APPENDIX G

SHUTDOWN OPERATIONS
SIGNIFICANCE DETERMINATION PROCESS

Office of Nuclear Reactor Regulation
Division of Systems Safety and Analysis
Probabilistic Safety Assessment Branch

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1.0 INTRODUCTION

Appendix G provides guidance for Phases 1 and 2 of the Significance Determination Process (SDP). The SDP Phase 1 guidance, presented as Attachment 1 of Appendix G, is a separate document in the manual chapter and consists of checklists for the various shutdown operating conditions for both PWRs and BWRs. The Phase 1 guidance is to be used by inspectors when performance deficiencies are identified that affect shutdown conditions. Each shutdown operating state, as defined in the various sections of Attachment 1, lists the types of findings that would require further evaluation by Phase 2 of the SDP. Once it is determined that a Phase 2 evaluation is needed, the inspector transitions the evaluation to a Senior Reactor Analyst for further review. The guidance for Phase 2, which are also separate documents in the manual chapter, is presented in Appendix G as Attachments 2 and 3. Attachment 2 provides Phase 2 guidance for PWRs and Attachment 3 provides Phase 2 guidance for BWRs. These attachments are generic in nature for both reactor types. Reference Figure 1 for the road map for shutdown inspection findings through SDP Phases 1 and 2.

2.0 BACKGROUND

In SECY 97-168, the staff requested the Commission to approve the publication of a proposed rule for comment that would cover shutdown and low power operation at nuclear power plants. The proposed rule was applicable during cold shutdown and refueling operation as defined in Technical Specifications. This rule would have required licensees to establish and implement procedures for training, quality assurance, and corrective actions to ensure that the safety functions of: decay heat removal, inventory control, and pressure control are maintained and monitored. The proposed rule also required the licensees to provide a mitigation capability. The mitigation capability would include the necessary equipment to maintain the reactor in a safe condition in the event of the loss of the operating decay heat removal system.

A quantitative regulatory analysis using PRA techniques was performed for SECY 97-168 to evaluate the benefit of the proposed rule. Core damage frequencies were developed for three cases of shutdown operation at PWRs and BWRs: the base case, the voluntary case, and the rule case. The base case represented the level of protection provided strictly by legally enforceable requirements, i.e., current regulations, technical specifications, licensee conditions and orders. It did not credit any measure that was voluntary or that could be unilaterally changed by the licensee, such as licensee commitments made in response to generic letters and bulletins. The base case was used to assess the benefit of the proposed new rule. The voluntary case represented the level of protection for plants operated with a reasonable implementation of voluntary measures, based on guidance from NUMARC 91-06 and GL 88-17. (NUMARC 91-06 provides guidance on improving outage management and GL 88-17 provides recommendations concerning the ability of a licensee to mitigate a potential loss of DHR during reduced inventory operations at PWRs). The voluntary action case also credited equipment assumed operable according to Technical

Specifications. The rule case represents the level of protection provided by all plants complying with the requirements of the proposed rule.

For both PWRs and BWRs, two voluntary action cases were performed using different interpretation of NUMARC 91-06 and GL 88-17. The higher CDF voluntary case represents a minimal implementation of both guidance documents. The lower CDF voluntary case represents an in-depth implementation of both guidance documents.

The Regulatory analysis reported core damage frequencies (per reactor year) on the order of E-2 per year and E-3 per year for PWRs and BWRs respectively for the base case. The core damage frequencies (per reactor year) estimated for the voluntary action cases ranged from 8E-5 to 2E-6 per year for PWRs and from 1E-5 to 6E-7 for BWRS.

Based on staff review of the base case, voluntary action cases, and the rule case, the staff reported in SECY 97-168 that: (1) the existing level of safety at shutdown is largely dependent upon measures that are not traceable to specific underlying regulations, and that could, therefore, be withdrawn by licensees without prior staff approval (2) little reduction of risk is achieved by the rule for the licensee who has adopted effective voluntary practices that reduce risk for shutdown operation.

In response to SECY 97-168, the Staff Requirements Memorandum (SRM) did not authorize the staff to issue the rule. As documented in the Federal Register (dated February 4, 1999, vol. 64, no. 23), the Commission did not believe that the proposed shutdown rule was needed given the staff's estimate of current industry performance. However, as directed in the SRM, the Commission "expects the staff to continue to monitor licensee performance, through inspections and other means, in the area of shutdown operations to ensure that the current level of safety is maintained." In addition, in the Federal Register (dated February 4, 1999, vol. 64, no. 23), it states, "the Commission will continue to monitor industry performance and may take further action if any adverse trends are identified." For more detailed information regarding the basis for this appendix, IMC 308, Reactor Oversight Process," should be referenced.

3.0 GUIDANCE

3.1 When Appendix G Should be Used

Appendix G is applicable during refueling outages, forced outages, and maintenance outages starting when the licensee has met the entry conditions for RHR and RHR cooling has been initiated, and ending when the licensee is heating up and RHR has been secured.

Note: If the licensee is in a refueling outage or forced outage and the plant is above RHR entry conditions, then the full power SDP tools should be used acknowledging: (1) decay heat is less compared to full power, potentially allowing for more time for operator recovery, (2) some mitigating systems may require manual operation

versus automatic operation, and (3) some containment systems may not be required to be operable potentially increasing the likelihood of containment failure.

3.2 Objective

Appendix G is used to screen shutdown findings for potential risk significance. When using this guidance to assess a finding, there are two possible outcomes: (1) the finding requires quantitative assessment (Phase 2 or Phase 3 analysis) to determine if the finding is potentially risk significant, or (2) the finding can be screened as having very low risk significance (Green). See Figure 1.

Caution: To determine if a shutdown finding needs quantitative assessment, the inspector should review (1) the checklists in Attachment 1 to ensure that the licensee is maintaining an adequate mitigation capability and (2) Table 1 if an event occurred that could be characterized as a loss of control.

3.3 Mitigation Capability

Attachment 1 contains checklists for shutdown operation to ensure that the licensee is maintaining an adequate mitigation capability. The checklists were developed for different plant operational states defined by: operational mode, time to boiling, reactor coolant system level, and reactor coolant system configuration. For each plant operational state defined in the checklist, there is a set of equipment, instrumentation, policies, and procedures that the staff expects the licensee to maintain during shutdown. This checklist is grouped by the five shutdown safety functions identified by NUMARC 91-06: decay heat removal, inventory control, power availability, reactivity control, and containment. As a plant enters into the different plant operational states, the inspector uses a different checklist. The inspector should check to ensure that each item on the checklist is being met. If an item is not being met, the inspector should review the section labeled, “Findings requiring phase 2 analysis,” to see if the finding needs to be quantitatively assessed. These conditions vary with plant configuration and time to boiling. Findings not requiring quantitative assessment may be screened “Green.”

The risk estimates used to produce the following tables recognize that certain plant configurations have inherently higher risks than others. For higher risk evolutions, the tables have more guidelines for each safety function. For example, based on past reviews of PWR shutdown PRAs, the staff has identified a step increase in risk that occurs when the RCS boundary is breached, and the steam generators cannot be used for DHR. A second step increase in risk occurs when mid-loop conditions are reached. During midloop conditions, the likelihood that DHR can be lost due to poor RCS level control or poor DHR flow control increases. The staff has also identified a step increase in risk during cold shutdown in BWRs. This increase in risk occurs because technical specifications allow for more equipment to be inoperable in cold shutdown than in hot shutdown. Also, the technical specifications allow the SRVs to be inoperable which are needed to provide an alternate decay heat removal path and pressure control if the DHR system is lost.

3.4 Losses of Control During Shutdown

In addition to ensuring that the licensees maintain a mitigation capability during shutdown, as part of the Significance Determination Process, the staff is also monitoring conditions or events that represent a loss of control. The staff is monitoring losses of control because the voluntary action case for the proposed Shutdown Rule assumed that, based on experience, losses of DHR are relatively infrequent. In Table One, conditions that meet a loss of control are listed. If these conditions occur, then the finding needs to be quantitatively assessed.

3.5 Finding Requiring Quantitative Assessment

If a finding needs quantitative assessment, then the finding should be forwarded to the SRA. The SRA will then decide if the finding should be forwarded to NRR for Phase 3 analysis or the finding will be evaluated using the Phase 2 PWR and BWR templates located in Attachments 2 and 3, respectively. The SRA should be sent the completed checklists associated with the finding and a complete description of the finding.

4.0 DEFINITIONS

Available: A piece of equipment is considered available if (1) it can be put into service within half the time that is needed for the equipment to perform its function, (2) procedures or standing orders exist for using the equipment to meet its intended function, (3) all necessary supporting systems (such as AC power, cooling water, and DC control power) can be put into service within half the time that is needed for the equipment to perform its function, and (4) operators have been trained for using the equipment for the given situation.

Reduced Inventory operation: Reduced inventory operation exists whenever the reactor vessel water level is lower than three feet below the reactor vessel flange.

Midloop Operation: Midloop conditions exist whenever the RCS water level is below the top of the flow area of the hot legs at the junction with the reactor vessel.

Shutdown Operation: Shutdown operation exists during hot shutdown, cold shutdown, and refueling when more than one fuel assembly is in the reactor vessel and the DHR system is in operation.

END

FIGURE 1: Road Map for Shutdown Findings

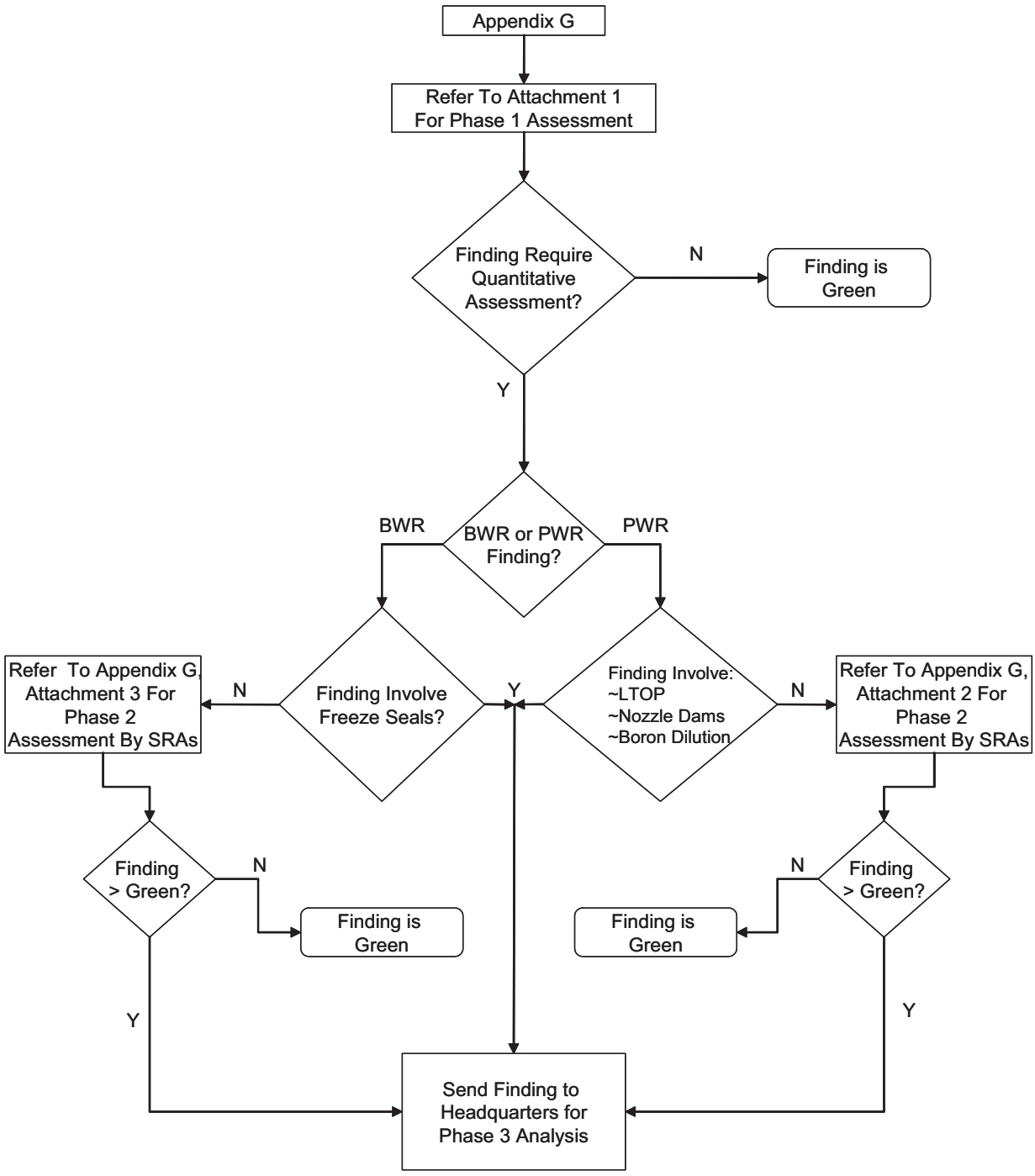

TABLE 1: Losses of Control

Loss of Thermal Margin (PWRs and BWRs)

(Inadvertent change in RCS temperature due to Loss of RHR)/(change in temperature that would cause boiling) > .2 (temperature margin to boil)

Loss of Level PWRs

Inadvertent loss of 2 feet of RCS inventory when not in midloop OR
Inadvertent entry into midloop conditions OR
Inadvertent loss of 2 inches of RCS inventory when in midloop conditions

Loss of Level BWRs

Inadvertent loss of 2 feet of RCS inventory OR
Inadvertent RCS pressurization

END