/UA) contrary to guidance provided in the latest revision of Appendix F. It is recognized that the guidance was revised, and the industry was made aware of the issue at the November 16, 2005 MSPI public meeting. The industry peers are communicating with the utilities and providing guidance to resolve.

Conclusions

The PRA outlier review performed by the staff was successful in identifying and resolving significant PRA modeling issues affecting major MSPI monitored components. The process provided significant insights to both the NRC staff and industry regarding the design and modeling features that account for plant-to-plant variation in PRA importances. It also provided the staff with detailed information on licensees' modeling techniques for many issues, and identified numerous opportunities for improving the SPAR models. In total, some two to three times as many SPAR model issues were identified as licensee PRA issues.

As discussed, valves and the few in-scope circuit breakers were not reviewed. Fortunately, these tend to have lower importance in the MSPI. It is also likely that the Birnbaum values for pumps and valves within a system are somewhat correlated so that valve outliers are unlikely to exist separately from pump outliers. The process to address PRA modeling issues affecting pump importance measures would address the valves as well. For example, correcting an unacceptably low loss of offsite power frequency would address low Birnbaum valves and pumps within the emergency service water system of a BWR.

The outlier identification process is a surrogate for addressing PRA quality for implementation of the MSPI. The process inherently relies on the conclusion that if the outputs of the licensees' PRA models are within the expected range, then the model inputs must be reasonable. Under some circumstances, non-conservative model inputs could be offset by conservative inputs. This might not be manifested in Birnbaum outliers for MSPI in-scope components, but could affect component basic event importances in plant systems not in-scope. Furthermore, the process was accepting of some degree of variability in Birnbaum values that might be the result of a modeling error as opposed to *bona fide* plant-to-plant modeling variability. Errors or unacceptable modeling techniques with small impact would not be identified by this process. Consequently, these reviews are limited to the determination of the acceptability of licensee PRAs for MSPI implementation, and not the acceptability of the PRAs for unlimited use.

When combined with the overall process of resolving or addressing all A & B Facts and Observations from the licensee peer reviews, the outlier identification process performed by industry and the staff does provide reasonable assurance that the major inputs to the MSPI have been verified. The outlier resolution process used by the staff supplemented the licensees' PRA cross-comparisons. Together, these model comparisons provided some of the most comprehensive reviews of PRA models ever undertaken on an industry-wide basis.

Part II

Basis Document Reviews

1.0 Basis Document Review - Heat Removal System (Reactor Core Isolation Cooling/Auxiliary Feedwater/Isolation Condenser Systems)

A. Basis Document Review

The audit team reviewed the licensees' basis documents for the Heat Removal systems for the boiling water reactors (Reactor Core Isolation Cooling or Isolation Condenser System) and pressurized water reactors (Auxiliary Feedwater (AFW) or Emergency Feedwater System). All of the basis documents were reviewed on a sample basis.

1.1 System Boundary Assessment

Using the guidance in NEI 99-02, Appendix F and G, the team determined the system boundaries for the MSPI using piping and instrumentation diagrams (P&IDs) then compared the results against the licensees' proposed boundary. In this review, the team verified that the licensees included the steam source for the turbines (where appropriate), alternate suction flow paths, recirculation or minimum flow paths, main system flow paths, cross-tie capabilities between system trains or reactor units, cooling water valves, and electrical controls and breakers.

In general, the licensees properly determined the boundaries of monitored systems. However, the team identified the following discrepancies:

- Three licensees did not include the turbine within the system boundaries.
- Several licensees included drawings that were either incomplete (no valve numbers or designators) or incorrect. The team also identified discrepancies between the P&IDs and the drawings. These issues were not significant.
- Many plants failed to mention that breakers, switches, last relay, etc. were part of the boundary. In contrast, other licensees clearly identified or noted that these components were part of the boundary. Additional guidance may clarify the documentation expectation.

1.2 Risk Significant Function(s) Assessment

The team verified that the licensees documented the decay heat removal function of these systems. No significant issues were noted. The team identified the following:

- With respect to the RCIC system, all of the licensees included the inventory control function of the system.

- Some of the BWR licensees did not take credit in their PRA analysis for the decay heat removal function for the RCIC system; therefore, the PRA values reflected only the inventory control function.

1.3 Success Criteria

The team verified that the licensees documented parameters to be used to define success for the MSPI monitored function. The team identified the following discrepancies:

- Based on review of the basis documents and further discussions with the licensees, it was clear that additional guidance is needed with respect to which values to use for the success criteria. For example, many plants stated design bases; however, during followup discussions, several licensees indicated that they did not know the specific values assumed in the PRA - that they will be using design values to avoid keeping “two books” (that is, a tracking system for maintenance rule failures, Technical Specification failures and MSPI failures.)

- Of the licensees using PRA parameters for MSPI success criteria, several did not include these values or a reference to where the inspector could find these values. Such information would prevent questions when a failure occurs.

1.4 Mission Time

The team verified that the licensees documented a mission time of 24 hours or provided justification for a lessor mission time. The team also verified that this mission time was used in determining the PRA values for the monitored components. The team identified the following discrepancies:

- More than half of the licensees provided two or more mission times depending on the assumed accident scenario. It was not clear whether the largest value (24 hours in most cases) was used in determining the PRA values for MSPI. Many of these licensees were required to re-run their PRA model using the largest mission time.

- Some of the licensees did not follow the guidance in section 2.3.4 of Appendix F by including the contribution from the anticipated transient without a scram event.

1.5 Monitored Components Assessment

The team verified that the licensees properly identified those components within the system boundary to be monitored for the unreliability portion of the MSPI. The team verified that each licensee included the system pumps and drivers and properly dispositioned all valves whose failure(s) would prevent fulfillment of the risk significant function for the system. The team identified the following discrepancies:

- Three licensees did not specify that the turbine driver was a monitored component.

- In many cases, the team needed clarification as to how valve(s) would impact the ability of a system to meet its risk significant function. For example, isolating the AFW flow to a faulted or ruptured steam generator was necessary at some plants to prevent diversion of flow to the intact steam generators. At other plants, this isolation feature was not necessary. It was not clear which scenario was appropriate for all plants. Once discussed, several plants re-assessed the steam generator isolation valves.

- Many boiling water reactor licensees failed to disposition the lube oil cooler inlet valve and turbine steam valves which trip on high reactor water level.

- Several licensees did not provide adequate justification for screening out valves. In addition, many plants screened out valves based on low Birnbaum ratios but did not provide the specific values.

- The team noted inconsistencies in the description of the system as compared to the components monitored. For example, some licensees stated that the RCIC system took suction from a non-safety related tank (condensate storage tank in most cases) and from the suppression pool. However, the licensees did not disposition the suction valves from the suppression pool nor state that the primary water source was sufficient to meet the mission time. Once discussed, several plants were required to re-assess the suction valves from the suppression pool.

1.6 Unavailability Data

The team verified that the licensees provided adequate information to determine the baseline unavailability term for the indicator. On a sampling basis, the team verified the accuracy of the FV/unavailability term provided by the licensee and confirmed that the licensees were following the guidance in Appendix F and G of NEI 99-02. The following discrepancies were identified:

- Some plants did not provide a <u>list</u> of short duration or operator recovery surveillances that would not count for unavailability.

- In several cases when a list was provided, the licensees did not provide justification as to why an operator recovery action was acceptable. (A short statement such as an operator is designated as dedicated to the task and recovery steps are in the procedure would suffice.)

- For planned baseline unavailability, many licensees provided the final value and didn’t provide a table with the details of the calculation such as the number of critical hours assumed.

- Many licensees incorrectly determined the maximum FV/UA ratio by not considering failure to start scenarios or by incorrectly considering failure to run scenarios.

1.7 Unreliability Data

The team verified that the licensees provided adequate information to determine the baseline unreliability term for the indicator. On a sampling basis, the team verified the accuracy of the FV/unreliability term provided by the licensee, appropriateness of the common cause correction factor, bases for the component demand and run hours. The team also confirmed that the licensees were following the guidance in Appendix F and G of NEI 99-02. The following discrepancies were identified:

- All of the documents require updating to the newly revised Appendix G guidance.

- Some licensees incorrectly determined the maximum FV/UR ratio by inappropriately considering test and maintenance scenarios.

- In most cases, the pressurized water reactor licensees correctly interpreted the guidance for determining the common cause adjustment factor. (A few licensees incorrectly used a CCF of 2 for valves which were not redundant and did not share a common cause function.) In contrast, a large percentage of the boiling water reactor licensees with RCIC incorrectly used a CCF greater than 1 for valves. Because RCIC was a single system, a CCF of 1 should be used in accordance with the guidance of Appendix F.

- Most licensee did not specify which method they were using in determining FV/UR.

- Many licensee did not provide adequate information with respect to how the licensee would determine the number of demands or run times for each component. For examples, in some cases, the licensees used an estimated value based on surveillances and operational activities. Actual engineered safety feature starts were not included (or clarification that is was considered was needed.) In several cases, the estimated values or the method used were not provided.

1.8 Observations and Unresolved Issues

Specific observations and comments on the Heat Removal System PI are provided in Appendix B.

2.0 Emergency AC Power - Emergency Diesel Generator (EDG) System

A. Basis Document Review

The audit team reviewed the licensee's basis documents for the Emergency AC Power Systems. All of the basis documents were reviewed on a sampling basis. A summary of the team's detailed review attributes and associated observations follows.

2.1 System Boundary Assessment

Using the guidance in NEI 99-02, Appendix F and G, the team determined the system boundaries for the MSPI using the basis documents and piping and instrumentation diagrams (P&IDs) then compared the results against the licensees' proposed boundary. The function monitored for the emergency AC power system is the ability of the emergency AC generators to provide AC power to the class 1E buses following a loss of off-site power. The emergency AC power system is typically comprised of two or more independent emergency generators that provide AC power to class 1E buses following a loss of off-site power. The emergency generator dedicated to providing AC power to the high pressure core spray system in BWRs is not within the scope of emergency AC power. In this review, the team verified that the licensees included the generator body, generator actuator, lubrication system (local), fuel system (local or day tank), cooling components (local), startup air system receiver, exhaust and combustion air system, dedicated diesel battery (which is not part of the normal DC distribution system), individual diesel generator control system, circuit breaker for supply to safeguard buses and their associated control circuit. Air compressors are not part of the EDG component boundary. The fuel transfer pumps required to meet the PRA mission time are within the system boundary, but are not considered to be a monitored component for reliability monitoring in the EDG system. Emergency generators that are not safety grade, or that serve a backup role only (e.g., an alternate AC power source), are not included in this indicator.

In general, the team determined that the licensees properly scoped the system boundaries. However, the team identified the following generic discrepancy. Many licensees simply provided the NEI 99-02, Appendix F, Figure F-1 to describe the system boundaries rather than provide a detailed drawing or description which provided component details and any site specific differences from Figure F-1. Licensees should provide a clear and concise description of the system. For the EDG system this should include more information than was contained in NEI 99-02, Appendix F, Figure F-1, such as:

- The number of dedicated EDGs per unit;
- If there are swing EDGs;
- If the EDGs can supply all units or all safeguards buses

- Type of cooling not specified (air or water)

- Specific type of isolation valves not specified (AOV, MOV)

- No table of contents was provided in several licensee basis documents; making the review difficult.

2.2 Risk Significant Function(s) Assessment

The risk significant functions of each identified train of the monitored system were compared to NEI 99-02, Appendix F, Section 2.1.1 and Section 2.2 guidance and the additional plant specific guidance of Section 5.0. Review team observation related to this assessment area is:

Train symmetry or lack of symmetry often was not specified.

2.3 Success Criteria

For each identified risk significant function, the licensee must clearly identify the success criteria used. Guidance for this attribute is provided in NEI 99-02, Appendix F, Section 2.1.1. The review team observed the following:

- A number of draft basis documents did not clearly state the criteria being used to define the system success or were silent with respect to the criteria used.

- Often the PRA was reference rather than using the design basis information without the necessary explanation and justification to know what the criteria are and which are most restrictive.

2.4 Mission Time

Per NEI 99-02, the basis document should identify the mission time for each risk significant function as identified in the design basis and/or plant specific PRA. Where mission times vary, the longest time (typically 24 hours) should be used. The review team observed that:

- The 24-hour mission time was not used for all EDG system functions without adequate justification

- Some facilities appeared to provide what was considered to be a risk significant time for the EAC system

2.5 Monitored Components Assessment

The review team examined the licensee's selection of components within the system boundary that satisfy the criteria for monitoring for unreliability. NEI 99-02, Appendix F, Section 2.2.2 specifies the criteria for inclusion/exclusion of monitored components. The team observed that most licensees provided a summary table of all major components (pumps and valves) within the system boundary and the associated basis for monitoring for reliability or for excluding from monitoring. The majority of the discrepancies noted involved the absence of information to support the exclusion of individual components from monitoring. Examples included:

- Some plants did not have a table with all monitored components listed.

- The fuel transfer pumps required to meet the PRA mission time are within the system boundary, but are not considered to be a monitored component for reliability monitoring in the EDG system. Additionally they are monitored for contribution to train unavailability only if an EDG train can only be supplied from a single transfer pump. Often plant specific details regarding the fuel transfer pump were not described.

2.6 Unreliability Data - Basis for Demands/Run Hours

The review team examined the basis documents to determine if sufficient information was provided to determine the basis for the number of system demands and total system run hours. Licensees generally provided adequate information to support their estimated or actual demands and run hours. Some notable exceptions were:

- In many plants the Load-Run Failure Mode was not addressed in the basis document.

- Some licensees did not indicate the basis for the baseline unavailability values. The values from all eight steps in Appendix F, Section 1.2.2 should be included.

- In some cases the basis for demand/run hour estimates was not provided. The method used to develop estimated values was not always documented.

2.7 Short Duration Unavailability

The team verified that the licensees provided adequate information to determine the baseline unavailability term for the indicator. On a sampling basis, the team verified the accuracy of the Fussell-Vesely/unavailability term provided by the licensee and confirmed that the licensees were following the guidance in Appendix F and G of NEI 99-02.

Some plants did not provide a <u>list</u> of short duration or operator recovery surveillances that would not count for unavailability. The following discrepancies were identified:

- In several cases when a list was provided, licensees did not provide justification as to why an operator recovery action was acceptable. (A short statement such as an operator is designated as dedicated to the task and recovery steps are in the procedure would suffice.)

- For planned baseline unavailability, many licensees provided the final value and did not provide a table with the details of the calculation such as the number of critical hours assumed.

2.8 PRA Information Used in MSPI

The team verified that the licensees provided adequate information to determine the baseline unreliability term for the indicator. On a sampling basis, the team verified the accuracy of the Fussell-Vesely/unreliability term provided by the licensee, appropriateness of the common cause correction factor, bases for the component demand and run hours. The team also confirmed that the licensees were following the guidance in Appendix F and G of NEI 99-02. The following discrepancies were identified:

- All of the documents require updating to the newly revised guidance.

- In a few cases, the CDF was not provided.

- In many cases, the truncation values were greater than 1E-11.

In some cases, the licensees incorrectly interpreted the guidance for determining the common cause adjustment factor.

- Many licensee did not specify which method they were using in determining FV/UR.

- Many licensee did not provide adequate information with respect to how the licensee would determine the number of demands or run times for each component. In several cases, the estimated values or the method used were not provided.

2.9 Observations and Unresolved Issues

Specific observations and comments on the Emergency AC Power System PI are provided in Appendix B.

3.0 Basis Document Review - High Pressure Injection (HPSI/HPCI/HPCS/FWCI) System

A. Basis Document Review

The audit team reviewed the licensees' basis documents for the High Pressure Injection systems for the boiling water reactors (High Pressure Coolant Injection, High Pressure Core Spray, or Feedwater Coolant Injection) and pressurized water reactors (High Pressure Safety Injection). All of the basis documents were reviewed on a sample basis.

3.1 System Boundary Assessment

Using the guidance in NEI 99-02, Appendix F and G, the team determined the system boundaries for the MSPI using piping and instrumentation diagrams (P&IDs) and then compared the results against the licensees' proposed boundary. In this review, the team verified that most of the licensees included the high and medium head injection pumps and valves in the suction and discharge paths from the refueling water storage tank and containment recirculation sump as well as the discharge from the residual heat removal system to the suction of each pump. Also, most documents included a statement that the electrical controls and breakers associated with components in the boundary were within the scope.

In general, the team determined that the licensees properly scoped the system boundaries. However, the team identified the following discrepancies:

- Several licensees included drawings that were either incomplete (no valve numbers or designators) or incorrect. The team also identified discrepancies between the P&IDs and the drawings. These issues were not significant.

- Many plants failed to mention that breakers, switches, last relay, etc. were part of the boundary. In contrast, other licensees clearly identified or noted that these components were part of the boundary. Additional guidance may clarify the documentation expectation.

- In many documents, the position of the boundary was not clearly shown, as only an unmarked depiction of the system was exhibited. Also, train boundaries were often not defined. A few examples were identified where the boundary did not include components that required inclusion.

- One facility had an incorrect drawing.

3.2 Risk Significant Function(s) Assessment

Most of the documents contained a listing of maintenance rule functions and a description that delineated which of these were pertinent to the MSPI. For the most part, there were no issues related to the functions described, as the MSPI

HPI function is narrowly focused on the injection of tank water followed by the recirculation of sump water following a loss of coolant accident. Some licensee's included subsidiary functions as an option, but these functions are not required to be monitored under the MSPI. Several findings were identified:

- Several facilities listed risk significant functions that were outside the MSPI function for the high pressure injection system

- At least five facilities failed to include either the swap-over to the refueling water tank or long-term recirculation from the containment sumps as risk significant functions or both.

3.3 Success Criteria

The team verified that the licensees documented parameters to be used to define success for the MSPI monitored function. The team identified the following discrepancies:

- Approximately 2/3 of the documents failed to completely describe the success criteria. Often a reference to the PRA was the only documented comment. The NEI guidance (App. F, Section 2.1.1) was revised to state that any departure from the design basis was to be described in the basis document, or otherwise stated, if true, that the PRA success criteria was equivalent to the design basis. Most of the licensees committed to include this information in their final submittal.

- Few facilities did not have success criteria for a risk significant function listed under the *risk significant functions* section, or conversely, had success criteria for risk significant functions that were not listed.

3.4 Mission Time

The team verified that the licensees documented a mission time of 24 hours or provided justification for a lessor mission time. The team also verified that this mission time was used in determining the PRA values for the monitored components. The team identified the following discrepancy:

- Approximately 1/4 of the licensees provided two or more mission times depending on the assumed accident scenario. It was not clear whether the largest value (24 hours in most cases) was used in determining the PRA values for MSPI. Two of these licensees re-ran their PRA model using the largest mission time.

3.5 Monitored Components Assessment

The team verified that the licensees properly identified those components within the system boundary to be monitored for the unreliability portion of the MSPI. The team verified that each licensee included the system pumps and drivers and properly dispositioned all valves whose failure(s) would prevent fulfillment of the risk significant function for the system. The team identified the following discrepancies:

- One licensee included two valves as a common cause group, but intended not to monitor them individually- that is, only a failure of both valves would be considered a failure under the MSPI. This was not in accordance with the guidance.

- Approximately 1/5 of the documents had errors regarding the basis used to justify exclusion of a component from monitoring. That is, the guidance provided in App. F. Section 2.1.2 was not followed.

- Many documents failed to list components within the system boundary in either the “monitored” or “not-monitored” lists. Although the unlisted components were obviously not monitored, the justifications for such were missing.

- Most plants that screened out valves based on low Birnbaum ratios but did not provide the specific values.

3.6 Unavailability Data

The team verified that the licensees provided adequate information to determine the baseline unavailability term for the indicator. On a sampling basis, the team verified the accuracy of the Fussell-Vesely unavailability term provided by the licensee and confirmed that the licensees were following the guidance in Appendix F and G of NEI 99-02. The following discrepancies were identified:

- approximately 10 licensees presented FV/UA data that was skewed between trains only because the PRA model assumed that one train was always running. These licensees agreed to correct this situation by averaging the ratios as described in the guidance.

- For planned baseline unavailability, many licensees provided the final value but didn’t provide a table with the details of the calculation such as the number of critical hours assumed.

- Approximately half of the licensees incorrectly determined the maximum FV/UA ratio by not considering failure to start scenarios or by incorrectly considering failure to run scenarios.

3.7 Unreliability Data

The team verified that the licensees provided adequate information to determine the baseline unreliability term for the indicator. On a sampling basis, the team verified the accuracy of the Fussell-Vesely/unreliability term provided by the licensee, appropriateness of the common cause correction factor, bases for the component demand, and run hours. The team also confirmed that the licensees were following the guidance in Appendix F and G of NEI 99-02. The following discrepancies were identified:

- All of the documents require updating to the newly revised Appendix G guidance.
- A few licensees incorrectly determined the maximum FV/UR ratio by inappropriately considering test and maintenance scenarios.

- In most cases, the pressurized water reactor licensees correctly interpreted the guidance for determining the common cause adjustment factor. (A few licensees incorrectly used a CCF of 2 for valves which were not redundant and did not share a common cause function.) In contrast, 75% of the boiling water reactor licensees with RCIC incorrectly used a CCF greater than 1 for valves. Because HPCS was a single system, a CCF of 1 should be used in accordance with the guidance of Appendix F.

- Many licensee did not specify which method they were using in determining FV/UR.

- Many licensees did not provide adequate information with respect to how the licensee would determine the number of demands or run times for each component. For example, in some cases, the licensees used an estimated value based on surveillances and operational activities. Actual engineered safety feature starts were not included (or clarification that is was considered was needed). In several cases, the estimated values or the method used were not provided. Many of the tables were incomplete and did not allow a reviewer to verify or understand how the baseline information was calculated, nor did they is some cases separate operational demands from those resulting from tests or maintenance.

- Spot check of mathematical precision was conducted and only one basis document was identified to contain errors (the numbers used to determine FV/UR were reversed).

- At least one licensee was identified to have performed birnbaum exclusions prior to application of the common cause factor, though this issue was emphasized with any licensee whose document did not positively state that the exclusions were performed afterwards.

3.8 Observations and Unresolved Issues

Specific observations and comments on the High Pressure Injection System PI are provided in Appendix B.

4.0 Basis Document Review - Residual Heat Removal (RHR) System

A. Basis Document Review

The staff examined the RHR section of the licensees' basis documents. For boiling water reactors (BWRs), the RHR function monitored under MSPI consist of the suppression pool heat removal function only. As defined in the NEI guidance, those portions of BWR residual heat removal systems that are not connected to a heat exchanger are not to be included within the scope of this indicator. For pressurized water reactors (PWRs), the RHR function monitored for this indicator is the long term decay heat removal capability. The typical PWR residual heat removal function to be monitored is low pressure injection to the reactor coolant system (RCS). This includes initial injection of water from the refueling water storage tank, until the inventory is depleted, followed by injection from the containment sump via one or more heat exchangers. Per the NEI guidance, the containment spray system should also be included if it provides a decay heat removal function. A summary of the team's detailed review attributes and associated observations follows.

4.1 System Boundary and Train Identification Assessment

The review team examined the plant specific piping and instrumentation diagrams (P&IDs) and related basis document simplified flow diagrams (if included) to compare the licensee's RHR system functional boundaries and train selection against the NEI 99-02, Appendix F, Section 1.1 guidance. Additional guidance for determining system boundaries is provided in Section 5.0 of NEI 99-02, Appendix F.

The review team observed that the majority of licensees appropriately identified the system boundaries for the RHR system. A few draft basis documents excluded the heat exchanger cooling valves or did not clearly identify all valves within the RHR system functional boundary. However, a number of draft basis documents were developed using an earlier revision of the NEI 99-02 guidance (Revision P), than the revision (Revision R2) used by the team. Consequently, more RHR system risk significant functions and associated components were identified for inclusion within the RHR system boundary than required by current guidance.

4.2 Risk Significant Function(s) Assessment

The risk significant functions of each identified train of the monitored system were compared to NEI 99-02, Appendix F, Section 2.2 guidance and the additional plant specific guidance of Section 5.0. Review team observations related to this assessment area are included in the previously mentioned table.

4.3 Success Criteria

For each identified risk significant function, the licensee must clearly identify the success criteria used. Guidance for this attribute is provided in NEI 99-02, Appendix F, Section 2.1.1.

The review team observed that a number of draft basis documents did not clearly state the criteria being used to define system success or were silent with respect to the criteria used. The basis documents which were identified to have insufficient or missing success criteria are listed in the previously mentioned table.

4.4 Mission Time

Per NEI 99-02, the basis document should identify the mission time for each risk significant function as identified in the design basis and/or plant specific PRA. Where mission times vary, the longest time (typically 24 hours) should be used. The review team observed that a 24-hour mission time was used for all RHR system functions.

4.5 Monitored Components Assessment

The review team examined the licensee's selection of components within the system boundary that satisfy the criteria for monitoring for unreliability. NEI 99-02, Appendix F, Section 2.2.2 specifies the criteria for inclusion/exclusion of monitored components. The team observed that most licensees provided a summary table of all major components (pumps and valves) within the system boundary and the associated basis for monitoring for reliability or for excluding from monitoring. The majority of the discrepancies noted involved the absence of information to support the exclusion of individual components from monitoring. Plant specific discrepancies in this area are listed in the previously mentioned table.

4.6 Unreliability Data

Basis for Demands/Run Hours - The review team examined the basis documents to determine if sufficient information was provided to determine the basis for the number of system demands and total system run hours. Licensees generally provided adequate information to support their estimated or actual demands and run hours. The plant specific discrepancies identified by the review team are provided in the previously mentioned table.

4.7 Short Duration Unavailability

The team examined the basis documents to verify that the licensee had provided a list of any periodic surveillances or evolutions, with a duration of less than 15 minutes, that would not be included in the accrued train unavailability time. NEI 99-02, Appendix G, Section G provides the guidance for this assessment item. The review team identified a number of draft documents that either did not provide this information (To Be Determined) or appeared to have misinterpreted the information being requested for inclusion in the basis document. The plant specific discrepancies identified by the review team are listed the previously mentioned table.

4.8 Common Cause Adjustment Factor

NEI 99-02, Appendix G and F, provide guidance on the correct common cause factor (CCF) to be applied. Either generic CCF values can be applied to the FV/UR ratios taken from Appendix F, Table 3, or a plant specific CCF value can be derived via guidance in Appendix F, Section 2.3. The review team identified a few discrepancies in this assessment area. The team's plant specific observations are listed in the previously mentioned table.

4.9 PRA Information Assessment

The review team examined the PRA information submitted in conjunction with the basis document. One item of particular concern was the truncation value selected by the licensee to demonstrate convergence of the CDF and Birnbaum values. A second item of interest was the status of open Category A and B Findings and Observations (F&Os) from earlier licensee peer reviews of individual plant PRAs. For open F&Os, licensee's were instructed to provided adequate justification for leaving an F&O open/unresolved prior to implementation of MSPI in January 2006. Based upon the team's review, a significant number of licensee's either did not have adequate justification for leaving an F&O open, beyond January 2006, or had no plans to have their A and B F&Os resolved prior to January 2006. The plant specific observations in this area identified by the review team are provided in the previously mentioned table.

4.8 Observations and Unresolved Issues

Specific observations and comments on the Residual Heat Removal system PI are provided in Appendix B.

5.0 Support Cooling Water Systems (limited review, four plants/region)

Basis Document Review

Due to time constraints, the staff performed an audit of the support cooling water systems for selected licensees. Each regional team reviewed four plant basis documents located within their region for a total of 16 plants. The sample was based on results from the front line system reviews, meaning that several plants who had issues with the guidance were selected. A few plants that did not show the same issues were also selected for review.

Additionally, the MSPI Working Group was aware that the support cooling water system guidance was not fully trial-tested at the time of the review and it was recognized as the most challenging area of the guidance. It was expected that problems and guidance clarifications would result from the review. An example of this was the guidance concerning use of the segments in lieu of defined trains and how this applies to the support cooling water and front line systems. Appendix F guidance allows licensees to either define trains or segments to track and account for unavailability. This flexibility was built into MSPI because of the difficulty in identifying standard trains in the support cooling water systems, which are very site specific. Since train/system boundaries defined by segments do not conform to normal train boundaries, the historical unplanned unavailability train values depicted by Table 1 in Appendix F, NEI 99-02, revision 4, can not be used for components within segments. The MSPI Working Group recently revised the guidance to require each licensee to manually input the correct value, corresponding to the approach adopted by the licensee. This will require all licensees who use the segment approach to change their values.

As previously mentioned, the staff audit of the support cooling water system consisted of four plant reviews per region. Findings were consistent in that licensees that were having difficulty in interpreting Appendix F guidance for the front line systems also experienced difficulty for the support cooling water system. Details of these findings are contained in Appendix B. Examples of issues documented include some licensees (1) did not provide information as to how they accounted for the adjustment of the support cooling water system initiator, and (2) did not include consideration of the effects of common cause when calculating $FV_{max.}$ These problems were generically addressed through Appendix F guidance clarifications after the staff review had been completed.