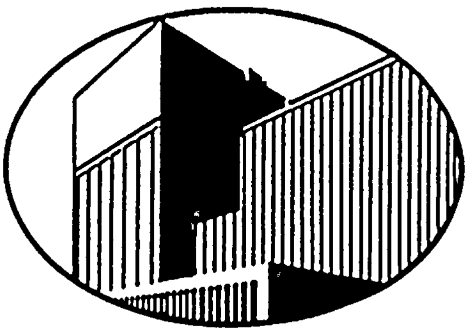
WASHINGTON NUCLEAR PLANT 2 DESIGN REVERIFICATION PROGRAM

Volume I: Final Assessment Report



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Washington Public Power Supply System
Richland, Washington 99352

WASHINGTON NUCLEAR PLANT 2

DESIGN REVERIFICATION PROGRAM

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APPROVAL: [signature]

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1.0 EXECUTIVE SUMMARY

1.1 INTRODUCTION

This report presents the results of the Washington Nuclear Power Plant 2 (WNP-2) Design Reverification Program. The program was established to reverify that WNP-2 was designed to meet the regulatory requirements committed to in the Final Safety Analysis Report. The WNP-2 design requirements for safety systems were reviewed to ensure that they are complete and clearly documented and that they were correctly reflected in the detailed design documents used during construction. Three reactor systems were reviewed in depth: the high-pressure core spray system (HPCS); the residual heat removal system (RHR); and the reactor feedwater system (RFW). In addition, five studies were conducted to evaluate the interactions between reactor systems. Those studies cover: 1) fire protection interaction with the residual heat removal system, 2) pipe breaks, missile, jet impingement, falling objects and flooding, 3) environmental qualification of safety-related equipment, 4) wall and floor slab structural loading and 5) Class 1E instrument racks.

To ensure an independent, objective review, the reverification program was performed by Supply System engineers and consultants who were not involved in the original design of WNP-2. An outside firm evaluated the technical adequacy of the program and monitored its implementation. Potential findings were evaluated by a committee composed of senior technical people with broad commercial nuclear experience.

The reverification program should be viewed as part of the overall process of assuring that WNP-2 is ready to operate. Design reverification is a part of a Plant Verification Program, which in turn is part of a broader WNP-2 Plant Completion Plan (see Figure 1-1).

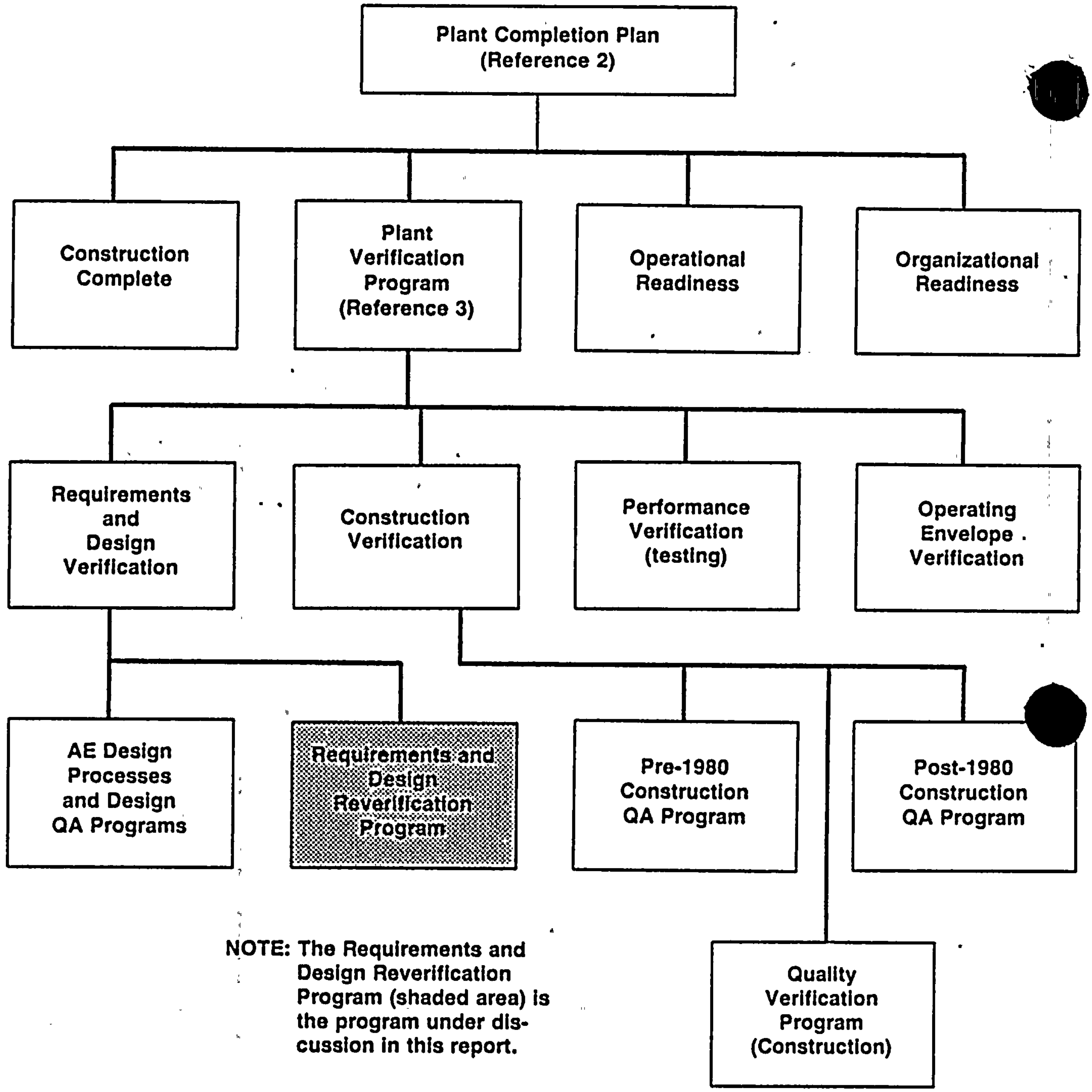

FIGURE 1-1 WNP-2 Approach to Ensuring Operational Readiness

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The process of plant verification spans the entire period of design, construction and testing. In January 1981, the Supply System Managing Director requested a "... a well documented basis for (his) acceptance of plant completion, safety and technical adequacy."[(1)] In response to his request, the WNP-2 Plant Completion Plan was developed to ensure that WNP-2 is ready to operate.[(2)] As one element of this overall program, a comprehensive Plant Verification Program[(3)] was published which describes the process of verifying the adequacy of WNP-2 design and construction. This verification report describes the quality assurance and verification controls that were in place during the early phases of design and construction as well as corrective actions that were begun by the Supply System during the 1980 suspension of construction. During the 1980 work stoppage, major changes were made in quality assurance programs and management of the project to ensure the adequacy of future work. For example, Bechtel was hired as an experienced construction management/ system completion contractor and Burns and Roe was assigned exclusive engineering responsibility. To ensure the adequacy of past work, a major program called Quality Verification was undertaken to identify and correct any deficiencies on construction work completed before the work stoppage.

Finally, noting the design quality problems encountered at Diablo Canyon and elsewhere, the Supply System undertook a program to reverify WNP-2 design adequacy. The results of this special Design Reverification Program are described in this report.

The WNP-2 Plant Verification Program and, in particular, the design reverification element of that program were specifically designed to address Nuclear Regulatory Commission (NRC) concerns that have led to independent design reviews of recently licensed nuclear plants. The WNP-2 Plant Verification Program was submitted to the NRC for review.[(4,5)] Following a November 10, 1982, meeting with the NRC staff, the program as proposed by the Supply System was accepted by the NRC.[(6)]

This final assessment report of the reverification program is presented in three major sections and two appendices. Section 1.0 summarizes the overall results and conclusions of the review. Section 2.0 presents the methodology for reviewing the design. One of the goals in establishing a methodology was to achieve an adequate degree of independence throughout the review. Section 3.0 presents the results of the review for each of the three systems. The results of the system interaction studies are also reported in this section. Appendix 1.0 is a list of all potential finding reports issued in the review, and Appendix 2.0 is a list of the documents reviewed. The two appendices are published in a separate volume for convenience.

1.2 SUMMARY OF RESULTS

The scope of the Supply System's design reverification program was greater than most programs undertaken by other utilities with plants nearing operation in that it examined three complete reactor systems in detail and included a requirements reverification review and five system interaction reviews. The Supply System's program involved the evaluation of the entire design process, including the translation of the Final Safety Analysis Report requirements into design input and the adequacy of design outputs and interfaces. As part of the review, the installed plant structures were physically examined to ensure that they conform to the design documents.

Approximately 3,500 documents were examined during the process of reviewing system interactions, the design requirements, and designs of three reactor systems (HPCS, RHR and RFW). The reviews were highly detailed and the threshold for issuing a potential finding was low as evidenced by the nature of those that were documented. Supply System and their contractors expended approximately 15 man-years of review effort. Approximately 2.2 man-years were expended by Technical Audit Associates in overviewing the program.

Formal potential finding reports were issued whenever deficiencies or concerns were identified by the reviewer. Each report was classified and evaluated by the Findings Review Committee (FRC). This formalized mechanism for identifying and resolving potential findings assured that any concerns identified would be addressed and that no pressure could sway the reviewer's technical judgment or capability to raise possible issues. As a result of this approach, a number of potential finding reports were issued because of a lack of complete information or an adequate understanding of the process or technical approach used in the design. Thus, 40 of the 165 documented potential finding reports were resolved based on subsequent information and were declared invalid.

Of the valid potential finding reports, 26 were classified as findings and the remaining 99 were classified as observations using the criteria described in Section 2.6. Table 1-1 shows the number of potential finding reports for each area reviewed.

TABLE 1-1

DISTRIBUTION OF FINDINGS BY SYSTEM

System	Number of Documents Reviewed	Findings	Observations	Invalid PFR's
Requirement Reverification	266	0	5	5
HPCS Design Review	1,056	8	46	18
RHR Design Review	667	5	22	4
RFW Design Review	834	3	13	7
System Interaction Reviews	675	10	13	6
TOTALS	3,498	26	99	40

The 26 findings are listed and categorized by type of error or deficiency in Table 1-2.

As described in Section 2.6, each potential finding report (PFR) was evaluated by the reviewers and the Findings Review Committee for reportability to the NRC under 10CFR50.55(e) or 10CFR21. If any PFR was considered to be potentially reportable, it was referred to WNP-2 Project Quality Assurance for assessment and reporting under the normal project procedures. During the course of the review it was determined that five PFR's identified reportable design or construction deficiencies. Several other findings were initially designated as potentially reportable but subsequent evaluation determined that no reportable deficiency had been identified. Evaluation of PFRs for reportability in accordance with 10CFR50.55e included a determination of any generic or common-mode errors for the entire plant. Each of the reportable findings is identified in Table 1-2 and in the corresponding Section 3.0 discussion of that PFR.

Five findings (EQ-11, -13, -14, -15 and -16) noted deficiencies in Supply System computations. Two of these PFRs (EQ-15 and -16) resulted in 10CFR50.55e reportable deficiencies. These findings involved errors in high-energy line break calculations that were used as a basis for environmental qualification of equipment. The deficiencies were the result of (1) breakdowns in the Burns and Roe (B&R)/Supply System interface in the environmental qualification area and (2) analytical errors such as in correct modeling of isolation valve closure characteristics.[1] Corrective actions in this area involve recalculating all high-energy line break profiles, rechecking all other design calculations performed by the Supply System, performance of an audit by Stone and Webster of the Supply System design controls, and implementation of design process modifications to assure that future Supply System design work will be adequate. The review identified the need to add barriers and heating and ventilation isolation devices in order to make the environmental calculational assumptions correct and minor changes in hardware due to changes in environmental profiles.

Eleven findings (listed in Table 1-2) involved deficiencies in B&R calculations that require either (1) additional assessment to verify the adequacy of the design or (2) minor design modifications. The number and nature of these findings prompted an additional evaluation of B&R's

TAB[illegible]
SUMMARY LIST AND CATEGORIZATION OF FINDINGS

Design Reverification Findings		Text Reference	Error in Supply System Design Calc	Error in B&R Calculations	B&R Engineering Error	Construction Deficiency	Design Interface Breakdown	Criteria/ Requirements not properly applied in design	GE Engineering Error	Documentation Checking Deficiency
HPCS-15	Calc. errors in evaluation of suction switchover transient	3.2.3.6.A		X	X					
HPCS-19	Airbox drain collection tank not provided	3.2.4.3						X		
HPCS-21	Gap between pipe clamps in excess of specified tolerances	3.2.6.4.B				X				
HPCS-46	Improper breaker design which could result in tripping entire motor control circuit	3.2.4.7							X	
HPCS-49	Incorrect application of ground fault alarm relays on bus SM-4	3.2.4.7			X					
HPCS-58	Typo in piping Design Guide resulting in calculational error and overstressed pipe design	3.2.5.1.B		X						X
HPCS-66	Incorrect hanger loads utilized in hanger design calculations	3.2.5.1.B		X	X		X			
HPCS-81	Incorrect scales used in input to ADLPIPE	3.2.5.1.A		X	X					
RHR-6	Failure to include RHR-FCV-64 on the remote shutdown panel per the design specification	3.3.3.4			X		X			
RHR-10	Error in design of second level undervoltage trips for busses SM-7 and SM-8**	3.3.3.1.D			X					
RHR-24*	Installation of RHR Heat Exchanger not in conformance with installation specs.** (see RHR-33)	3.3.5.2.B				X				

TABLE 1-2 (Continued)

Design Reverification Findings		Text Reference	Error in Supply System Design Calc	Error in B&R Calculations	B&R Engineering Error	Construction Deficiency	Design Interface Breakdown	Criteria/ Requirements not properly applied in design	GE Engineering Error	Documentation Checking Deficiency
RHR-25	Anchor Bolt Analysis due to increased loading incomplete	3.3.5.2.B		X			X			
RHR-33*	Lugs on RHR Heat Exchanger not properly shimmed during installation (see RHR-24)**	3.3.6				X				
RFW-6	Undersized relief valve on feedwater heater	3.4.4.1						X		
RFW-11	Failure to meet downstream pipe length requirement for flow element	3.4.4.3					X			
RFW-21	Method used to size control flow control valve did not prevent cavitation	3.4.4.1			X					
EQ-11	Environmental calculation predicts excessive wall ΔP	3.5.5.6	X				X			
EQ-13	Non-conservative isolation valve closure assumed in calculation	3.5.5.6	X							
EQ-14	Incorrect assumption regarding isolation signals in EQ calc.	3.5.5.6	X		X		X			
EQ-15	Failure to consider worst case single active failure in EQ calculation**	3.5.5.6	X				X			
EQ-16	Incorrect assumption on HVAC operation in EQ calc.**	3.5.5.6	X				X			
PB-1	Use of incorrect allowables	3.5.4.1.B		X	X					
PB-3	Post accident damage sequence varied from that postulated by B&R calculation	3.5.4.1.C		X	X					

TABLE 1-2 (Continued)

	Design Reverification Findings	Text Reference	Error in Supply System Design Calc	Error in B&R Calculations	B&R Engineering Error	Construction Deficiency	Design Interface Breakdown	Criteria/ Requirements not properly applied in design	GE Engineering Error	Documentation Checking Deficiency
PB-6	Error in methodology for targetdetermination for jet impingement outside of containment	3.5.4.2.B		X						
PB-7	Pipe break target determination calculation deficiency	3.5.4.1.E		X						
WL-2	Error in Main Steam Tunnel North Wall deflection calculation	3.5.6.2		X	X					

* RHR-24 and RHR-33 were deficiencies in the installation of RHR equipment. At the time of the IDR the installation work packages were not closed out by Bechtel. It is arguable that the final Bechtel reviews may have detected these errors.
** Reportable under 10CFR50.55(e) or 10CFR21.

process for updating and finalizing calculations. Based on this evaluation, which involved looking at the calculation closure status in all engineering disciplines, it was concluded that an adequate process (i.e., procedures) for calculation closure existed during the design. Effective implementation depended on individual group supervisors in each discipline. For the most part implementation was acceptable; however, some problems were found in the timeliness and adequacy of the updating process in some of the disciplines. In particular, the updating of electrical calculations was found to be deficient and a priority effort was initiated to update them all. Problems were also noted in the updating of wall loading calculations and the methodology for performing pipe break/ jet impingement and calculations. Programs were implemented to update wall loading calculations and improve the criteria to be utilized in the final pipe break/jet impingement walkdowns. A few other problems of lesser significance were noted in updating of Burns and Roe calculations in other disciplines. Action was initiated in each of these cases to correct the deficiencies. Because of the inherent conservatisms in the B&R design approach, none of the PFR's involving B&R calculational errors have necessitated modification of installed hardware with the exception of some minor electrical modifications to improve breaker performance and ground-fault alarm sensitivity (see PFR-HPCS-46 and PFR-HPCS-49).

The HPCS piping stress analyses review identified one finding and three observations which involved the use of out-of-date or incorrect hanger loads and deflections. These reports prompted a closer examination of the interface between the piping stress analysis activities at the B&R headquarters in Woodbury, New York, which generated hanger loads as input to the hanger design, and the B&R site organization, which performed the actual hanger design. Corrective actions were initiated by B&R to strengthen the process for transmitting and reviewing hanger loads. Since the HPCS stress analyses reviewed as part of the reverification program were the first as-built analyses to be completed, the corrective actions will preclude similar problems with the remaining analyses. As part of the corrective action, a Supply System quality assurance audit of the hanger load transmittal process will be conducted once a substantial number of the final as-built analyses are complete to verify the effectiveness of the B&R corrective actions.

Two findings (PFR-RHR-24 and PFR-RHR-33) identified deficiencies in the installation of RHR equipment and one identified an installation error on an HPCS hanger (PFR-HPCS-21). These findings were construction rather than design deficiencies.

The two RHR installation problems were reported as 50.55e deficiencies. It should be recognized however that these problems may have been identified by Bechtel in the final close-out of installation packages since these work packages had not been closed out at the time of the design reverification. Regardless, in response to these findings a complete review of Contract 215 (i.e., mechanical equipment) installation work was undertaken. This review consisted of:

- Researching plans and specifications, including Project Engineering Directives (PED) and vendor instructions, and preparing a list of installation requirements.

- Comparing the requirements with existing inspection records. Where the records are specific and clearly indicate that the components were inspected as required, the inspection record was taken as proof that the requirement was met in the field. If the inspection record was not specific, a field reinspection was conducted to ensure the requirement was implemented. This program looked at 438 equipment installations--a 100% sample.

This inspection program has been completed. It involved review of an estimated 10,000 installation attributes and resulted in the identification of 38 additional installation deficiencies that are being corrected or dispositioned.

For the HPCS pipe clamp construction deficiency (PFR-HPCS-21), corrective actions were initiated to evaluate all similar clamp installations to ensure that this finding was an isolated deficiency. No other similar problems were identified.

Eight findings (listed in Table 1-2) involved difficulties with design interfaces. Detailed examination of the individual cases, however, did not reveal a generic problem with interfaces except for the Supply System environmental calculation issue discussed earlier, which reflected inadequacies in the B&R/Supply System interface associated with that program. The B&R/General Electric (GE) interface was observed to be handled effectively. There were some instances where B&R did not follow nonmandatory GE recommendations, but these instances were documented and were design decisions within B&R's scope of responsibility. Appropriate GE reviews and involvement did occur. In summary, the review did not reveal substantive problems with either the B&R/GE interface or with other B&R/contractor interfaces.

The review of the HPCS included an in-depth review of piping and support as-built stress analysis. A similar review will be done of the RHR system and published as an addendum to this report. The HPCS pipe and support calculations selected for review were among the first as-built stress problems to be finalized by Burns and Roe. The reverification review in this area identified the need for several corrective actions to ensure that past errors have been corrected and similar errors will not occur in the remaining as-built stress analyses which are scheduled for completion during the next few months. The design reverification of the RHR, which will be documented in the addendum, will help confirm the effectiveness of the corrective actions implemented as a result of the HPCS stress review. The need for further independent evaluation of the as-built stress work will be assessed as part of the RHR addendum.

The remaining findings were engineering errors or failures to correctly implement design criteria. These findings identified human errors of the type that are inherent in large, complex designs. They were judged to be of an isolated nature and were corrected as described individually in Section 3.0 of this report.

The valid PFR's classified as observations were provided to project personnel for action. These included minor drafting errors, minor computational errors, failures to document assumptions clearly in calculations, inconsistencies in the Final Safety Analysis Report (FSAR), missing tags on equipment, etc. Because care was taken to assure complete objectivity, the Findings Review Committee tended to classify some items as observations that might have been declared invalid. In any case, none of the deviations classified as observations were found after investigation to represent a significant safety hazard.

As with the findings, the observations were evaluated for root cause and for generic issues or trends. The sample size of three reactor systems and five additional specific studies was considered sufficient to determine if any significant patterns or trends were present. Any items found that may be considered generic issues were not closed until satisfactorily resolved. The evaluation of observation trends re-enforced the need to strengthen the B&R calculation closure process as discussed above. It also prompted actions to strengthen B&R's checking of the final as-built stress analysis that is currently in progress. Several other minor trends were evaluated and in certain cases corrective actions were implemented. One example involves several observations that deal with GE instrument data sheets (see discussion of PFR-HPCS-35 in Section 3.2.4.6 for more detail). Based on these observations, GE has implemented a program to update and correct these documents. Minor trends of this type that resulted in corrective actions are discussed in the individual PFR descriptions in Section 3.0 of this report. Certain other trends were evaluated with the conclusion that further action was not necessary. For example, a number of FSAR inconsistencies were observed, primarily in the

HPCS review; however, upon evaluation it was concluded that the nature of the deficiencies did not warrant a general re-evaluation of the entire FSAR. Relatively few trends were identified from the PFR's that were classified as observations. The bulk of the observations were either related to problems previously identified by the finding evaluations (discussed above) or were isolated errors or inconsistencies that might be expected on any large project. The frequency of these deviations is not excessive and was judged not to be indicative of a significant deficiency in the design or its implementation.

1.3 CONCLUSIONS

Through the WNP-2 Design Reverification Program a broad sample of design elements was reviewed in-depth, providing a substantive basis for judging the adequacy of the overall design and its implementation. The following conclusions were drawn with respect to the WNP-2 design:

1. The review indicated no major deficiencies in the design process. The procedures and controls utilized for design by Burns and Roe (B&R) conform to the WNP-2 Quality Assurance Program requirements and the requirements of 10CFR50, Appendix B and were generally effective in achieving a satisfactory design.

2. Based on the review of 126 design requirements, it was concluded that the regulatory requirements committed to in the WNP-2 Final Safety Analysis Report were incorporated in both GE and B&R design documents in an accurate and applicable manner. Of the ten potential finding reports issued in the requirement reverification review, five were observations and were not considered to be significant deficiencies. The remainder were invalid (see Section 3.1).

3. Burns and Roe's implementation of the design was found to be conservative, and in our judgment the design of the systems examined would have been adequate to ensure public health and safety even if this independent review had not been conducted. In the areas of Supply System environmental calculations, B&R calculation closure, and as-built stress analyses (as discussed in the preceding section), it was judged that implementation of corrective action programs was warranted. For the most part, other deficiencies were isolated errors of the type that are inherent in any major project and were accommodated within the margins and conservatism of the design. Despite the errors identified, it is concluded that the basic margins in the plant design and in B&R's design process would have been adequate to ensure safe operation.

4. The B&R/GE/Contractor/Supply System design interfaces appear to have been handled effectively with the exception of the breakdown in the Supply System/B&R interface associated with the environmental qualification calculation area. In that case all design calculations performed by the Supply System were either redone or rechecked and actions were taken to avoid recurrence of the problem.

5. Based on a comparison of selected as-built structures with the design documentation, it was concluded that the plant was constructed in accordance with the design with the exception of the failure to properly implement GE's equipment installation specifications for the RHR heat exchanger. This finding, as discussed above, resulted in a comprehensive corrective action program to ensure proper installation of all Class 1 mechanical equipment. Other construction deficiencies observed were determined to be isolated errors of minor significance.

6. Except for previously noted problems in the calculational area (i.e., environmental calculation, pipe break methodology and floor and wall loadings computations), the system interaction reviews showed that adequate procedures were followed in the consideration of system interaction (see Section 3.5).

In summary, it is concluded that the overall WNP-2 design process was conservative and produced a safe plant conforming to FSAR and regulatory requirements. With implementation of the corrective actions identified, no reason was found to prevent issuance of an operating license.

2.0 DESIGN REVERIFICATION PROCESS

The Design Reverification Program for WNP-2 included three major elements: requirements reverification; in-depth design reverification for three plant systems; and special reviews to ensure that system interactions were properly considered in the design process.

The process used in the reverification reviews is summarized in Figure 2-1. The process involved the selection of systems or areas to be reviewed followed by collection of the engineering documentation and preparation of a detailed review plan. The review plans specify the areas of review, sample selection and design review checklists to be used. Detailed plans were prepared for each of the system interaction reviews as well as for each of the in-depth system reviews. Methods used for design reverification included (1) design reviews (using checklists), (2) alternate calculations, and (3) system walkdowns. Deficiencies or errors identified during the independent reverification reviews were documented in potential finding reports for evaluation by the Finding Review Committee (FRC) and for corrective actions as appropriate. The entire process was overseen by an independent auditor, Technical Audit Associates, Inc. (TAA).

2.1 SELECTION OF REVIEW AREAS

The first step in the reverification process was to select the reactor systems to review. Three systems were selected: the high-pressure core spray system (HPCS); the residual heat removal (RHR) system (the suppression pool cooling mode); and the reactor feedwater system (RFW) from condensate valves V-142A and B to the reactor vessel nozzle. All three systems are complex and interact with other safety and nonsafety systems. Other criteria used to select these systems were:

- their importance to safe shutdown and cooldown of the reactor;

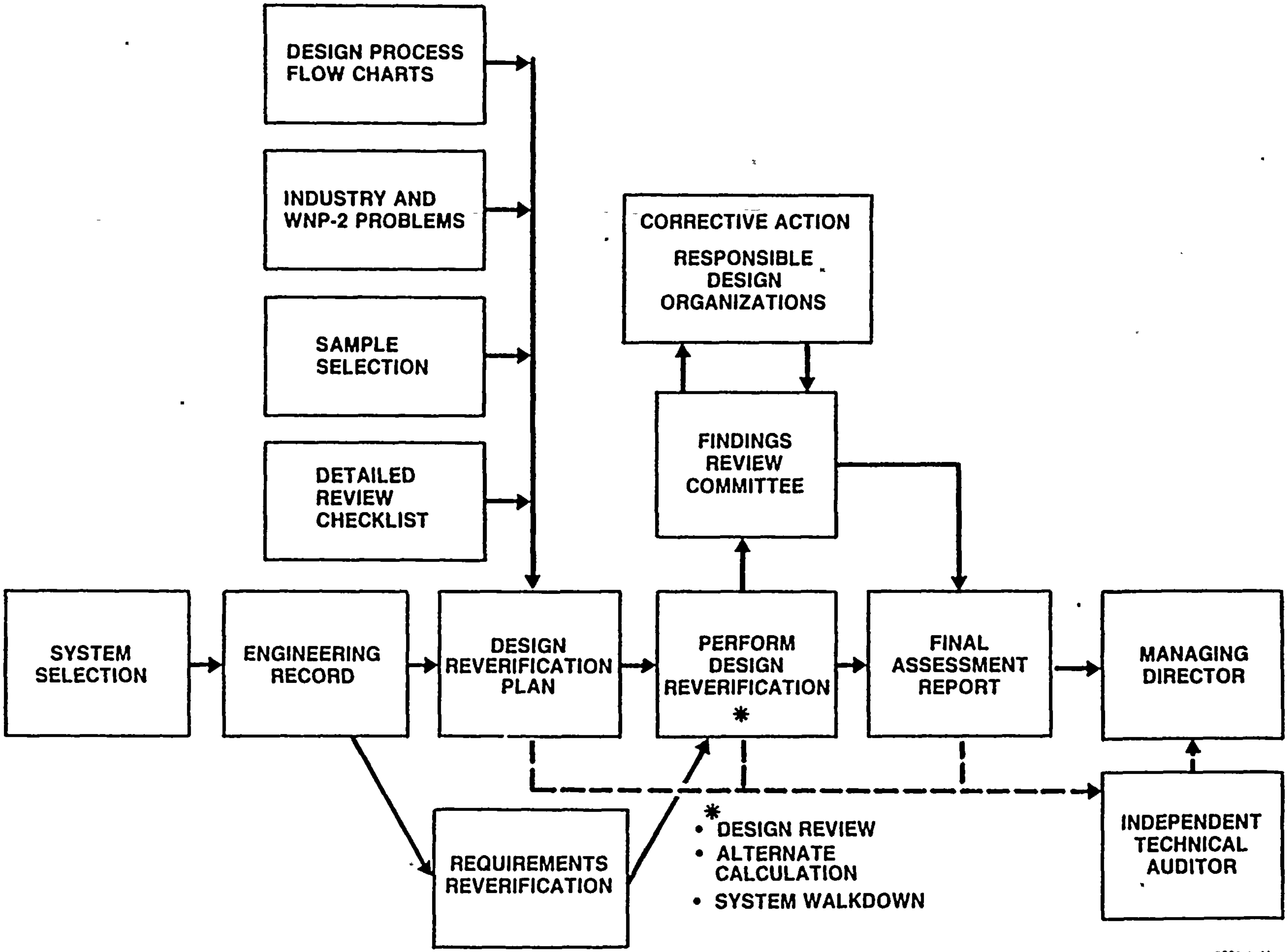

FIGURE 2-1 Flow Chart—Requirements and Design Reverification

- the major design interface between GE (NSSS vendor), Burns and Roe (AE) and construction contractor;

- the design interface between engineering disciplines, including structural, mechanical, piping, instrumentation, electrical equipment and cabling;

- the application of required seismic criteria and new containment hydrodynamic loads.

In addition to reviewing individual systems, the Supply System looked at the affect of individual systems on the operability of other safety and nonsafety systems. Several instances where systems interact were selected for review based on the following criteria:

- interactions that affect the primary functions of the systems to shut down and cool down the reactor,

- areas where the interaction is complex and design error could have a major effect on system function,

- interactions involving major programs that were not already being reviewed (e.g., equipment qualification).

Five interaction studies were undertaken:

(1) the interaction of the fire protection and RHR suppression pool cooling mode systems,

(2) equipment qualification for environmental and seismic conditions for selected HPCS and RHR equipment,

(3) pipe break/missile/jet impingement/flooding--the impact of a failure in one system causing problems such as flooding in another,

(4) wall and floor slab structural loadings describing the interaction of system support and selected building walls and floors,

(5) Class 1E instrument rack design--special review to examine a design for which Burns and Roe had sole procurement responsibility. While this review did not address physical interaction as did the four described above, it did address multiple design interfaces not specifically evaluated in the other reviews.

2.2 REQUIREMENTS REVERIFICATION

The design requirements for the RHR, HPCS and reactor feedwater systems were reviewed to ensure that they are current and complete and that the design commitments in the Final Safety Analysis Report (FSAR) had been incorporated. The review was conducted by discipline for each system.

The FSAR review was performed using 22 design review questions as a guide in identifying FSAR commitments related to the design of the HPCS, RHR, and RFW systems. For this review, the FSAR through Amendment 26, was taken as the basis for defining the commitments to other regulatory documents (e.g., 10CFR50 and Regulatory Guides). This was a sample review in that it addressed 126 design commitments related to the HPCS, RHR, and RFW systems that were identified in FSAR Chapters 1, 3, 5, 6, 7, 8, 9.5, 10 and Appendix F. The review was accomplished by extracting or paraphrasing applicable paragraphs from the FSAR and then comparing these commitments with applicable paragraphs or paraphrases extracted from the design requirements documentation. A statement explaining the comparison was then prepared by the reviewer.

The sample of 126 Final Safety Analysis Report commitments was selected to cover each major design area such as seismic requirements, equipment qualification service conditions, electrical supply redundancy, instrumentation logic, hydrodynamic loads and code requirements. The 126 points cover all 22 design review questions.

Figure 2-2 shows the relationship between the requirement reverification and the system design reverification. This figure shows that the applicable regulatory requirements are an essential input into the FSAR. The FSAR then describes the Supply System commitments to the applicable regulatory requirements. The sample overlap indicates that only some of the commitments selected in the requirements reverification review were followed to the final plant design in the system design reverification reviews.

2.3 SYSTEM DESIGN REVERIFICATION

For each system, an evaluation plan was prepared and then reviewed by Technical Audit Associates. Those plans were prepared as described below:

- A knowledgeable engineer was assigned as team leader for each system.
- Flow charts were developed for the major design areas (e.g., new containment loads, Figure 2-3; and seismic design, Figure 2-4) showing the design process and interfaces.
- Each system's design documentation was obtained.
- The design features and components to be reviewed were selected.
- The methods of review were determined (e.g., walkdown, alternate calculations, etc.) and review questions and checklists were developed.

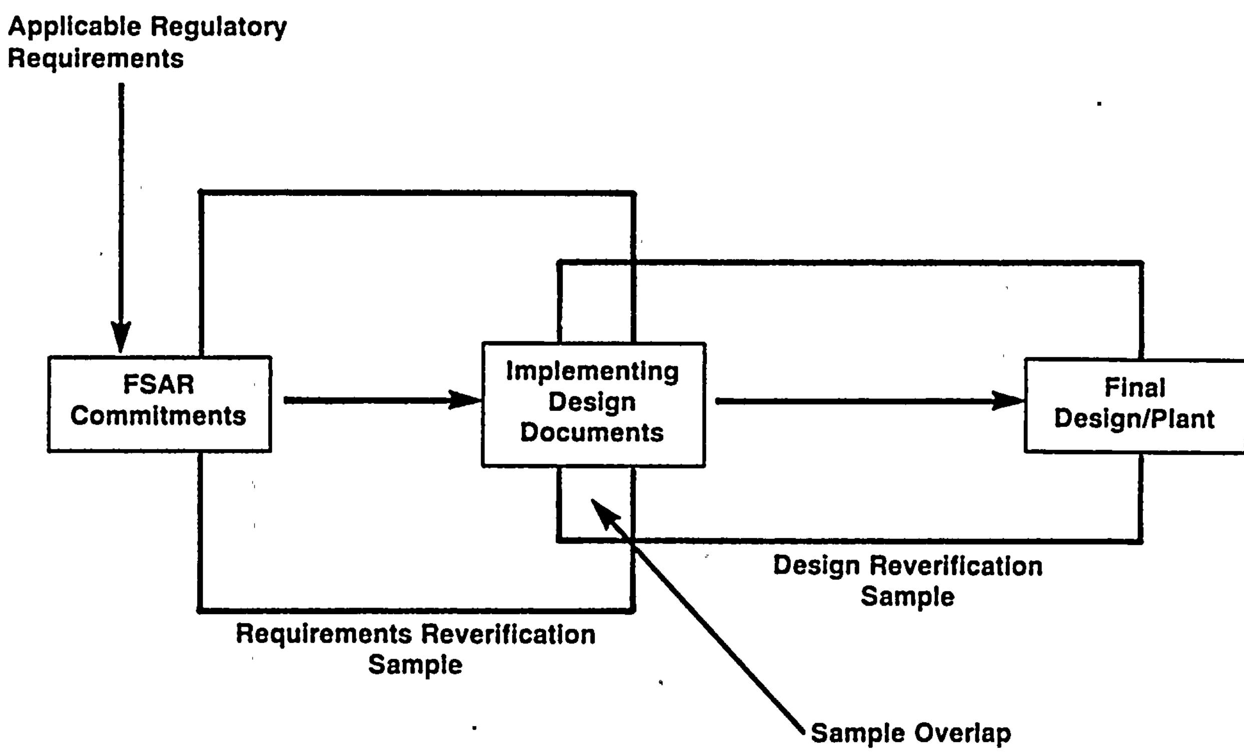

FIGURE 2-2 Requirement Reverification/Design Reverification Relationship

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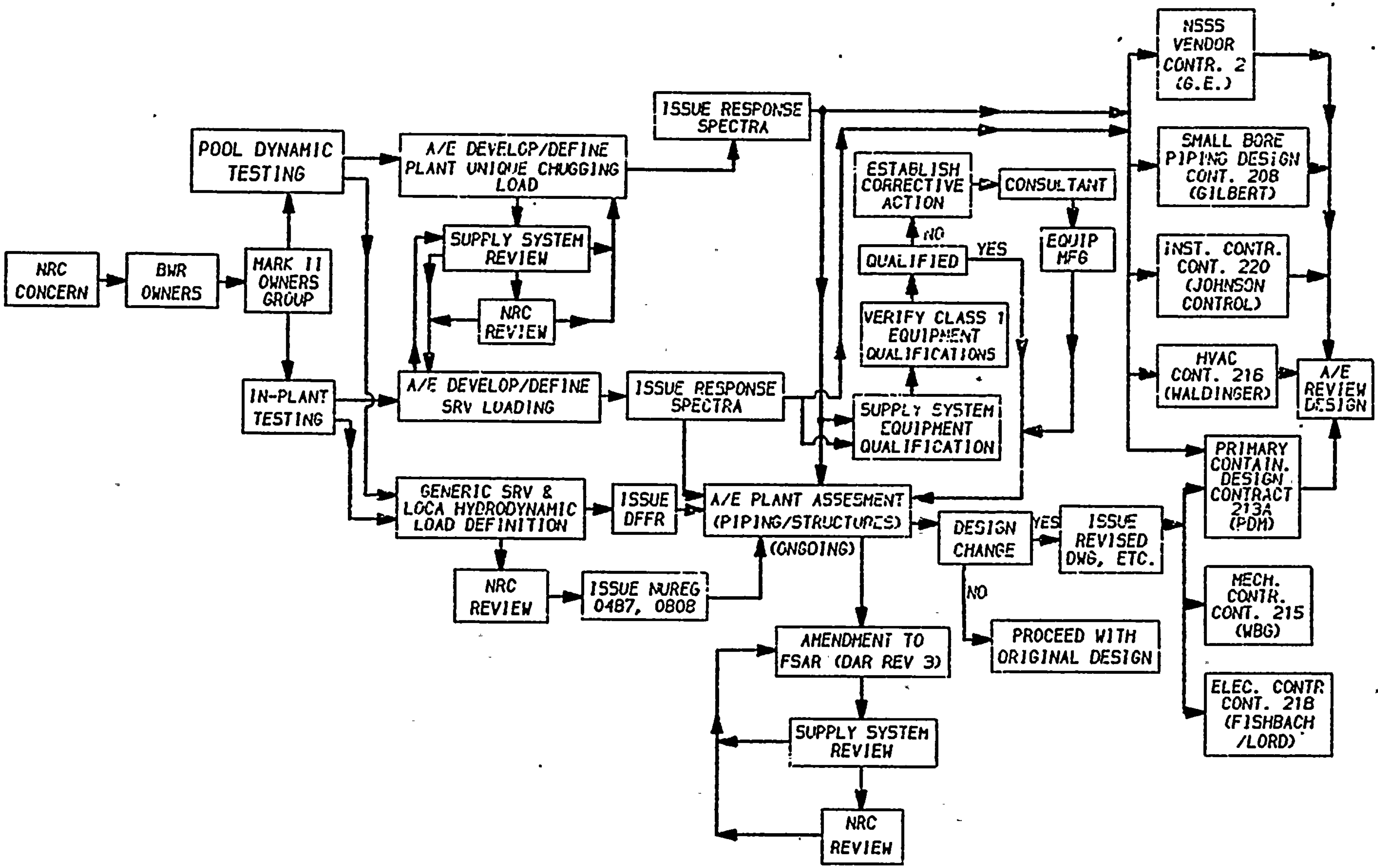

FIGURE 2-3 Design Process Flow Chart—New Containment Loads

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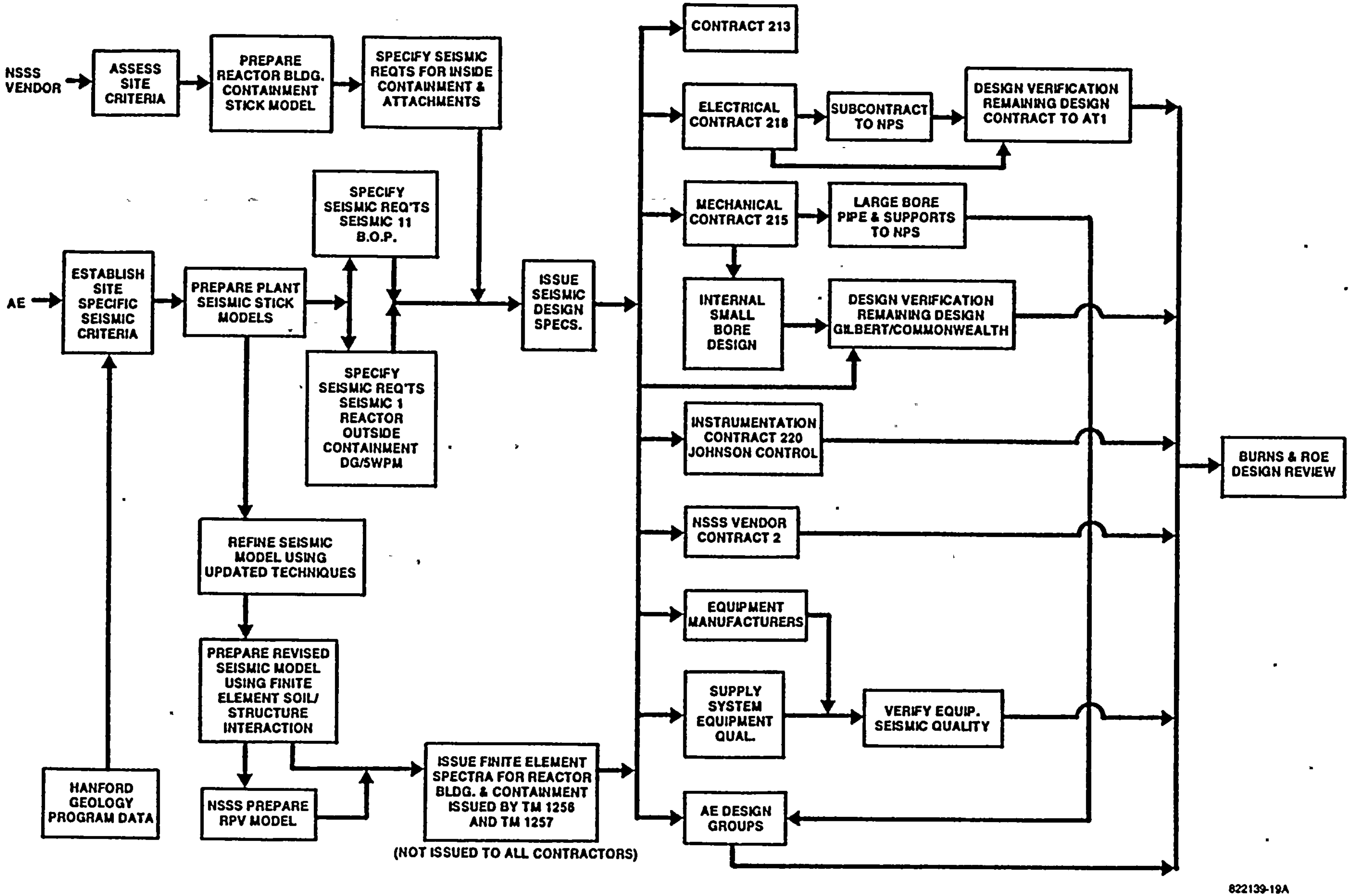


FIGURE 2-4 Design Process Flow Chart—WNP-2 Seismic Design

The selection of design features and components to review was a key step in the reverification process. A comprehensive sample was selected based on the following criteria:

- <u>System Functions</u>--These are the operations that must be performed for the system to meet the functional requirements listed in the FSAR.
- <u>Major Components</u>--These are the components that support the system's functional requirements.
- <u>Interorganizational Interface</u>--Resolutions of design input and output between organizations were sampled.
- <u>Interdiscipline Interfaces</u>--These are design issues that were resolved by several engineering disciplines.
- <u>Industry Recurring Problems</u>--Problems that have occurred in other boiling water reactors (or applicable areas in pressurized water reactors) were evaluated to ensure that the problems cannot occur at WNP-2.
- <u>WNP-2 Recurring Problems</u>--Previous WNP-2 problems were evaluated to ensure that they had been corrected.
- <u>Random Sample</u>--A number of components and design features were selected randomly to help ensure that items which fall outside the specific criteria were included.

Using these criteria, features from each system were selected for review. Examples of HPCS sampling matrices used to ensure a comprehensive sampling process are shown in Figures 2-5 and 2-6.

SYSTEM LEVEL REVERIFICATION ITEM	SAMPLING SELECTION CRITERIA: MAJOR FUNCTION OR COMPONENTS	MAJOR ORGANIZATIONAL INTERFACE	RANDOM SAMPLE	INDUSTRY RECURRING PROBLEM	WNP-2 RECURRING PROBLEM	INTERDISCIPLINARY INTERFACE
SYSTEM FLOW REQUIREMENTS	X	X				
WATER HAMMER ANALYSIS				X		X
DIESEL AIR START AVAILABILITY	X	X		X		
DIESEL AIR INTAKE PRESSURE DROP		X				
DIESEL EXHAUST PRESSURE DROP		X				
DIESEL COOLING WATER HEAT BALANCE		X		X		
DIESEL AIR START CAPACITY	X	X		X		
DIESEL AIR START PRESSURE DROP		X				
CONTROL LOGIC - AUTOMATIC INITIATIVE FROM TEST MODE	X					
CONTROL LOGIC - AUTOMATIC SUPPRESSION POOL SUCTION ON LOW CST	X					
CONTROL LOGIC - MINIMUM FLOW CONTROL VALVE	X					X
ELECTRIC POWER SUPPLY TO CORRECT DEVICES	X					
ELECTRICAL PROTECTIVE TRIPS	X					
ELECTRICAL SHORT CIRCUIT, UNDER AND OVER VOLTAGE AND ANTI-MOTORING PROTECTIVE DEVICES	X					

FIGURE 2-5 System Level Sampling Matrix (Example)

822139-12A

SAMPLING SELECTION CRITERIA

COMPONENT LEVEL REVERIFICATION ITEM		MAJOR FUNCTION OR COMPONENTS	MAJOR ORGANIZATIONAL INTERFACE	RANDOM SAMPLE	INDUSTRY RECURRING PROBLEM	WNP-2 RECURRING PROBLEM	INTERDISCIPLINARY INTERFACE
HPCS-LS-2A	SUPPRESSION POOL HIGH LEVEL SWITCH			X			
	TUBING FOR HPCS-LS-2A		X	X			
HPCS-FT-5	FLOW TRANSMITTER	X					X
	TUBING FOR HPCS-FT-5	X	X				
HPCS-DPIS-9	DIFFERENTIAL PRESSURE SWITCH			X			
	TUBING FOR HPCS-DPIS-9		X	X			
HPCS-FIS-6	FLOW SWITCH	X					X
HPCS-PS-12	PRESSURE SWITCH	X					X
HPCS-FE-7	FLOW ELEMENT	X					X
M200-2	DISCHARGE LINE INSIDE CONTAINMENT	X	X				
HPCS-901N	SNUBBER ON M200-2	X					
HPCS-616	SUPPORT ON M200-2	X					
M200-100A	MAIN SUCTION LINE	X	X				

FIGURE 2-6 Component Level Sampling Matrix (Example)

822139-16A

Once the sample was selected and the reverification plans approved, the design reviews were begun. Activities were structured by the approved plans. Systems were walked down and compared to the design documents using the detailed checklists. The checklists and review questions were also used in conjunction with alternate calculations to complete the design reviews. Discrepancies and deficiencies were documented on potential finding reports. Those reports were evaluated by the discipline lead engineers and by the FRC. The finding review process is discussed in more detail in Section 2.6.

Approximately 3,500 documents were reviewed during the course of the reverification program. A list of those documents is provided in Appendix 2. The categories of documents examined are:

- FSAR design commitments
- GE, Burns and Roe and Westinghouse engineering criteria
- GE purchase specifications
- GE Plant requirements
- GE installation specifications
- B&R design calculations
- B&R technical memoranda
- Vendor manuals
- Drawings and outstanding changes (e.g., PEDs)
  - B&R
  - GE
  - Other vendors as applicable
- Memoranda
- Contract specifications
- Test data
- Standards (e.g., IEEE, NEMA)
- Lists (Class 1E equipment and parts lists)

2.4 SYSTEM INTERACTION STUDIES

The design reverification planning efforts recognized the need to evaluate the implementation of certain generic programs (such as fire protection, environmental qualification of equipment, etc.) that can impact system design in an interactive fashion. Five areas of this type were selected for review as previously discussed in Section 2.1.

The methodology for performing the interaction studies was similar to that used in the system reviews. First, FSAR commitments were traced to design requirements. For example, in the fire hazards evaluation, FSAR commitments formed the basis for the review. Second, a reverification plan was prepared describing the selection of design features, the method of review and the checklists to be used. The system interaction reviews were then conducted by walkdowns (where appropriate), design reviews and alternate calculations; discrepancies were documented in potential findings reports.

2.5 INDEPENDENCE

The Supply System has taken care to assure that the requirements and design reverification reviews were independent and objective. The approach taken by the Supply System was different from most other recently licensed nuclear plants. Typically, plants have hired an outside engineering firm to perform an independent design review. The Supply System used its own engineers who were not involved in the original design.(7) An outside firm, Technical Audit Associates, Inc.(1), evaluated the technical adequacy of the reverification program and monitored its implementation through frequent onsite surveillance and audits. While the former option may have been more expedient in the short term, the long-term benefits of a strong, internal acceptance review program are believed to outweigh the advantages of a more limited third party

(1)Technical Audit Associates is a professional technical auditing firm which does not perform engineering or technical services for the nuclear industry.

review. The knowledge gained as a result of the in-depth review will be retained within the organization; thus strengthening safety programs during future operation of WNP-2. In addition, the depth and scope of this review was greater than has been conducted for most other reviews.

The reverification reviews were assigned to the Technology organization which reports directly to the Managing Director--independent of the WNP-2 Program Director (see Figure 2-7). Multidisciplined review teams were established for each of the system reviews using individuals who had not been involved in the original design. Each individual certified that he met the independence criteria established by the Managing Director.

Figure 2-7 shows the Supply System organizations that were responsible for the design, construction and testing of WNP-2. The technical personnel who performed the reviews were chosen primarily from the Systems Design Engineering Group (also shown in Figure 2-7) which, as part of Technology, is independent of WNP-2. Personnel from other Supply System organizations and consultants were used to supplement the permanent Supply System Technology staff as needed. Burns and Roe personnel were involved in collecting the engineering records and checking them for completeness. However, they were not involved in either the requirements or design reverification reviews.

The overall program is managed by a senior Technical Specialist who reports directly to the Managing Director. He is responsible for assuring a meaningful, objective reverification program and administering the contract with Technical Audit Associates, Inc. The Technical Specialist approves the overall scope of the reviews, directs the findings review process, selects the findings review committee and conducts special reviews. This includes independent reviews of the program scope and of implementation by organizations both inside and outside the Supply System.

PLANT VERIFICATION AB[illegible]ED ORGANIZATION

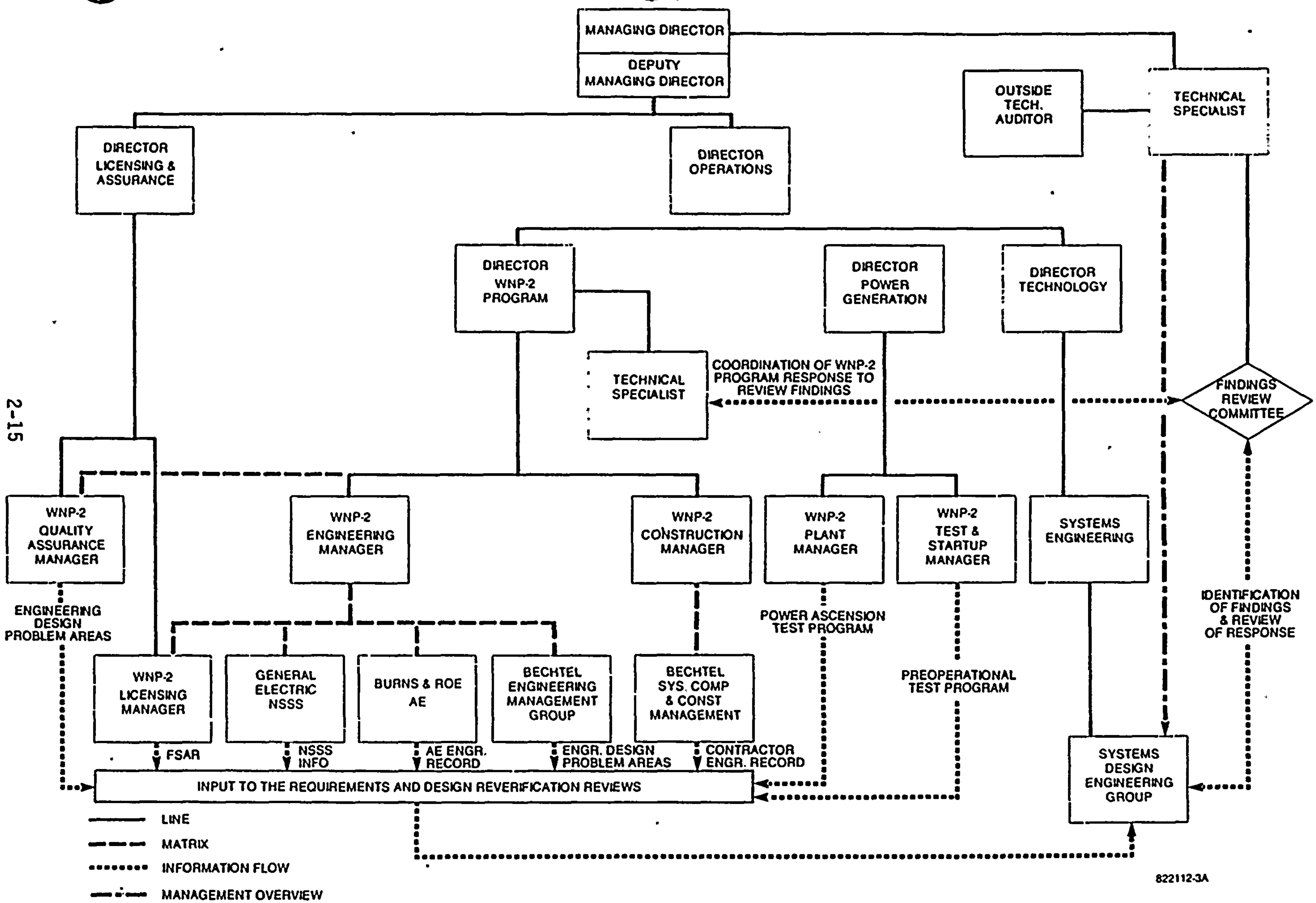


FIGURE 2-7

A contract was established with Technical Audit Associates, Inc. (TAA) to review the reverification plans and to monitor the reviews through frequent onsite surveillance by their resident design engineer and through periodic audits by their review panel. As the independent auditor, it also monitored the processing of the potential finding reports and is evaluating the final report. The role of TAA is to overview the Supply System implementation of the Design Reverification Program and provide conclusions with regard to its adequacy. They were not chartered with making a technical judgment on the adequacy of the WNP-2 design.

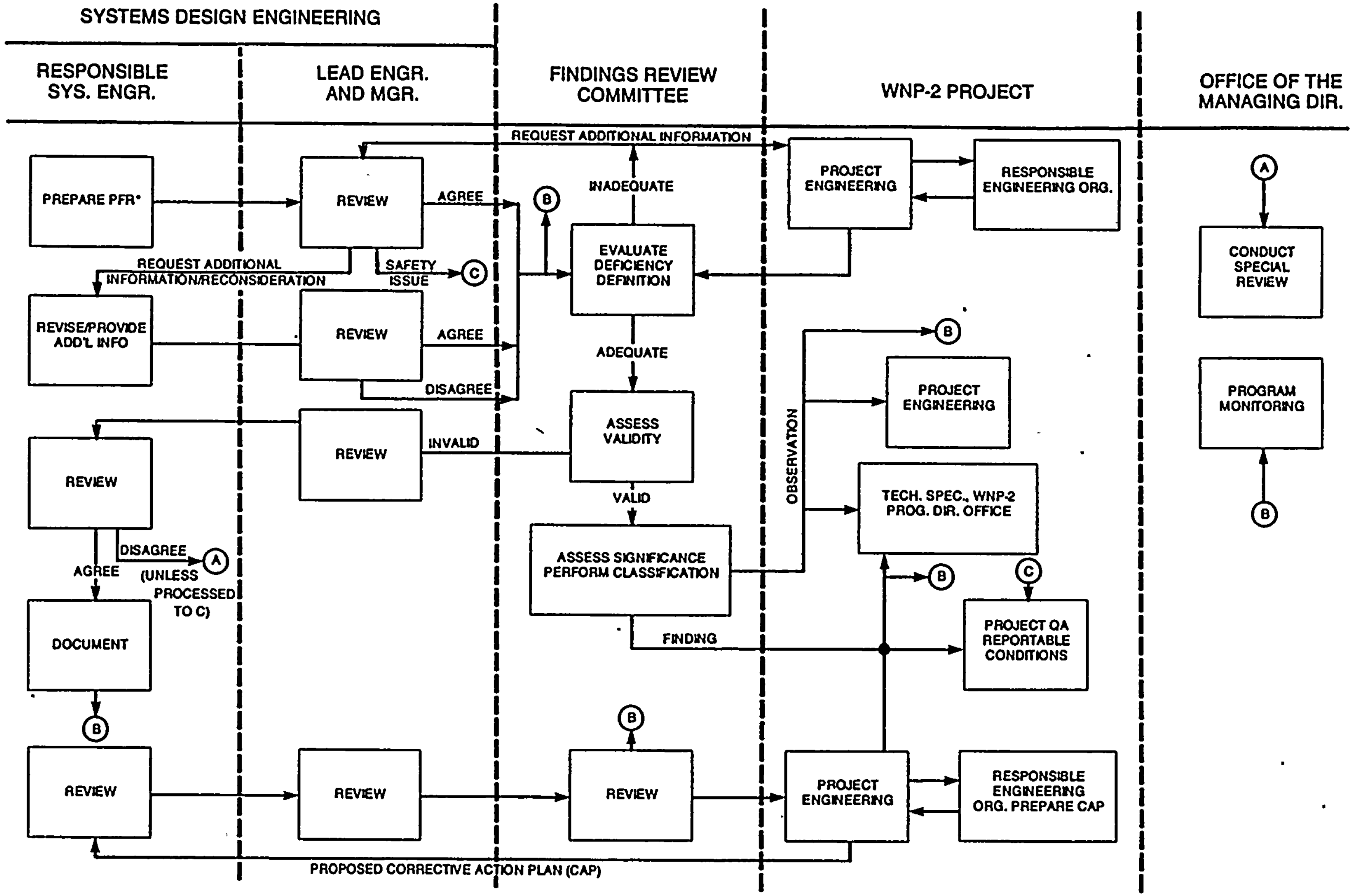
The independent TAA audit team consisted of individuals qualified in engineering and complex technological issues and experienced in nuclear and boiling water reactor technology. Members of the team were:

Robert V. Laney, Chairman
Frank B. Jewett, Jr., Review Panel Assignment Manager
Louis H. Roddis, Jr., Member of Review Panel
Dr. Herman E. Sheets, Member of Review Panel
Dr. Soloman Levy, Consultant to the Review Panel
Charles Q. Miller, Consultant to the Review Panel and onsite TAA resident

The Technical Audit Associates, Inc. final evaluation of the WNP-2 Design Reverification Program will be issued independently of this report without review or editing by the Supply System.

2.6 REVIEW OF FINDINGS

This subsection discusses the processing of potential findings identified during the design reverification reviews. Findings were reviewed, evaluated and classified, and appropriate corrective action was initiated for each. In addition, the findings were evaluated for generic causes and trends. Figure 2-8 is a flowchart of the findings review process.



*PFR - POTENTIAL FINDING REPORT

FIGURE 2-8 Findings Review Flow Chart

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A potential finding report was issued upon identification by a reviewer of a design deficiency. The potential finding report describes the deficiency, the basis for identifying the deficiency as a potential finding, the probable cause, its significance, and a recommended classification. The reviewer was encouraged to identify a proposed corrective action at his option.

Each report was then reviewed by independent review team leaders for adequate content, accuracy, and initial conclusions before it was given to the review committee for evaluation and classification. If the potential finding was a potential 10CFR50.55(e) or 10CFR Part 21, it was processed in parallel by project quality assurance in accordance with project procedures.

Following the Systems Engineering review the PFRs were transmitted to the FRC for evaluation. The committee included a balance of engineering disciplines. To convene a meeting, at least five members had to be present. The committee chairman informed committee members and the independent technical auditor (TAA) of the scheduled meetings and the agenda. A TAA representative attended many of the meetings.

The charter of the Findings Review Committee is defined in a Supply System Corporate Policy and Procedure (CPP-4.3.7, Rev. 3), which includes the following guidelines to be used in classifying potential finding reports.

<u>FINDING</u>

1. PFR's that are reportable under 10CFR50.55(e)/10CFR21.
2. All valid PFR's that identified a condition that was:
   a) not previously identified by the project for resolution.
   b) not previously planned to be verified as part of the test program.

and represents one of the following:

- o An open question on design adequacy that must be resolved to assure that the system will satisfy the FSAR design commitments.
- o A design change required to assure that the system will satisfy the FSAR design commitments.
- o A deviation between the approved for construction design and the accepted installed hardware that must be corrected to assure that the system will satisfy the FSAR design commitments.
- o Design procedure deficiencies/violations that require further evaluation to assess the impact on the adequacy of the design.
- o Multiple findings or observations that represent a trend that requires further evaluation to assess the impact on the adequacy of the design.
- o A design/hardware change needed to prevent plant personnel injury or significant equipment damage.

<u>OBSERVATION</u>

All other valid PFR's including those that identify an existing condition previously identified for resolution or verification during testing.

<u>NOT VALID</u>

PFR's that were not factually correct or judged to not represent a deficiency. Examples of reasons for classifying a PFR as invalid include:

a) Reviewer's conclusion not correct.

b) Condition identified in finding not correct.

c) Condition identified in finding was previously corrected independent of reverification review.

d) The condition identified is correct but it is not a deficiency.

The committee reviewed each potential finding identified during the design reverification reviews. Each potential finding was discussed by the committee. Based on this review the committee determined if the potential finding report contained enough information to classify it. The committee obtained additional information as needed from Systems Design Engineering or the responsible engineering organization.

Valid PFR's were evaluated to determine if the problem may be generic to the overall WNP-2 design. Where items were evaluated to have potential generic implications, the committee would request that additional samples be taken to determine if similar errors could be identified or if deficiency trends exist. The B&R calculation closure issue, installation of mechanical equipment (Contract 215), and the hanger load input to hanger design are example areas where the sample size was increased and the generic implication of individual PFR's was addressed.

If the committee found a potential finding report to be invalid, it was returned to the originator with the reasons for that conclusion. If the originator concurred with the committee's evaluation, he documented his concurrence. If the originator disagreed with the committee's position, a special review was conducted under the direction of the Director of Technology to resolve the issue.

Observations were given to WNP-2 project engineering for evaluation or corrective action as appropriate by the responsible engineering organization (Burns and Roe or GE). If appropriate, the observation was recorded for later action. Findings were also provided to WNP-2 project engineering for transmittal to the responsible engineering organization for corrective action. The proposed corrective action plans were reviewed and concurred with by the original reviewer and by the committee.

3.0 REVERIFICATION REVIEW RESULTS

3.1 REQUIREMENTS REVERIFICATION RESULTS

One hundred and twenty-six FSAR commitment areas were examined in the requirements reverification. Since many of the commitment areas included FSAR statements that contained several commitments, more than 126 actual commitments were addressed. The 126 areas fell into four categories:

Generic Commitments	67
HPCS Commitments	30
RHR Commitments	19
RFW Commitments	10
Total	126

Table 3-1 gives the number of FSAR commitments reviewed for each of the design input categories discussed in Section 2.2 and lists the potential finding reports issued for each of the input categories. Table 3-2 shows how the 126 commitments were distributed among the three systems and each engineering discipline. It should be noted that where areas were not addressed, one would not normally expect to find pertinent commitments or design requirements (e.g., design input category 11 which deals with hydraulic requirements does not apply to I&C or electrical design).

After up-to-date design requirement packages for the systems were assembled, the review was accomplished by extracting or paraphrasing applicable paragraphs from the FSAR and then comparing these commitments with the applicable paragraphs or paraphrases extracted from the design requirements documentation. A statement explaining the comparison was then documented. Details of these reviews are documented in Reference 8.

Ten potential finding reports were issued during the review; however, based on additional information five were determined to be invalid. The five remaining valid PFR's were classified as observations. Two were in

TABLE 3-1
SUMMARY OF POTENTIAL FINDING REPORTS
(Requirements Reverification)

	Requirements Reverification Checklist Question (Requirements Category)	FSAR Commitments Reviewed	PFR's Issued	Classification: Not Valid	Classification: Observation	Classification: Finding
1.	Functions of the system and the major components and structures of the system.	14	None			
2.	Performance requirements such as capacity, rating, and system output.	9	None			
3.	Codes, standards, and regulatory requirements including the applicable issue and/or addenda.	15	HPCS-1	X		
			HPCS-9		X	
			HPCS-10	X		
			HPCS-14		X	
			RHR-4		X	
4.	Design conditions such as pressure, temperature, fluid chemistry and voltage.	1	None			
5.	Loads such as seismic, wind, thermal, and dynamic.	13	None			
6.	Environmental conditions anticipated during operation such as pressure and temperature.	9	None			
7.	Interface requirements including definition of the functional and physical interfaces.	5	None			
8.	Material requirements including such items as compatibility, electrical insulation properties, protective coating, and corrosion resistance.	6	HPCS-6	X		
			HPCS-12	X		
			HPCS-13	X		
9.	Mechanical requirements such as vibration, stress, shock, and reaction forces.	3	HPCS-20		X	
10.	Structural requirements covering such items as equipment foundations and pipe supports.	5	None			
11.	Hydraulic requirements such as pump net positive suction head, allowable pressure drops, and allowable fluid velocities.	2	None			
12.	Chemistry requirements such as provisions for sampling and limitations on water chemistry.	1	None			
13.	Electrical requirements such as source of power, voltage, raceway requirements, electrical insulation, and motor requirements.	8	None			
14.	Layout and arrangement requirements.	1	None			
15.	Operational requirements under various conditions.	3	None			
16.	Instrumentation and control requirements including indicating instruments, controls and alarms.	3	None			
17.	Redundancy, diversity, and separation requirements of structures, systems, and components.	7	None			
18.	Failure effects requirements of structures, systems, and components.	4	None			
19.	Test requirements including in-plant tests and the conditions under which they will be performed.	10	None			
20.	Fire protection or resistance requirements.	3	RHR-5	X		
21.	Materials, processes, parts, and equipment suitable for application.	2	None			
22.	Safety requirements for preventing personnel injury.	2	None			
	Totals	126	10	6	4	0

TABLE 3-2
REQUIREMENTS REVERIFICATION REVIEW AREAS ADDRESSED

	Requirements Reverification Checklist Question (Requirements Category)	Mechanical	Instrument & Control	Electrical	Engineering Mechanics
1.	Functions of the system and the major components and structures of the system.	HPCS, RHR	HPCS,RHR,RFW		HPCS,RHR
2.	Performance requirements such as capacity, rating, and system output.	HPCS,RHR RFW		HPCS	Generic
3.	Codes, standards, and regulatory requirements including the applicable issue and/or addenda.	HPCS, RFW	Generic and RFW	Generic	Generic
4.	Design conditions such as pressure, temperature, fluid chemistry and voltage.	Q-1,2,6, 12,15	Q-8	Generic	
5.	Loads such as seismic, wind, thermal, and dynamic.		Generic and RFW	Generic	Generic
6.	Environmental conditions anticipated during operation such as pressure and temperature.	HPCS, RHR, RFW	Generic	Generic	Generic
7.	Interface requirements including definition of the functional and physical interfaces.	RFW	Generic		Generic
8.	Material requirements including such items as compatibility, electrical insulation properties, protective coating, and corrosion resistance.	Generic	Generic	Generic	Generic
9.	Mechanical requirements such as vibration, stress, shock, and reaction forces.		Q-6	Q-5	Generic
10.	Structural requirements covering such items as equipment foundations and pipe supports.				Generic
11.	Hydraulic requirements such as pump net positive suction head, allowable pressure drops, and allowable fluid velocities.	HPCS			
12.	Chemistry requirements such as provisions for sampling and limitations on water chemistry.	RHR			
13.	Electrical requirements such as source of power, voltage, raceway requirements, electrical insulation, and motor requirements.			Generic, HPCS	
14.	Layout and arrangement requirements.	HPCS	Q-17	Q-17	
15.	Operational requirements under various conditions.	HPCS	Q-6	Generic	Generic
16.	Instrumentation and control requirements including indicating instruments, controls and alarms.		HPCS, RHR, RFW		
17.	Redundancy, diversity, and separation requirements of structures, systems, and components.	HPCS, RHR	Generic	Generic HPCS & RHR	Generic
18.	Failure effects requirements of structures, systems, and components.	HPCS,RHR, RFW	Q-16 and Q-17	Generic	Q-17
19.	Test requirements including in-plant tests and the conditions under which they will be performed.	HPCS, RHR, RFW	HPCS, RHR	HPCS, RHR	Generic
20.	Fire protection or resistance requirements.	Fire Protection Review	Fire Protection Review	Generic, Q-3 and Fire Protection Review	
21.	Materials, processes, parts, and equipment suitable for application.	HPCS and Q-8			Generic
22.	Safety requirements for preventing personnel injury.	RFW		Generic	

the mechanical discipline, two were in the engineering mechanics discipline and one was in the electrical area. The specifics of these observations and their resolution follow:

PFR-HPCS-1, classified as an observation, addressed inconsistencies between the Reverification Checklist requirements and the Burns and Roe criteria document. The same concerns related to updating and clarifying the scope of the criteria document had been identified in September, 1982, during Supply System QA Audit 82-226. Burns and Roe was in the process of revising the criteria document in response to the QA audit by the time the PFR was processed. Since the same concerns were already identified by the QA audit and have been satisfactorily resolved in response to the audit, this PFR was closed with no further action required.

PFR-HPCS-9, classified as an observation, identified a discrepancy in the FSAR description of the HPCS diesel cooling water heat exchanger. The FSAR, in a generic description of the cooling water systems for all the diesels, incorrectly identified all the heat exchangers as ASME-III, Class 3. Although the heat exchangers for the emergency power diesels procured by B&R are ASME-III, Class 3, the HPCS diesel heat exchanger, which was procured earlier by GE, is ASME-VIII as specified and is not required to be ASME-III. It was concluded that the equipment installed is adequate and in compliance with the specification. The WNP-2 Project has stated in response to the observation that corrections to the FSAR and the related Piping and Instrumentation Diagram (P&ID) will be prepared. No other deficiencies of this nature were found.

PFR-HPCS-14, classified as an observation, cited an FSAR discrepancy. The FSAR error had already been detected and an FSAR change was in progress by others; a fact not known to the independent reviewer. However, since the FSAR change had not been completed at the time of the review this PFR was retained as an observation and provided to the Project for information.

PFR-HPCS-20, classified as an observation, noted a discrepancy in FSAR Table 3.7-1 which states that a 0.5 percent damping coefficient is used for vital piping under Operating Basis Earthquake (OBE) conditions. The Burns and Roe design guide permits a 1 percent coefficient under certain conditions. This is consistent with Regulatory Guide 1.61; therefore, the design basis is adequate. The WNP-2 Project has stated that the FSAR will be updated in response to this observation.

PFR-RHR-4, classified as an observation, reported an erroneous FSAR reference to Nureg-0800 instead of NUREG-75/087 in FSAR section 3.10.12. This reference was corrected.

3.2 HIGH PRESSURE CORE SPRAY (HPCS) SYSTEM DESIGN REVERIFICATION RESULTS

3.2.1 SYSTEM DESCRIPTION

The High Pressure Core Spray System (HPCS) and its power supplies, including an emergency backup diesel generator, comprise one system in the Emergency Core Cooling Systems (ECCS) at WNP-2. The HPCS system was designed and much of the physical equipment was procured and provided by General Electric (GE). Burns and Roe (B&R) provided the detailed HPCS design and interfacing within the overall WNP-2 design.

The major purpose of the HPCS system is to deliver cooling water from the Condensate Storage Tanks or Suppression Pool to the reactor vessel in sufficient quantities to prevent damage to the fuel during loss-of-coolant accidents.

The HPCS system consists of an electric motor-driven pump and auxiliary equipment, piping and valves, instrumentation and controls necessary to maintain reactor inventory until the reactor vessel is depressurized in the event of a loss-of-coolant accident, and prevent excessive fuel cladding temperatures. The HPCS system also supplies makeup coolant in the event of small breaks to allow for complete plant shutdown and supplies makeup water to the reactor vessel in the event of reactor isolation and failure of the Reactor Core Isolation Cooling System (RCIC). The HPCS system is capable of automatic startup upon receipt of an initiation signal without preheating or prelubrication.

This subsection describes the scope of the HPCS system reverification efforts which includes the HPCS mechanical system, the mechanical portion of the HPCS diesel systems, the HPCS instrumentation and controls, the HPCS electrical systems, and the HPCS piping, supports and restraints. The boundaries of the HPCS systems subjected to reverification are shown schematically in Figures 3-1 and 3-2.

The boundary of the mechanical portion of the HPCS extends from the 24" condensate supply gravity flow line, downstream of valves COND-V-9A and

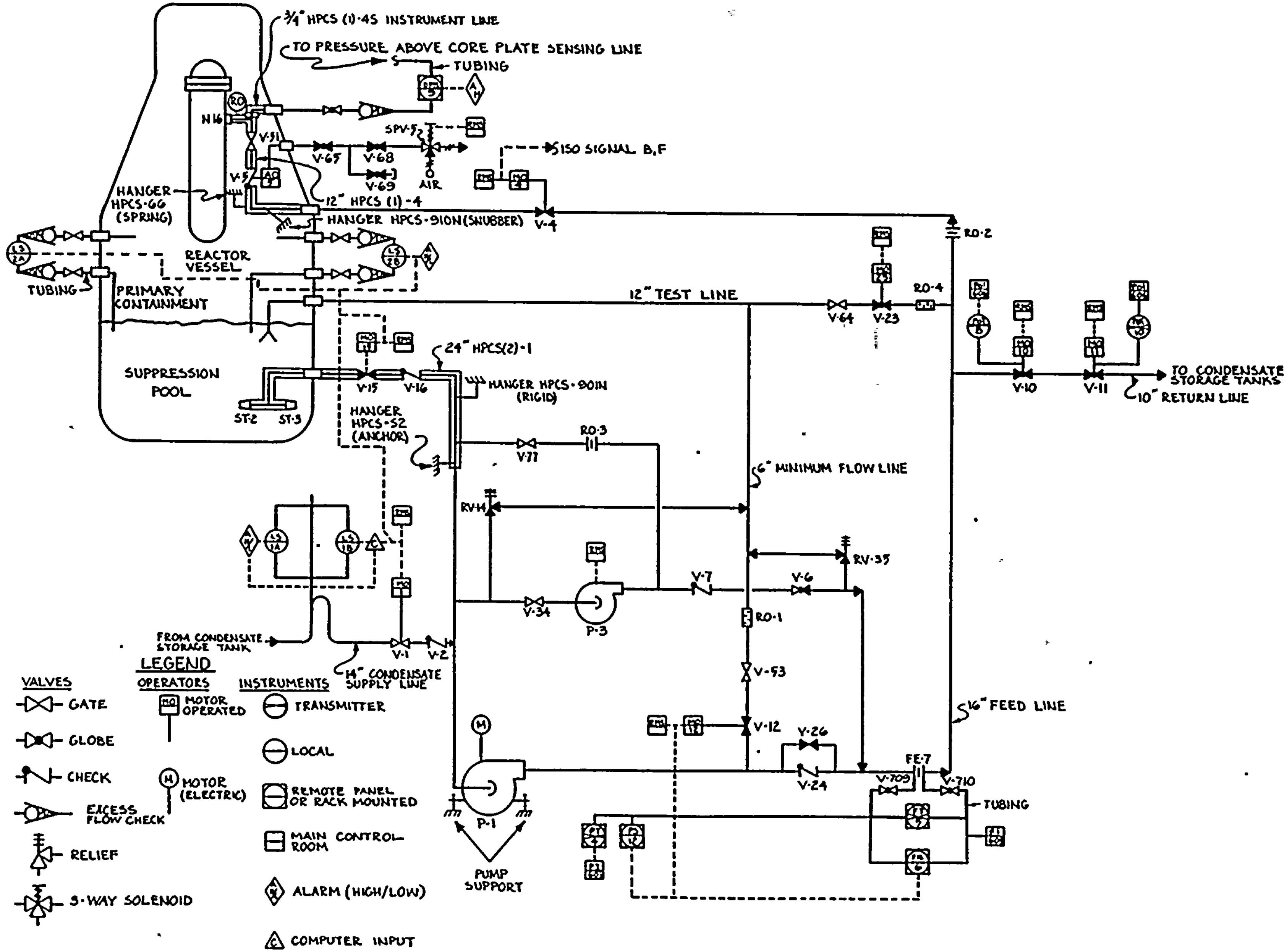

FIGURE 3-1 SCHE[illegible]C OF HPCS SYSTEM

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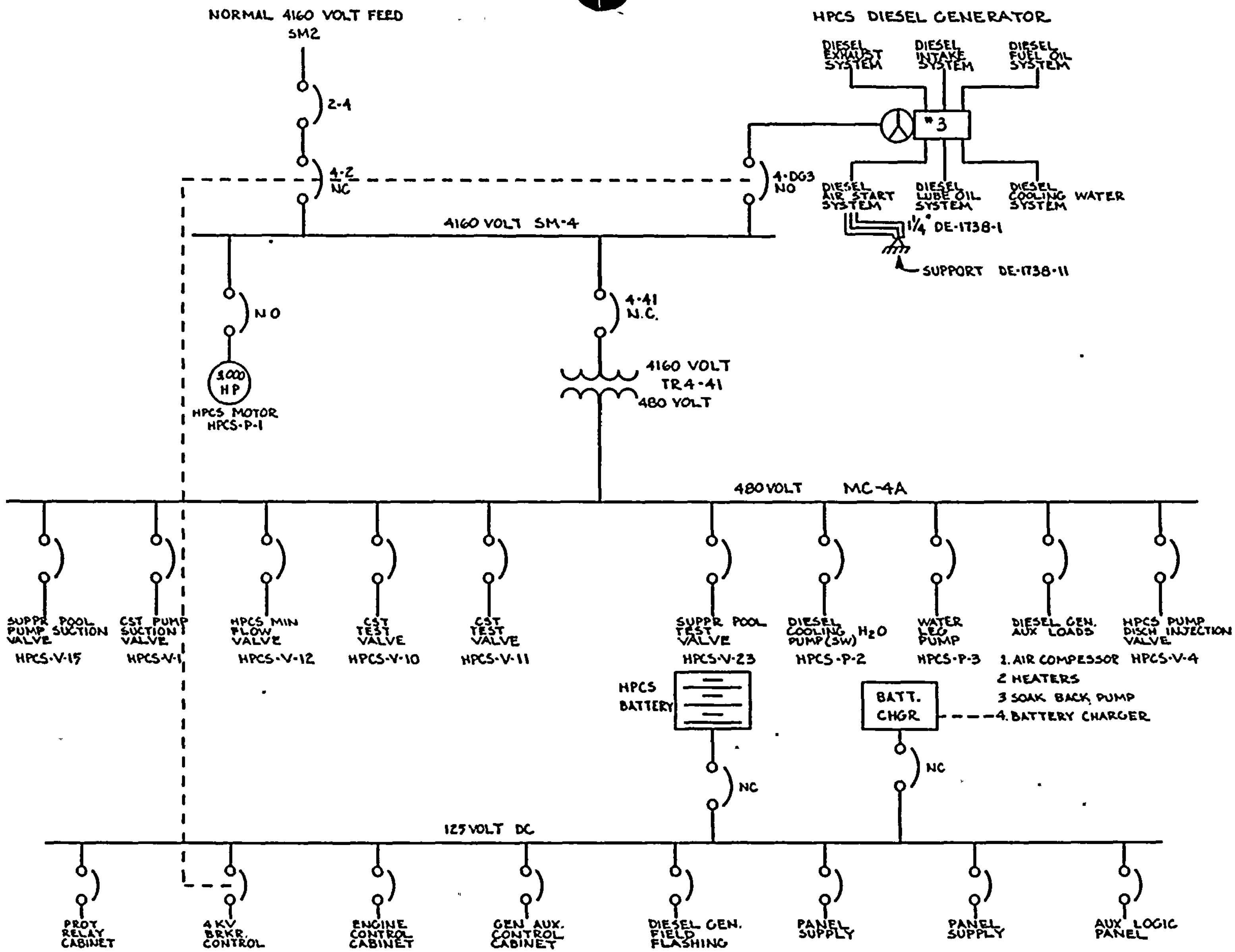

FIGURE 3-2 HPCS DIESEL SYSTEMS & POWER DISTRIBUTION SCHEMATIC

831070-5A

9B, to the HPCS penetration into the Reactor Pressure Vessel (N-16). It includes the alternate water supply from the suppression pool via HPCS-ST-2 and HPCS-ST-3, a return line to the condensate storage tank ending where HPCS-V-11 enters 10" COND (155)-15, and a condensate flushing supply from the Reactor Building 4" Condensate Supply Header controlled by COND-V-25. The mechanical portion of the HPCS includes all piping and mechanical components between the boundary points specified.

The boundaries of the HPCS Diesel Generator (DG) system include the diesel engine which is a 20 cylinder, turbocharged, 2-cycle engine capable of simultaneously starting and powering the largest combination of HPCS system electrical loads. The system includes the following six subsystems necessary for operation of the diesel engine.

1. The air intake system which consists of an oil bath air intake filter, an inline silencer, an air turning box, and a flexible connection to the turbocharger inlet.

2. The exhaust system consisting of a turbocharger, after-cooler, exhaust manifold, an exhaust flexible connection, and an exhaust silencer.

3. The lube oil system which is self-contained on the diesel engine skid, and includes a deep lube oil sump, a strainer, scavenging oil pumps, a main lube oil filter, lube oil cooler, and an auxiliary motor-driven pump to lubricate the turbocharger bearings and pick up heat during standby conditions.

4. The cooling water system on the engine which consists of an expansion tank, a left bank and right bank engine-driven circulating pump, a three way thermostatic control valve, a heat exchanger cooled by the service water system and an immersion heater set to maintain water in the oil cooler between 125-155°F. In addition, the dedicated loop of the Standby Service Water System that provides the cooling for the skid

mounted heat exchanger via the HPCS cooling water pump (HPCS-P-2) is included in the scope of these reverification activities.

5. The fuel oil system which consists of two redundant systems external to the engine fuel manifolds. Each system from the day tank to the manifolds contains a fuel supply line, a strainer, a fuel oil pump, a duplex filter, a pressure gauge, and relief and check values. The system on the engine has redundant suction strainers, pumps, and filters.

6. The air start system which has two subsystems containing air compressors, air tanks, wye strainers to minimize moisture, pressure reducing valves, and starting motors. One air compressor is driven by an AC motor and the other by a small diesel engine.

The HPCS system instruments and controls include those on the following flow paths:

A. The HPCS pump suction line from the condensate storage tanks
B. The HPCS pump suction line from the suppression pool
C. The HPCS pump discharge line into the reactor vessel
D. The minimum flow bypass line from the HPCS pump discharge to the suppression pool
E. The test bypass line from the HPCS pump discharge to the condensate storage tanks
F. The test bypass line from the HPCS pump discharge to the suppression pool
G. The standby water leg, fed by the separate auxiliary pump (HPCS-P-3)

The HPCS Suppression Pool high water level switches, plus interfaces with the following instrumentation, are also included:

A. Reactor water low level measurements for HPCS
B. Containment drywell high pressure measurements for HPCS
C. Reactor water high level measurements for HPCS.

The HPCS diesel instruments and controls include those on the following flow paths and subsystems:

A. The HPCS diesel cooling water loop between the diesel engine and the heat exchanger (DCW-HX-1C)
B. The HPCS diesel lube oil subsystem
C. The HPCS diesel fuel oil subsystem
D. The HPCS diesel air start subsystem.

The HPCS electrical system consists of the following equipment:

1. A standby power supply system (Onsite Power Source) consisting of a diesel-engine-driven generator and all of its accessories.

2. The 4160-volt power system which provides switching for protection and control of power from the normal power source (Offsite Power Source), or the standby source, and carries power to the HPCS pump motor and HPCS motor control center.

3. The 480-Volt Power System consisting of a stepdown transformer and motor control center which provides power, control, and protection for all HPCS system auxiliary loads.

4. The 125-Volt DC control power system consisting of a battery and battery charger which provides control power for all HPCS system equipment.

3.2.2 SUMMARY OF HIGH PRESSURE CORE SPRAY SYSTEM REVIEW

The review of the HPCS system design included a multidisciplined evaluation of ten system design areas; detailed component design reviews covering 34 mechanical, electrical, and instrumentation and control components; as-built field inspections of each of the components reviewed; and a detailed review of the final as-built pipe and hanger stress analyses on selected items. Four piping analyses (two large bore and two small bore) and seven pipe and equipment supports were reviewed.

The design was evaluated by design review utilizing formal checklists and alternate calculations when appropriate. More than 1900 checklist items were addressed and 14 alternate calculations were performed. Approximately 1056 design related documents were used as part of the HPCS system review.

Table 3-3 identifies the areas reviewed, the PFR's issued in each area, and their classification. Seventy-two PFR's were issued during the HPCS review, 18 of which were determined to be invalid. Of the 54 valid PFR's, eight were classified as findings and the remainder were classified as observations. It should be noted that many of the areas reviewed were satisfactory and that the number of valid PFR's is small in view of the extensive scope and depth of the review and the low threshold used for issuing a PFR.

Of the eight HPCS findings issued, three required minor plant equipment changes. PFR-HPCS-21 was an isolated construction deficiency involving the installation configuration of a pipe clamp. PFR-HPCS-46 and PFR-HPCS-49 resulted in minor relay changes for coordination and more sensitive ground fault protection purposes.

Three findings (PFR-HPCS-58, -66 and -81) identified problems with stress analysis calculations and involved corrective action to ensure that these sorts of errors will not occur in the remaining final as-built stress analyses.

PFR-HPCS-15 also identified a deficient calculation relating to the transfer of HPCS suction from a condensate storage tank to the suppression pool.

Table 3-3
SUMMARY OF POTENTIAL FINDING REPORTS (HPCS)

Review Area	Number of Review Questions	Number of Documents Reviewed	PFR's Issued	Classification: Not Valid	Classification: Observation	Classification: Finding
3.2.3 SYSTEM LEVEL REVIEWS						
3.2.3.1 Functional Requirements						
A. System Flows	12 cases	78	None			
B. Hydraulic Transients	3 cases		None			
C. Diesel Starting	4	11	HPCS-44		X	
D. Diesel Cooling	2	28	HPCS-2		X	
3.2.3.2 System Control Logic	3	17	HPCS-7		X	
			HPCS-41		X	
3.2.3.3 Power Supply Adequacy	11	38	HPCS-48		X	
			HPCS-50		X	
			HPCS-52		X	
			HPCS-53		X	
3.2.3.4 Codes and Standards	4	62	HPCS-30		X	
			HPCS-42	X		
			HPCS-45	X		
3.2.3.5 Separation						
A. Mechanical	2	19	None			
B. Inst. & Controls	2	24	HPCS-8	X		
			HPCS-31		X	
C. Electrical	2	9	None			
3.2.3.6 Redundancy						
A. Mechanical	2 cases	10	HPCS-3		X	
			HPCS-15			X
B. Inst. & Controls	1	1	HPCS-11	X		
C. Electrical	1	12	HPCS-51		X	
3.2.3.7 Containment Isolation						
A. Mechanical	4 penetrations	12	HPCS-16	X		
			HPCS-55		X	
B. Inst. & Controls	2 penetrations	23	HPCS-39		X	
3.2.3.8 Corrosion Requirements	3	10				
A. Corrosion Allowance			None			
B. Corrosion Inhibitors			None			
C. Corrosion Resistant Piping			None			
3.2.3.9 ALARA Requirements	3	23	None			
3.2.3.10 Layout & Arrangement						
A. Pump NPSH	1 case	24	HPCS-4		X	
B. Diesel Intake and Exhaust	2 cases	8	HPCS-5		X	
C. Instrument Racks	2	8	None			
3.2.4 COMPONENT LEVEL REVIEW						
3.2.4.1 Valves						
HPCS-V-4	16	14	None			
HPCS-V-5	16	11	None			
HPCS-V-12	16	12	None			
HPCS-RV-35	16	8	None			
[illegible].2 Pumps						
HPCS-P-1	9	7	None			
HPCS-P-2	9	5	None			

Table 3-3 Continued

Review Area	Number of Review Questions	Number of Documents Reviewed	PFR's Issued	Classification		
				Not Valid	Observation	F
3.2.4.3 Speciality Items						
Orifice (RO-4)	7	6	HPCS-43		X	
Strainer (ST-2)	11	10	None			
Diesel Air Compressor (SA-C-2C)	2	2	HPCS-17		X	
Diesel Air Box Drain (DG-ENG-1C)	2	6	HPCS-19			X
Diesel Oil Tank (DO-TK-4)	6	8	HPCS-18		X	
Diesel Heat Exchanger(DCW-HX-1C)	19	7	None			
3.2.4.4 Instrument Tubing						
HPCS-LS-1A	46	15	None			
HPCS-LS-2A	46	9	None			
HPCS-DPIS-9	46	21	HPCS-33	X		
HPCS-FT-5	46	16	None			
3.2.4.5 Flow Element						
HPCS-FE-7	19	16	HPCS-29		X	
			HPCS-34	X		
3.2.4.6 Process Instrumentation		65				
HPCS-FIS-6	30		None			
HPCS-LS-1A	30		None			
HPCS-LS-2A	30		None			
HPCS-DPIS-9	30		HPCS-35		X	
HPCS-PS-12	30		HPCS-32		X	
3.2.4.7 Circuit Breakers and Motor Controllers		41				
HPCS-CB-4DG3	40		None			
HPCS-CB-HPCS	40		HPCS-49			
HPCS-CB-42	40		HPCS-47		X	
HPCS-42-4A5B	40		HPCS-46			X
HPCS-42-4A7C	40		None			
3.2.4.8 Motors and Motor Operators		38				
HPCS-M-1	26		None			
HPCS-M-3	26		None			
HPCS-MO-4	26		None			
3.2.4.9 Electrical Cable		39				
3HPCS/0030	35		None			
3HPCS/0080	35		None			
3HPCS/0340	35		None			
3.2.5 PIPE AND SUPPORTS						
3.2.5.1 Pipe Design Review						
A. HPCS Discharge Line (M-200-2)		46				
Design Data Transmittal	10		None			
Isometric Check	4		None			
Modeling Check	8		HPCS-78	X		
			HPCS-79		X	
			HPCS-80	X		
Deadweight Analysis	2		None			
Thermal Analysis	4		None			
Seismic Analysis	19		HPCS-77	X		
			HPCS-81			X
Anchor Movements	6		None			
Load Combinations	16		HPCS-74		X	
Pipe Stress Check	7		None			
Support Loads	8x2*		HPCS-27		X	

*2 supports, 16 questions total

Table 3-3 Continued

Review Area	Number of Review Questions	Number of Documents Reviewed	PFR's Issued	Classification: Not Valid	Classification: Observation	Classification: Finding
B. HPCS Suction Line (M-200-100A)		29				
Design Data Transmittal	10		None			
Isometric Check	4		None			
Modeling Check	8		HPCS-68		X	
			HPCS-69		X	
			HPCS-70	X		
Deadweight Analysis	2		None			
Thermal Analysis	4		HPCS-65		X	
			HPCS-67		X	
			HPCS-71	X		
			HPCS-72	X		
Seismic Analysis	19		HPCS-62		X	
			HPCS-63		X	
Anchor Movements	6		None			
Load Combinations	16		HPCS-61	X		
Pipe Stress Check	7		HPCS-58			X
			HPCS-59		X	
			HPCS-60	X		
Support Loads	8x2		HPCS-64		X	
			HPCS-66			X
C. Air Start Diesel Exhaust Line (DE-1738-1)		17				
Design Data Transmittal	10					
Isometric Check	4					
Modeling Check	8		HPCS-83		X	
Pipe Stress Check	7					
Support Loads (2 supports)	16					
Alternate Calculations	31					
D. Instrument Line (X-73A)		19				
Design Data Transmittal	7		None			
Isometric Check	4		HPCS-23	X		
Modeling Check	8		HPCS-24		X	
Deadweight Analysis	2		None			
Thermal Analysis	4		None			
Seismic Analysis	14		None			
Anchor Movements	4		None			
Load Combinations	7		HPCS-26		X	
Pipe Stress Check	7		HPCS-25		X	
Support Loads (3 supports)	21		None			
3.2.5.2 Pipe Support Review						
A. Spring Support (HPCS-66)		5				
Code/Design Guide	3		None			
Procedural Control	3		None			
Design Check						
Loads	4		None			
Welding	1		None			
Materials/Geometry	6		None			
Allowable Stress	5		None			
Movements	2		None			
Member Stress	4		HPCS-57		X	
B. Snubber (HPCS-910N)		12				
Code/Design Guide	4		None			
Procedural Control	3		None			
Design Check						
Loads	5					
Welding	1		None			
Materials/Geometry	6		None			
Allowable Stress	6		None			
Movements	2		None			
Member Stress	5		HPCS-56		X	

Table 3-3 Continued

Review Area	Number of Review Questions	Number of Documents Reviewed	PFR's Issued	Classification: Not Valid	Observation	g
C. Rigid Support (HPCS-901N)		5				
Code/Design Guide	4		None			
Procedural Control	3		None			
Design Check						
Loads	9		None			
Welding	1		None			
Materials/Geometry	5		None			
Base Plate/Anchors						
Allowable Stress	5		None			
Movements	1		None			
Member Stress	5		None			
D. Anchor (HPCS-52)		5				
Code/Design Guide	4		None			
Procedural Control	3		None			
Design Check						
Loads	9		HPCS-82		X	
Welding	1		None			
Materials/Geometry	5		None			
Base Plate/Anchors	4		None			
Allowable Stress	5		None			
Movements	1		None			
Member Stress	5		None			
E. Small Bore Support (DE-1738-11)		10				
Code/Design Guide	4		None			
Procedural Control	3		None			
Design Check						
Loads	6		None			
Welding	1		None			
Materials/Geometry	4		None			
Base Plate/Anchors	4		None.			
Allowable Stress	7		None			
Movements	2		None			
Member Stress	6		None			
F. Inst. Line Support (B-670-35)		10				
Code/Design Guide	3		None			
Procedural Control	3		None			
Design Check						
Loads	5		None			
Welding	1		None			
Materials/Geometry	6		None			
Base Plates	2		None			
Allowable Stress	5		None			
Movements	2		None			
Member Stress	7		None			
3.2.5.3 Equipment Supports (HPCS-Pump P-1)		11				
Procedural Control	3		None			
Design Check						
Loads (Alternate Calculation)			HPCS-22		X	
Materials/Geometry	2		None			
Allowable Stress (Alternate Calculation)	3		None			
Member Stress (Alternate Calculation)	4		None			

Table 3-3 Continued

Review Area	Number of Review Questions	Number of Documents Reviewed	PFR's Issued	Classification: Not Valid	Classification: Observation	Classification: Finding
3.2.6 COMPONENT ON-SITE INSPECTION						
3.2.6.1 Mechanical Components						
HPCS-V-4	7		None			
HPCS-V-5	7	19	None			
HPCS-V-12	7		None			
HPCS-RV-35	7		None			
HPCS-P-1	9	4	None			
HPCS-ST-2	4	6	None			
HPCS-RO-4	4	5	None			
Diesel Start Air	37	10	None			
Diesel Air Intake	30	6	None			
Diesel Service Water Pump	11	7	None			
3.2.6.2 Inst. & Controls						
HPCS-FE-7	11	1	HPCS-36	X		
HPCS-FIS-6	13	3	None			
HPCS-LS-1A	13	1	None			
HPCS-LS-2A	13	1	HPCS-38		X	
HPCS-DPIS-9	13	3	None			
HPCS-PS-12	13	3	HPCS-40	X		
Tubing for LS-1A, LS-2A, FT-5, DPIS-9	60	11	HPCS-37		X	
3.2.6.3 Electrical		34				
CB-4DG3	8					
CB-42	8					
CB-HPCS	8					
42-4A5B	8					
42-4A7C	8					
M-1	3		HPCS-54		X	
M-3	3					
MO-4	3					
CBL-3HPCS/0030	6					
CBL-3HPCS/0080	6					
CBL-3HPCS/0340	6					
3.2.6.4 Piping and Support Inspections						
A. Piping Inspections						
M-200-2	17		None			
M-200-100A	17		None			
DE-1738-1	17		None			
X-73A	17		HPCS-28		X	
B. Pipe Support Inspections						
HPCS-66	9		None			
HPCS-910N	9		HPCS-21			X
HPCS-901N	9		None			
HPCS-52	9		None			
DE-1738-11	9		None			
B-670-35	9		None			
Totals	1930	1056	72	18	46	8

PFR-HPCS-19 identified the need to add a small oil collection associated with the HPCS diesel. This PFR is of relatively minor importance relating mainly to personnel safety and a limited diesel fire because of pool housekeeping in the diesel area.

Based on the sampling review, it is concluded that the HPCS design is adequate, subject to satisfactory completion of corrective actions associated with the PFR's identified above. Overall conclusions regarding WNP-2 design and design process are discussed in Sections 1.2 and 1.3.

3.2.3 SYSTEM LEVEL REVIEW

This subsection describes the efforts undertaken in accordance with the High Pressure Core Spray System Design Reverification Plan[9] to reverify that system design requirements were adequately and correctly incorporated into the design of the HPCS System at WNP-2.

The design features selected for reverification were chosen to demonstrate compliance with FSAR commitments, representing a broad spectrum of design requirements and design interfaces.

To accomplish the system-level reverification, HPCS system requirements and descriptions were thoroughly reviewed by the interdisciplinary review team to ensure that the primary design requirements were correctly interpreted and incorporated into each stage of the design process and that the integrated system would function as specified. The system level review results are summarized in the sections that follow.

3.2.3.1 System Functional Requirements

The review of system functional requirements covered the following four areas:

A. System flow requirements

B. Pump start and valve closure hydraulic transients

C. Diesel starting air capacity

D. Diesel cooling water adequacy

A. System Flow Requirements

System flow requirements are specified by GE to ensure that the core will have adequate cooling over the entire spectrum of possible conditions requiring use of the HPCS system. These requirements have been reverified by use of an independent analytical model of the HPCS system to predict system flows versus pressures. The Stoner and Associates computer code LIQSS was used to verify that the system will perform in accordance with the design requirements under steady-state conditions. The piping isometric drawings were used to formulate the analytical model to represent the system. Flow losses through the various elements were modeled using standard techniques or measured flow characteristics from manufacturer's test reports, if available. The predicted flow rates under steady conditions from the LIQSS code were also compared to some measured flows obtained during physical system testing to provide additional assurance that the system will function properly.

The 78 documents examined to aid in the modeling and review include two GE design specifications, one GE Process Diagram, 11 B&R calculations, 26 B&R drawings, 36 vendor drawings, the FSAR, and one Technical Memorandum.

The results of system flow evaluation (see calculation NE-02-83-09) confirmed the adequacy of the HPCS system to deliver required flows.

No Potential Finding Reports were written as a result of this evaluation area.

B. Hydraulic Transients

Adequate system design requires that hydraulic transients (waterhammer) be accommodated in the design so that normal events, such as pumps starting and valves closing, do not cause damage to or overpressurization of the system. A water leg pump is required to keep the system piping filled to prevent pump starts against an empty piping network.

The Stoner Associates computer code LIQT was used to evaluate the HPCS system model to determine whether any undesirable transient effects were evident during pump starts or rapid downstream valve closures. Valve HPCS-V-4 was modeled to close rapidly at full runout flow to determine whether the resultant water hammer would overstress the piping. The rapid valve closure transient analysis did not result in unacceptable calculated effects from waterhammer on the system piping (see Calculation NE-02-83-10). Calculated pressures and forces were within the design tolerances of the piping.

The HPCS pump start was modeled using the vendor-supplied characteristics of HPCS-P-1. The analysis showed that the pressure in the suction piping would be significantly reduced for a few seconds in a cyclic pattern until full flow is established. This caused no perceptible pump discharge effects in the model, but it would affect the water level in the CST/Suppression Pool level switch standpipe. The reduced pressure could cause the water level to fall enough to trip the level switches and change the suction source from the CST to the suppression pool. The exact magnitude and duration of effects on the standpipe are difficult to predict analytically. This potential problem had been anticipated by the Project and is being verified as part of the testing program.

No PFR's were issued as a result of this review.

C. Diesel Starting Air Capacity

The HPCS diesel air start system was provided by GE. B&R was responsible for sizing the air start piping. The GE purchase specification requires that the system be capable of starting the diesel generator a minimum of three times in rapid succession without use of the air compressors between starts.

The review involved the examination of eleven documents including two GE specifications, a GE licensing topical report, the FSAR, five piping isometric drawings and two vendor manuals. In addition, the pressure drop in the as-built piping system was checked using the Stoner Associates GASSS Code.

The capability of the GE-provided components to meet the minimum three start requirement was demonstrated by factory prototype testing as documented in GE Licensing Topical Report, "HPCS Power Supply" (NEDO-10905), which is referenced in the FSAR as part of the alternate approach for compliance to Reg. Guide 1.9, Rev. 0. The review noted an inconsistency between two FSAR sections relative to the capacity of the HPCS diesel air start system. FSAR section 8.3 stated that each system has the capacity to start the engine five times without recharging as demonstrated by test whereas FSAR Appendix C referenced the GE licensing topical report which demonstrated a three start capability for the system (both receivers). The capacity and pressure drop calculation performed as part of the review indicates that the capability of achieving five starts without recharging the air receivers is marginal. PFR-HPCS-44 was issued to document this condition. Further review identified that the FSAR inconsistencies had been previously documented in startup problem report SPR-M-1222 and corrected by a B&R FSAR change (SCN-82-349) to indicate a three start capability. The affected pages had not been revised at the time of the review; however, the pending change was properly tracked by both the Safety Change Notice (SCN) and Start-up Problem Report (SPR) logs. During plant testing the HPCS diesel generator started five times in succession without recharging the air receivers.

PFR-HPCS-44 is classified as an observation on the basis that the system as installed is consistent with the GE purchase specification requirements and the performance indicated in the GE licensing topical report for the HPCS diesel generator. While it can be argued that this PFR is not valid in that the FSAR inconsistencies had been reported and that the diesel did start five times during plant testing, the pressure drop in the air supply lines is unnecessarily high, which reduces the margin available to accommodate system aging or other adverse conditions. This PFR was referred to WNP-2 Project Engineering for consideration as a future plant improvement.

D. Diesel Cooling Water (DCW) Adequacy

To verify that the DCW system will adequately cool the engine, the system was analyzed using the Stoner Associates LIQSS computer code. Pipe dimensions, configurations, and elevations were obtained from system isometric drawings; pump data were taken from vendor supplied test data. The required flowrates were taken from B&R Technical Memorandum Number 1232.

The analysis showed that the heat exchanger outlet valve, SW-V-82, must be throttled to obtain desired flowrates (see Calculation NE-02-82-14). WNP-2 Startup confirmed the results, but no flow balancing had been done on the system at the time of the analysis, so no quantitative comparisons could be made. However, the calculation does indicate that the cooling system is adequate for meeting its required function.

PFR-HPCS-2, classified as an observation, noted that the diesel cooling water heat exchanger (DCW-HX-1C) was not labeled consistently on all drawings. The installed hardware is correctly identified. Further review identified that correction of labeling discrepancies was being addressed as part of the hydrostatic testing program, the fill and flush testing and the preparation of electrical wiring diagrams. In addition, the plant staff, as part of the release for operation program conducts a walkdown which also includes a final check of component labeling. This PFR was referred to Project Engineering for correction of the indicated discrepancy. In view of the ongoing programs in this area no additional action was considered necessary.

3.2.3.2 System Control Logic

The HPCS system's functional Instrumentation and Control requirements were specified by GE and included control logic to accomplish the following actions:

1. Automatic HPCS initiation from the test mode

2. Automatic transfer of HPCS pump suction from condensate storage tank to the suppression pool on condensate storage low level indication

3. Automatic HPCS minimum flow control valve operation for blocked discharge path.

Seventeen documents were examined and a logic diagram prepared to check the overall system control logic. The documents included system design specifications, flow diagrams, electrical wiring diagrams (elementary diagrams), and the drawing control log.

Review of the logic diagram showed that for each mode inputs to the relay logic resulted in valve sequencing as specified by the design criteria.

Two PFR's were issued for this review.

PFR-HPCS-7, classified as an observation, noted a drafting error on Flow Diagram M527, Rev. 43, in that no reference was shown for Detail "B". Burns and Roe agreed to issue PED 215-M-K975 to correct the drawing. Since the detail on the drawing was correct, this was considered to be a simple referencing error and no further action beyond correcting the specific drawing is necessary.

PFR-HPCS-41, classified as an observation, noted that the interlock control function for HPCS-LS-2A was not shown on B&R flow diagram M543. The control function was correctly shown on the GE functional control and elementary diagrams and the installation is correct. At WNP-2 the complete I&C logic is shown on the GE functional control diagrams and the B&R logic diagrams. Selected I&C control functions are shown on the B&R flow diagrams for convenience but it is not intended that B&R flow diagrams show all I&C control functions. While it can be argued that this PFR is not valid on the basis that no requirement was violated, it was classified as an observation and referred to the Project for consideration as a clarification to the flow diagram.

3.2.3.3 Electrical Power Supply Adequacy

The HPCS electrical power system design was evaluated to ensure that it could supply adequate electrical power to required system loads for all normal and off-normal conditions established in the FSAR. GE specified the requirements and designed the major components of the system. B&R was responsible for design of equipment installation, interconnections between equipment, and the offsite power source to meet GE's requirements.

The 4160 volt switchgear and the Motor Control Center were checked for loading, voltage drop, and short circuit duty. The B&R calculations in these areas were reviewed for accuracy of transfer of vendor information used in the calculation, results, and application of the results in the design.

Thirty-eight documents were examined during the review, including the B&R Engineering Criteria document, 11 B&R Calculations, three B&R Drawings, two GE Design Specifications, a GE Topical Report, Okonite Cable Data, and 19 GE Drawings.

The electrical power system was found to be capable of carrying the HPCS system loads without exceeding its continuous or short time ratings and was capable of providing acceptable voltage levels to all system loads. The fault interrupting devices and load switching devices were found to be applied within the momentary, short time, and interrupting capability of these devices.

Four PFR's were issued as a result of this review.

PFR-HPCS-48, classified as an observation, noted that B&R calculation 2.06.03 did not use the correct transformer TR4-41 impedance for the voltage drop computation. The designer used the estimated value of 6%, instead of the actual 3.3% value provided by the manufacturer, for the final as-built calculation. The calculation was conservative so no hardware changes were necessary. B&R will be requested to update the calculation using the correct impedance for its next revision.

PFR-HPCS-50, classified as an observation, reported that during the preparation of Calculation 2.06.03, Rev. 5, the effects of simultaneous starting of the 4kV and 480 V motors were not considered when these were powered from the normal plant supply. Consequently, the voltage levels fall below the required 80% level stipulated in the FSAR. During accident conditions, the bus is powered by the HPCS diesel generator and NEDO tests have verified that all the motors do start satisfactorily at lower than the 80% value. The FSAR will be changed to reflect this exception to the 80% criteria.

PFR HPCS-52, classified as an observation, reported that the B&R print file contained two different sets of transformer (TR4-41) outline and nameplate drawings. Since the applicable drawing can be identified via the GE computerized EIS report, it was concluded that there was no process control problem. B&R is in the process of purging obsolete documents from the files as part of the engineering transition program, thus, it was concluded that no further action was required beyond identification of the specific drawings to project engineering for action.

PFR-HPCS-53, classified as an observation, noted that B&R did not include MC-4A in its short circuit calculations. Follow-up by B&R indicated that MC-4A is GE-supplied and no short circuit information was provided with it. (NOTE: MC-4A is part of GE's standard HPCS design and experience has determined its characteristics to be satisfactory.) Since GE did not provide the information, B&R should have either done its own calculations or requested data from GE. Although the process did not work in this case, MC-4A is unique and it is the only equipment for which the calculation was not done. B&R has subsequently included MC-4A in calculation 2.03.10 which verified its sizing. In addition, the reviewer performed an alternate calculation which verified there is no problem. On this basis the observation was closed.

3.2.3.4 System Codes and Standards

The applicable codes and standards requirements for the HPCS system and associated piping specified by GE and the B&R Engineering Criteria Document were reviewed to assure compliance with the ASME Code and seismic requirements.

Sixty-two documents were examined, including review of the applicable installation contract specifications to assure that the required ASME Code and seismic classifications were properly transmitted as reflected by incorporation into the specifications. N-5 data reports for selected HPCS system piping lines, prepared by the installation contractor, were reviewed to ascertain certified compliance with the specified ASME Code requirements.

The B&R HPCS system Flow Diagram (M-520) and vendor isometric, installation and component drawings were also reviewed to assure that the specified ASME Code and seismic requirements were properly indicated in compliance with the specifications.

The review verified that the HPCS system piping has been properly specified and installed in accordance with the WNP-2 FSAR design commitments and GE design specifications. One valid PFR was issued and is discussed below.

PFR-HPCS-30, classified as an observation, addressed documentation ambiguities in the Code classification for the condensate storage tank (CST) to HPCS pump suction piping. This is an old problem that was recognized and has been worked on for over three years. The line from the CST to HPCS-V-1, identified as seismic Category I and ASME-III, Class 2 by the original GE design specifications, was specified by B&R as Seismic Category II and ANSI B31.1, with upgraded weld inspection requirements. The B&R approach is acceptable provided an adequate supply of water is provided for the HPCS pump during switchover to suction from the suppression pool. This issue was addressed between GE and B&R during the design process (see letter BRGE-2-79-043) and necessitated moving the CST level switches from the tanks to their present position inside the Reactor Building to accommodate possible loss of the non-Seismic Category I piping during a Design Basis Accident (DBA). It was concluded that the design and the design process had functioned properly except for documentation ambiguities in the identification of code classification in the FSAR drawings and the specification. The documentation was modified to clarify these ambiguities and the observation was closed.

3.2.3.5 System Separation Requirements

Separation requirements for HPCS mechanical, instrumentation and control and electrical components were reviewed to ensure that the HPCS design properly incorporates provisions for physical separation.

A. Mechanical Separation

The GE Design Specification states that mechanical equipment and piping, including control safety conduit and tubing for the Emergency Core Cooling Systems and the engineered safety subsystems, shall be segregated so that no single credible event is capable of disabling sufficient equipment to prevent reactor shutdown, removal of decay heat from the core, or to prevent isolation of the primary containment in the event of a design basis accident. It further states that emergency core cooling systems components shall be separated into three functional groups: 1) HPCS, 2) LPCS and 1 LPCI with one heat exchanger and ADS, and 3) two LPCI pumps with one heat exchanger and ADS. The equipment in each group shall be separated from that in the other groups by the maximum practical distance. In addition, the distance between the HPCS and the RCIC shall be maximized.

These requirements for mechanical separations were evaluated in a review of 19 design drawings by identifying nearby components and evaluating damage potentials from pipe breaks, missiles, fire, and flooding. The reviews were supplemented by the component field inspections which included evaluation of potential targets actually present in the immediate vicinity. The safe shutdown analysis in FSAR Section 15 applicable to the HPCS system was also reviewed to assure consistency with the actual design.

Although one drain line goes from the HPCS pump room to the RHR system for flushing the suction piping, no violation of separation requirements occurs because this line is isolated by locked-closed HPCS-V-19 and check valve HPCS-V-25. No other mechanical components of systems required to be separated from the HPCS system are located in the HPCS pump room. No other mechanical component targets along the routing of the HPCS piping were identified which violate the separation requirements. The HPCS system is laid out and arranged to provide the specified separation for lines entering the reactor vessel nozzles.

No PFR's were issued as a result of this review.

B. Instrumentation and Control Separations

A review of GE and B&R design criteria, instrument installation contract drawings, and contractor prepared drawings was accomplished to show that equipment and instrument tube separation requirements were consistently extended to design and installation documents. I&C design requirements were specified by GE whereas B&R and contractors using B&R criteria and specifications performed the design.

Twenty-four documents were reviewed. These include two GE design specifications, the B&R design criteria, a construction contract, two instrument rack connection diagrams, and 18 instrument tube layout drawings.

The review showed that divisional separation as determined by design requirements was incorporated in design, contract, and contractor documents and drawings. However, the minimum separation distance was not consistently specified at the different levels of design. It is noted, though, that as part of the design criteria, B&R approves all installation and routing drawings and performs a pipe break and missile impact evaluation to assure that adequate separation criteria are met.

PFR-HPCS-31, classified as an observation, described an apparent inconsistency between the B&R engineering criteria for tubing separation and the 220 Contract implementation of separation. These criteria amount to conservative guidance to avoid future rework since B&R analyzes separation in all cases based on the applicable hazards at each location. As a result of this PFR, the FRC recommended that B&R clarify the criteria document to describe the applicable analyses governing installation acceptability and B&R committed to do so.

C. Electrical Separation

The HPCS system design was reviewed to determine that the HPCS System electrical equipment was physically separated from the equipment of redundant systems. The design was also reviewed to assure that the electrical power components were properly associated with their electrical separation division and were electrically separate from redundant systems.

GE was responsible for establishing the requirements and both GE and B&R were responsible for portions of the design.

Nine documents were examined in the separations review, including the B&R Engineering Criteria Document, Design Specifications, three B&R drawings, and two IEEE Standards.

The design was found to be in compliance with the requirements on separation in all areas reviewed.

No PFR's were written as a result of this review.

3.2.3.6 System Redundancy Requirements

System redundancy requirements for mechanical, instrumentation and control, and electrical components were reviewed to assure proper functioning of the HPCS system as designed.

A. Mechanical Redundancy

This review addressed the requirements for redundant water supplies for the HPCS system and the redundancy aspects of the air start system for the HPCS diesel. The design requirement for redundancy from the GE design specification states that a reserve of water shall be maintained in the condensate storage tank for the HPCS or Reactor Core Isolation Cooling System. . . , and that if the water level in the condensate storage tank falls below a predetermined level or the suppression pool water level exceeds a specific level, the pump suction supply shall automatically transfer to the suppression pool.

The availability of the redundant HPCS-P-1 suction supply in the piping arrangment as designed by B&R was checked by review of B&R calculations, two flow diagrams, four isometric drawings, and several letters exchanged between B&R and GE on the suction switchover question.

The review confirmed that the design of the HPCS pump suction supply which utilizes level switches on a standpipe in the Reactor Building instead of locating the level switches on the CST and providing a Seismic Category I line from the CST is comparable with the GE design requirements. However, the review identified two concerns plus several minor discrepancies in B&R calculation 5.19.13, Rev. 1. This calculation evaluated the adequacy of the water volume in the suction line to assure switchover to the suppression pool in the event of a break in the line from the CST. Potential finding report HPCS-15 was issued to document the questions raised as a result of the review of this calculation.

PFR-HPCS-15 was classified as a finding on the basis that the B&R calculation did not address two areas important to the evaluation of the adequacy of the water volume in the supply line. The calculation assumed instantaneous response of the level switches which initiate the transfer of the suction supply to the suppression pool. In the normal mode of operation, a delay on the order of a second or more should be included to account for the time required for the water level in the standpipe to fall to the setpoint of the level switches. In the test mode the suction valve to the suppression pool (HPCS-V-15) is interlocked to prevent opening before the test return valves to the CST (HPCS-V-10 and 11) are closed which results in a delay of about 50 seconds. The test mode was not addressed in the calculation. As a result of this PFR, the adequacy of the water volume in the HPCS suction line was re-evaluated. Review of this re-evaluation confirmed that the suction line volume is adequate to assure switchover in the event of a suction line break while in the normal mode of operation when appropriate delays are included for the level switch response. In their corrective action plan associated with this finding the WNP-2 Project committed to completion of plant tests and revision of the calculations necessary to show an adequate water volume in the supply line. The corrective action plan was reviewed and accepted as a basis for closure of this finding.

PFR-HPCS-3, classified as an observation, concerned descriptive material in the FSAR which applied the wrong meaning of redundancy to the HPCS diesel generator air start system. The redundancy requirement for the HPCS diesel air start system is that it be independent of the air start systems for the two emergency power diesel generators. Review of the design drawings and the installation confirmed that the three air start systems are independent such that a failure or malfunction in one system will not impair the ability of the other systems to start their diesel engines. It was noted that the FSAR description of the HPCS diesel air start system implied that it was redundant within itself; it is not. As stated in FSAR 6.3.2.5, "No individual system of the ECCS is single failure proof with the exception of the ADS; hence, it is expected that single failures will disable individual systems of the ECCS." The acceptability of the loss of the HPCS diesel to a single failure in the WNP-2 ECCS single failure evaluation, FSAR, Table 6.3-7. This discrepancy had been previously identified in Startup Problem Report M-1222 and a correction initiated by B&R (SCN-82-349) prior to the reverification review. Project correspondence confirmed that the HPCS design basis stated above is correct. An FSAR change (SCN-83-158) has clarified the appropriate sections.

B. Instrumentation and Control Redundancy

The system control logic diagram described in subsection 3.2.3.2 was used to check that a redundant source of HPCS pump suction is automatically selected. System operation, as described by the logic diagram, shows that the HPCS pump suction will automatically transfer from the condensate storage tanks to the suppression pool for condensate tank low level or suppression pool high level signals. This system response is as specified by system design requirements.

No valid PFR's resulted from the review.

C. Electrical Redundancy

The HPCS System electrical power system design was reviewed to assure that redundant components were supplied from redundant power systems and that redundant offsite and onsite power sources were available that complied with specified requirements.

GE was responsible for the requirements and both GE and B&R were responsible for parts of the design.

Twelve documents were reviewed to assure that the required redundancy was provided in the system design.

The design was found to meet all the requirements in the original criteria and design specifications. However, the HPCS power system design did not provide the degraded voltage power source transfer and the automatic return to standby mode controls for the HPCS Diesel Generator. Both of these requirements were imposed on the WNP-2 design by the NRC during the WNP-2 FSAR review process and had not been incorporated in the design at the time of review.

PFR-HPCS-51, classified as an observation, stated that the HPCS electrical design made no provision for transferring the loads to the diesel generator in case of degraded bus voltage or return of the controls to the normal mode in the event of an auto start signal while in the test mode. Both provisions were required by the NRC late in the project. Investigation revealed that design requirements for the transfer function had been sent to GE in August, 1982 and that GE had issued FDI-TCKZ to incorporate the design. The other change shown on PED 218-E-A923 was given to GE in March, 1983. GE issued its portion of the design on FDDR-KK1-1099. The item was being tracked on the Licensing open items log. There was no deficiency observed by this PFR. It could be argued that this PFR should have been classified as invalid; however, it was maintained as an observation simply because the NRC-required changes had not yet been completed.

3.2.3.7 Containment Isolation Requirements

Mechanical and Instrumentation and Control containment isolation requirements were reviewed to assure compliance.

A. Mechanical Isolation Requirements

The FSAR, Section 6.2, describes the commitments to the NRC on primary containment isolation. FSAR Table 6.2-16 lists the valves considered by B&R to be containment isolation valves. The FSAR commitments were reverified by design review of B&R drawings for the HPCS system and the applicable design installation documents to assure that the commitments were met by the installed isolation valves.

The review confirmed that the isolation mechanisms described in the FSAR for all HPCS mechanical penetrations of the containment have been installed as required.

PFR-HPCS-55, classified as an observation, noted that the FSAR Table 6.2-16 designations for containment penetration isolation valves used outdated nomenclature. The correct designation for the valves should be HPCS-V-XX, not PI-VX. It was also noted that HPCS-V-69 had not been added to penetration X-78e. This PFR was submitted to the Project to correct the affected pages in the FSAR. The changes were implemented by SCN 83-285.

B. Instrumentation and Control Isolation Requirements

Design requirements were compared with flow diagrams, contract drawings, contractor-prepared isometrics, vendor data, and elementary wiring diagrams to assure that requirements for containment isolation of instrument lines as specified by GE were incorporated into B&R design criteria.

Twenty-three documents were reviewed which include the GE P&ID, B&R design criteria, 11 contractor installation drawings, two flow diagrams, two contract instrument connection diagrams, two wiring diagrams, four vendor drawings, and the installation contract.

The review showed that containment isolation for HPCS instrument lines penetrating containment satisfies the design requirements except for the suppression pool level monitoring line where an orifice was not used. No calculations were found to show the line size alone is sufficient to comply with isolation requirements. PFR-HPCS-39 was written to address this question.

Further review of this issue raised by PFR-HPCS-39 confirmed that the existing design is adequate in that for instrument lines not directly connected to the reactor coolant pressure boundary the line size itself is sufficient to limit the offsite dose to acceptable values. However, B&R, in evaluating this PFR, identified a discrepancy between the FSAR and the criteria used to size orifices in instrument lines which do connect to the reactor coolant pressure boundary. The instrument line break analysis in FSAR Chapter 15 assumed a 1/4" orifice whereas the sizing criteria provided the I&C contractor permitted up to 1/2" orifices depending on the line size. Subsequent analysis has shown that orifices are not required for lines 1" and smaller; therefore, this discrepancy is not safety significant.

PFR-HPCS-39 was classified as an observation on the basis that the design is adequate. The Project has initiated a revision to FSAR Chapter 15 and Table 6.2-16 to accurately describe the existing installations. No further action is considered necessary.

3.2.3.8 System Corrosion Requirements

Requirements for corrosion allowances, for corrosion inhibitors in the diesel cooling water system, and corrosion resistant piping were reviewed.

A. Corrosion Allowances

The corrosion allowances for HPCS system piping and components from the GE Design Specification were reviewed to determine that they were consistently used in the design of the system components.

The B&R Engineering Criteria Document, Contract 2802-215 Specifications and B&R Nuclear Calculations 5.19.01 and 5.19.07 were reviewed to assure that the specified corrosion allowances were used for determining proper line sizes.

Design documents for several components in the HPCS system, including pipe spools, valves, pumps and strainers were also reviewed to assure that compliance with the specified corrosion allowance was certified, as noted in the component review section of this report. Piping schedules from B&R Nuclear Calculation 5.19.07 were determined to have been used, as reverified by review of the contract specifications and installation isometric drawings. No discrepancies were observed in the use of corrosion allowances in the design of the HPCS system.

No PFR's were written as a result of this review.

B. Corrosion Inhibitors

The chemistry control of the DCW system is specified in the diesel engine technical manual. It is recommended that chemistry be controlled by the addition of chromates, borate-nitrite, or silicate-nitrite. WNP-2 Start-up called for the addition of Nalco brand borate-nitrite corrosion inhibitor, one of the additives recommended in the instruction.

No PFR's were written as a result of this review.

C. Corrosion-Resistant Piping

The diesel engine technical manual warns that galvanized pipe should not be used in the fuel oil piping. When galvanized pipe comes into contact with fuel oil it causes the galvanizing to corrode and flake off, possibly fouling the system. To assure that this requirement was met, the B&R Engineering Criteria Document and the material specifications of Contract 215 were reviewed. The system isometrics were then reviewed for material specifications. No galvanized pipe was found in the system.

No PFR's were written as a result of this review.

3.2.3.9 System ALARA Requirements

The layout of the HPCS system was reviewed to ensure that ALARA considerations were properly incorporated into the overall system design to minimize radiation exposure potentials to plant personnel to the degree reasonably achievable. FSAR Section 12 outlines the WNP-2 commitments to the ALARA philosophy.

The B&R layout and arrangement drawings and locally mounted instrument drawings for the HPCS system were compared with WNP-2 FSAR Figures 12.3-36, -37 and -38 to determine the expected radiation levels in the locations of HPCS system equipment. HPCS-V-4 is the only piece of mechanical equipment in the HPCS system outside the drywell that is located in a high radiation zone (Zone IV), and it cannot be relocated because of the requirement to be as close as reasonable to the primary containment because it is a containment isolation valve.

The mechanical equipment in the HPCS Pump Room is located in a Zone III area which will require controlled access to minimize exposures. There were no relocations of mechanical equipment nor addition of shielding identified that appears to be feasible when alternate locations of equipment and placement of radiation shielding to reduce exposures were evaluated. Planned maintenance and occupancy requirements are consistent with the Zone III designations in the HPCS Pump Room.

No further modifications to the HPCS system mechanical locations or shielding provisions have been identified which would serve to reasonably reduce radiation exposures.

The reviews indicated that ALARA considerations were incorporated into the design and that the instrumentation reviewed was located where the exposure to maintenance personnel was within the limits specified in 10CFR20.101.

No PFR was issued as a result of this review.

3.2.3.10 System Layout and Arrangement Requirements

Layout and arrangement requirements for HPCS Pump NPSH, diesel intake and exhaust sizing, and instrument rack environmental qualification were reviewed to assure that the requirements were properly incorporated into the system design.

A. HPCS Pump Net Positive Suction Head (NPSH)

GE specified a minimum Net Positive Suction Head (NPSH) as a requirement for the system layout.

B&R Calculations were reviewed to reverify that the system layout and arrangement provides adequate NPSH for the main HPCS pump. The LIQSS calculations using the HPCS model described in Subsection 3.2.2.1.1 evaluated the available NPSH provided to the HPCS pump under specified operating conditions.

The alternate calculations show that adequate NPSH is provided for the HPCS main pump under specified operating conditions by the system layout and arrangement using certified vendor pump test data and the "as-built" configuration of the HPCS system. Therefore, this aspect of the design of the HPCS system is verified and acceptable. One minor PFR (HPCS-4) was issued as a result of the HPCS pump review.

PFR HPCS-4, classified as an observation, reported that calculation B&R 5.19.14 (Rev. 0) did not reference the latest revision to calculation 5.19.11 which it used. Further review indicated that B&R had used the correct data and revision but had incorrectly referenced a wrong revision number. This error was identified for correction by the project.

B. Diesel Intake and Exhaust Sizing

The diesel air intake system consists of an oil bath intake filter, an inline air silencer, an air turning box, and flexible connections. The maximum allowable pressure drop is specified to be 6 inches of water.

An alternate calculation was performed to verify that this requirement is met (see calculation ME-02-82-11). The pressure drop of the air intake system is calculated to be less than 6 inches of water.

The diesel exhaust system consists of a turbocharger, aftercooler, exhaust manifold, exhaust adapter, exhaust flexible section, and exhaust silencer. The maximum allowable pressure drop is specified to be 5 inches of water. The alternate calculation showed the resulting pressure drop to be greater than the allowed 5 inches of water.

The diesel engine manufacturer was contacted and questioned about the effect of high backpressure on the engine exhaust. The exhaust backpressure limit is based on normal maintenance schedules. Having a larger backpressure may result in accelerated wear, but will not prevent the engine from starting or operating at full load. Preoperational testing of the HPCS diesel has been performed at 108% of full load, confirming the operability of the diesel generator system.

PFR HPCS-5, classified as an observation, described a pressure drop calculation error made when the diesel engine exhaust system was designed. While the exhaust line pressure drop is greater than the manufacturer's recommendations, preoperational testing has demonstrated that all three diesel generators meet or exceed their performance requirements. It was therefore concluded that this error is not safety significant; however, it does relate to the generic B&R calculation problem which is discussed in Section 1.2. In considering whether similar errors could have impacted the other diesels, it was concluded that the HPCS is the most limiting situation.

C. Instrument Rack Qualification

Design requirements for environmental compatibility of the HPCS instrument rack with the system layout were reviewed to ensure that the functions of the instruments as arranged and laid out in the plant would not be adversely affected by local environmental conditions during upsets or accidents.

Eight documents were reviewed which include three GE design documents, Burns and Roe Design Criteria, Equipment Qualification Report, General Arrangement drawing, and two calculations for the pipe break and missile study.

The review showed that the instruments associated with the instrument rack are qualified for the environment except for HPCS-FT-5 which is listed for replacement in the Qualification Report. Location of the rack allows access for maintenance and is not susceptible to damage from pipe break or missiles.

No PFR was written as a result of this review.

3.2.4 COMPONENT LEVEL REVERIFICATION

In addition to the integrated system level reverification efforts described in Subsection 3.2.2, 34 components of the HPCS system were selected for detailed review. Proper transmittal and use of the design requirements across organizational interfaces for the chosen components were reverified by review of applicable design, procurement, and vendor documentation as described in the following subsections for each type of component reviewed.

A series of component checklists were completed for each of the selected components to assure that the applicable requirements were incorporated into the component design. The HPCS components selected for review are listed in Table 3-4.

3.2.4.1 Reverification of HPCS System Valves

Four different valves were selected for evaluation to provide confidence that all valves in the system were properly designed and specified to meet the applicable requirements. These four valves are of different types, have different operators and manufacturers, and were specified by both GE and B&R. The valves selected were HPCS-V-4, -V-5, -V-12 and -RV-35.

TABLE 3-4

HPCS COMPONENTS SELECTED FOR REVIEW

Mechanical Components

Valves

HPCS-V-4	HPCS injection valve
HPCS-V-5	Testable check valve
HPCS-V-12	Minimum flow bypass valve
HPCS-RV-35	Water leg line relief valve

Pumps

HPCS-P-1	HPCS main pump
HPCS-P-2	Diesel cooling water pump

Speciality Items

HPCS-RO-4	Test line orifice
HPCS-ST-2	Suction strainer
SA-C-2C	Diesel air start compressor
DG-ENG-1C	Diesel air box drain
DO-TK-4	Diesel fuel oil day tank
DCW-HX-1C	Diesel cooling water heat exchanger

Instrumentation and Control Components

Instrument Tubing

HPCS-LS-1A
HPCS-LS-2A
HPCS-DPIS-9
HPCS-FT-5

Flow Element

HPCS-FE-7 HPCS flow indicator and bypass flow control

Process Instruments

HPCS-FT-5	Flow transmitter
HPCS-FIS-6	Flow switch
HPCS-LS-1A	Level switch
HPCS-LS-2A	Level switch
HPCS-DPIS-9	Differential pressure switch
HPCS-PS-12	Pressure switch

TABLE 3-4 Continued

HPCS COMPONENTS SELECTED FOR REVIEW

Electrical Components

Circuit Breaker and Motor Controllers

HPCS-CB-4DG3	HPCS diesel generator breaker
HPCS-CB-HPCS	HPCS pump circuit breaker
HPCS-CB-42	HPCS normal source breaker
HPCS-42-4A5B	Motor controller for HPCS-V-4
HPCS-42-4A7C	Motor controller for water leg pump

Motors and Motor Operators

HPCS-M-1	HPCS pump motor
HPCS-M-3	HPCS water leg pump motor
HPCS-MO-4	Motor operator for HPCS-V-4

Electrical Cables

HPCS-CBL-3HPCS/0030	Feeder for HPCS-V-4
HPCS-CBL-3HPCS/0080	Feeder for water leg pump
HPCS-CBL-3HPCS/0340	Feeder for HPCS pump

HPCS-V-4

Valve HPCS-V-4 must open upon system initiation during a LOCA to provide a flow path to the reactor. It is an Anchor-Darling 12", 900# gate valve, motor-operated by the automatic control system and which also has provisions for manual operation. It is specified by GE as ASME-III, Class 1, and is also an outer primary containment isolation valve.

Four GE design and purchase specifications pertinent to HPCS-V-4 and the Anchor-Darling Instruction Manual were reviewed and compared to information from the Anchor-Darling construction drawing, B&R Flow Diagram, and isometric drawing. Five NRC I&E notices and circulars applicable to this valve and its Limitorque operator were reviewed to ensure that industry experience was properly considered in the final HPCS system design incorporating this valve. The Vendor NPV-1 Form for this valve was reviewed to reverify certification of compliance with the specified requirements. The reviewed areas were in compliance with specified requirements and the valve is appropriate for its intended use.

HPCS-V-5

Valve HPCS-V-5 is a 12" Velan air-testable 500# BB swing check valve serving as the inner primary containment isolation valve downstream of HPCS-V-4. This valve holds the reactor vessel pressure during operations and allows HPCS system injection into the reactor vessel through nozzle N-16. This valve was specified by B&R as ASME-III, Class 1.

The GE design specification, B&R Engineering Criteria Document, Contract Specification, and Velan Operating and Maintenance Manual were reviewed and compared to information from the Velan Drawing, B&R Flow Diagram and isometric drawing. Three applicable NRC I&E bulletins and notices on Velan swing check valves were reviewed to ensure that industry experience was properly considered in the final design incorporating this valve.

The Vendor NPV-1 form for this valve was reviewed to reverify certification of compliance with specified requirements. The reviewed areas were in compliance with specified requirements and the valve is appropriate for its intended use.

HPCS-V-12

HPCS-V-12 is the minimum flow bypass valve specified by GE. It is a 4" Anchor-Darling motor operated 900# gate valve that closes as flow through flow element HPCS-FE-7 increases, and serves to provide a minimum flow path to protect the HPCS main pump from low flow conditions. This valve was specified by GE as ASME-III, Class 2.

Three GE design and procurement specifications pertinent to HPCS-V-12 and the Anchor-Darling Instruction Manual were reviewed and compared to information from the Anchor-Darling construction drawing, B&R Flow Diagram, and isometric drawing. Four NRC I&E notices and circulars applicable to this type of valve and its Limitorque operator were reviewed to ensure that industry experience was properly considered in the final HPCS system design incorporating this valve. The vendor NPV-1 form for this valve was reviewed to reverify certification of compliance with specified requirements. The areas reviewed were in compliance with specified requirements and the valve is appropriate for its intended use.

HPCS-RV-35

HPCS-RV-35 is a 1-1/2" X 2" Lonergan spring operated pressure relief valve on the discharge piping of the water leg pump selected to represent this type of valve in the HPCS system. This valve was specified by B&R as ASME III Class 2. HPCS-RV-35 is a primary containment isolation valve, being the first valve from the suppression pool test inlet pipe on its respective line.

The GE design specification data sheet, B&R Engineering Criteria Document and contract specification were reviewed and compared to information from the Lonergan drawing, B&R Flow Diagram, isometric drawings, and PED-215-M466. The vendor NPV-1 form for this valve was reviewed to reverify certification of compliance with specified requirements.

The areas reviewed were in compliance with the design requirements. The valve was not provided with double gasketed flanges to permit type B containment leak testing as recommended by GE. While this is a desirable feature which the Project had identified as a deferred plant improvement, it is not a design requirement. The valve as installed is appropriate for its intended use.

No PFR's were issued as a result of the review of HPCS valves.

3.2.4.2 Reverification of HPCS Pumps

HPCS-P-1

A major component of the HPCS system is the main pump, HPCS-P-1. Because the proper functioning of the whole system in delivering water to the reactor core depends on this pump, it has been selected for reverification. This pump was specified and supplied by GE. It is an Ingersoll-Rand 12" discharge, 20" suction, 8 stage centrifugal, double-suction first stage pump, specified to ASME-III, Class 2 requirements, and rated to deliver 6942 gpm at 1780 rpm and 662' TDH.

As described in the discussion of alternate calculations on transient and steady state flow conditions in Subsection 3.2.2.1, the certified pump performance test curves have been used to reverify that the GE specified flow requirements are met. Three GE design and procurement specifications pertinent to this pump and the GE Process Diagram 731E932A were reviewed and compared with vendor data from Ingersoll-Rand's NPV-1 form and the "High Pressure Core Spray Pump Manual", VPF 3069-30-3, B&R Flow Diagram M520 and IR Seal Piping Drawing D-12x20KD321x2C. The areas of pump design and performance reviewed comply with specified requirements and the pump is appropriate for its intended use.

HPCS-P-2

The HPCS Diesel Cooling Water (DCW) system is driven by pump HPCS-P-2. This pump was specified and supplied by GE as part of the DCW system as meeting ASME-III, ND requirements. Certified pump performance curves for HPCS-P-2 were used as the basis for the LIQSS computer code modeling of the DCW system described in the system functional requirements section of this report. The GE design and purchase specifications pertinent to this pump were reviewed, as were the vendor drawings and pump manual, certified performance curves, and vendor certification of compliance with the design specifications. The areas of pump performance reviewed were in compliance with the design requirements and the pump is appropriate for its intended use.

No PFR's were issued as a result of the review of HPCS pumps.

3.2.4.3 Reverification of Specialty Items

The specialty items reverified in this effort are the test line restrictive orifice and the suppression pool suction strainer, and four diesel system components.

HPCS-RO-4

There are seven restrictive orifices in the HPCS mechanical system designed to provide proper pump minimum and runout flow conditions. HPCS-RO-4 was selected to represent the orifices in the system. It provides head loss to assure proper main pump flow conditions while operating in the test mode delivering water to the suppression pool. This orifice was specified by B&R as ASME-III, Class 2.

One GE design specification data sheet and process diagram were reviewed to determine flow requirements for the full flow test line delivering water to the suppression pool. One B&R calculation was reviewed in which HPCS-RO-4 was sized. An alternate calculation was performed to reverify

that the actual flow limiter nozzle as designed and delivered by Permutit met the specified requirements and would not cavitate. The B&R contract specification, isometric drawing and Flow Diagram were also reviewed to ensure consistency with specified requirements.

PFR HPCS-43, classified as an observation, noted that the design of a restrictive orifice did not include a cavitation calculation and that the designer's recommendation for a multi-stage orifice was not followed. In addition, BRI calculation 5.19.11, Rev. 4, contained some minor discrepancies. None of these observations affected plant safety. The alternate calculation identified some potential for cavitation which could be eliminated (if encountered) by throttling the downstream valves. Cavitation was encountered during preoperational testing and B&R has issued directions to throttle valves HPCS-V-23 and 64. No further action is considered necessary.

HPCS-ST-2

Suction for the pumps from the suppression pool is provided through a redundant set of identical strainers. These strainers are critical to proper cooling water flow to the HPCS system during a LOCA. HPCS-ST-2 was selected for reverification. This strainer was specified by B&R to meet the applicable requirements of ASME-III, Class 2 without "N" stamping. The strainer was designed and manufactured by Zurn Industries under PDM purchase order. The Zurn design description, calculations and drawings, loss coefficient calculation (see calculation NE-02-82-11), the HPCS-P-1 Manual and five additional design drawings were reviewed to reverify that applicable specified requirements were consistently applied and provided by the strainers. The strainer is appropriate for its intended use and meets the specified requirements in the areas reviewed.

No PFR specific to this strainer was written.

Diesel Starting Air Compressor (SA-C-2C)

The HPCS diesel engine technical manual warns that a shutoff valve should not be installed between the compressor head and the air receivers without installing a safety valve. The field inspection revealed that a relief valve is installed on the compressor head. This relief valve is an integral part of the compressor and is described in the compressor technical literature in the diesel engine technical manual.

The diesel engine technical manual also recommended that the Lister diesel engine running the compressor have an exhaust pipe with a 1-1/4 inch diameter if its length is less than or equal to 20 feet, or if over 20 feet in length it should have a diameter of 1-1/2 inches. The Lister diesel engine exhaust line is greater than 50 feet in length and has a diameter of 1-1/4 inches. This exhaust line is also connected to the main diesel engine exhaust. PFR-HPCS-17 was issued to document this condition.

Further review indicated that the Project had identified this discrepancy and a potential for exhaust back flow from the main diesel in 1981. At that time resolution was deferred until the engine performance could be checked during the test program. Review of the test file confirmed that it included the 1981 correspondence identifying these potential problems for resolution during the test program. The testing has been conducted and the performance is satisfactory. Operations is currently reviewing the maintenance program for the Lister engine to assure that it is adequate. In addition, the Project has recommended modification of this line as a deferred change to improve the system performance.

PFR-HPCS-17 was classified as an observation on the basis that the problem had been previously identified by the Project and corrective action was in process at the time of the reverification review. No further action is considered necessary.

Diesel Air Box Drain (DG-ENG-1C)

The HPCS diesel engine technical manual requires that the air box drain be left open and that a one or two gallon collection tank be provided to collect oil accumulation blown down through this drain. Air intake system isometrics were reviewed and a field inspection was made. There is no valve on the drain line, so the requirement that it be left open is met. However, no collection tank is provided. The waste oil is blown down directly on the floor below the engine catwalk. There is no floor drain in the immediate area.

PFR HPCS-19, classified as a finding based on potential personnel safety considerations, noted that a collector tank for the air box drain was not provided. Without a collector, oil would be blown down onto the floor creating potential personnel and fire hazards. The plant technical staff agreed to provide an airbox blowdown collector; therefore, the PFR is closed.

Diesel Fuel Oil Day Tank (DO-TK-4)

The HPCS diesel fuel oil day tank was reviewed for adequacy of fire mitigation features and sizing of the tank to meet the eight hour fuel supply requirement stated in the B&R Engineering Criteria Document.

The fuel oil day tank has several fire mitigation features. The tank is located in a room with no other equipment. This room has a raised door jam so that the entire contents of the tank can spill into the room without overflowing into the diesel room. The tank is also equipped with flame arrestors and the room has a sprinkler system. As stated in the FSAR, the system conforms to the intent of ANSI Standard N195. There is no overflow line between the fuel oil day tank and storage tank. However, redundant level switches have been provided in the day tank which will preclude the overflow of oil from the day tank by stopping the transfer pump at a set high level in the day tank. PFR-HPCS-18 notes an FSAR error describing the system.

Burns and Roe performed no calculations sizing the HPCS diesel fuel oil tank specifically. Instead, the calculations were performed for the Division 1 and Division 2 day tanks and the same size day tank was used for the HPCS diesel. The maximum fuel consumption rate is for the Division 2 diesel, and is 5.4 gallons per minute. No fuel consumption tests have been performed for the HPCS diesel, but GE predicts 3.4 gallons per minute in their topical licensing report; thus the HPCS diesel day tank is conservatively sized. The day tank holds about 3000 gallons, or enough fuel for about 14 hours of operation.

One PFR resulted from the reviews of the fuel oil system.

PFR-HPCS-18, classified as an observation, noted that the FSAR description of the HPCS diesel fuel oil system states that NFPA standards are met. Since there is no overflow return line from the day tank to the storage tank, the design does not meet NFPA 37. However, the system has redundant level switches in series with the pumps which meets the intent of that standard. The Project was requested to change the FSAR to correct the statement.

Diesel Cooling Water System Heat Exchanger (DCW-HX-1C)

The diesel cooling water heat exchanger was supplied as part of the skid mounted diesel engine package. Although other skid mounted systems or components usually were not chosen for reverification, the heat exchanger met the criteria of being a multi-organizational design. The diesel engine was specified by GE to EMD, who in turn specified the heat exchanger to Thermxchanger. A review of the design input specified by GE and a check of the general sizing of the heat exchanger was performed using methods published in the open literature. Although some differences were noted among the individual heat transfer coefficients, the calculated overall heat transfer coefficient was within one percent of the specified value.

No PFR's were written as a result of this review.

3.2.4.4 Instrument Tubing

Four instruments having different piping/tubing configurations were selected. Review consisted of comparing a checklist against design criteria, installation contract, and installation drawings. The checklist addresses code and material requirements, flexibility, routing, design details, data required on installation drawings, isometric/flow diagram comparison, A/E approval of installation isometrics.

HPCS-LS-1A

The pipe supporting HPCS-LS-1A is a close-coupled local mount designed and specified by Burns and Roe and procured by the piping construction contractor.

Fourteen documents were reviewed which include the B&R Engineering Criteria Document, six installation isometric drawings, three flow diagrams, and three GE System Design Specifications.

The review showed that design requirements were properly extended to each level of design.

No PFR's were written as a result of the review of this tubing.

HPCS-LS-2A

The tubing connecting HPCS-LS-2A to the process was designed and specified by Burns and Roe and procured by the instrument installation contractor.

Nine drawings were reviewed which include three GE system design specifications, B&R Engineering Criteria Document, instrument installation contract, two flow diagrams, and two installation drawings.

The review showed that the design requirements for the tubing were incorporated at each level of design.

No PFR's were written.

HPCS-DPIS-9

The tubing connecting instrument rack mounted DPIS-9 to the process was designed and procured by the instrument installation contractor to the design criteria specified by GE and Burns and Roe.

Twenty-one drawings were reviewed which include three GE system design specifications, the B&R Engineering Criteria Document, two flow diagrams, 13 installation drawings, two instrument rack layout and pipe connection drawings, and the installation contract.

The review showed that the design requirements were incorporated at each level of design.

No valid PFR's resulted from this review.

HPCS-FT-5

The tubing connecting instrument rack mounted HPCS-FT-5 to the process was designed and procured by the instrument installation contractor to the design criteria specified by GE and Burns and Roe.

Sixteen documents were reviewed which include three GE systems design specifications, the B&R Engineering Criteria Document, the installation contract, one flow diagram, two instrument rack layout and pipe connections and eight installation drawings.

The review showed that the design requirements were incorporated at each level of design.

No PFR's were written as a result of review of this component.

3.2.4.5 Flow Element (HPCS-FE-7)

The flow element is used to develop a flow related signal for indicating HPCS flow and to control the HPCS pump minimum bypass valve. The flow element was specified and procured by GE.

Sixteen documents were reviewed which include two GE purchase specifications, three GE system design specifications, one flow diagram, one installation isometric, two vendor drawings, three fabrication drawings, one calibration sheet, two ASME Boiler Test Code curves (straight pipe length, unrecovered pressure loss), and a table for pipe ID and wall thickness. The review consisted of comparing these documents with a checklist which addressed accuracy, mechanical and signal conditioning interfaces, code, maintenance, and Q/A.

The review showed that the flow element satisfies GE system and procurement specifications. However, in reviewing the installation isometric, it was noted that the pressure flange taps were located on top which could allow air entrapment in the instrument lines creating the potential for measurement error.

Evaluation of this concern by B&R demonstrated that the design is adequate in that once the system is filled and vented. Pressurization by the water leg pump will maintain the air in solution well below the solubility limit. During HPCS pump operation the solubility is further increased due to the order of magnitude pressure increase. Some air would be expected to come out of solution when the water leg pump is shutdown. Upon restart of the water leg pump the volume of air would be substantially reduced and there is space in the instrument lines for air to collect without affecting the instrument. However, it is considered prudent to vent both the process and instrument lines following shutdown and restart of the water leg pump until operating experience confirms that the amount of air released is not significant.

PFR-HPCS-29 was classified as an observation on the basis that the design is adequate. This PFR was referred to the Project with a recommendation to vent the process and instrument lines following shutdown and restart of the water leg pump. Operations has revised the Annunciator Response procedure for all the ECCS and the RCIC system to include this provision and is evaluating the need for similar provisions in the procedures for the Standby Service Water System. No further action is considered necessary.

3.2.4.6 Process Instrumentation

Six instruments considered important to HPCS control and monitoring were selected for review. These include two level switches, a flow transmitter, a flow switch, a pressure switch, and a differential pressure switch. These instruments were specified and procured by GE.

The review consisted of comparing a checklist with instrument data sheets, system design specifications, vendor manuals, purchase specifications, installation drawings, and flow diagrams. The checklist addresses performance, power, mechanical and signal interfaces, mounting, tagging, nuclear qualification, ALARA, testability, code, and Q/A.

HPCS-FT-5

The WNP-2 Environmental Equipment Qualification Report (response to NUREG-0588) lists HPCS-FT-5 as not qualified. A qualified replacement is being procured; therefore, the installed instrument was not reviewed further.

HPCS-FIS-6

HPCS-FIS-6 is a flow switch located in instrument rack H22-P024 to control the minimum flow control valve. The review showed that the flow switch as described by vendor data satisfies the procurement specification and system design criteria.

No PFR was written.

HPCS-LS-1A

HPCS-LS-1A is a level switch that transfers HPCS pump suction from condensate storage to the suppression pool. The switch is local-mounted on a standpipe in the reactor building. The review showed that the level switch as described by vendor data satisfies the procurement and system design criteria.

No PFR was written.

HPCS-LS-2A

HPCS-LS-2A is a level switch locally mounted on the containment wall to provide auto transfer of HPCS suction from condensate storage to the suppression pool for a high pool level.

The review showed that the level switch as described by vendor data satisfies the procurement specification and system design criteria.

No PFR's were written.

HPCS-DPIS-9

HPCS-DPIS-9 is a differential pressure switch located in instrument rack H22-P024 and is used to detect an in-containment HPCS pipe break.

The review showed that the switch as described by vendor data satisfies the procurement specification and system design criteria except that the nameplate range of the installed switch was less than that specified in the instrument data sheet. The range covers the specified setpoint and therefore is not considered to be a problem.

PFR-HPCS-35, classified as an observation, was issued to document this observed discrepancy in range specifications. Evaluation of this PFR by GE confirmed that the correct instrument is installed. A revision to the instrument data sheet has been issued to show the proper range. No further action is considered necessary for this PFR.

GE was asked to address the generic aspects of the concern. In its letter to the Project on this subject, GEWP-2-83-169 (July 11, 1983), GE documented the hierarchy of their various documents. The Design System Data Sheets (DSDS) sheets are for instrument loop accuracy and instrument setpoint data. The Instrument Data Sheets (IDS) is to be used for calibration data. A program has been initiated to verify that the IDS and DSDS requirements indeed are consistent and that instruments installed at the site are compatible with the design documentation. GE does not expect this program to have any impact on hardware. Any resulting revisions will have been completed by document turnover to the Project.

HPCS-PS-12

HPCS-PS-12 is a pressure switch located in instrument rack H22-P024 and is used to control the HPCS pump minimum control valve in conjunction with HPCS-FIS-6.

The review showed that the accuracy and range of the switch were not consistently specified in the system design specification, instrument data sheet and the purchase specification. The nameplate data on the installed switch satisfies the requirements of the latest version of the system design specification data sheet, and the installed switch is considered to be acceptable.

PFR-HPCS-32 was classified as an observation on the basis that the correct instrument is installed. GE has revised the instrument data sheet and is in the process of correcting the design specification data sheet and the purchase specification. No further action on this PFR is considered necessary (see PFR-HPCS-35 for evaluation of this trend).

3.2.4.7 Circuit Breaker and Motor Controllers (CB/42)

The electrical components reviewed in this category were as follows:

HPCS-CB-4DG3	Circuit Breaker for HPCS Diesel Generator
HPCS-CB-HPCS	Circuit breaker for HPCS Pump Motor
HPCS-CB-42	Circuit Breaker for Normal Power Source
HPCS-42-4A5B	Motor Controller for HPCS Valve 4 Motor Operator
HPCS-42-4A7C	Motor Controller for HPCS Water Leg Pump Motor

The circuit breakers and HPCS-V-4 motor controller were specified, procured, and the application designed by GE. The motor controller for the water leg pump motor was specified and procured to GE requirements by B&R. The physical installation of this equipment was designed by B&R to GE and/or vendor requirements.

The continuous load currents over the range of expected voltage, short time currents, short circuit interrupting and momentary currents, ambient temperatures and elevation, voltages, switching frequency and control power voltages imposed on these devices by their loads or the power system were checked to determine that all were within the ratings of the components.

The B&R calculations were reviewed to determine that the calculation of the above duties was done correctly.

The protective relays which trip the breakers to protect the loads and feeder cables from damaging overloads or short circuits were checked for proper selection, application, and settings.

The components were checked for proper identification, qualification, and physical separation as Engineered Safeguards (Class 1E) equipment.

In performing this evaluation, three procurement specifications, 20 drawings, eight calculations, one B&R Technical Memorandum, the B&R Engineering Criteria Document, and eight IEEE and Industry Standards were reviewed.

Three PFR's resulted from these reviews. Two were classified as findings and one as an observation. Resolution of these PFR's is discussed below.

PFR-HPCS-46, classified as a finding, reported that the GE-supplied breaker 4-41 was provided with an adjustable range of from 10 to 40 Amperes as opposed to the specified setting of 95 Amperes. GE issued FDDR KK1-815 to correct the problem. There was also a generic problem with the BOP protective relays for the medium voltage cables in that instantaneous overcurrent tripping is required. As a result of B&R Calculation 2.06.19, PED 218-E-C178 was issued to modify eleven 6.9 and 4.16 kV circuit breakers to correct the deficiency.

PFR-HPCS-47, classified as an observation, reported that the normal power source breaker (4-2) for the HPCS had been installed with both instantaneous and time overcurrent relay elements and that the former had been connected. This arrangement is not satisfactory for incoming line relays as they will trip with any lower level relays on a fault, thus losing power to the entire bus and not just the feeder. GE letter GEWP-2-81-189 had recommended that the instantaneous element not be connected and B&R issued PED 218-E-A188 to change their drawings. At the time of walkdown, the elements had not been changed. However, unknown to the reviewer, GE had issued engineering direction to make the required modifications (FDI TCIM, May 1981). Since all of the elements of the design process had functioned correctly, it could be argued that this PFR should be invalid. However, since all the work had not been accomplished it was classified as an observation and closed.

PFR-HPCS-49, classified as a finding, reported deficiencies in the HPCS pump feeder ground fault alarm relay and the ground fault alarm scheme for MCC-MC-4A. This equipment is GE-supplied. Following instructions to modify it, GE issued an appropriate FDDR which will be used to track completion of the repairs. This PFR also raised a generic question about the adequacy of the sensitivity of the doughnut current transformer (CT--electromechanical (E-M) relay ground detection schemes used in the rest of the plant. B&R investigated the problem and indicated that there was no Class 1E equipment involved and that the existing scheme is adequate even though its sensitivity may be somewhat marginal. B&R recommended to the Project that the reviewer's recommended changes be classed as future improvements and that they be considered by the DCRB. No additional action is required for the generic part of this PFR.

3.2.4.8 Motors and Valve Motor Operators

The components reviewed in this category were as follows:

HPCS-M-1	HPCS Pump Motor
HPCS-M-3	HPCS Water Leg Pump Motor
HPCS-MO-4	HPCS Injection Valve 4 Motor Operator

The HPCS Pump Motor and the Valve 4 Motor Operator were specified and procured by GE. The actual motor design to meet the specifications was done by the motor vendor. The Water Leg Pump Motor was specified and procured by B&R to GE's requirements. The design of the motor itself was by the motor vendor.

The capability of the motors to drive their loads within their rating was reviewed for normal and anticipated abnormal voltages and applicable normal and accident environmental conditions. The calculations were reviewed to assure that the voltage levels calculated at the motors were correct. The physical separation, proper electrical power division identification, proper safety class designation and qualification were checked.

The following documents were reviewed: the B&R Engineering Criteria Document, 12 drawings, 11 GE specifications, one B&R specification, two B&R calculations, five vendor and contractor reports, two Supply System reports, one B&R Technical Memorandum, and three Industry Standards.

Of the 78 component checklist items reviewed, there were no problems found.

No PFR's were written as a result of the review of these components.

3.2.4.9 Electrical Cable

The components reviewed in this category were:

HPCS-CBL-3HPCS/0030	Cable Feeder for Valve 4 Motor Operator
HPCS-CBL-3HPCS/0080	Cable Feeder for Water Leg Pump Motor
HPCS-CBL-3HPCS/0340	Cable Feeder for HPCS Pump Motor

The cable was specified, procured, and its installation designed by B&R.

The cable application was reviewed for load current, voltage drop, ambient, short circuit capacity, overload capability, and material, stranding, and construction of the cable. The calculations were reviewed for correct length and cable size inputs. The cables were reviewed for correct quality class designation and qualification. The cable pulling calculations were reviewed for correct inputs and results.

The following documents were reviewed: the B&R Engineering Criteria Document, one B&R Technical Memorandum, two B&R procurement specifications, seven B&R calculations, three Industry Standards, three IEEE Standards, five vendor or contractor reports, ten drawings, five GE Specifications, and two Supply System Documents.

Of 105 component checklist items reviewed, there were no problems found.

No PFR's were written as a result of the cable reviews.

3.2.5 PIPING AND SUPPORT REVIEW

In the HPCS system, the large bore and ASME-III, Class 1 small bore piping were designed by B&R. The remaining small bore pipe was designed by Gilbert Commonwealth and the process instrument piping was designed by Johnson Controls. To verify the adequacy of the design of the HPCS piping and supports, a representative sample of piping and supports was selected for review. The sample includes the major piping sizes and code classifications, the three design organizations, a range of pipe support types and the HPCS pump support. The piping and supports were selected in a manner to assure coverage of the methodology, interorganizational interfaces, and the compliance by each organization with the design requirements. The reverification was based on a comprehensive design review approach utilizing detailed checklists and preparation of alternate calculations. The checklists were developed based on the Supply System's experience with ASME peer reviews. They address the following critical areas of design control, design analysis, and field inspection:

Piping Design Review

- Design data transmittal
- Isometric check
- Modeling check
- Deadweight analysis
- Thermal analysis
- Seismic analysis
- Anchor movements
- Load combinations

- o Pipe stress check
- o Support loads
- o Field inspection

Pipe Support Design Review

- o Code/design guide check
- o Procedure/control check
- o Design check

  Loads
  Welding
  Materials/Geometry
  Base Plates/Anchor Bolts
  Allowable stresses
  Member stresses

- o Field inspection.

In addition to the checklist reviews, alternate calculations were performed for one small bore line, two pipe supports, and the HPCS pump support. The review included a total of 303 feet of piping and 41 pipe supports. Six of these supports were subject to a detailed design review. Table 3-3 lists the HPCS piping and supports reviewed.

3.2.5.1 Piping Design Review

The primary requirement of the pipe stress analysis is to ensure the structural integrity of the piping system during normal operation and after any postulated accident condition which could occur during plant life. The design of the HPCS system piping and its supports is governed by either the ASME-Section III or ANSI B31.1 codes. The applicable design code is specified in the Burns and Roe Engineering Criteria Document for WNP-2.

The four piping designs chosen for reverification included ASME Class 1, Class 2 and B31.1 piping.

A. <u>HPCS Discharge Line (HPCS M200 - Sheet 2 Piping)</u>
ASME Class 1 B&R Calculation 8.14.82
Burns and Roe Design Scope

The pipe run detailed on M200-2 includes the HPCS discharge piping from reactor pressure vessel nozzle N-16 to containment penetration X-6. Burns and Roe completed the structural analysis model which included three valves, 12 pipe supports, and end points at fixed anchors.

Verification of structural adequacy was determined by review of the Burns and Roe calculations and computer runs. Burns and Roe analyzed the piping system using Revision D of the ADLPIPE structural analysis computer program. The mathematical model of the piping system used in the computer runs was verified in detail against design data as defined in various Burns and Roe design documents and against the status as-built isometric drawings. Specifically, the following items were verified for accuracy:

- Piping geometry
- Support types (rigid, snubber, springs)
- Support locations and orientation
- Valve weights, orientations, inertial properties, and locations
- Locations of branch pipe connections

- o Pipe and fitting sizes, materials, weights including water and insulation, and lengths

- o Stress indices for fittings

As a result of checking the design data input to the computer model and checking the stress isometric, one valid Potential Finding Report was issued:

PFR-HPCS-79, classified as an observation, noted an input data error in modeling valve HPCS-V-5 that resulted in the addition of 1047 lbs. to the valve weight. The error was caused by a failure to specify a weight per unit length for the valve. If no value is specified, the ADLPIPE Code defaults to the previous value (a 12" pipe weight) which is used in addition to the concentrated valve weight. Further evaluation indicated that utilization of the correct weight had very little effect on the stresses and loads for this system. To assure that this error has not been made in similar calculations, B&R checked a sample of similar calculations for the correct modeling of valve weights. The sample was selected based on the methodology described in IE Bulletin 79-02 which provides for increasing the sample size if further problems are encountered. No similar problems were identified. Since the design was determined to be adequate and the error appeared to be an isolated incident the PFR was classified as an observation and closed.

The structural analysis was checked to determine if all load cases as. specified in the WNP-2 Engineering Criteria Document, the FSAR, and the ASME Code had been completed and properly combined. The following narrative describes the Burns and Roe analysis logic:

> The piping system was analyzed for deadweight and thermal expansion using the static analysis option of the ADLPIPE computer program. Four different thermal expansion modes which enveloped all operating and transient conditions were considered. The thermal movements of equipment nozzles and supports were applied in the thermal expansion analysis.

Response spectra analyses using the enveloped building spectra were performed for Operational Basis Earthquake (OBE) and combined, as required, with hydrodynamic loads, chugging and annulus pressurization loads. The Safe Shutdown Earthquake (SSE) was assumed as twice the OBE. The multiple input response spectrum method was used for Safety Relief Valve hydrodynamic loading case. Appropriate damping values and modal combinations were used for all dynamic load calculations. The effects of the seismic differential displacements between piping supports at various elevations was added absolutely as secondary stress.

One PFR was issued related to the seismic/dynamic analyses as a result of the structural analysis check.

PFR-HPCS-81, classified as a finding, involved the use of log-log scale for interpolation of the response spectra input by the analyst into the ADLPIPE program. The ADLPIPE user manual specifies a unique key entry to define the type of response spectra scale entered by the analyst. If log-log interpolation is used instead of log-linear or linear-linear the G value interpolated by the computer between data points entered by the analyst could be smaller than if the proper scale was entered. This could cause unconservative prediction of stress in the piping system.

In order to resolve this finding, B&R evaluated their ADLPIPE calculations and found 20-30 which contained the discrepancy identified by the finding. Six of these cases were selected for a study comparing the results if the discrepancy is eliminated. The study evaluated whether the remaining calculations need to be corrected. As a result of the study, B&R found that the ADLPIPE interpolation discrepancy did not affect the adequacy of the existing piping designs.

To complete the load combinations required for ASME-III, Class 1 piping analysis, the secondary stress intensity ranges were calculated between all pairs of load-sets. A load set was defined by the state of combined loadings which takes place when a piping system undergoes an up thermal and/or pressure transient (high load-set) or down thermal and/or pressure transient. The events with no change in temperature and pressure were categorized as neutral load-set. An inventory of high and low load-sets from GE thermal transient drawings was performed. All the high and low load-sets were enveloped into a few high and low load-set envelopes in which each envelop conservatively represents a group of similar load-sets. The number of occurrences of the enveloped load-set was taken as the sum of the number of occurrences of each load-set that it represents.

Computer program EA-2100 was used to calculate the linear and non-linear components of through the wall temperature gradient and average temperature difference across a discontinuity during the thermal transient event for the pipe fittings. To simplify the process, the enveloping method was again used and 9 enveloped fittings were identified. Transient heat transfer analysis was performed for these fittings to calculate the thermal discontinuity quantities. The largest values of these quantities during the interval of the entire event were used in the evaluation of secondary and peak stresses.

The proper load combinations as specified in Engineering Criteria Document, Section I, Table 6 were used for primary load design evaluation. The equation 9 stress intensity for each service level, normal and upset, emergency and faulted was calculated and compared with the appropriate allowable.

Primary plus secondary stress intensity ranges due to mechanical and/or thermal loadings were calculated for all pairs of load-sets and compared against the allowable. Fatigue evaluation was done by calculating the peak stress intensity range and usage factor per ASME Code requirements at each node point for all pairs of load-sets.

All the welded attachments used in the piping system were evaluated according to the ASME Code Case N-122 (1745) and found to be structurally adequate.

As part of the final pipe stress level check, pipe break evaluation was included in this calculation to show that the pipe break exclusion area criteria in Tech. Memo 1240, Rev. 1 was satisfied for the piping between the isolation valve HPCS-V-5 and the containment penetration. The postulated pipe break locations for the piping between the RPV nozzle and Valve HPCS-V-5 were selected in separate calculations.

During the check of the pipe stresses it was noted that valve end loads (i.e., piping reactions) were not tabulated.

PFR-HPCS-74, classified as an observation, noted that the HPCS piping analysis did not tabulate the valve end loads and accelerations and reconcile them with vendor allowables as required per the Engineering Criteria Document and the Piping Design Guide. Further evaluation identified that the Engineering Criteria Document and Piping Design Guide had not been updated to reflect the valve qualification program as it evolved. Currently, the Supply System is responsible for the valve operability evaluation, and B&R is responsible for reconciliation of valve end loads. Throughout the program, valve accelerations were tabulated by B&R and appropriately transmitted to the Supply System for the operability evaluation. However, for a period of time the responsibility for the reconciliation of valve end loads was not clearly defined. This problem had been recognized by B&R and resolution was in process at the time of the reverification review. The Engineering Criteria Document and the Piping Design Guide are being revised to reflect the program as implemented. The B&R review of valve vendor stress reports is in progress. In all cases reviewed thus far, the pipe reactions assumed by the vendor are significantly higher than those calculated for the WNP-2 piping systems; therefore, no valve end load problems are anticipated. Checks of all ASME, Class 1 valves have been completed and no deficiencies found. Both the valve accelerations and valve end loads are subject to a final reconciliation as part of the final as-built stress analysis. No further action is considered necessary.

Finally, support loads used for design by the site organization were checked against the latest loads in the piping calculation; PFR-HPCS-27 resulted.

PFR-HPCS-27 was classified as an observation on the basis that the site hanger design group was using the correct revision of the Load and Deflection Data Sheet (Rev. 8). The B&R Home Office, in the process of preparing the Class I Stress Report, has made some minor revisions to the piping analysis. The initial results of these revisions were recorded as Rev. 9 which contained some loads greater than Rev. 8. Further refinements to the piping analysis documented in an appendix of the calculation reduced all the loads below those in Rev. 8. As a result, the Home Office did not issue Rev. 9 to the site. While the existence of Rev. 9 to the Load and Deflection Data Sheet has the potential to cause confusion, there was no design process error. To eliminate this potential for confusion, B&R has voided the Rev. 9 data sheet and revised their process for finalizing the stress analysis to eliminate the preparation of revised load and deflection data sheets for interim calculations performed as part of the evaluation process. The generic implications are discussed under PFR-HPCS-64.

To complete the review, the calculation (19 volumes of calculations and computer input/output) was checked against the applicable GE drawings and specifications, the WNP-2 FSAR, Burns and Roe Technical Memos, Engineering Criteria Document, and various design drawings. Forty-six documents and references were reviewed during the reverification of the pipe calculation.

B. HPCS Suction Line (HPCS-M200-100A)
ASME Class 2 B&R Calculation 8.14.64A

Reverification was accomplished by means of a design review of Burns and Roe calculations 8.14.64A, Rev. 0, "Stress Analysis of ISO: M200 - Sht. 100, Rev. 7A". The calculation package consisted of five volumes of hand calculations and computer runs which documented the stress analysis of the 24" HPCS(2)-1 subsystem, which consists of 24" piping leading from the suppression pool strainers, HPCS-ST-2 and HPCS-ST-3, through containment penetration X-31, and ending at anchor HPCS-52.

The stress analysis was performed using ANSYS, which is a general purpose finite element computer program. A conventional ASME-III, Class 2 analysis was performed using linear elastic structural and spring elements. The model consisted of two valves, six supports, one penetration, one strainer assembly and the connecting 24" piping. There are four small diameter branch pipes connecting with the 24" piping, ranging from 3/4" to 3" in diameter. These small bore lines are decoupled for analysis purposes.

All aspects of the mathematical model of the piping system used in the computer runs were verified to be in agreement with the isometric drawings. Specifically, the following items were checked:

- o Piping geometry
- o Support types (rigid, snubber, springs)
- o Support locations and orientation
- o Valve weights, orientations, inertial properties, and locations
- o Locations of branch pipe connections
- o Pipe and fitting sizes, materials, weights including water and insulation, and lengths
- o Stress intensification factor for fittings
- o Support stiffness

A few minor dimensional inconsistencies were found that were insignificant in terms of the stress analysis.

The locations of valves, supports, and branch lines were checked in particular and found to be correct.

As a result of the model check the following PFR's were issued:

PFR-HPCS-68, classified as an observation, stated that during the preparation of calculation 8.14.64A, stress intensification factors (SIF) were not applied to certain pipe fittings. Further evaluation indicated that the B&R procedure is to include the SIF evaluation for all fittings, either by hand or computer, and that the proper SIF had been applied. In one case (a 20x20x20 tee) where the total stress was less than 4 ksi, the proper SIF was determined but not included in the calculation because it would not affect the high stress nodes. B&R has revised the calculation to note that the stress at this tee meets the code allowable when the SIF for the fitting is applied. There may be other areas where the engineer performing the stress calculation may have used his experience to determine that SIF's need not be applied for low stress areas where there would be no effect on the final design. No further action is required.

PFR-HPCS-69, classified as an observation, noted that the rigid element connecting the body to the operator in the valve model had been assigned a density which resulted in the inadvertent addition of 4153 lbs. to the valve weight. Evaluation of this PFR by B&R identified the cause of the problem as a keypunching error in preparation of the input. The calculation has been corrected and shows no increase in total loads or deflections except for support HPCS-901N. The increase in loads to support HPCS-901N is unrelated to this problem (see PFR-HPCS-66). In addition, B&R has reviewed all calculations containing similar input methods for valve weight and found no additional occurrences of this problem. No further action is considered necessary.

Each individual load evaluation was reviewed to assure that the loadings were correctly defined and that the resulting pipe loads and deflections were reasonable and were within acceptable limits. The load cases reviewed were pressure, deadweight, minimum and maximum thermal expansion, seismic (OBE and SSE which is assumed to be twice OBE) and the hydrodynamic loadings (SRV, chugging and LOCA jet). In total, about 25 computer runs were reviewed in detail, ranging from simple static runs to detailed time-history SRV analyses.

Two PFR's were issued due to errors found during the review of the thermal analysis.

PFR-HPCS-65, classified as an observation, noted that in a piping thermal expansion calculation, a containment temperature of 120°F was used instead of 40°F. The FSAR contains references indicating system temperatures as low as 40°F. Further evaluation confirmed that the analysis is correct. The 40°F temperature will only be achieved if the wetwell is filled during the winter when the condensate storage tanks are at 40°F. Since such an operation is expected only a few times during the life of the plant, the 40°F condition will be seen less than 25 times and, based on ASME Code rules, it need not be considered in the piping thermal analysis. B&R has issued a change to the Engineering Criteria Document to clarify the applicability of this temperature to the design of the piping systems. No further action is considered necessary.

PFR-HPCS-67, classified as an observation, identified two valid deficiencies made during the preparation of revised thermal expansion computer runs for calculation 8.14.64A. In the first, the analyst inadvertently transposed two numbers in the coefficient of thermal expansion value while entering the data into the computer. B&R reran the calculation with the correct number and the review showed no increase in total loads and deflections with the exception of one reported for other reasons in PFR-HPCS-66. In addition, B&R reviewed all similar calculations performed by the same analyst to see if the error was person-oriented. There were no other such cases; hence, this was concluded to be a random key punch error. In the second deficiency, the reviewer assumed that the analyst doing the calculation arbitrarily assumed a ten foot boundary condition zone since he could find no justifications for the number. The review showed that the analyst linearly interpolated the containment anchor movement at the desired elevation, using an effective containment shell thickness of four inches (to consider the effects of the tee stiffeners) instead of the actual 1.5 inches. This increased the effective boundary length to 111 inches (approximately 10 feet) as determined by the equation in question. In addition, the analyst used sufficient conservatisms to account for the fact that the interpolation is not precisely linear as assumed. The design was found to be adequate and no re-analysis was necessary. No further action was required.

Two PFR's were issued against the Seismic/Hydrodynamic analyses.

PFR-HPCS-62, classified as an observation, noted that the source of the loading data for use in the chugging, SRV and LOCA jet direct load analysis was not referenced, although the correct data was used. This PFR was referred to the Project with the recommendation to revise the affected documents to clearly indicate the source of the direct loads input. No further action is considered necessary.

PFR-HPCS-63, classified as an observation, reported three concerns with the seismic analysis in calculation 8.14.64A; (1) 2 percent instead of 0.5 percent damping was used per FSAR Table 3.7-1; (2) the response spectra used did not come from the stated reference; and (3) the static seismic analysis performed did not conform to the requirements of the Engineering Criteria Document. Further evaluation indicated that:. (1) when hydrodynamic loads are considered with seismic loads, the 2 percent damping coefficient is appropriate per the latest FSAR amendment and NRC regulatory guides; (2) the spectra used in the calculation envelop those contained in Technical Memorandum 1257; and (3) the Engineering Criteria Document notwithstanding, the static seismic analysis used is correct. B&R has initiated a revision to the Engineering Criteria Document to reflect the more realistic approach. Since there was no error in the calculation, no further action is considered necessary.

To show compliance with ASME Code requirements, the individual load cases must be combined together into normal, upset, emergency and faulted condition combinations, as defined by Table 6 of the Engineering Criteria Document, Section I. The primary stress producing loads are: pressure, deadweight, seismic (OBE, and SSE), SRV, and LOCA. Stresses caused by thermal expansion as well as anchor motions due to thermal, seismic and SRV events, are considered to be secondary stresses and are included in the secondary stress equations of the code.

Stresses were also checked for compliance with Burns and Roe functional capability requirements. Pipe break/crack location calculations were reviewed for compliance with the requirements of SRP 3.6.2, and the WNP-2 FSAR.

Summary tables containing loads, deflections or accelerations, as applicable for each support, valve or branch location, were also reviewed for accuracy and completeness. The summary tables are compiled for transmittal to the appropriate equipment design organization.

Four PFR's were issued to note deficiencies in the summation of load combinations and stress evaluations.

PFR-HPCS-58 was classified as a finding on the basis that it represented an open question on the adequacy of the design that must be resolved to assure that the system will satisfy the FSAR design commitments. This PFR reported an error in the Piping Design Guide section which describes the criteria for postulating cracks in moderate energy ASME-III, Class 2 and 3 lines. The Design Guide stated that no cracks are postulated if Equation 10 of the ASME Code is less than the allowable value of $0.4\ (1.2S_h + S_a)$. The FSAR and NUREG-0800, Section 3.6.2, state that the sum of Equations 9 and 10 should be compared to this allowable. The most likely cause of the problem appears to be a typographical error in the Design Guide. B&R has corrected the Design Guide and reviewed the calculations for all the affected piping. It was found that all the affected piping satisfy the correct criteria; therefore, there was no design or construction impact due to this error. No further action is required.

PFR-HPCS-59, classified as an observation, noted that the piping functional capability was not evaluated using appropriate criteria and that the results were not recorded in accordance with the procedure. While it was considered likely that the pipe in question would satisfy the appropriate criteria, B&R Technical Memorandum 1240 only applies to the pipe where the D_o/t is less than or equal to 50. In this case, D_o/t was equal to 64. B&R has revised Technical Memorandum 1240 to update the functional capability criteria and completed a preliminary review for all pipe with a D_0/t greater than 50. The results of this preliminary review indicate that all piping systems fall within the proper stress limit. The final evaluation is in progress. It was concluded that the B&R corrective action adequately addressed the problem identified in this PFR.

PFR-HPCS-64, classified as an observation, noted a problem in the identificatin of the correct revisions of support load tables. Further evaluation determined that the correct loads were utilized in this case; however, this PFR (combined with PFR-HPCS-27, -66 and -82) indicated a need to strengthen the B&R procedures for transmittal and review of hanger loads. As part of the corrective action plan a Supply System QA audit will verify the effectiveness of the added controls implemented by B&R on the final as-built stress/hanger design calculations.

PFR-HPCS-66 was classified as a finding on the basis that it represented an open question on the adequacy of the design that must be resolved to assure the system will satisfy its design requirements. This PFR reported that when the combined loads were tabulated for pipe support HPCS-901N, the moment loads were neglected. When the moment loads are incorporated, the results are significantly higher than the loads which were evaluated for this support. In response to this PFR, B&R has corrected the load summary sheet and reanalyzed pipe support HPCS-901N. In addition, all other calculations prepared by this analyst have been reviewed. One similar problem was found in calculation 8.14.63A. Reanalysis confirmed that the design of support HPCS-901N and two supports affected by calculation 8.14.63A were adequate when the correct loads were applied. Thus, these errors had no impact on the installed hardware. It was concluded, based on this review which checked the loads for more than 100 supports, that the problem was the result of a random oversight by the analyst, not a systematic error. No further action is considered necessary.

C. Diesel Exhaust, DE-1738-1
Gilbert Commonwealth (G/C)

Reverification of the air-start diesel exhaust line, DE-1738-1 was done by reviewing the G/C TPIPE stress analysis calculation. In addition, an alternate calculation to verify Gilbert/Commonwealth design of DE-1738-1 small bore line of the HPCS system was performed. This calculation, ME-02-83-48 Rev. 0 makes use of ADLPIPE computer program, Version 34. Pipe stresses are confirmed to be within the allowable values for the applicable equations of the pipeing code. Pipe response like mode frequencies, displacements and stresses due to various loadings are in general agreement, within 10%, with the original design calculation.

To complete the reverification a total of 21 design documents and references were reviewed.

PFR-HPCS-83, classified as an observation, was issued as a result of checking the mathematical model used for analysis. The PFR notes that Gilbert Commonwealth used Schedule 40 elbow dimensions rather than dimensions which represent the 3000 lb. socket weld fittings installed in the piping run. Socket weld fittings increase the pipe line stiffness which has an effect on the stress analysis. During the reverification Gilbert Commonwealth was requested to rerun their analysis with the actual socket weld fitting dimensions. The revised analysis was reviewed for correctness and to determine the effect of increased elbow stiffness. The pipe stresses increased a maximum of 7%, well within the code allowables; and since this is a high temperature line, the condition is bounding and not expected in other similar piping systems.

All other reverification checks of the piping analysis were acceptable. These included reverification of the following items:

- design data transmittal
- isometric check

- deadweight, thermal, seismic, and anchor movement analyses
- all load combinations, stress checks, and load summaries.

D. <u>Instrument Line X-73a</u>
ASME Class 1
Johnson Controls, Inc. (JCI) Design Scope

Instrument line X-73a starts at a 12" x 10" reducing elbow of the HPCS discharge line M200-2. The line runs from the elbow to containment penetration X73a and ends in instrument rack H22-P024. The purpose of the line is to provide pressure sensing above the reactor core plate. The line is affected by the thermal and dynamic movements of the Burns and Roe piping (M200-2) and the containment penetration.

Reverification of the X-73a piping design was completed by detailed review of the JCI NUPIPE computer model. The instrument line was designed to ASME Class 2 rules as permitted by ASME paragraph NB-3630(d)(1). Therefore, the design review followed the approach indicated for Burns and Roe pipe line M200-100A. Load cases checked included deadweight, thermal, and seismic. Hydrodynamic loads on the instrument line were enveloped by the conservative seismic analysis as justified in Burns and Roe Tech. Memo 1268 Rev. 1.

Nineteen design documents and references were reviewed. As a result of the review, three observations were issued:

<u>PFR-HPCS-24</u>, classified as a observation, noted that the final stress analysis for an instrument line did not include the proper stress intensity factor (SIF) for a socket weld in the as-built configuration. Incorporation of the correct SIF demonstrated that the stress is within allowables. All other as-built configuration changes were properly included in this calculation. Several additional calculations were reviewed for proper incorporation of as-built changes and no errors were found. Since the change in question was simple and could readily be

evaluated by inspection and all other as-built changes had been incorporated it was concluded that this was an isolated documentation error. The calculation has been corrected to show the proper SIF. No additional action is required.

PFR-HPCS-25, classified as an observation, reported that JCI calculation JCI-220-CLC-574 used an unjustified SIF of 2.1 in their design of lug sizes for 3/4" pipe. In reviewing this PFR, both JCI and B&R conclude that the application of an SIF of 2.1 is acceptable since all lines meet intensified stress allowables and all lugs are adequate. It could be argued that as no physical changes were made as a result of this PFR, it could be classified as invalid. However, since the review did note increased stresses in some cases (even though they were still within allowables) and since the B&R review did require considerable effort to demonstrate that sufficient conservatism existed to account for local lug stresses within the bounding parameters provided by the JCI specifications, it was decided to keep it as an observation.

PFR-HPCS-26, classified as an observation, noted that PI instrument line X-73a stress analysis did not justify the exclusion of an evaluation for the faulted load condition. The stress analysis is correct in that the emergency/upset condition analyzed is the bounding case for WNP-2. Since the correct load condition was properly evaluated, the lack of a justification for exclusion of the faulted condition is not significant.

3.2.5.2 Pipe Support Review

The Pipe Support Review included review of selected hanger design calculations as well as verification of the hanger design guide.

A. HPCS-66 Spring Support for M200-2

The B&R design calculation for the spring support was reviewed against ten design-affecting documents to check design adequacy. Review of the design guide input and calculation procedures revealed that B&R design practices were correctly followed.

Design loads, pipe movements, and material sizes, types, and properties were correctly included in the support design.

Review of the support structural analysis revealed several errors in design assumptions and calculation of member stresses and weld stresses.

PFR-HPCS-57, classified as an observation, listed the following errors in the design calculation:

1. The designer incorrectly assumed rotational rigidity of frame member.

2. Calculated support reactions do not show equilibrium of forces and moments.

3. There is no explanation to indicate the source of Mx on Page 5 of the calculation.

4. Torsional stress due to Mz on the Supporting I-beams was not calculated.

5. Weld stress at the I-beam connection to the Sacrificial Shield Wall considered Mz twice.

6. Weld calculation (P-6) at spring frame connection to the supporting beams should include the full moment value 45348 in-lbs.

B&R agreed with the reviewer that Items 2, 3, 4 and 6 were the result of poor checking by an inexperienced checker. Of the other two, Item 1 resulted from an overconservative assumption, not a design deficiency, while the fifth one was shown to be correct. In addition, B&R checked ten other calculations made by the originator and ten checked by the checker to assure that the problem was not related to either individual only. In addition, B&R was asked to review some of the calculations done by the checker as the originator. These activities revealed no patterns and the errors are assumed to be random in nature associated with this calculation. No further action is necessary.

B. HPCS 910N Snubber for M200-2

Design review was the method chosen to verify the B&R design for the HPCS-910N snubber. During the review, 12 design documents/references were used to check design adequacy.

The calculation followed criteria from the B&R design quide correctly and was issued according to the calculation procedure.

Loads used for design matched the hanger load transmittal from the B&R pipe stress group.

The hanger calculation was checked for the following items:

- o Member loads
- o Correctness of materials, member sizes, and member orientation for calculation purposes
- o Correct pipe/structural movements
- o Member and weld stresses
- o Allowables for design acceptance.

PFR-HPCS-56, classified as an observation, noted that the evaluation of local pipe stresses due to support lug reactions in the calculation for pipe support HPCS-901N did not include faulted conditions as required by ASME III, Class 1, systems per the Pipe Support Design Guide. However, review of the piping stress analysis confirmed that the pipe stresses due to support lug reactions were properly evaluated and that the pipe is not overstressed. Further evaluation identified that for Class I systems the pipe stress evaluation due to lug loads performed by the support design group is to determine a recommended lug size for support design. The final evaluation of pipe stresses due to lug loads is performed by the pipe stress engineer as part of the Class I pipe stress analysis. When issued, this analysis supersedes the calculation performed by the support design group. To preclude further confusion in this area, B&R has revised the Pipe Support Design Guide to state that for Class I systems the lug sizing calculation will be finalized by the pipe stress engineer as part of the Class I stress report. In addition, as the Class I stress reports are issued, the lug calculations performed by the support design group will be voided and referenced to the applicable pipe stress calculation. No further action is required.

C. HPCS-901N Rigid Vertical Support for M200-100A Calculation

Reverification of the Burns and Roe design for HPCS-901N was accomplished by means of an alternate calculation. The calculation for member forces, moments and stresses was completed on a verified Westinghouse structural analysis computer program called PIPSAN. The design loads for the model were checked against the hanger load transmittal form. PFR-HPCS-66 on the support HPCS 901N design loads was issued as part of the M200-100A review. Discussion of the PFR was included in the piping section of the review. Because the loads used in the support design matched the load transmittal from the pipe stress group, reverification of the hanger design proceeded.

The hanger structure was modeled based on the as-built hanger details. Six load cases were evaluated. They included loads up or down due to normal, upset, and faulted conditions.

Stresses in all members were checked against the allowable stresses for component supports. All member stresses were within the allowable limits.

Independent hand calculations were performed to verify the adequacy of all as-built welds in the structure.

No PFR's were issued as a result of the alternate calculations.

D. HPCS-52 Anchor for M200-100A

The Burns and Roe (B&R) design calculation 8.15.656 was reviewed to check design adequacy. All loads used in the design of the overall support and individual members were checked.

For the purpose of design verification the load sheet dated 10/17/82 in the pipe support calculation No. 8.15.656 was assumed to be correct.

Two McDonald Douglas STRUDL computer runs were reviewed to check the following items:

- o Materials and support geometry
- o Member loads and stresses
- o Load combinations.

It was noted that B&R had added all loads regardless of sign to give peak loads. This is a conservative procedure.

- o Weld stresses were verified separately and compared to the design guide allowable stresses.
- o Base plate and anchor bolt designs were determined to comply with the B&R Engineering Criteria Document Appendix A.

The review of the HPCS-52 anchor uncovered no design deficiencies in support members, welds, base plates or anchor bolts. An inconsistency in thermal loads was documented by PFR-HPCS-82.

PFR-HPCS-82, classified as an observation, noted that the thermal loads listed in the design calculation for pipe support HPCS-52 do not agree with the support load transmittal sheet or the support loads in the pipe stress analysis. Further evaluation confirmed that the loads used in the support design calculation are in agreement with the load transmittal data sheet and that the correct loads were used. The discrepancy between the load transmittal data sheet and the pipe stress analysis was the result of an interim analysis performed in the finalization of the as-built piping analysis. B&R has taken appropriate action to eliminate the potential for confusion as a result of interim analysis as described under PFR-HPCS-27. No further action is required.

E. <u>Gilbert Commonwealth Small Bore Pipe Support</u>
DE-1738-11 Rigid Support for Pipe DE-1738-1

The small bore support consists of a structural frame which provides support for the DE-1738-1 pipe in two locations. The method of reverification chosen for the G/C calculation was by analysis review. The G/C calculation for the support included use of the computer program PIPESUP. The calculation was reviewed and it confirmed that all loads were correctly transmitted to each member of the structural frame and into the base plate. Correct material properties and sectional properties were input into the computer program. Member and weld stresses were below allowable values. Verification of the stress levels printed out by the program was performed by manually calculating the forces, moments, and stresses on a random basis. This crosscheck confirmed the internal program verification completed by Gilbert Commonwealth.

A total of ten design documents and references were reviewed during the course of reverification of the support. The design of support DE-1738-11 is adequate for its intended loading.

No PFR's were issued as a result of the design review.

F. <u>JCI X-73a Instrument Line Support</u>
B-670-35

The reverification covered the design procedure employed by Johnson Controls and a calculation review to verify design adequacy. The support reviewed is a standard type which is used throughout the plant to support instrument lines. As a standard support, it is covered by a generic capacity calculation.

Ten design documents and references were reviewed. The design guide was reviewed and its correct implementation was verified. Support loads from the pipe stress analysis were correctly applied and verified to be less than the design capacity. Member and weld stresses for the actual loads are not calculated, rather maximum allowable loads were applied in the generic capacity calculation. The actual loads are lower and, therefore, are acceptable. All items reviewed met the contract and design specification.

No PFR's were issued and the support design is adequate.

3.2.5.3 Equipment Support (HPCS Pump Support R-1)

The HPCS pump is mounted on the concrete floor by means of ten, 1.75 in. diameter, high-strength anchor bolts. The number and size of bolts were specified by the pump vendor, Ingersoll-Rand, and the bolt details were designed by Burns and Roe.

The review was focused on determining whether the anchor bolts provided are adequate. A search was made for documents specifying loads and vendor requirements. Design calculations were then reviewed for compliance and finally an alternate calculation was performed.

It was found that the designer does not have a calculation traceable to this specific pump support. The design performed by B&R is for the RHR pump support which uses the same anchor bolt designation as used for the HPCS pump.

An alternate calculation performed by the reviewer made use of the allowable nozzle loads specified by the vendor as the bounding value for all loads coming from the pipe system including hydraulic flow loads furnished by the Mechanical Department (calculation number ME-02-83-05). The various loadings were combined in accordance with the Engineering Criteria Document. The calculation indicates that concrete and anchor bolt stresses are within allowables and, therefore, the support provided is adequate.

To complete the design adequacy check a total of twelve documents were reviewed consisting of the pump vendor drawing, General Electric specifications and equipment data sheet, structural construction drawings, Engineering Criteria Document and other design requirement references, and the designer's calculations.

The HPCS pump support is adequately sized to accommodate all design loads, but the designer's choice of design by similarity to the RHR pump was not adequately documented. This deficiency is documented in PFR-HPCS-22.

PFR-HPCS-22, classified as an observation, reported an apparent error in the calculation of punching shear and noted that the B&R calculation performed for the RHR pump support contained no reference to indicate that it was used as the basis for design of the HPCS pump support by similarity. Further evaluation confirmed that the B&R calculation of punching shear was correct. In addition, an independent analysis of the HPCS pump support confirmed that it is adequate and that it is reasonable to use the RHR pump support analysis as the basis for the HPCS pump support design. B&R has revised the RHR pump support calculation to indicate that it includes the HPCS pump by similarity. No further action is required.

3.2.6 COMPONENT ON-SITE INSPECTIONS

To assure that the HPCS system was installed in accordance with the design requirements, on-site inspections of all the components listed in Table 3-4 were performed by the reviewing discipline engineers as described in the following subsections.

3.2.6.1 Mechanical Components

On-site inpsections were performed to verify the accuracy of the design documentation describing the system or component being inspected, and to determine that specified components matched and were actually installed as indicated in the design documents. These physical inspections were documented by filling out the applicable component inspection checklists from information contained in the design documentation and from the field inspection.

Four HPCS system valves, HPCS-V-4, -V-5, -V-12 and -RV-35, were inspected. Seven B&R design drawings, five isometric drawings, four vendor drawings and several GE design specifications were reviewed prior to the field inspections to determine applicable requirements for the valves. Three design drawings and one vendor drawing were reviewed prior to the pump HPCS-P-1 inspection to ensure that requirements were properly identified. Three design drawings, an isometric drawing and one vendor drawing were reviewed for the HPCS-RO-4 inspection, and five design drawings and one vendor drawing showing HPCS-ST-2 were reviewed to ensure that requirements to be inspected were identified. The only deviation noted during the inspections was that the identical suppression pool suction strainers were not individually identified by EPN but were instead marked "HPCS" in keeping with the purchase specification. All requirements were found to be met during the field inspections, and all components inspected were correctly installed in accordance with applicable specifications.

No PFR's were written as a result of the mechanical walkdown inspections.

Because the diesel engine has several systems supporting it, some of these systems were treated as components during the as-built inspections. When a system is treated as a component, its design is reviewed before the walkdown. Recommendations made in the diesel engine technical manual were noted, and where appropriate, were incorporated into a special checklist/inspection guide made for that specific system. The GE process diagram was compared to the Burns and Roe Flow Diagram, and the proper isometrics were reviewed. The system was then walked down using the generic "Diesel Generator Subsystem As-Built Inspection Checklist" and the system specific checklist as a guide.

In addition, some individual components were chosen from these supporting systems and inspected using the particular generic checklist as a guide. When this was the case, certified vendor information was reviewed to determine if the component supplier imposed any special requirements on the installation. If there were requirements or recommendations, a note was made and specifically looked for in the field.

The systems selected for inspection were the starting air system and the air intake and exhaust system. Components inspected were the DCW heat exchanger and the HPCS diesel service water pump.

It was noted that moisture removal in the air start system is accomplished by manual blowdown with the blowdown frequency administratively controlled by operating procedures. The Project has committed to install air dryers by the first refueling outage and this item is tracked on the licensing commitment tracking log (Item LICSAR-00399).

No PFR's were issued as a result of the field inspections of the HPCS diesel components.

3.2.6.2 <u>I&C Component As-Built Inspection</u>

As-built inspection was accomplished by use of a separate checklist for each component of the three groups. Each of the checklists included a list of installation drawings, inspection items and associated data to be compared with data recorded during on-site inspection of the components. The component groups consisted of a flow element, process instruments, and tubing.

Components included in the as-built inspection are the same as those listed in the component review except for HPCS-FT-5 which is to be replaced. The following is a list of components with the type and quantity of documents used in the inspection:

	DOCUMENT TYPE		
COMPONENT	GE Design Spec. Drwgs.	Installation ISO/Detail Dwgs.	Tube Layout Dwgs.
HPCS-FE-7		1	
HPCS-FIS-6	2	1 (SH 1-20)	
HPCS-LS-1A		1	
HPCS-LS-2A		1	
HPCS-DPIS-9	2	1 (SH 1-20)	
HPCS-PS-12	2	1 (SH 1-10)	
Tubing HPCS-LS-1A		2	
Tubing HPCS-LS-2A		2	
Tubing HPCS-FT-5		1 (SH 1-20)	2
Tubing HPCS-DPIS-9		1 (SH-1-20)	3

GE Design specifications and tube layout drawings were the latest revision. Installation isometric/detail drawings were as-built except for HPCS-LS-1A which was "release for construction".

A. Flow Element

The as-built inspection showed that the flow element satisfies design and installation requirements. The only deviation observed was that the upstream and downstream straight pipe runs were less than that specified in the B&R Engineering Criteria Document but meet the ASME Power Test Code requirements referenced in GE design specifications and, therefore, is not considered to be a problem.

No PFR's were written as a result of this walkdown.

B. Process Instruments

The as-built inspection showed that the process instruments satisfy design and installation requirements. The only discrepancies noted relate to missing/incorrect identification tags on HPCS-LS-2A and 2B. These conditions were documented in PFR-HPCS-38.

PFR HPCS-38, classified as an observation, concerned tags that had fallen off two switches. One had been put back on the wrong switch and the other lost. Retagging will be accomplished as part of the Project's Release for Operations program which assures that, prior to turnover to Operations, each system is complete, has functioned properly during test, and reflects the design documentation by part number and description. No further action is considered necessary.

C. Pipe/Tubing

As-built inspection of accessible sections of instrument sensing lines showed that the lines were installed and routed according to construction isometrics and design tube layout drawings. However, in some areas the line slope was not maintained in accordance with the 1/4" per foot criteria specified by B&R. PFR-HPCS-37 was issued to document this condition.

PFR-HPCS-37 was classified as an observation on the basis that this problem had been previously identified and corrective action was already underway. At the time of the review, the project had evaluated approximately 14,000 feet of instrument lines ($\sim$300 lines) for adequate slope and identified 1100 feet ($\sim$8%) as requiring rework. For the HPCS system, four lines each having zero slope for a length of about 10 feet, were identified by B&R for rework. The reverification field inspection confirmed that work on these lines was in progress. No further action is considered necessary.

3.2.6.3 Electrical Component As-Built Inspections

All the electrical components included in the reverification were inspected in the field to determine if they were the type, size, and rating indicated in the design documents. Protective relays for the Circuit Breaker components were inspected to determine that the relay type and settings agreed with the relay setting drawings. The combination motor controllers were inspected to determine that their short circuit and overload protective devices were consistent with the Motor Control Center Data sheet drawings. The cable components were inspected to determine if they were routed, marked, and sized as indicated in the design documents.

- The components inspected were as follows:

Components	Inspection Findings
HPCS-CB-4DG3	None
HPCS-CB-42	None
HPCS-CB-HPCS	None
HPCS-42-4A5B	None
HPCS-42-4A7C	None
HPCS-M-1	HPCS-54 (Observation)
HPCS-M-3	None
HPCS-MO-4	None
HPCS-CBL-3HPCS/0030	None
HPCS-CBL-3HPCS/0080	None
HPCS-CBL-3HPCS/0340	None

- The following documents were reviewed as the basis of the walkdown inspections: the B&R Design Criteria, six GE specifications, two B&R specifications, 20 B&R drawings, and five vendor drawings.

Of the 67 component-checklist items checked, one problem was found. This was an observation regarding a missing ground connector bolt for the two-bolt ground connector for HPCS-M-100 as reported in PFR HPCS-54.

PFR-HPCS-54 was classified as an observation on the basis that it did not impact reactor safety and appeared to be an isolated error. The project has issued a startup problem report to correct this deficiency. No further action is considered necessary.

3.2.6.4 Piping and Support Inspections

Each piping run or support chosen for design reverification was inspected to determine if the 'As-Built' configuration matched the assumptions or details of the design calculation and drawings.

A. Piping Inspections

As-built inspection of piping systems included verification of the following pertinent information:

- o Pipe diameters, lengths, and locations of branch lines or specialty items
- o Valve locations, types, and orientations
- o Support locations, direction of restraint, and clearances
- o Verification of boundary conditions, anchors, nozzles, and penetrations
- o Possible interferences caused by surrounding walls, equipment, piping, etc.

Inspections were conducted for the following piping runs:

M200-2

All as-built checks were satisfactory. No PFR's were issued.

M200-100A

Piping outside containment was inspected. Piping inside the containment wetwell which was added to the original M200-100A pipe model was not inspected because the suppression pool was filled. All piping outside containment was satisfactory and no PFR's were issued.

DE 1738-1

All as-built checks of this piping configuration were satisfactory. No PFR's were issued.

X-73A

Inspection of this piping run resulted in one PFR as follows:

PFR-HPCS-28, classified as an observation, was issued to indicate the presence of a potential interference between the instrument line and a large bore MSRV line. All other as-built checks were satisfactory. Further evaluation revealed the existence of a Project program that would have identified this problem. Since this appeared to be an isolated occurrence and programs were already in place to detect and correct this type of deficiency, the PFR was provided to the Project for information and closed.

B. Pipe Support Inspections

As-built inspection of pipe and component supports included the following checks as applicable to the individual supports:

- Verification of members, welds, anchor bolts, base plates for sizes, types and quantities

- Check of support clearances and direction of action

- Critical dimensions check

- Verification of correct standard component sizes and types for springs, snubbers, clamps, struts, etc.

As-builts of the following component supports were verified to be satisfactory:

HPCS-66
HPCS-901N
HPCS-52
DE-1738-11
B-750-335
Support for HPCS-P-1

One potential finding report (HPCS-21) was issued as a result of the inspection of HPCS-910N.

PFR-HPCS-21 was classified as a finding on the basis that rework of the installation was required to assure that the pipe supports would perform as designed. This PFR reported that two pipe clamps, designed to be in contact with each other, were installed with a 3/16" gap between them. The clamps, as installed, permit motion that could interfere with the operation of the attached pipe snubbers. Evaluation of this PFR by B&R confirmed that this deficiency needs to be corrected. B&R has issued directions to correct this deficiency and inspect all other supports which utilize a similar design where the pipe clamps are required to be in contact. Completion of this reinspection will be tracked under B&R Task No. 5180.

3.3 RESIDUAL HEAT REMOVAL SYSTEM REVERIFICATION RESULTS (Suppression Pool Cooling Mode)

3.3.1 SYSTEM DESCRIPTION

The residual heat removal (RHR) system is capable of operation in a number of modes, one of which is an ECCS function. The RHR system consists of three independent loops, each containing an electrically driven pump, piping, valves, instrumentation and controls. Loops A and B also include heat exchangers cooled by the standby service water system. In the suppression pool cooling mode (SPCM), the RHR system transfers heat from the suppression pool to the atmosphere via the cooling towers on the spray ponds. The suppression pool cooling mode of the RHR system was selected for reverification on the basis that this is the most frequent mode identified for the RHR system in response to containment isolation events. Loop B was selected because it is somewhat more complex than Loop A and includes the capability for operation from the remote shutdown panel.

Figure 3-3 is a simplified flow diagram of Loop B during operation in the suppression pool cooling mode. Under normal conditions, water is withdrawn from the pool through strainers in a 24-inch suction line to the main pump. The pump (RHR-P-2B) is a multistage, deepwell, centrifugal, vertical shaft pump. The mechanical shaft seals are cooled by the pump seal cooler mounted on the pump housing.

When the pump is started, a valve (RHR-FCV-64B) in the minimum flow line opens automatically to assure a minimum flow through the pump. This valve can be closed manually, or it closes automatically when the flow rate in the primary flow path through the heat exchanger reaches about 15 percent of full flow. Nominal pump flow is 7,450 gal/min at a head of 280 feet (121 psid).

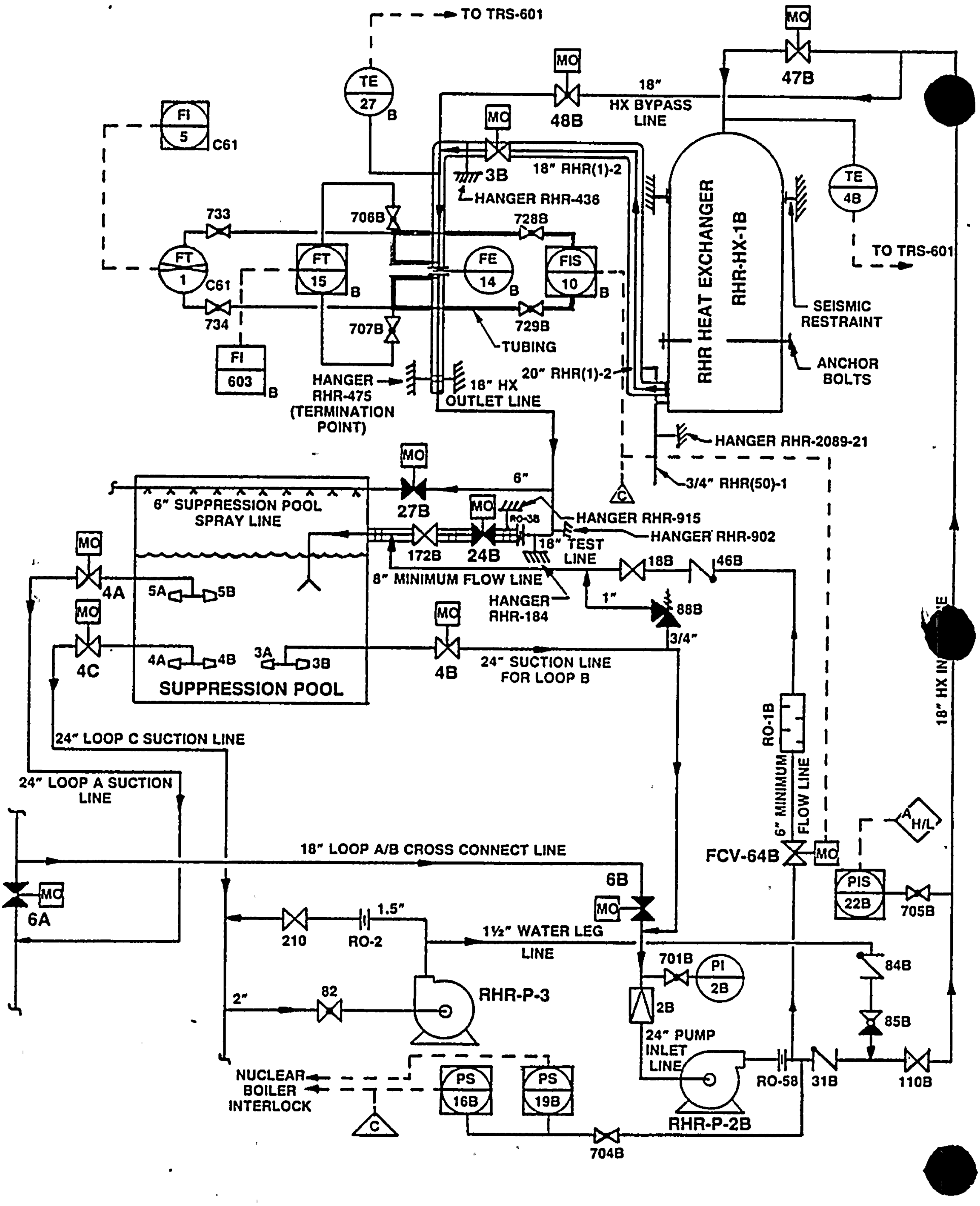

FIGURE 3-3 SCHEMATIC OF THE RHR SYSTEM SUPPRESSION POOL COOLING LOOP B

831070-6A

Water flows from the pump through an 18-inch discharge line to a heat exchanger (RHR-HX-1B). The heat exchanger is a vertically mounted U-tube type. Its capacity is about 7.6 MW (26 Mbtu/h). The actual heat removal rate depends on the positions of the bypass valve (RHR-V-48B), the pool return valve (RHR-V-24B), and on the service water's inlet temperature.

The water leaves the heat exchanger through an 18-inch outlet where the primary flow element measures the total loop flow. The flow rate is displayed both in the main control room (RHR-FI-603) and the remote shutdown room (RHR-FI-5). The nominal flow rate of suppression pool water through the shell side of the heat exchanger is 7,450 gal/min. The nominal flow rate of service water through the tube side is 7,400 gal/min. After leaving the heat exchanger, the pool water returns to the suppression pool through a spray ring header or the pool return line.

Generally, all valves, orifices, piping, strainers, pumps, instrumentation and electrical components in Loop B required for the suppression pool cooling mode of operation were included in the scope of the reverification activity. This includes the waterleg pump (RHR-P-3) with strainers (RHR-ST-4A, RHR-ST-4B), valves (RHR-V-4C, RHR-V-210, RHR-V-82), reducing orifice (RHR-RO-2), check valve (RHR-V-84B), stop check valve (RHR-V-85B) and all piping associated with these components. Also included was the section of 24-inch suction line of Loop C from the inlet strainers to the junction where the 2-inch suction line of waterleg pump RHR-P-3 branches off. In addition, the 18-inch heat exchanger bypass line was included with the bypass valve RHR-V-48B as well as the 6-inch suppression pool spray sparger with spray injection valve RHR-V-27B.

3.3.2 SUMMARY OF RHR SYSTEM REVIEW

The review of the RHR system design included a multidisciplined evaluation of eight system design areas, detailed component design reviews covering 30 mechanical, electrical and instrumentation and control components, as-built field inspections of each of the components reviewed and a detailed review of the RHR heat exchanger lateral restraints and anchor bolts.

The review will also include detailed reverification of several final as-built RHR pipe and hanger stress analyses. The independent review results of the final as-built stress analysis was not complete at the time of this report and will be published in an addendum.

The design was evaluated by design review utilizing formal checklists and alternate calculation when appropriate. Approximately 869 checklist items were addressed and 18 alternate calculations were performed. About 667 design related documents were used as part of the RHR system review.

Table 3-5 identifies the areas reviewed, the PFR's issued in each area, and their classification. A total of 31 PFR's were issued during the RHR review, four of which were determined to be invalid. Five of the 27 valid PFR's were classified as findings and the remaining 22 were classified as observations. It should be noted that many of the areas reviewed were satisfactory and the number of valid PFR's is small considering the depth and scope of the review and the low threshold for issuing a PFR.

Two of the findings, RHR-24 and RHR-33, were construction deficiencies that were determined to be reportable under 10CFR50.55(e). They did not involve design or design process deficiencies. Corrective action to resolve issues raised by these findings involves a comprehensive reevaluation and, when appropriate, re-inspection of all Class I mechanical equipment installations. This program is described in more detail in Section 3.3.5 under RHR-24 and in the overall summary of results, Section 1.2.

Based on the sampling review it is concluded that the RHR design is adequate, subject to completion of corrective action identified in this report. Overall conclusions regarding WNP-2 design and design process are discussed in Section 1.2 and 1.3.

3.3.3 SYSTEM LEVEL REVIEW

The system review was intended to examine the capability of the RHR

TABLE 3-5

SUMMARY OF POTENTIAL FINDING REPORTS (RHR)

Review Area	Number of Review Questions	Number of Documents Reviewed	PFR's Issued	Classification		
				Not Valid	Observation	Finding
3.3.3 SYSTEMS LEVEL REVIEW						
3.3.3.1 System Functional Requirements						
A. Thermal/hydraulic	6	11	None			
B. HVAC	1	2	None			
C. I&C	1	47	RHR-2		X	
			RHR-9		X	
D. Electrical	1	24	RHR-10			X
			RHR-11		X	
			RHR-12		X	
			RHR-15	X		
3.3.3.2 System Codes and Standards	2	10	None			
3.3.3.3 System Separation Requirements	7	19	RHR-8		X	
3.3.3.4 System Redundancy	8	71	RHR-6			X
			RHR-7		X	
3.3.3.5 Containment Isolation Requirements	4	48	RHR-3		X	
3.3.3.6 System Corrosion Requirements	2	9	None			
3.3.3.7 System ALARA Requirements	3	23	None			
3.3.3.8 System Layout and Arrangement	3	13	None			
3.3.4 COMPONENT LEVEL REVIEW						
3.3.4.1 Mechanical Components						
A. Valves						
- RHR-V-3B	16	48	None			
- RHR-V-24B	16	48	None			
- RHR-FCV-64B	28	6	RHR-13		X	
B. Pumps (RHR-P-2B)	9	6	None			
C. Restricting Orifices (RHR-RO-1B,-3B,-5B)	3	3	RHR-20		X	
			RHR-21		X	
D. Heat Exchangers (RHR-HX-1B)	10	12	None			
3.3.4.2 Instrumentation and Control Components						
A. Flow Element (RHR-FE-14B)	18	6	RHR-14		X	
			RHR-17		X	
B. Process Instrumentation						
- RHR-PS-16B	30	8	None			
- RHR-FIS-10B	30	5	None			
- RHR-FT-1	30	9	None			
- RHR-FI-5	30	7	RHR-18		X	
C. Instrument Tubing	47	7	None			
3.3.4.3 Electrical Components						
A. Circuit Breakers and Motor Controllers		43	RHR-30		X	
			RHR-35		X	
- RHR-CB-2B	40					
- RHR-42-3BA3D	40					
- RHR-42-8BA4B	40					
- RHR-42-8BB5D	40					

TABLE 3-5 (Continued)

Review Area	Number of Review Questions	Number of Documents Reviewed	PFR's Issued	Classification Not Valid	Observation	...nding
B. Motors and Motor Operators		50				
RHR-M-2B	26		None			
RHR-MO-3B	26		None			
RHR-MO-24B	26		RHR-19	X		
RHR-MO-64B	26		None			
C. Electrical Cable		35				
.1 Power						
2SMB/0050	35		RHR-1		X	
2M8BA/0020	35		RHR-16		X	
			RHR-22		X	
.2 Associated						
BP8A2/9129	1		None			
BP8A2/9170	1		None			
BP8A2/9171	1		None			
BSM8/9052	1		None			
BSM8/9053	1		None			
3.3.5 PIPE AND SUPPORTS						
3.3.5.1 Pipe and Support Design Review		To be provided in Pipe and Support Addendum				
3.3.5.2 Equipment Support (RHR-HX-1B)						
A. Lateral Restraint		8				
Design Data Transmittal	7		RHR-26		X	
Design Loads Checks			RHR-29		X	
Materials/Geometry			RHR-28		X	
Support Reactions			RHR-27	X		
(Alternate Calculation)	15					
Allowable Stress			None			
Member Stress			None			
(Alternate Calculation)						
B. Lower Anchor		9				
Design Data Transmittal	7		RHR-24			X
Design Loads Check			RHR-25			X
Materials/Geometry			RHR-23		X	
Allowable Stress	15		None			
Member Stress			None			
3.3.6 FIELD INSPECTIONS						
3.3.6.1 Mechanical						
RHR-P-2B	9	2	None			
RHR-HX-1B	5	3	None			
RHR-V-3B	7	2	None			
RHR-V-24B	7	2	None			
RHR-RO-1B	5	2	None			
RHR-RO-3B	5	2	None			
RHR-FCV-64B	6	3	None			
3.3.6.2 Inst. and Controls						
RHR-FE-14B	7	4	None			
RHR-PS-16B	12	7	None			
RHR-FIS-10B	12	4	None			
RHR-FI-1	12	5	None			
RHR-FI-5	12	6	None			
FE-14B Tubing	13	15	None			

TABLE 3-5 (Continued)

Review Area	Number of Review Questions	Number of Documents Reviewed	PFR's Issued	Classification		
				Not Valid	Observation	Finding
3.3.6.3 Electrical						
RHR-CB-P2B	8	4	None			
RHR-42-8BA3D	8	2				
RHR-42-8BA4B	8	2	RHR-31	X		
RHR-42-8BA5B	8	2				
RHR-M-2B	3	2	None			
RHR-MO-3B	3	1	None			
RHR-MO-24B	3	1	None			
RHR-MO-64B	3	1	None			
RHR-CBL-2SM8/0050	6	2	None			
RHR-CBL-2M8B4/0020	6	2	None			
3.3.6.4 Engineering Mechanics						
RHR-HX-1B	13	4	RHR-33			X
TOTALS	869	667	31	4	22	5

system to function effectively as an integrated entity, as opposed to examining individual components. The review was conducted in accordance with the RHR system Design Reverification Plan(10).

During the review, emphasis was placed on the design features essential to the primary function of RHR system Loop B suppression pool cooling mode. The design, reliability and interface requirements of the heat exchanger, piping, pumps, motors, control valves, instrumentation, and other associated features critical to the operation of the RHR system were reviewed.

3.3.3.1 System Functional Requirements

The RHR System functional requirements were reviewed in the following areas: (A) thermal/hydraulic requirements, (B) heating, ventilation, and air conditioning system requirements, (C) instrumentation and control system requirements and (D) electrical system requirements.

A. Thermal/Hydraulic Requirements

As part of the system review, selected functional requirements were reviewed to assure that the RHR system will effectively limit the suppression pool's temperature during a variety of design basis events. The functional requirements that were evaluated are specified in General Electric's process diagram. Those requirements cover:

1. flow capability
2. thermal capacity
3. cavitation from pump runout
4. testing capability at full flow
5. minimum pump flow
6. potential for possible waterhammer.

A total of 11 design documents were examined during the system functional requirement reverification investigation. These included five Burns and

Roe calculations, various test data sheets and the General Electric containment analysis as documented in Section 6.2 of the FSAR, which includes calculation of suppression pool temperature at various abnormal plant conditions. In addition, a Stone and Webster suppression pool temperature analysis report was reviewed.

This review confirmed that the design documents reflect the design requirements and that the design meets the functional requirements for the system in the six areas listed above.

No PFR's were issued in this area of review.

B. HVAC System Requirements

To determine if design information transfer was accomplished for the Reactor Building HVAC system design, a review was made to assure that Burns and Roe had utilized the RHR pump motor heat output in designing the HVAC. General Electric's design specifications point out the necessity for this heat load to be carried by the local HVAC system. Burns and Roe's design calculation for the HVAC system and its design criteria document were examined and found to adequately incorporate the additional thermal load.

No PFR's were issued as a result of this review.

C. Instrumentation and Control System Requirements

The system instrumentation and control functional requirements were originally defined in General Electric's system design specification "Residual Heat Removal System, 22A2817" and were then developed in the General Electric functional control diagrams, elementary diagrams and connection diagrams. These diagrams were then converted by Burns and Roe into detailed design drawings which in turn gave rise to specific construction and installation documentation. This design reverification activity checked to determine if the information from General Electric's requirements documents was properly incorporated and implemented into Burns and Roe's electrical wiring diagrams. Additionally, component reviews checked that these requirements are further transmitted into construction and installation documents. Forty-seven documents were reviewed including the requirements document plus 46 drawings. The drawings that were reviewed included nine functional control diagrams, 23 electrical drawings, three of General Electric's control drawings and 11 of Burns and Roe's electrical wiring diagrams. It was determined that the system's components could be effectively controlled by the operator, and that all of the system's required interlocks had been provided. PFR-RHR-2 and PFR-RHR-9, were issued as a result of this review. They were both classified as observations and resolved as discussed below.

PFR-RHR-2, classified as an observation, noted discrepancies among GE and B&R drawings for five valves which had been installed as non-throttling types with seal-in circuits per the GE elementaries. Evaluation of the PFR disclosed that the seal-in circuit for Valve 48B, which is supposed to throttle, resulted from a B&R drafting error (Valve 48A in Loop A was correct on the drawings and correctly installed). The safety function of Valves 48A and B is to open upon receipt of a LOCA signal; throttleability has no bearing on that action. Therefore, no change would be required for the valve to accomplish its safety function. Nonetheless WNP-2 has elected to remove the seal-in circuit from Valve 48B (PED 218-E-A357). For Valves 52A and B and 87A and B, the discrepancy is between the GE elementary and functional control drawings; the former are controlling and the B&R drawings are consistent with them. The 52 valves should not throttle so their seal-in circuits will remain. On the other hand, Valves 87A and B should throttle so the seal-in circuits will be removed. These two sets of valves are used in the steam condensing mode and have no safety functions. GE has been requested to correct the drawing discrepancies. No further action is considered necessary.

PFR-RHR-9, classified as an observation, reported a discrepancy between GEK71336 and FCD-731-E999, Sheet 5, in that the former calls for partial opening of the valve whereas the elementary diagram shows seal-in circuits, for both opening and closing, which preclude partial valve positioning. Upon inquiry, GE stated that their elementary drawings are controlling documents. Operations also confirmed that there is no need to throttle RHR-V-3B; therefore, the seal-in jumpers indicated on the Burns and Roe EWD's for the valve are correct. GE was requested to update the FCD and the PFR was closed.

D. Electrical System Requirements

The electrical area review included an evaluation of the system's power supply to provide assurance that critical components' demand for power will be satisfied when called upon for operation. The switchgear and motor control center designs were evaluated and investigated for loading, voltage drop and short circuit rating. This included review of Burns and Roe calculations in these areas to check for accurate incorporation of vendor information into them, review of the calculation results, and review of the system electrical design for compliance with those results. Alternate calculations were performed to verify the design in these areas. A total of 24 documents were utilized, consisting of the Burns and Roe Engineering Criteria Document, one technical memorandum, 15 drawings, and seven Burns and Roe calculations. In addition, Burns and Roe E528 series drawings were used as the source for the motor full load current (nameplate).

Except for the finding on the design of the SM7 and 8 undervoltage trip relays (RHR-10) described below, the electrical system is a well designed system. The buses are sized for the appropriate loads and the short circuit currents. Voltages, as calculated, will not drop below required levels during various operating modes.

PFR-RHR-10 was identified as a finding, reportable under the provisions of 10CFR50.55(e). On a degraded (87.5 percent of rated) voltage condition in critical buses SM 7 and 8 which supply the ESF loads, second level undervoltage (UV) relays trip the source breakers (whether normal or backup) and initiate load shedding. These relays self-reset following closure of the alternate source breaker and normal voltage on the critical bus. However, due to design error, a seal-in circuit, with a manual reset following the degraded voltage conditions, was applied to these UV relays. This arrangement would prevent successful automatic transfer to the backup source and prevent the ESF load breakers from reclosing. (See 50.55(e) Report 240 for further details.) B&R issued PED-218-E-4618 which corrects the problems. It is also noted that during the evaluation of this PFR, Burns and Roe presented convincing evidence that their engineers had discovered this design error simultaneous to and completely independent of the design reverification. Since SM-7 and 8 are the only Burns and Roe designed buses with second level undervoltage trips and no other generic issues were identified, the FRC concluded that no other action is required beyond completion of the plant modification.

PFR-RHR-11 and PFR-RHR-12 were issued which relate to updating of electrical calculations. Both were classified as observations and resolved as discussed below.

PFR-RHR-11, classified as an observation, indicated that calculation 2.02.07 was in error for not showing loads for MC-7BA and 7BB. This calculation had not been updated to its final configuration. The subfeed calculations (voltage drop and feeder sizing) were correct and there is no plant design impact. As a result of the generic issue raised regarding calculation updating (discussed in Sections 3.3.4.3.c and 1.2), B&R is updating electrical calculations on a priority basis. This observation was given to Burns and Roe for information and closed.

PFR-RHR-12, classified as an observation, noted that the breaker feeding MC-7BB was set to trip at 300 Amperes whereas the preliminary load calculation (2.02.07, Rev. 2) indicated a 313 Ampere load. The calculation was not up to date, and the present load current is only 228 Amperes. Since the calculation had not been finalized, the problem was simply identified as an observation to Burns and Roe and closed. As noted in PFR-RHR-11, the electrical calculations are being updated on a priority basis.

3.3.3.2 System Codes and Standards

Code classifications for the mechanical aspects of the RHR system were reviewed to assure that the system design meets all specified code requirements. Ten documents were examined, including General Electric design specifications and Burns and Roe Design Criteria Document and drawings. The review showed that code classifications correctly reflect General Electric specifications. Code breaks are clearly documented on Burns and Roe flow diagrams, and all of the isometric diagrams reviewed contain the appropriate code information.

No potential finding reports were issued.

Code and standard requirements for the instrumentation and control and electrical areas are addressed in the component review sections.

3.3.3.3 System Separation Requirements

The mechanical area system separation is straightforward. The three RHR pumps are housed in individual concrete rooms, separated by watertight doors. Similarly, the two heat exchangers are in individual rooms, closed off with radiation-attenuating doors. Piping for the three loops--A, B and C--is routed in three segmented areas around the primary containment, and the suction lines are in separate areas in the suppression pool. It was determined that the system's mechanical separation requirements have been met.

No potential finding reports were issued in this area.

The instrumentation and control separation requirements were contained in three General Electric Design Specifications and the Burns and Roe Design

Criteria Document, Section D. These requirements were verified by design review of two rack drawings and two layout drawings which confirmed the Division II cable and tubing separation from Division I was met. The review of these eight documents disclosed no discrepancies.

No potential finding reports were written.

The RHR system's electric power supplies were evaluated to ensure that redundant components are physically separated and do not receive power from the same bus. General Electric and Burns and Roe established the requirements based on Regulatory Guides and IEEE standards. Burns and Roe designed the electrical system based on those requirements.

Eleven documents were examined, including General Electric specifications, Burns and Roe Design Criteria Document, several IEEE standards, and Burns and Roe cable tray drawings and one-line diagrams resulting in issuance of PFR-RHR-8.

PFR-RHR-8, classified as an observation, noted an error in drawing E503-8, Rev. 23, which indicates that RHR pump 3 is non-Class 1E. Investigation disclosed that this was a drafting error and that, in fact, the procurement and subsequent installation were to Class 1E requirements. PED 218-E-A671 was issued by the Project to correct the error.

3.3.3.4 System Redundancy Features

Within the scope of a single RHR loop, redundancy is provided for some sensing equipment and for electric power supplies. A single loop by itself is not intended to incorporate functional redundancy. Therefore, system redundancy was not examined in the mechanical area.

The instrumentation and control redundancy requirements were contained in three General Electric documents: 22A2817, Design Specification for Residual Heat Removal System; 22A2817AY, Design Specification Data Sheet; and 22A3085, Design Specification for Remote Shutdown System. A total of

56 documents were examined, the three documents identified above and 53 drawings. The 53 drawings included nine functional control diagrams, 23 electrical diagrams and two General Electric piping and instrumentation diagrams, two Burns and Roe flow diagrams and 17 Burns and Roe electrical wiring diagrams.

Two PFR's were issued as a result of this review. One noted a missing control function for valve RHR-FCV-64B on the remote shutdown panel. The other reported an inconsistency in the GE specification for the remote shutdown panel. All other redundant controls and indications were provided as required in the control room and on the remote shutdown panel.

PFR-RHR-6 was classified as a finding on the basis that a modification was required to assure that the system would perform as designed. This PFR noted that valve RHR-FCV-64B was listed in the GE specification as controlled from the remote shutdown panel but was not shown on the GE functional control diagrams or elementaries and not included on the panel provided by GE. Review by GE indicated that the discrepancy was due to an omission from the elementary diagram which propagated into other documents. It was not intended to delete this function from the remote shutdown panel. GE has issued a modification to the remote shutdown panel to incorporate this control function (FDDR-KKI-1082). Completion of this modification is being tracked via the WNP-2 Electrical FDDR status report. Other RHR B control functions were incorporated as required and no further action is considered necessary.

PFR-RHR-7, classified as an observation, addressed an apparent inconsistency in the GE remote shutdown design specification in that it states that the remote shutdown panel design should not create additional common points of vulnerability to fire or other hazard. This was considered to be an unattainable design goal with a single remote shutdown panel since the existence of the remote shutdown panel itself creates a "common" area. An exposure fire is the only hazard for the location of the remote shutdown panel, and it is adequately addressed in the FSAR Appendix R evaluation. Furthermore, the Project has committed to providing a redundant remote shutdown system by the first refueling.

The RHR-SPCM electrical power supply system's redundancy was reviewed to ensure that there are alternate (redundant) sources of power to the devices and that these alternate sources would automatically respond to maintain power to the devices when called on under normal and abnormal plant conditions. This was done by reviewing the one-line for alternate power sources and the electrical elementaries for the circuit breakers connecting the alternate power supplies. General Electric was responsible for establishing the requirements and B&R for designing the system.

Fourteen documents were examined during the review, two General Electric design specifications and 12 Burns and Roe drawings. Burns and Roe one-line diagrams showed that the power to the 4.16 KV Class 1E switchgear is supplied by the main station generator, with alternate sources being the 230 KV startup source, the 115 KV backup source and the onsite diesel generators. Burns and Roe's elementary diagrams further showed that the switchgear is properly transferred to the alternate sources upon loss of power.

No PFR's were issued related to this portion of the electrical system redundancy review.

3.3.3.5 Containment Isolation Requirements

In the mechanical area, the General Electric design specifications for containment isolation were found to be accurately reflected in the Burns and Roe flow diagram. Four documents were examined, including General Electric's system design specification 22A2817, piping and instrumentation diagram for the RHR system and process diagram and the Burns and Roe flow diagram. All of the required isolation valves were identified on the Burns and Roe diagram.

No potential finding reports were issued in this area.

The containment isolation requirements for instrumentation and control are listed in General Electric design specifications. Forty-four documents were examined to verify that the containment isolation signals initiate the proper responses and are properly displayed in the control room. One PFR (RHR-3) was issued.

PFR-RHR-3, classified as an observation, noted that the limit switch charts on B&R electrical wiring diagrams for several RHR isolation valves indicate that the contacts providing position indication to Technical Data Acquisition System (TDAS) actuate before the valve is either full open or full closed. Investigation of the PFR revealed that there is no hardware error and the controlling document is correct. The electrical wiring diagrams are not controlling design documents as presumed in the PFR. A program is in place at the WNP-2 Project to identify and revise those diagrams with misleading limit switch charts. Hence the information in the PFR was provided to the Project as an observation and the matter was closed.

3.3.3.6 System Corrosion Requirements

In the mechanical area, water purity requirements and corrosion allowances were reviewed. Nine documents were examined, including several General Electric specifications and the corresponding Burns and Roe design criteria. One Burns and Roe calculation was also reviewed. It was determined that the design documents accurately reflect the design requirements.

No potential finding reports were issued.

3.3.3.7 System ALARA Requirements

Radiation exposure of plant personnel should be as low as reasonably achievable both during normal operation and during shutdown. General Electric's specification clearly states that the arrangement of the system inside and outside containment must minimize exposure during maintenance. Fifteen location and radiation zone maps and drawings were examined and it was determined that the system layout satisfies applicable ALARA requirements.

No potential finding reports were issued.

The instrumentation and control ALARA requirements are contained in the Burns and Roe Design Criteria Document, Section G. The reverification investigation consisted of reviewing this document and three drawings, two general arrangement diagrams, plus one electrical layout diagram, to compare the location of instrumentation with other radiation zone locations in the reactor building. It was shown in this investigation that the present location of instrumentation is within the lowest level zone practically achievable.

No potential finding reports were issued.

3.3.3.8 System Layout and Arrangement Requirements

In the mechanical area, the review focused on the possibility of flooding in the pump rooms of the emergency core cooling system. To evaluate this area, nine documents were examined, including several location drawings and the flow diagram for the radioactive floor drain system. The review showed that flooding from a single internal source will not affect more than one pump room.

No potential finding reports were issued in this area.

In the instrumentation and control area, layout requirements for instrument rack H22-P021 are contained in the Burns and Roe Design Criteria Document. Seven documents were examined: Burns and Roe's Design Criteria Document, three general arrangement drawings, and three layout drawings. It was determined that maintenance on this instrument rack can be done with sufficient ease.

No potential finding reports were issued.

In the electrical area, layout and arrangement have been investigated only insofar as they relate to the issue of electrical separation and the results have been reported under that particular section.

3.3.4 COMPONENT LEVEL REVIEW

To further verify the accuracy of the RHR design, the 30 components listed in Table 3-6 were reviewed. The selection of these components was based on examining key design features and on assuring that design requirements were properly transmitted across companies, organizations, and discipline interfaces.

3.3.4.1 Mechanical Components

A. Valves

RHR-V-3B is a carbon steel, keylock operated gate valve in the 18 inch heat exchanger outlet line. It is a seismic Category I, ASME Code Class 2 valve, with a design pressure of 500 psig, manufactured by Velan Company. This valve can also be operated from the remote shutdown panel.

The review involved the examination of 48 documents, including the General Electric specifications, process data sheets and process diagram. Various vendor documents, contract specifications, and Burns and Roe pressure drop calculations and flow diagrams were also examined. In addition to basic functional requirements, the ASME code requirements and materials compatibility requirements were also addressed.

Gate valve RHR-V-3B was determined to be adequate for its function, and the documents reviewed properly reflected all the design requirements.

No potential finding reports were issued.

TABLE 3.6

RHR COMPONENTS SELECTED FOR REVIEW

Mechanical Components

Valves

RHR-V-3B	Gate valve
RHR-V-24B	Globe valve
RHR-FCV-64B	Flow control valve (reviewed by I&C discipline)

Pumps

RHR-P-2B	Residual heat removal loop B pump

Restricting Orifices

RHR-RO-1B	Minimum pump flow orifice
RHR-RO-3B	Pool return line orifice
RHR-RO-5B	Trim orifice

Heat Exchangers

RHR-HX-1B	Residual heat removal heat exchanger in loop B

Instrumentation and Control Components

Flow Elements

RHR-FE-14B	Measures heat exchanger outlet flow in loop B

Process Instruments

RHR-PS-16B	Pressure switch, permissive signal to automatic depressurization system
RHR-FIS-10B	Flow switch, close signal to RHR-FCV-64B
RHR-FI-5	Flow indicator for loop B, on remote shutdown panel
RHR-FT-1	Primary side flow transmitter for RHR-HX-1B

Instrument Tubing

Sensing line from flow element 14B to flow switch 10B
Sensing line from flow element 14B to flow transmitters 15B and 1.

Electrical Components

Circuit Breakers and Motor Controllers

RHR-CB-2B	Circuit breaker for motor 2B
RHR-42-3BA3D	Controller for motor 64B
RHR-42-8BA4B	Controller for motor 24B
RHR-42-8BB5D	Controller for motor 3B

TABLE 3.6 (Continued)

RHR COMPONENTS SELECTED FOR REVIEW

Motors and Motor Operators

RHR-M-2B	Motor for pump 2B
RHR-MO-3B	Electric operator for valve 3B
RHR-MO-24B	Electric operator for valve 24B
RHR-MO-64B	Electric operator for valve 64B

Power Cables

RHR-CBL-2SM8/0050	Main motor power cable
RHR-CBL-2M8BA/0020	RHR-MO-4B power cable

Associated (Control) Cables

RHR-CBL-BP8A2/9129	RHR-M-2B heater control cable
RHR-CBL-BP8A2/9170	RHR-M-2B heater control cable
RHR-CBL-BP8A2/9171	RHR-M-2B heater control cable
RHR-CBL-BSM8/9052	RHR-CB-RHR-2B alarm cable
RHR-CBL-BSM8/9053	Loop B data logging cable

RHR-V-24B, manufactured by Anchor Darling Company, is a carbon-steel globe valve for throttling service. It can be used to control the flow through Loop B in either the test or the suppression pool cooling mode. This valve is the last motor-activated valve in the 18-inch pool return line. As such, it fulfills a containment isolation function and its position is displayed on the isolation valve panel. This valve is also operable from the remote shutdown panel. Its design pressure is 500 psig and it is Seismic Category I and ASME Code Class 2.

Essentially the same documents were examined for this valve as were examined for gate valve RHR-V-3B, except that the vendor documents were from different companies. The valve was determined to be properly designed.

No potential finding reports were issued.

RHR-FCV-64B, supplied by Fisher Controls, is a 3-inch flow control globe valve in the minimum flow line for RHR-P-2B. The valve was selected to provide a review of design information transfer from General Electric to Burns and Roe and subsequently to the valve vendor, Fisher Controls. The review was performed by the instrument and control discipline with particular focus on the automatic control loop functions of the valve.

To evaluate the flow control valve, six documents were examined. They were a valve coefficient calculation, the General Electric System Design Specification and data sheet, the General Electric Specification for Pressure Integrity of Piping and Parts, a Burns and Roe calculation, and the contract specification prepared by Burns and Roe.

PFR-RHR-13, classified as an observation, reported a discrepancy between the GE and B&R specifications for the maximum operating time for valves RHR-V-64A, B and C. The operator had been changed from pneumatic to electric motor and the corresponding specification had not been updated. Further review of project change documents confirmed that this change had been appropriately reviewed and approved by GE. Since the installation is correct and the basis for the change adequately documented in the engineering record, the inconsistency between the GE and B&R specification was considered to be a minor documentation error. B&R has initiated revisions to the affected documents. No further action is considered necessary.

B. Pumps

RHR-P-2B

General Electric supplied pump RHR-P-2B. The pump was manufactured by Ingersoll Rand.

Six documents were examined to verify the adequacy of the pump's design. These were the General Electric process diagram, which summarizes the pump's flow and head requirements for all modes of RHR operation, and the General Electric low-pressure coolant injection system specification data sheet which provides the design flow and head requirements for pump 2B. Also reviewed were the General Electric purchase specification, purchase data sheet and purchase order.

The review showed that the pump design complies with all functional, material and ASME code requirements.

No potential finding reports were issued.

C. Restricting Orifices

RHR-RO-1B, -3B, -5B

The design of restricting orifices was examined because of a known cavitation problem with the orifice in the RHR pump's minimum flow line (RHR-RO-1B). Two additional orifices, RHR-RO-3B and RHR-RO-5B, were examined for possible cavitation. Three Burns and Roe calculations were reviewed and four alternative calculations were performed during this review.

As a result of the review, two PFR's (RHR-20 and 21) were issued. Both were classified as observations and resolved as described below.

PFR's RHR-20 and 21 observed that no cavitation checks had been performed in the design calculations for two different orifices in the RHR system. Prior to the design reverification review, cavitation was detected during system tests and the offending orifices had been replaced. Since actual orifice performance is checked by testing, the absence of a calculational cavitation check was not considered a major design deficiency; however, calculational checks could minimize testing problems. Additionally, two RHR orifices were mislabeled in the calculation. Although the tag numbers referenced in the calculation do not represent the as-built plant conditions, they are consistent with the provided sketches and need not be changed. These PFR's were provided to the WNP-2 Project for information and the PFR's were closed.

D. Heat Exchangers

RHR-HX-1B

In the suppression pool cooling mode, the heat exchanger is a major component of the RHR system. Therefore, the heat exchanger design was thoroughly reviewed.

Alternative calculations were performed to evaluate the heat transfer coefficient, outlet water temperature and heat transfer capability of the heat exchanger, and to check the hydraulic pressure drop. In addition, 12 documents were reviewed, including General Electric's specifications, the heat exchanger's drawing and process data sheet, as well as other design documents. The review covered tube vibration, material selection and codes and standards. The documents reviewed accurately reflect the design requirements.

No potential finding reports were issued in this area of review.

3.3.4.2 Instrumentation and Control Components

A. Flow Element

RHR-FE-14B

Flow element RHR-FE-14B is a simple orifice plate used to measure the outlet flow from the RHR heat exchanger in Loop B. It provides a differential pressure signal to flow transmitters RHR-FT-1 and 15B and to flow switch RHR-FIS-10B. It was specified and supplied by General Electric. Instrumentation tubing from the flow element was installed by Johnson Controls.

Six documents were examined during the review, including the General Electric specification data sheets, the Burns and Roe Design Criteria Document, Section G, the flow diagram, the purchase specifications, a vendor calibration curve and the construction installation drawing. Two PFR's (RHR-14 and RHR-17) were issued from these reviews. Both were classified as observations and resolved as follows:

PFR-RHR-14, classified as an observation, described a discrepancy between the GE Instrument Data Sheet, the as-installed instrument model number, and the setpoint of Switch FIS-10B. The suitability of the installed instrument (Barton Model 289A) was evaluated and confirmed by GE and the documentation and setpoint discrepancies corrected. This PFR was closed on the basis that the installation is correct and the affected documents were being revised. However, it was noted that several similar inconsistencies in the GE Instrument Data Sheets had been encountered during the HPCS system review (see Section 3.2.4.6, PFR-HPCS-35, for trend evaluation).

PFR-RHR-17, classified as an observation, noted that flow transmitters FT-1 and FT-15B share a common impulse line in conflict with Drawing M521. Evaluation of the PFR indicated that this deficiency had been previously identified on a Startup Problem Report (SPR-M-226) and B&R had issued PED 215-I-M514 to correct Flow Diagram M521, Rev. 38. Installation direction, given to the installing contractor per PED 220-I-0271, reflects the as-built conditions. Since this item was identified by the WNP-2 Project prior to the reverification review and no design process deficiencies were detected, this PFR might have legitimately been declared invalid. However, since the drawing revision had not been completed, it was retained as an observation and closed.

B Process Instrumentation

Four types of instruments were reviewed: a pressure switch, a flow indicating switch, a flow transmitter and a board-mounted flow indicator. Each of these was supplied by General Electric and evaluated by comparing General Electric design requirements with vendor information and installation drawings.

RHR-PS-16B

Pressure switch RHR-PS-16B provides a permissive signal to the automatic depressurization system. It was installed by General Electric.

Eight documents were reviewed: one General Electric instrument data sheet, and Burns and Roe Design Criteria Document Section G, the vendor and installation drawings, two vendor-rack diagrams, two Burns and Roe wiring diagrams, and one Contract 220 drawing. It was determined that the design requirements and guidelines for the pressure switch have been met.

No potential finding reports were issued.

RHR-FIS-10B

Flow indicating switch RHR-FIS-10B provides a CLOSE signal to flow control valve RHR-FCV-64B, which controls the flow to the main pump (RHR-P-2B) to protect it from overheating. The flow indicating switch was installed by General Electric.

Five documents were examined as part of this review. They are: the instrument data sheet, the Burns and Roe Design Criteria, two vendor information documents, and the instrument rack connection diagram.

No potential finding reports were issued.

RHR-FT-1

Flow transmitter 1 provides an independent indication to the remote shutdown panel as the flow through Loop B. It was field mounted by the contractor. The information transfer from General Electric, through Burns and Roe to Johnson Controls, the 220 contractor, was examined.

Nine documents were examined: the design specifications, the instrument data sheet, and Burns and Roe Design Criteria Document, three vendor information documents, the installation contract, a layout drawing, and a product quality certificate.

No potential finding reports were issued.

RHR-FI-5

Flow indicator RHR-FI-5 is the Loop B flow indicator for the remote shutdown panel. This indicator was specified, furnished, and mounted by General Electric.

Seven documents were reviewed: the General Electric design specifications and instrument data sheet, Burns and Roe Design Criteria Document, three vendor information documents, and the Burns and Roe connection wiring diagram. The review produced one PFR (RHR-18) as follows.

PFR-RHR-18, classified as an observation, reported a discrepancy between the flow range of the installed instrument and the GE Instrument Data Sheet. Further review confirmed that the correct instrument is installed and GE has initiated revision of the affected documents. Since the installed instrument is correct and the documentation error is being corrected, no further action is necessary for this PFR.

C. Instrument Tubing

Two sensing lines from flow element RHR-FE-14B to flow switch RHR-FIS-10B and to flow transmitters RHR-FT-15B and 1 were selected for review. Seven documents were examined as part of the review. These include the General Electric Design Specifications, Process Instrumentation and Pressure Integrity of Piping and Pressure Parts and Burns and Roe Design Criteria Document, Section G for instrumentation and controls. Four implementing documents were also examined: Construction Contract 220 Instrumentation and Control Installation, Burns and Roe drawings M-619 and M-706 and Johnson Controls drawing D220-0090-H22-P021. This review noted that instrument line slopes were a problem, but since the generic issue was already being addressed by the Project and was identified by PFR-HPCS-37, a separate Potential Finding Report was not issued in the RHR review on this topic.

After the complete review, it was determined that all design requirements and guidelines were met.

No potential finding reports were issued from this review.

3.3.4.3 Electrical Components

A. Circuit Breakers and Motor Controllers

Circuit breaker 2B (for RHR-M-2B) was specified by Burns and Roe and designed by Westinghouse. The three motor controllers (RHR-42-8BA3D for RHR-MO-64B, RHR-42-8BA4B for RHR-MO-24B, and RHR-42-8BB5D for RHR-MO-3B) examined were specified and procured by Burns and Roe and were supplied by ITE.

Forty-three documents were examined during the review: two prepurchased equipment contracts, 12 design calculations, 18 drawings, seven IEEE standards, the Burns and Roe Design Criteria Document, one Burns and Roe technical memorandum and two Supply System documents. One area of particular focus in the review was seismic and environmental qualification of this equipment. Setpoints and separation were also examined closely. In addition to reviewing documents, various alternate calculations were performed to demonstrate that the devices would function when called on in different modes of plant operation under both normal and abnormal conditions.

No potential finding reports were issued on circuit breaker 2B.

Two potential finding reports (RHR-30 and 35) were issued on the motor controllers.

PFR-RHR-30, classified as an observation, noted that when the off-site 230 kV line is at maximum swing (240 kV) and the plant is lightly loaded, then TR 8-81, the connected Control Power Transformers (CPT's), and loads at the 480 volt level will be at 115% of rated voltage. The transformers are rated for 110%. In its SER, WNP-2 committed to set the transformer taps TR-S and TR-8-81 to obtain optimum voltage levels from no-load to fully loaded conditions. Operations conducted no-load (lightly load) tests and B&R analyzed the data, run the calculations, and determined that the tap settings will be sufficient to obtain the optimum conditions. No design or design process error therefore occurred; however, this was maintained as an observation since the tap adjustment had not been completed. No further action is required.

PFR-RHR-35, classified as an observation, observed that no calculations or documentation was found to indicate that branch circuit fuses were coordinated with the incoming line breakers for short circuit conditions. B&R stated that such calculations would be made as Test and Startup used them for system checkout. The calculations were made and the PFR closed with no further action required.

B. Motors and Motor Operators

One motor (RHR-M-2B for pump RHR-P-2B) and three motor operators (RHR-MO-3B for RHR-V-3B, RHR-MO-24B for RHR-V-24B, and RHR-MO-64B for RHR-V-64B) were examined. The motor was specified, designed and procured by General Electric. The motor operators were specified by Burns and Roe using data provided by General Electric. They were procured by Burns and Roe as part of the valves. The valve manufacturers (Velan, Anchor-Darling, Fisher Controls, respectively) procured the actuators from Limitorque Corp. and Limitorque procured the motors from Reliance.

Fifty documents were examined during the course of the review. They were: the Burns and Roe Design Criteria Document, seven General Electric specifications, three Burns and Roe design calculations, five vendor test data reports, two industry standards, three IEEE standards, four prepurchased contracts, a Burns and Roe technical memorandum, 23 drawings and one Supply System document. Of particular interest were the environmental data, separation requirements and grounding. In addition, alternative calculations were performed to verify the voltage conditions that were used in selecting the motors.

No valid findings or observations resulted from this review.

C. Electric Cables

Two power cables were selected for the scope of this investigation, RHR-CBL-2SM8/0050 and RHR-CBL-2M8BA/0020. Both cables were specified and procured by Burns and Roe. The first cable was supplied by Okonite, the second by Raychem. In addition to these power cables, a sample of five associated cables was selected for this investigation. Three of these cables supply control power, one is an alarm cable, and the fifth is for data logging. For the power cables, an extensive review of the design documentation, including design calculations, was performed to determine whether their construction, sizing, routing (separation), installation and flammability testing were in compliance with applicable design criteria and requirements. Special emphasis was placed on investigation of the equipment qualification records.

The scope of this investigation covered 35 documents: the B&R Engineering Criteria Document, two Burns and Roe Technical Memorandums, six Burns and Roe Design Calculations, three Industry Standards, three IEEE Standards, one Regulatory Guide, two Prepurchase Contracts, and 17 drawings.

For the associated cables, the investigation was centered on the routing drawings in order to determine if the cables were routed in compliance with required installation and separation requirements and criteria. No case of noncompliance or potential infraction of any kind was uncovered with the associated cables.

The power cables reviewed were found to be in compliance with the requirements for testing, installation and routing and are appropriate for their intended use. Three PFR's were issued as a result of this review. One noted a minor documentation discrepancy in the C1E list and the other two reported cases where the cable sizing calculations had not been updated to reflect current data. In both cases the installed cables were adequate. However, since this was a small sample, an additional 20 loads on motor control center E-MC-8B were reviewed to determine if the process for updating the cable sizing calculations where required was adequate. The results of this additional review indicated five cases where the full load current (I_{fl}) listed on the equipment was greater than used in the calculation. In four cases the I_{fl}, when adjusted for the ambient correction factor and the B&R standard derating factor (1.25) slightly exceeded the cable ampacity (i.e. 3%). This was considered acceptable in view of the large (25%) derating factor used by B&R. The fifth case exceeded the cable ampacity by 17%. This cable was identified by B&R in 1981 and replaced per PED-218E-4315; however, the calculation was not updated. Based on this review, it was concluded that B&R appeared to be taking appropriate action to change cables where necessary, but that the calculations had not been updated to reflect current information.

PFR-RHR-1, classified as an observation, noted that not all Class 1E cable sizes were listed in the C1E list. Further review confirmed that the cables are qualified. Cable qualification is documented by cable type not cable size. This was considered to be a minor documentation problem in the early versions of the C1E list. B&R has been directed to include all cable sizes as well as cable types in subsequent revisions of the C1E list. No further action is considered necessary.

PFR-RHR-16, classified as an observation, noted that calculation 2.06.10 was based on old load data and had not been updated since 1974. Using the latest data, the reviewer found that the voltage drop from the 480 V switchgear to MCC-8BB exceeded the three percent criteria of the National Electric Code. B&R noted correctly that the 3% rule from the National Electric Code is a guide; not a design requirement. In this case, the design requirement is that the voltage level not fall below the 80% level for Class 1E motors which it did not. The calculation will be updated by B&R and the specific observation was closed on that basis. The generic issue related to updating of calculations is discussed below.

PFR-RHR-22, classified as an observation, reported several cases where the full load current used in the cable sizing calculation had not been updated based on the additional sample of 20 loads. The specific cases identified were not a problem. The generic issue related to updating of electrical calculations is discussed below. No further action is considered necessary.

The specific cases identified in RHR-16 and RHR-22 were not major design problems. However, in conjunction with RHR-11 and RHR-12 (which also noted problems associated with updating electrical calculations) these observations seemed to indicate a trend that required further evaluation to assure adequacy of the design. The observations suggested that the process for updating electrical calculations was late/incomplete and required corrective action by the Project. As discussed in Section 2.2, a comprehensive evaluation of the B&R design updating and closure program was conducted. This evaluation confirmed that about 3% of the electrical calculations required a major update and about 10% required a minor update. These updates have been completed. A maximum of 22 out of approximately 18,000 cables have been identified for upgrading. Although the calculations are conservative, the cables are being tested to determine which actually require upgrading. Thus far only one of the 11 cables tested required replacement. Testing of the remainder will follow the system test schedule. Additionally, some fuse breaker coordination is being evaluated and may result in the change out of a few fuses. It was concluded that completion of this corrective action will adequately address the concern identified as a result of this review area.

3.3.5 PIPING AND SUPPORT REVIEW

The Design Reverification Plan for the RHR system includes the review of two piping sections, a detailed review of five pipe supports, plus a review of the lower anchor and upper lateral support for the Loop B heat exchanger.

3.3.5.1 Piping and Pipe Support Design Reviews

The review of the piping and pipe supports is in process and will be reported as an addendum to this report.

3.3.5.2 Equipment Support (RHR-HX-1B)

A. Lateral Restraint

A review of the RHR heat exchanger upper lateral restraint and the lower anchor bolts was conducted. The lateral restraint is a rigid frame that supports the heat exchanger under faulted conditions. Its main members consist of W14 x 167 wide flange sections with secondary members 4 x 4 x 0.313 angles, all made of A36 steel. The restraint was designed by Burns and Roe and supplied by the 215 contractor.

The review of the restraint involved performing alternative calculations and examining eight documents. An alternate calculation was conducted using the computer program "STRUDL" and as-built data to obtain support reactions based on the loading conditions specified by General Electric. Those reactions were then used to hand calculate the reactions of individual members of the restraint. The documents reviewed included Burns and Roe calculations and design drawings and General Electric installation specifications, the heat exchanger outline drawing and the Burns and Roe Engineering Criteria Document.

The reverification review, including the alternate calculations confirmed that the lateral restraint design is adequate. Three potential finding reports related to documentation discrepancies were issued as a result of this review and resolved as follows:

PFR-RHR-26, classified as an observation, reported that B&R calculations which evaluated the effect of revised loads on the support design were not referenced to the original calculations nor was the original calculation marked to indicate that it had been superseded. The calculations were correct and the proper loads were used. B&R was requested to appropriately reference/mark the two calculations. No further action is necessary.

PFR-RHR-28, classified as an observation, reported that no calculation could be found for sizing the embedded bolt and washer plate which anchor the lateral support to the building. Alternate calculations confirmed that the design meets the criteria of ACI-71 and the AISC Specification and is, therefore, adequate. Since the B&R calculation package contained a dimensioned sketch of the bolt and plate and subsequent analyses confirmed the design to be adequate, it was concluded that either a calculation was performed but inadvertently excluded from the package or that the anchor was designed by similarity but not referenced to the appropriate calculation. B&R has revised the calculation package to include the analysis of the bolt and washer plate. No further action is considered to be necessary.

PFR-RHR-29, classified as an observation, noted that the design of the heat exchanger lateral support included an allowance for hung loads and several small pipe and conduit supports were hung from this support but a final reconciliation had not been performed. This PFR should be considered an open item rather than a deficiency since construction work was still in process and the heat exchanger room had not been turned over at the time of the review. Part of the turnover process includes an inspection by B&R for hung loads and floor loads and a reconciliation where required. The review confirmed that this activity is underway and is tracked as B&R Task Number 5180. No further action is necessary.

B. Lower Anchor Supports

In addition to the lateral restraint, the heat exchanger lower anchor bolts were examined. The lower supports are attached to the concrete floor at the 572.0 ft level by 12, 3-inch diameter, A807 anchor bolts. The bolts are a stud-type with nuts at each end and are inserted through 6-inch-diameter steel sleeves that are firmly embedded in the concrete. Their function is to prevent vertical movement of the heat exchanger and to transfer shear loads from the heat exchanger supports to the baseplate and onto the concrete during a faulted condition. General Electric specified the diameter of the bolts, provided loading data and provided the installation procedure. Burns and Roe designed the anchorage.

Nine documents were examined as part of the review. They included Burns and Roe calculations, design drawings and the Engineering Criteria Document and General Electric installation specifications and the heat exchanger outline drawing.

The review concluded that the heat exchanger lower anchorage as installed was not adequate and that field modifications would be required. The PFR's issued as a result of this review were resolved as follows:

PFR-RHR-23, classified as an observation, described a discrepancy between the dimensions for the RHR heat exchanger lower anchor bolt base plates and those used in the calculation. GEBR-2-81-189 changed the plate width from 22" to 15", and thus the bearing load from 65 psi to 126 psi. Since the allowable for the concrete is 2400 psi, the revised load was accepted by inspection and a new calculation is not required.

PFR-RHR-24 was classified as a finding, reportable under the provisions of 10CFR50.55(e) on the basis that a change to the heat exchanger lower anchorage is required to meet the design requirements. The GE specification provides two methods to transfer the lateral dynamic loads at the lower heat exchanger support, (1) through the anchor bolts to the embedded base plate or (2) through restraining blocks welded to the embedded base plate. In both methods shims are required to limit the gap between the heat exchanger support and the bolts or restraining blocks. The B&R design calculation in this area was based on transferring these loads through the bolts and thus the calculation included the sizing of a weld between the bolt and the base plate. However, it appears that this approach was abandoned in favor of restraining pads for ease of construction. The GE installation requirements were properly transmitted to the mechanical contractor for implementation. No specific guidance was included on the base plate drawing as to which method was preferred. The heat exchanger was installed with neither the anchor bolts welded nor restrianing blocks and the required shims were not installed. Further review indicated that the responsibility for installation of the heat exchanger had been transferred from the original 215 contractor to Bechtel prior to completion of final alignment and that Bechtel had just initiated the final equipment installation documentation review. In response to this deficiency, and PFR-RHR-33 which reported that the upper lateral restraint was not shimmed as required, the Project initiated a major program to re-evaluate equipment installation.

The program consisted of a complete re-evaluation of installation plans and specifications for Quality Class I and II mechanical equipment (including PED and vendor manuals) and preparation of a list of installation requirements. The installation requirements were then compared with installation records. If inspection records were incomplete or not definitive with respect to the requirement, field re-inspections were conducted. The program looked at approximately 438 equipment installations, a 100% sample. The program results are summarized in Section 1.2.

PFR-RHR-25, classified as a finding, noted the absence of a calculation update to demonstrate that the lower anchor washer plate was of sufficient thickness and area to accommodate the hydrodynamic loads specified by GE in GEBR-2-81-189. Further investigations indicated that the GE outline drawing was not updated to be consistent with the GEBR-2-81-189 letter either. Evaluation of the installation using up to date load conditions, concluded that there is no need to consider loading of the washer plate. Consequently the current washer plate installation is adequate. The generic issue, design information transfer by letter without updating the drawings that Burns and Roe normally uses for interfaces, is being discussed with GE by the WNP-2 Project. The Project has committed to evaluate GE's response to this generic concern to determine which, if any, GE documents should be updated at this stage of the project.

3.3.6 COMPONENT ON-SITE INSPECTIONS

To provide assurance that the RHR system is installed in conformance with appropriate installation requirements and guidelines, onsite field inspections were performed on the components selected for design review (Table 3-5). The as-built inspection consisted of physical examination of the installed components, utilizing criteria developed as part of the Design Reverification Plan for RHR.

All of the drawings used for onsite field inspection were of current revision, although the installation drawings used for the RHR-FE-14B Tubing (last item in the second group of components) were the unsigned, final as-builts. No changes were expected to these drawings.

No new potential finding reports resulted from the onsite inspection for either the mechanical components or for the instrumentation and control components. The installed instrument tubing for Flow Element RHR-FE-14B was examined for adequate slope and it was determined that the slope was adequate for the particular application. During the inspection of electrical components, all components were found to be in compliance with all applicable requirements. In the engineering mechanics area, Potential Finding Report RHR-33 was issued as a result of the heat exchanger upper restraint inspection. Apart from that, all member sizes including bolts and welds were found to be in compliance with the applicable requirements and drawings.

PFR-RHR-33, classified as a finding and reported under the provisions of 10CFR50.55(e) (part of Report No. 258), noted that the 1B heat exchanger top keyway brackets had not been shimmed per GE Specifications. The investigation indicated that an open PED (215-CS-2677) dated April 8, 1980 addressed the problem; therefore, the contractors were aware of the shimming requirement even though the work had not been implemented. The RHR upper support installation has been corrected. Any similar problems will be identified and corrected by the equipment installation inspection program discussed under PFR-RHR-24 in Section 3.3.5.B.

3.4 REACTOR FEEDWATER SYSTEM REVERIFICATION RESULTS

3.4.1 REACTOR FEEDWATER SYSTEM DESCRIPTION

The reactor feedwater system's primary function is to maintain the reactor vessel water level within predetermined limits during all reactor operating modes. The system controls the temperature, pressure and flow of the feedwater to the reactor vessel. The boundaries of the feedwater system are shown schematically on Figures 3-4, 3-5 and 3-6.

The feedwater system is normally defined as the high-pressure section of the condensate-feedwater system from the feedwater pumps through the high-pressure sixth stage of feedwater heaters and piping to the reactor vessel. For design reverification, the system was expanded to include the fifth stage of low-pressure heaters to reverify both high- and low-pressure heaters design. The feedwater system's expanded boundary extends from the inlet isolation valves and the low-pressure heaters fifth stage bypass valve to the reactor vessel nozzles and includes the following four parts:

- recirculating flow path through the feedwater pumps and high-pressure heaters back to the condenser hotwell

- minimum flow recirculating flow path for the feedwater pumps to prevent pump overheating and cavitation

- low-flow startup valve to control the reactor vessel level during low-power operation

- control system to monitor and maintain reactor vessel level.

The extended system starts at the fifth-stage low-pressure heater inlet isolation and bypass valves (COND-V-142A, COND-V-142B and COND-V-44) which are located on a common 24-in. header supplying the two 50% capacity, fifth-stage, low-pressure heaters. The outlets of each fifth-stage

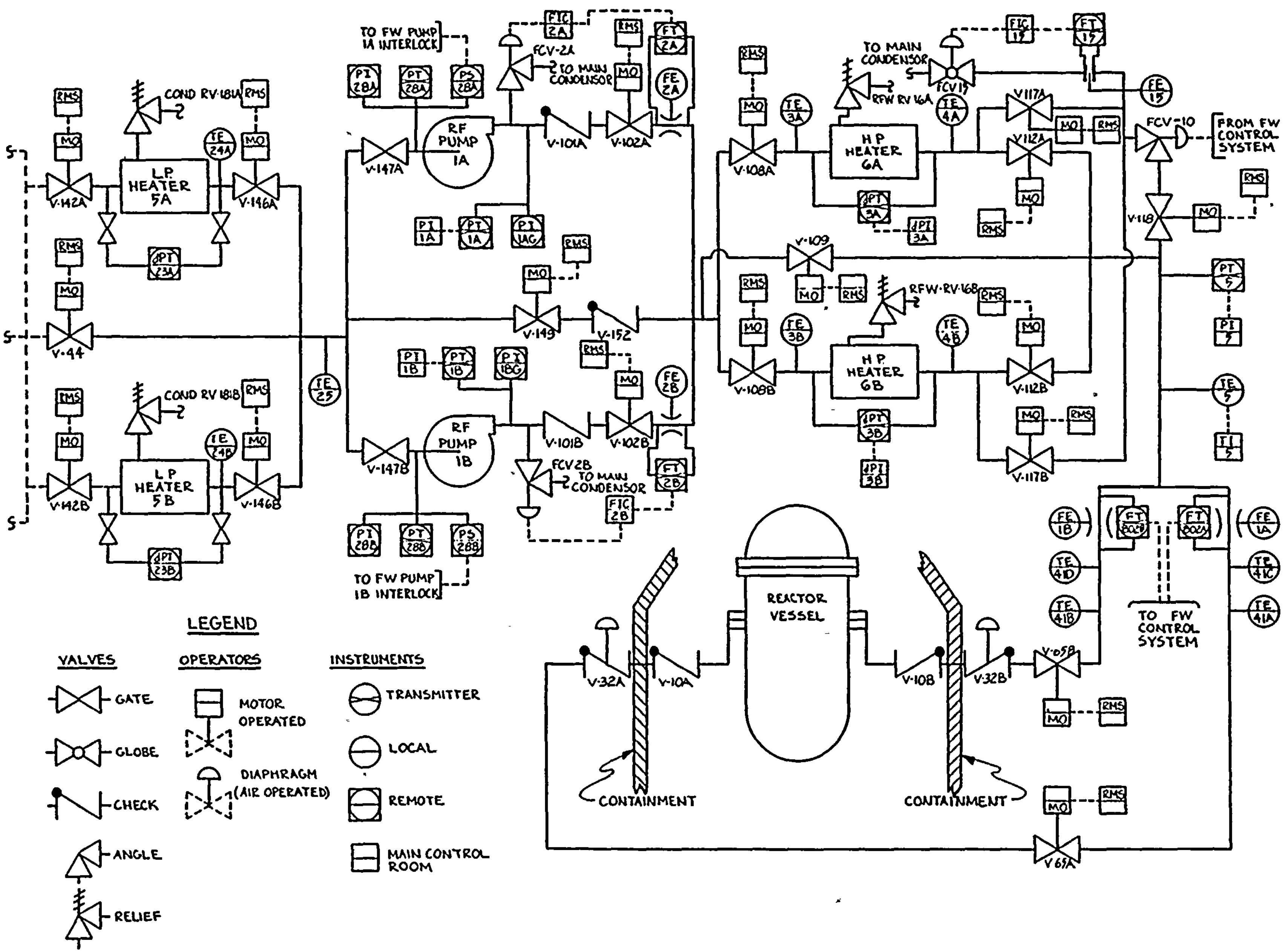

FIGURE 3-4 CONDENSATE HEATERS 5A [illegible] AND THE REACTOR FEEDWATER SYSTEM

831070-7A

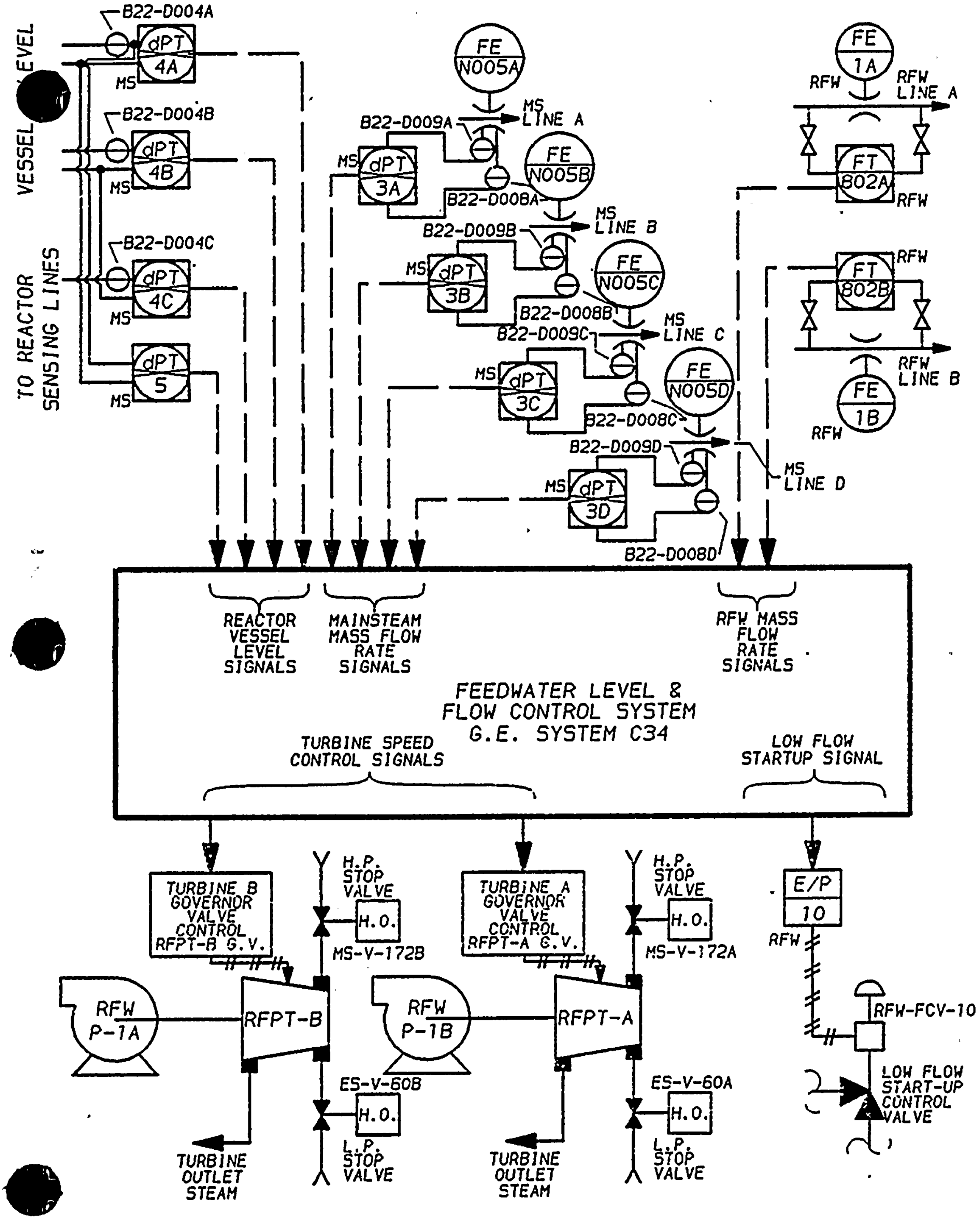

FIGURE 3-5 FEEDWATER LEVEL & FLOW CONTROL SYSTEM G.E. SYSTEM C34

831070-8A

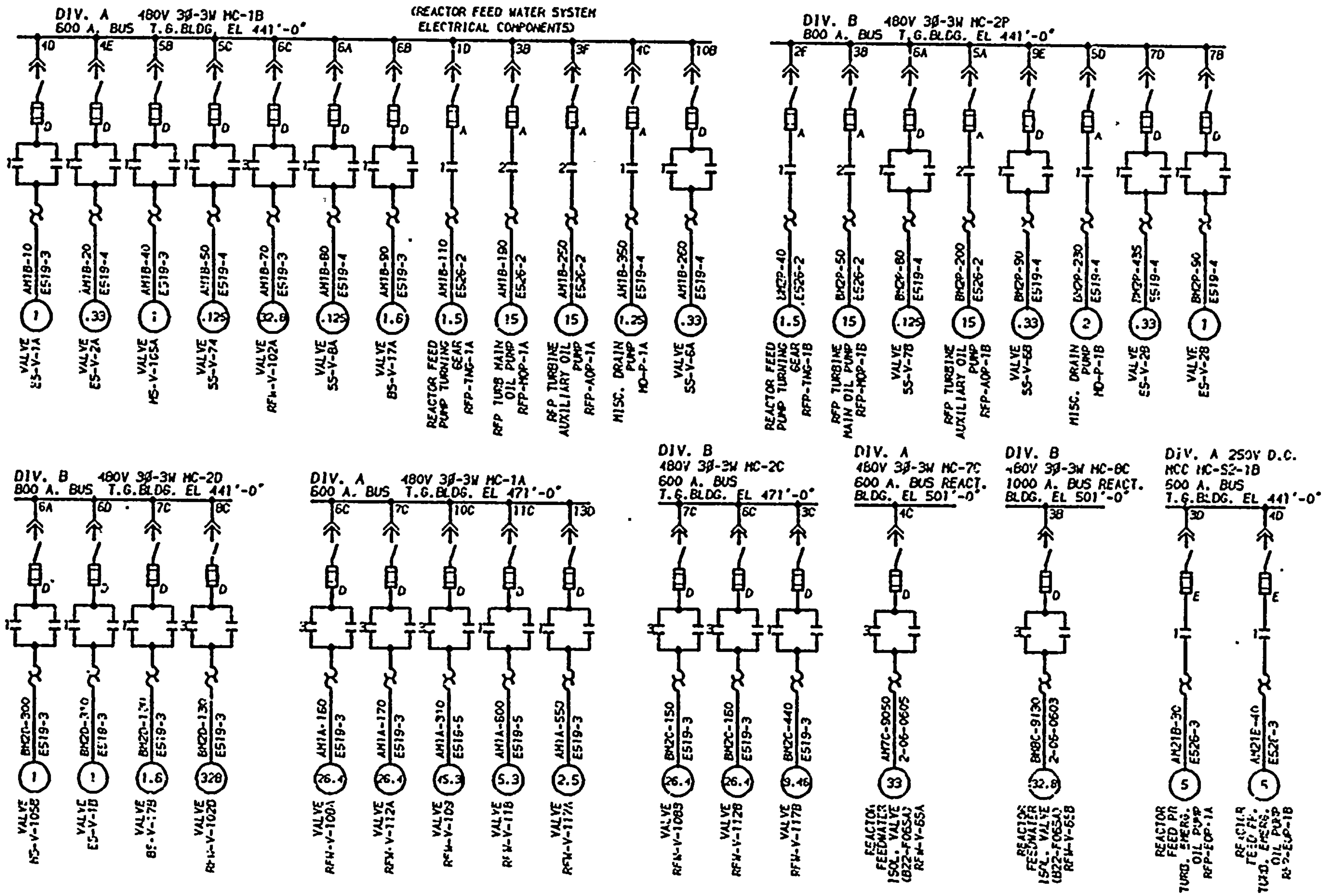

FIGURE 3-6 ELECTRICAL F[illegible] WATER SYSTEM BOUNDARY

heater join in a common 30-in. suction header for the reactor feedwater pumps. The two 50% capacity turbine-driven centrifugal feedwater pumps are arranged in parallel and discharge through individual 24-in. headers into a common 30-in. header. Each pump discharge header is equipped with a check valve, a motor-operated isolation valve and a flow-measuring element.

Each reactor feedwater pump has a minimum flow recirculation header which routes feedwater from a point upstream of the pump discharge check valve through an air-operated flow control valve to the main condenser. The minimum flow recirculation systems allow a flow path for feedwater during system low-flow conditions to prevent pump heat up. The minimum flow control valves respond to controllers monitoring the individual pump discharge flow and are interlocked with the feedwater turbine stop valve positions.

A bypass line around the feedwater pumps is also provided. The bypass has a motor-operated control valve and a check valve and routes condensate from the 24-in. reactor feedwater pump suction header to the common 30-in. discharge header. The pump bypass is used to supply condensate to the reactor during startup preparation and low-power operation when the reactor feedwater pumps are off-line.

The discharge flow from the reactor feedwater pumps and/or the feedwater pump bypass header is routed through the high pressure sixth-stage feedwater heaters. These heaters consist of two 50% capacity parallel heat exchangers which provide the final stage of feedwater heating. Both high-pressure feedwater heaters have a motor-operated supply and discharge isolation valve.

The 24-in. outlet headers from the twin sixth-stage high-pressure feedwater heaters combine downstream of their respective discharge isolation valves to form a common 30-in. header.

The sixth-stage high-pressure feedwater heaters can be partially or completely bypassed (through a 20-in. bypass header) from the common 30-in. heater supply header to a point downstream of the individual heater discharge isolation valves. This bypass header is equipped with a motor-operated bypass valve (RFW-V-109).

A feedwater recirculation header and control system has also been provided with a flow path from the discharge of the sixth-stage high-pressure feedwater heater to the main condenser. During startup preparations, this flow path will allow recirculation through the entire condensate and feedwater systems, up to the discharge of the high-pressure feedwater heater, to the main condenser for water quality cleanup. Each recirculation line takes off between the outlet of its high-pressure heater and its respective outlet isolation valve. They then combine to form a common 16-in. header which returns flow to the main condenser. A flow control valve (RFW-FCV-15) and flow-measuring device, located in this common return header, are used to measure and control the amount of recirculation flow to the main condenser.

The startup feedwater level control valve (RFW-FCV-10) in a 12-in. header is located between the common feedwater recirculation header and the main feedwater supply header to the reactor. This startup low-flow valve controls make-up to the reactor vessel during startup when the feedwater pumps are off-line. RFW-FCV-10 is an air-operated valve, controlled by a single-element system which receives its signals from the feedwater control system.

The main 30-in. feedwater supply header splits into twin 24-in. headers (Line A and Line B) before leaving the turbine generator building. Each feedwater supply line has a flow-measuring element which is used by the feedwater control system. These headers penetrate the primary containment and sacrificial shield structures to supply the reactor vessel. Each of these feedwater supply lines is also equipped with three containment isolation valves: a motor-operated gate valve and a positive-acting check valve, both outside and adjacent to the containment, and a second check valve immediately inside containment. The motor-operated gate valve is operated manually from the control room and is used for long-term isolation of the feedwater lines. The two check valves in series in each line provide immediate containment isolation. Downstream of the second check valve each feedwater line splits three ways prior to penetrating the sacrificial shield and connecting to the reactor vessel feedwater supply nozzles.

3.4.2 SUMMARY OF REACTOR FEEDWATER SYSTEM REVIEW

The review of the reactor feedwater system design included a multidiscipline evaluation of seven system design areas, detailed component design reviews covering 30 mechanical, electrical and instrument and control components, as-built field inspections of each component reviewed and a check of the design loads for six equipment nozzles and five pipe supports. The design was evaluated by design review using formal checklists and alternate calculations when appropriate. Approximately 1,300 checklist items were addressed and seven alternate calculations performed. The alternate calculations ranged from simple hand calculations to a complete thermal hydraulic analysis of the system using the CDC THERM and Stoner Associates LIQSS codes. Approximately 839 design related documents were reviewed.

Table 3.7 provides a summary of the review areas, the PFR's issued, and their classification. Twenty-three PFR's were issued during the review, 16 of which were determined to be valid. Three of the 16 valid PFR's were classified as findings and the remaining 13 were classified as observations. It should be noted that many of the areas reviewed were satisfactory and that the number of valid PFR's is small in view of the extensive scope and depth of the review and the low threshold used for issuing a PFR.

The reactor feedwater system is not a safety system and only a small portion of the system reviewed involved Quality Class I equipment. The

TABLE 3-7

SUMMARY OF POTENTIAL FINDING REPORTS (RFW)

Review Area	Number of Review Questions	Number of Documents Reviewed	PFR's Issued	Classification: Not Valid	Observation	Finding
3.4.3 SYSTEMS LEVEL REVIEW	53					
3.4.3.1 Functional Requirements		75	None			
3.4.3.2 Codes and Standards		23	None			
3.4.3.3 Separation Requirements		21	None			
3.4.3.4 Redundancy		51	RFW-18	X		
			RFW-19		X	
			RFW-20	X		
3.4.3.5 Containment Isolation		67	None			
3.4.3.6 Layout and Arrangement		22	None			
3.4.3.7 System Control Requirements		109	None			
3.4.4 COMPONENT LEVEL REVIEW						
3.4.4.1 Mechanical System Components						
A. Feedwater Heater	20	9				
COND-HX-5A			None			
RFW-HX-6A			None			
B. Valves	52	23				
RFW-V-65A			None			
RFW-V-32A			RFW-5	X		
RFW-FCV-15			RFW-21			X
			RFW-22		X	
RFW-RV-116A			RFW-6			X
C. Pumps	9	21				
RFW-P-1A			None			
3.4.4.2 Electrical System Components		65				
A. Combination Motor Controllers	68					
RFW-42-7A3C			None			
RFW-42-1B3B			None			
B. Valve Motor Operators and Motors	130					
RFW-MO-65A			RFW-7		X	
RFW-MO-109			None			
RFW-MO-112A			None			
RFT-M-TNGA			None			
RFT-M-MOPA			None			
C. Electric Power Cables	80					
RFW-CBL-1M7A/1060			None			
RFW-CBL-AM1B/1090			None			
3.4.4.3 Instrumentation and Control System Components	592	216				
A. Process Intrumentation						
RFW-dPT-803A			None			
RFW-dPT-4A			None			
RFW-FT-802A			None			
RFW-TT-602A			None			
RFW-E/P-10			None			
RFW-FT-15			None			
RFW-SQRT-15			None			
RFW-FIC-15			None			
RFW-E/P-15			None			
B. Temperature Elements						
RFW-TE-41A			RFW-2		X	
C. Valve Instrumentation						
RFW-AO-32A			RFW-9		X	
D. Flow Elements						
RFW-FE-15			RFW-4		X	
RFW-FE-1A			RFW-10		X	
			RFW-11			X
			RFW-12	X		
			RFW-13	X		
			RFW-14	X		
			RFW-16		X	
E. Instrument Tubing			None			

TABLE 3-7 (Continued)

Review Area	Number of Review Questions	Number of Documents Reviewed	PFR's Issued	Classification		
				Not Valid	Observation	Finding
3.4.5 PUMP/HX NOZZLE & HANGER LOADS		5				
3.4.5.1 Heat Exchanger Nozzle Loads	2 cases		None			
3.4.5.2 Hanger Loads	5 cases		None			
3.4.5.3 Pump Nozzle Loads	2 cases		NL-1		X	
3.4.6 COMPONENT AS-BUILT INSPECTIONS						
3.4.6.1 Mechanical Components	47	25	None			
3.4.6.2 Electrical Components	43	36	None			
3.4.6.3 I&C	188	71	RFW-1		X	
			RFW-3		X	
			RFW-8		X	
			RFW-15	X		
			RFW-17		X	
TOTALS	1291	839	23	7	13	3

system was selected because of its importance to plant availability and because it was considered representative of a major segment of the B&R balance-of-plant design activity.

Based on the sampling review, it is concluded that the RFW design is adequate. Three findings were issued; PFR-RFW-6, -11, and -21. RFW-6 was an issue related to under sizing of pressure relief valves on the tube side of the feedwater heaters which could lead to equipment damage or personnel injury in the event that a heater was incorrectly isolated. The relief valves are adequate to protect the heaters for a normal isolation condition with leakage past the isolation valves. PFR-RFW-11 documents an isolated error in the design of the feedwater flow element. The error was a failure to implement the required downstream distance of straight pipe. It was an error of minor significance in that no hardware change was necessary and no other similar errors were noted in checking several other flow elements. PFR-RFW-21 identified a calculational error that had been previously identified by system testing and corrected. It was classified as a finding because of the potential for generic significance. Additional control valves are being examined for similar calculational errors. To date, ten additional valves have been reviewed and no similar errors found. All three of the RFW findings are considered to be of rather minor significance.

Overall evaluations of trends and conclusions regarding WNP-2 design adequacy are discussed in Sections 1.2 and 1.3.

3.4.3 SYSTEM LEVEL REVIEW

An interdisciplinary approach to reverification of the reactor feedwater system was undertaken to assure that the system's primary design requirements were correctly incorporated into each stage of the design process and that the integrated system would function as specified. A representative sample of system requirements was reviewed to assure that critical reactor feedwater system design requirements had been addressed. These were selected after reviewing all of the feedwater system's design requirements.

The review was conducted in accordance with the Reactor Feedwater System Design Reverification Plan[11]. The areas reviewed, along with the results of each review, are described in the following subsection.

3.4.3.1 Functional Requirements

The functional requirements review covered the following three areas:

1. system flow and thermal requirements
2. power supply and reliability requirements
3. system control requirements.

The flow and thermal requirements, specified by General Electric (GE), include flow, pressure and temperature at 68%, 105% and 115% of rated feedwater flow. Thermal requirements at the reactor vessel feedwater nozzles and maximum allowable feedwater temperature losses due to heater or feedwater line valving were also specified.

The review of the Burns and Roe (B&R) design to meet these functional requirements was accomplished by performing alternate calculations using the CDC THERM code to verify system thermal design requirements and the Stoner Associates LIQSS code to verify system flow and pressure requirements. The THERM Code was benchmarked against the Westinghouse 100% and 105% heat balances and the LIQSS Code was documented and verified by Stoner Associates against a nationally known program (WATSIM) and against field test data.

The power supply and reliability requirements were specified by B&R and include system short circuit and minimum voltage loads during startup and normal operation.

Reverification of the B&R design to meet the feedwater system's electrical functional requirements was accomplished through a design review.

It assured that correct system loads, cable size and length were used in voltage drop and short circuit calculations for switchgear, motor control centers, circuit breakers and motor starters, and that system minimum voltages were greater than the minimum nominal bus voltages specified for the electrical system during startup and normal operation.

General Electric established the functional control requirements, designed the feedwater system control, and interacted with B&R to assure the interface requirements between the nuclear steam supply system and balance-of-plant equipment were properly addressed.

The review of the GE/B&R design of the feedwater/level control system was accomplished through a review of the control system design documentation and the interfacing equipment such as the startup flow control valve and the reactor feed pump turbines. The control system review covered all automatic and operator-initiated control modes of feedwater level/control at various reactor power levels from startup to rated power conditions.

Seventy-five documents were examined during the course of the review by all reviewing disciplines. These included 13 GE design specifications and drawings, four sections of the B&R Engineering Criteria Document, seven B&R equipment specifications, four B&R calculations and 15 vendor manuals and drawings.

Based on the review and alternate calculations, it was verified that the feedwater system, including the system pumps, is capable of meeting design flow and pressure requirements at rated, 105% and 115% of rated feedwater flow with a maximum calculated feedwater pump speed of 5590 rpm. This speed is within the pump design speed of 5650 rpm and well within the turbine mechanical and electrical overspeed trips of 6220 and 6243 rpm, respectively. It was also verified that the system can meet the 68% of rated flow and pressure requirements with a single feedwater pump operating at less than 5000 rpm. Thermal equilibrium in all feedwater lines to the reactor vessel was verified and the maximum calculated temperature drop due to a loss of the largest heaters was calculated to be 12°F, well below the 100° value used for accident analysis.

The system's electrical equipment and cabling were also found to be capable of supporting the feedwater system in all operating modes. The minimum calculated system load voltages during startup and operation exceed design values, and short circuit ratings of circuit breakers and motor starters are not exceeded.

The control system design meets all design requirements and is capable of maintaining the reactor vessel level within ± 2 inches at steady state under all power modes.

The integrated discipline review showed that the system design can meet all functional requirements that were checked.

No PFR's resulted from these reviews.

3.4.3.2 System Codes and Standards

Code classifications for all feedwater system components, piping, instrument lines and local instrument racks were reviewed to assure that the system design meets all specified code requirements.

Code classifications specified by GE were compared to those in the B&R Engineering Criteria Document, specifications and drawings to verify that they had been correctly transferred through the design process.

Twenty-three documents were examined during the course of the review by all reviewing disciplines. These included one GE design specification, three sections of the B&R Engineering Criteria document, eight B&R drawings and nine B&R specifications.

Based on the documents reviewed, it was verified that code classifications were properly transferred from GE criteria through the B&R design process to the contractors. The criteria, specifications and drawings all correctly show the system code classifications and the code classification change at the outermost isolation valve (reactor pressure boundary) from Quality Group Classification A (ASME III-1) to D (ANSI B31.10).

No PFR's resulted from these reviews.

3.4.3.3 System Separation Requirements

There are no mechanical or electrical separation requirements listed for the reactor feedwater system upstream of the outermost containment isolation valves, and because instrumentation and control components are classified as Division II Equipment, there are no instrumentation and control separation requirements. Therefore, the separation requirement review was limited to the mechanical and electrical designs associated with the reactor feedwater system isolation valves and associated equipment.

In the mechanical area, GE separation, missile and pipe whip requirements were compared with B&R engineering criteria and drawings and contractor isometrics to verify that the separation requirements had been correctly transferred through the design process.

In the electrical area, the design review was to assure that the reactor feedwater system Division 1 and Division 2 motor control centers and switchgear meet separation requirements and that the motor-operated containment isolation valves are assigned to the proper electrical division.

Twenty-one documents were examined during the course of the review by both reviewing disciplines. These included one GE specification, three sections of the B&R Engineering Criteria Document, 15 B&R drawings, and electrical codes and standards.

Based on the documents reviewed, it was verified that the GE separation requirements were properly transferred through the B&R design process to the contractors. Containment valves are separated by a barrier (the containment) and the feedwater and steam lines use piping restraints to maintain separation. The electrical Division 1 and 2 motor control centers and switchgear are separated by barriers and divergent routing.

The system separation design is in accordance with design requirements and reflects NRC separation criteria.

No PFR's were issued.

3.4.3.4 System Redundancy

There are no redundancy requirements for the reactor feedwater system except for the containment isolation valves, the Class 1E power supply to these valves and the reactor feedwater level control input/output channels.

The design review of the isolation valves consisted of comparing GE and B&R isolation valve requirements with the system design, as reflected on B&R drawings and contractor isometrics, to verify valve redundancy and assure containment isolation after a single active failure.

The design of the Class 1E electrical supply to the motor-operated containment isolation valves was reviewed to assure that the critical loads automatically transfer from offsite to onsite power sources as required in the B&R design criteria and drawings and industry standards.

Level control system redundancy was reviewed to assure that the GE design requirements were correctly implemented in the B&R specifications and in the designs for all feedwater control system interfacing equipment.

Fifty-one documents were examined during the review by all reviewing disciplines. These included 22 GE specifications, manuals and drawings, three sections of the B&R Engineering Criteria Document, 16 B&R drawings, ten contractor drawings and manuals, and electrical codes and standards.

The design requirements specify that systems related to safety be designed such that a single active failure does not result in a loss of capability to perform the safety function.

The only feedwater system components required to perform a safety function are the feedwater isolation valves. Redundant valves are provided such that the loss of one valve as the result of a single active failure will not result in a loss of containment isolation. Redundant valve installations were confirmed on all B&R and contractor drawings and by field inspection.

Redundant AC power sources to the Class 1E motor operators on the containment isolation gate valves were verified by confirming that the critical system loads are automatically transferred from offsite to onsite sources when required.

All of the system feedwater level/flow control system inputs and outputs are needed for reactor vessel level control. However, the system can accept a single active failure of any one input or output channel and still provide acceptable control because system trips and interlocks will avert any undesirable plant transients.

The mechanical and electrical reviews concluded that the redundancy requirements were met and the design is considered acceptable.

The instrumentation and control system design for redundancy is also considered acceptable.

PFR-RFW-19, classified as an observation, was issued to document that a loss-of-signal lockup feature in the GE control specification was not incorporated. This GE design document specifies lock-up of RFW-RFPT-1A, RFW-RFPT-1B and low-flow control valve RFW-FCV-10 on loss of control signal to these components. Project documentation confirmed that this feature was discussed with GE in 1975 and determined to be a recommendation related to plant availability, not a design requirement. In the context of design reverification, this PFR can be considered not valid in that no design requirement was violated. However, since it is a desirable feature from a plant availability viewpoint, it was classified as an observation and referred to Project Engineering for consideration as a post fuel load improvement (DCRB Item No. 110).

3.4.3.5 Containment Isolation

Feedwater system containment isolation is provided by a swing-check isolation valve inside containment and a positive-acting check valve outside containment. A second motor-operated gate valve is also located outside containment upstream of the positive-acting check valve to provide long-term containment isolation.

The design was reviewed to assure GE and B&R design criteria conformed to the NRC General Design Criteria and Standard Review Plan for configuration, testability and diversity of power sources specified for containment isolation valves.

There are no isolation signals to the reactor feedwater system isolation valves. Therefore, the instrumentation and control review covered isolation signals displayed in the control room and other applicable panels and local instrument racks.

Sixty-seven documents were examined during the course of the review by all reviewing disciplines. These included six NRC criteria, 12 GE specifications and drawings, 42 B&R drawings, two sections of the B&R Engineering Criteria Document and five contractor drawings and manuals.

Based on the containment isolation design review, it was found that the design configuration and testability of the feedwater isolation valves meet FSAR requirements and that the required diversity in power sources is provided. The review also concluded that there is adequate containment isolation control and annunciation in the control room.

No PFR's were issued based on these reviews.

3.4.3.6 System Layout and Arrangements

The layout and arrangement of system components were reviewed by alternate calculations to verify that system pumps and piping arrangements ensure that pump net positive suction head (NPSH) requirements are met for all operating conditions. The design was also reviewed to assure that instruments and racks were located for easy maintenance, environmental compatibility and protection from physical damage.

Twenty-two documents were examined during the course of the review by all reviewing disciplines. These included four GE specifications, two sections of the B&R Engineering Criteria Document, four B&R design criteria, ten B&R specifications and drawings, one B&R calculation and one vendor drawing.

Alternate calculations were performed using the LIQSS computer program to simulate feedwater system flows of 105% and 115% of rated flow with both reactor feedwater pumps operating and 86% of rated flow with one reactor feedwater pump operating. The results show good agreement with B&R calculations. The LIQSS computer simulation also showed that the net positive suction head available exceeds the suction required by a factor of four for the 105% case, a factor of 2.8 for the 115% case and a factor of 4.7 for the 68% flow case.

The review of the instrumentation and control components and racks verified that there is sufficient clearance for maintenance and that the components are environmentally compatible. Additionally, all components and racks are adequately protected by barriers or distance from any equipment that could cause damage.

The system feedwater layout and arrangement are therefore considered to meet all stated design requirements.

No PFR's were issued as a result of the system layout and arrangement review.

3.4.3.7 System Control Requirements

System control designs were reviewed to: 1) assure that all necessary interlocks were provided; 2) verify the design of the operator-controlled start and stop components; and 3) verify that the feedwater level/flow control system provides adequate three-element control, backup single-element control and control tolerances.

All reactor feedwater system interlocks with the recirculation flow control system, main turbine, control rod drive system, and various reactor feedwater system trips were reviewed. Required reactor feedwater system components that have direct on/off control room controls were also reviewed.

General Electric design requirements were reviewed for the required interlocks. The associated B&R drawings were reviewed for correctness and consistency with the design requirements. The same process was followed for the required reactor feedwater system components.

Fifty-nine documents were examined during the course of the review. These included six GE specifications, drawings and manuals and 53 B&R drawings.

Based on the design review, it was found that all system interlocks are included as specified and are adequately implemented in the B&R installation drawings. Design requirements for required reactor feedwater system equipment on/off control were met via the specified control room board controls or the applicable B&R installation drawings.

The feedwater level/flow control system and interface to output equipment were reviewed from the standpoint of single-element (level sensing) control, three-element (level, steam flow and feedwater flow sensing) control, and control tolerances adequacy. All applicable documents were reviewed to determine if the general capabilities of the feedwater level/flow control system are adequate for reactor level control under steady-state and transient conditions.

The system design review questions applying to this area were answered from the standpoint of system accuracy, response and stability. General

Electric design criteria documents and GE instrument data sheets and drawings were reviewed for system control accuracy and response criteria. These response criteria assume feedwater system sensor response times, controller settings, loop gains and lead/lag compensator settings. Dynamic response and steady-state accuracies of a certain minimum tolerance or better are also assumed for the B&R specified feedpumps, feedpump turbines and the low-flow startup flow control valve. General Electric reviewed the B&R specified vendor equipment with respect to overall system responses and accuracies. Ingersoll-Rand, Inc. provided the reactor feedwater pumps; Delavel Turbines, Inc. provided the feedpump turbines; and Babcock and Wilcox provided the RFW-FCV-10 valve which B&R specified using GE criteria. Vendor data was reviewed with respect to GE requirements and modeling analysis for overall feedwater system expected responses over given ranges of feedwater control system settings.

For this section of the review, 50 documents were examined. These included 40 GE specifications and drawings, five B&R technical memos, four vendor manuals and one ISA Standard.

Based on the system control review, it was determined that the feedwater level/flow control system has an adequate range of controller settings, loop gains and lead/log compensator settings to accommodate the characteristics of the reactor vessel, input sensors and output interfacing equipment.

No PFR's were issued as a result of these reviews.

3.4.4 COMPONENT LEVEL REVIEWS

To further verify the accuracy of the design process, 30 selected components from the reactor feedwater system were analyzed to determine whether applicable requirements were properly identified, transmitted and incorporated into the component design. Design interfaces were evaluated, where appropriate, to ensure that imposed design requirements were considered. The component design reverification activities were categorized along discipline lines.

The reactor feedwater system components selected for reverification are listed in Table 3-8 and include those most important to system operation.

3.4.4.1 Mechanical System Components

The reactor feedwater system mechanical components selected for reverification included fifth- and sixth-stage feedwater heaters, four valves and one of the reactor feedwater pumps.

A. Feedwater heaters COND-HX-5A and RFW-HX-6A

Low-pressure feedwater heater COND-HX-5A provides the fifth stage of heating of the condensate being routed to the suction of the reactor feedwater pump. High-pressure heater RFW-HX-6A provides the last stage of feedwater heating before the reactor pressure vessel. The design parameters for both heat exchangers were determined by Westinghouse as part of the turbine cycle heat balance calculations. B&R was responsible for the procurement specification. Southwestern Engineering Company (SWECO) supplied the feedwater heater package and was responsible for the detailed mechanical design.

Both heat exchangers were evaluated through design reviews and alternate calculations. The design reviews involved the examination of nine documents including the B&R procurement specification, the heat balance calculation, two vendor drawings, the vendor manual, and four industry codes and standards. The alternate calculations were performed using the AIDEX computer code to evaluate the performance of the feedwater heaters. The physical details of the heater vessel and the inlet flow conditions were used as input to the computer code which then calculated the performance.

The review verified that the feedwater heater design parameters were properly specified during the design process. The alternate calculations confirmed that the furnished equipment meets the design requirements. The review showed that the heat exchanger designs were satisfactory with

Table 3-8

Reactor Feedwater System Components Selected for Review

Mechanical Components

Feedwater Heaters

COND-HX-5A	low-pressure condensate heater
RFW-HX-6A	high-pressure feedwater heater

Valves

RFW-V-65A	containment isolation valve - motor-operated
RFW-V-32A	containment isolation check valve
RFW-FCV-15	recirculation control valve
RFW-RV-116A	heater relief valve

Pumps

RFW-P-1A	reactor feedwater pump

Electrical Components

Combination Motor Controllers

RFW-42-7A3C	RFW-V-65A motor controller
RFW-42-1B3B	RFW-MOP-1A motor controller

Valve Motor Operators for:

RFW-V-65A	containment isolation valve
RFW-V-109	high-pressure heater #6, bypass valve
RFW-V-112A	high-pressure heater #6, discharge block valve

Motors

RFT-M-TNGA	feedwater turbine turning gear motor
RFT-M-MOPA	feedwater turbine main oil pump motor

Table 3-8 Continued

Power Cable	
RFW-CBL-1M7A/0160	RFW-V-65A motor cable
RFW-CBL-AM1B/0190	RFT-M-MOPA motor cable

Instrumentation and Control Components

Process Instrumentation	
RFW-dPT-803A	differential pressure transmitter
RFW-dPT-4A	differential pressure transmitter
RFW-FT-802A	flow transmitter
RFW-TT-602A	temperature transmitter
RFW-E/P-10	voltage to pneumatic signal converter
RFW-FT-15	flow transmitter
RFW-SQRT-15	square root extractor
RFW-FIC-15	flow indicating controller
RFW-E/P-15	voltage to penumatic signal converter
Temperature Elements	
RFW-TE-41A	temperature element
Valve Instrumentation	
RFW-AO-32A	outboard containment isolation check valve and associated equipment
Flow Elements	
RFW-FE-15	flow element
RFW-FE-1A	venturi flow element

Instrument Tubing

instrument tubing run from RFW-E/P-2B to RFW-FCV-2B respect to the shell and tube side fluid velocities and pressure drops, overall heat transfer coefficients, fouling factors, duty exchanged, tube vibration prevention, material selection, and choice of codes and standards.

No PFR's were generated during the review.

B. Valves

RFW-V-65A and RFW-V-32A

Valve RFW-V-65A is a motor-operated gate valve used for long-term containment isolation of the feedwater system during a loss-of-coolant accident. Valve RFW-V-32A is a swing-check valve with an air actuator to assure fast positive closure. Both valves are considered part of the reactor coolant system pressure boundary and are designed to meet reactor coolant system design temperatures and pressures. The valves must also be virtually leak tight against a steam/air mixture at a maximum containment pressure of 34.7 psig to meet containment isolation requirements and minimize bypass leakage from the reactor building during a loss-of-coolant accident.

The valves were evaluated through a design review, which involved the examination of 18 documents including two GE design specifications, three sections of the B&R Engineering Criteria Document, two B&R specifications, two B&R calculations, two B&R drawings, two vendor drawings, reports and manuals, two 10CFR50 appendices and one Supply System report.

The review confirmed that both valves meet all functional, code, installation, interface and material requirements stated in the GE and B&R specifications.

No valid PFR's were issued based on the review of these valves.

RFW-FCV-15

Recirculation flow control valve RFW-FCV-15 is used to maintain and control a clean-up flow through the feedwater system to the condenser before startup. It is also used to bypass feedwater to the condenser during startup to maintain the feedwater startup control valve within its operating range.

Burns and Roe designed the feedwater system and determined the specifications for the recirculation flow control valve. The original valve provided by Fisher Controls was identified as a potential cavitation problem in 1977 due to an error in the process of sizing the valve. This valve was later replaced with a Component Control (CCI) valve. The review confirmed that the CCI valve meets all the specification requirements. However, in reviewing this change, no evidence was found to indicate that B&R checked other flow-control valves sized in the same calculation for similar problems. In addition, the sizing calculation and the specification had not been updated to reflect the substitution of the CCI valve. PFR-RFW-21 and PFR-RFW-22 were issued to document these discrepancies.

<u>PFR-RFW-21</u>, classified as a finding because of its generic implications, reported that the design delta pressure drop calculated for the FCV-15 had not been implemented in the piping design. Consequently, full system pressure was applied across the valve and cavitation resulted. This concern had been previously identified and corrected for the valve in question. Because of the generic concern, the project has initiated corrective action under B&R Task No. 5180 to review flow control valves in the following system configurations which are particularly susceptable to cavitation:

- Liquid lines connected to the main condenser
- Liquid lines from the Reactor Pressure Vessel
- Liquid lines that discharge to atmosphere and have a high upstream elevation
- Liquid lines that have a single pressure reducing stage providing a large pressure drop.

The initial phase of this study examined ten safety related and critical control valves and found no additional problems. It was concluded that this corrective action is adequate to resolve the concern raised by the finding.

PFR-RFW-22, classified as an observation, noted that there is no sizing calculation for flow control valve RFW-FCV-15 and neither the procurement specification nor Calculation 7.00.50 (p.6A) contained the correct design conditions. During the course of construction, the original valve was removed and replaced with a drag valve to alleviate the cavitation concern. B&R issued PED's 215-M-G134, H482 and K505 which support the as-built conditions concerning this valve and revise the affected drawings, the valve lists and specification sheets. This activity included a new calculation for RFW-FCV-15, and no further action was considered necessary.

RFW-RV-116A

Relief valve RFW-RV-116A provides overpressure protection on the tube side (feedwater side) of the sixth-stage high-pressure feedwater heater. The relief valve was manufactured by Crosby Valve and Gage Company and supplied as part of the feedwater heater package by SWECO. Burns and Roe specified the design temperature and pressure requirements for the feedwater heaters and accessories based on the Westinghouse turbine cycle heat balance. The heater vendor was responsible for the relief valve parameters and specified to the valve supplier the particular valve model number and design requirements.

This valve was evaluated through a design review and an alternate calculation. The review involved the examination of five design documents which included the B&R specification, three industry standards and codes, and the heater vendor manual. Information from the valve vendor's catalog was also used.

The review confirmed that the valve meets all the B&R specifications and the Heat Exchanger Institute (HEI) Standard for closed feedwater heaters. However, neither the B&R specifications nor the HEI standard specified the valve orifice size or capacity and no sizing calculations were performed by B&R or SWECO. An independent calculation based on the sizing criteria in American Petroleum Institute (API) Standard RP-520 indicates that the valve has adequate capacity for anticipated conditions (i.e., feedwater heater isolated with steam leakage past the isolation valve) but only half the capacity required to accommodate the water side expansion corresponding to inadvertent isolation of design steam flow rates. PFR-RFW-6 was issued to document this condition.

PFR-RFW-6, classified as a finding, reported that the feedwater heater relief valves are undersized and could create a personnel safety hazard should the feedwater side become isolated with steam flowing. The finding is not a nuclear safety concern because all valves that could affect plant safety are sized by calculation rather than by the API-RP-520 standard. It was noted that the valve meets the industry standard referenced in the specification; however, an alternate calculation indicates that the required relief capacity is twice that allowed by the existing orifice. To preclude significant equipment and personnel injury in case of inadvertent isolation, the relief valve on the tube side of each feedwater heater should be replaced. It is noted that the relief side of each feedwater heater should be replaced. It is noted that the relief valve is adequate for expected conditions of an isolated heater with steam leakage past the isolation valve. The Project has identified this item for future action and it is tracked as Design Change Review Board (DCRB) Item 115. This future action will include consideration of other applications that may have utilized the API standard that led to this finding.

C. Pumps (RFW-P-1A)

The reactor feedwater pumps increase the pressure from the condensate booster pumps to the pressures required to provide feedwater to the reactor vessel in operational modes and at required flow conditions.

Pump head, flow and operating conditions are specified by GE. Burns and Roe was responsible for pump design specification and procurement. The pump was supplied by Ingersoll-Rand and installed by WBG, Contract 215.

Reactor feedwater pump 1A was evaluated through a design review and alternate calculations. The review involved the examination of 21 documents including two GE design specifications, three sections of the B&R Design Engineering Criteria Document, one B&R calculation, one B&R specification, one B&R calculation, two B&R drawings, four vendor drawings and manuals, four contractor drawings and three Supply System calculations.

The review confirmed that the pump meets all pressure and flow requirements for 105%, 115% and 68% (one pump operation) of rated without exceeding pump design speeds and that pump minimum flow requirements are met. Bearing cooling and seal water requirements and pump code and material requirements also meet design requirements.

No PFR's were issued during the review.

3.4.4.2 Electrical System Components

The reactor feedwater system electrical components selected for reverification included two combination motor controllers, five valve motor operators and two power cables as shown in Table 3-8.

A. Combination Motor Controllers: RFW-42-7A3C and RFW-42-1B3B

These components provide circuit protection and motor control capability for motor-operated valve RFW-V-65A and the feedwater turbine main oil pump motor.

The controllers were specified by B&R and designed and supplied by ITE. The controllers were evaluated through a design review which involved the examination of ten documents including B&R design criteria, B&R contract specifications/technical memos, purchase orders, architect/engineer and vendor drawings, vendor test certificates and industry standards.

For RFW-42-1B3B (combination motor controller for RFT-M-MOPA) and for RFW-42-7A3C (combination motor controller for RFW-MO-65A), the continuous current rating exceeded the rating of the load. For both the motor controllers, the continuous current rating exceeded the load at 90% voltage and the short-time load rating exceeded the motor-locked rotor current.

The motor controllers, as designed, meet all B&R design requirements.

No PFR's were issued as a result of this review.

B. Motors and Motor Operators

Motors RFT-M-TNGA and RFT-M-MOPA and motor operators for Valves RFW-V-65A, 109 and 112A were selected for this reverification.

These components were evaluated through a design review which involved the examination of 40 documents including B&R design criteria, specifications, calculations and drawings as well as vendor drawings, test reports and industry standards.

The review verified that the motor operators develop sufficient torque to drive their loads at 90% voltage and that their thermal capability at 90% voltage is greater than their short-time thermal capability.

The review also verified that: 1) the voltage drop calculations for motors and valve motor operators, cable length, size and amperage input are correct; 2) the motors and valve motor operators receive more than 80% normal voltage during starting and more than 90% voltage during running conditions; 3) they are able to start fully loaded and can accelerate to rated speed with only 80% of motor rated voltage per requirements; 4) they have either weather proof or totally enclosed fan-cooled type enclosures which meet the design requirements; and 5) their grounding wire size is larger than #8 AWG.

The review verified that the motors and valve motor operator designs were properly specified and meet all design requirements. One documentation discrepancy was noted by PFR-RFW-7 as described below.

PFR-RFW-7, classified as an observation, noted that the project engineering directive which authorized the change in the power source to RFW-MO-65A was issued without including drawing E-528, sheet 27. The purpose of this drawing is to document the final sizing of motor overloads and fuses which is performed during system lineup testing. Since the one-line diagram which is used in the selection of overload and fuse sizes was correct, this oversight on the E-528 drawing has no impact on the installation or the process of selecting fuse and overload sizes. In addition, the E-528 drawing is subject to a field verification during the system lineup testing which would be expected to correct such discrepancies. This PFR was referred to WNP-2 Project Engineering to update the affected portion of the drawing. No further action was considered necessary.

Electrical Power Cables: RFW-CBL-1M7A/0160 and RFW-CBL-AM1B/0190

The cables reviewed were specified by B&R and supplied by Rockbestos and Raychem.

The cables were evaluated through a design review which involved 15 documents. These included B&R design criteria, contract specifications, calculations and drawings, as well as industry standards.

The review confirmed that the cables are sized to carry a minimum of 125% full load current and can withstand the short circuit. The cable lengths, ohms/1000 ft, load amperage, raceway fill, and ambient temperatures were selected correctly. Both the cables are Type G_1, single conductor copper with Class "B" stranding, tinned with lead and rated 1000 volts. Cables were procured 1E, qualified as 1E and routed in the proper raceway divisions.

Based on the review, it was verified that the cables were properly specified and meet all design requirements.

No PFR's were generated as a result of this review.

3.4.4.3 Instrumentation and Control System Components

The following categories of reactor feedwater system instrumentation and control components were evaluated:

A. process instrumentation

. temperature elements

C. valve instrumentation

D. flow elements

E. instrument tubing.

The components selected for these reviews are listed in Table 3-8 and include a representative sample of various contractor design and installation responsibility interfaces.

A. Process Instrumentation

The reactor feedwater system instrumentation and control components selected for reverification are:

RFW-dPT-803A	differential pressure transmitter
RFW-dPT-4A	differential pressure transmitter
RFW-FT-802A	flow transmitter
RFW-TT-602A	temperature transmitter
RFW-E/P-10	voltage to pneumatic signal converter
RFW-FT-15	flow transmitter
RFW-SQRT-15	square root extractor
RFW-FIC-15	flow indicating controller
RFW-E/P-15	voltage to pneumatic signal converter.

All of the process instrumentation listed above was evaluated through a design review which involved the examination of 113 documents including GE specifications, drawings and data sheets, B&R specifications, engineering criteria and drawings, and contractor/vendor specifications, drawings and manuals.

The review verified that all of the process instrumentation examined meet all specification and design requirements.

No PFR's were generated during the process instrumentation review.

B. Temperature Elements

Temperature element RFW-TE-41A is used to measure the reactor feedwater inlet flow temperature in the "A" feedwater inlet header. This temperature element was evaluated by design review which involved the examination of 24 documents including GE design specifications, drawings and data sheets, B&R engineering criteria, specifications and drawings, and contractor drawings.

The review verified that the temperature element meets all specified criteria.

One PFR was issued as a result of this review.

PFR-RFW-2, classified as an observation, noted the apparent incorrect installation/tagging of the reactor feedwater temperature sensors as compared with the installation isometric drawing, RFW-418-1.2. The FRC determined that this discrepancy resulted from an interference which caused the sensors to be relocated. PED 215-M-A539, dated 7-28-81, documents the changes. The isometric drawing will be corrected to reflect the as-built orientation and a missing label replaced. See RFI CO 500 N-2151.

C. Valve Instrumentation

Valve RFW-V-32A (RFW-AO-32A) provides containment isolation under loss-of-coolant accident conditions. The auxiliary equipment to this valve (e.g., air operator, solenoid pilot valves, etc.) was also reviewed.

The valve assembly was evaluated through a design review. The review involved the examination of 38 documents including GE design specifications, documents and drawings, B&R criteria documents, directives, drawings and specifications and contractor specifications and drawings.

The review verified that the component and auxiliary equipment satisfy the design requirements. Several minor documentation inconsistencies were identified and documented in PFR-RFW-9.

PFR-RFW-9, classified as an observation, noted discrepancies on a GE and a B&R drawing. Those on the GE drawing had been previously identified and a correction initiated by GE (FDDR-KKI-751). The discrepancy on the B&R drawing related to an incorrect instrument rack number on a connection diagram. The project engineering directive which relocated the instrument correctly identified the new rack number and the wiring details on the connection diagram were correct. Project Engineering initiated action to correct the B&R drawing. The discrepancy had no impact on the installation and no additional action was considered necessary.

D. Flow Elements

Two flow elements, RFW-FE-15 and RFW-FE-1A, were reviewed. Flow element RFW-FE-15 is located downstream of the #6 feedwater heaters in the reactor feedwater system recirculation loop to the main condenser. This component generates a differential pressure for use by RFW-FT-15. RFW-FE-1A is a venturi flow element assembly that measures the feedwater flow going through feedwater headers to the reactor vessel. There is an identical flow element for the "B" feedwater header. The differential pressure is transmitted via instrument tubing lines to RFW-FT-802A.

The flow elements were evaluated through a design review which involved the examination of 34 documents including GE specifications and drawings, B&R design criteria, specifications, calculations and drawings, and vendor manuals and drawings.

The review of RFW-FE-15 confirmed that the flow element provided meets the specification requirements. However, the use of an orifice for the process conditions specified is beyond normal engineering practice and may result in marginal flow element performance. PFR-RFW-4 was issued to document this condition. Four PFR's were issued as a result of the review of flow element RFW-FE-1A.

PFR-RFW-4, classified as an observation, noted that flow element RFW-FE-15 is poorly designed in that an orifice was chosen as the flow restriction instead of a flow nozzle. The Beta for the element slightly exceeds 0.75, the upper cutoff for orifices, and the specified differential pressure of 750 in. of H_2O is very high. However, since the design meets the specification requirements and since the actual performance will be verified as part of the normal startup test program, no further action is considered necessary at this time. Twelve other orifices designed by the same engineer were checked and found to be satisfactory. It was concluded that this observation was not indicative of a generic problem. The PFR was referred to project engineering for consideration as a future plant improvement.

PFR-RFW-10, classified as an observation, noted that the upstream straight-length piping section above flow element FE-1A does not meet the requirements of the B&R Engineering Design Criteria which states that the minimum length should be 15 piping inside diameters. There is no problem, however, as the design of the section includes an upstream honeycomb multisection flow straightener. No further action is required.

PFR-RFW-11 was classified as a finding. The flow element was installed as designed with 4.3 instead of 5.0 pipe diameters of straight pipe downstream as recommended by the manufacturer and specified in the B&R

criteria document. Evaluation by B&R and GE established that the necessary accuracy can be achieved without modification of the installation; thus no hardware changes are necessary. To evaluate the potential for similar design errors on other flow elements B&R evaluated the other major flow elements in the ECCS and Service Water Systems (a total of eight elements). No other similar errors were found. Consequently the PFR was determined to be the result of an isolated design error and no further action is considered necessary.

PFR-RFW-16 was classified as an observation. Review of the calibration data for RFW-FE-1A noted that the data for tap set 2 conformed very well to the theoretical curve but that the data for tap set 1 did not appear to meet the accuracy requirements in the GE procurement specification. Further evaluation resulted in agreement that both tap sets meet the requirements of the GE specification and that the more well behaved tap set (#2) should be used for process measurements. The PFR was referred to project engineering with the recommendation to use tap set #2 for process measurements. There is no generic implication and no further action is considered necessary.

E. Instrument Tubing

The design of the instrument tubing from RFW E/P-2B to RFW-FCV-2B was reviewed. RFW-E/P-2B supplies control air to RFW-FCV-2B via this tubing run on command signals from RFW-FIC-2B.

The tubing design was evaluated through a design review which involved the examination of seven documents including B&R engineering criteria and drawings, contractor specifications and drawings, and American National Standard Institute standards.

The review verified that the tubing run was correctly specified with regard to temperature, pressure and size. The correct Quality Class II, Seismic Class II and ANSI B31.1 requirements were specified and met by the resulting design.

No PFR's were issued against this review section.

3.4.5 REVIEW OF REACTOR FEEDWATER PUMP AND HEAT EXCHANGE NOZZLE LOADS AND HANGER LOADS

The scope of the reactor feedwater system reverification did not include detailed reviews of final stress computations as was done in the high-pressure core spray system and residual heat removal system reviews. However, several nozzle and hanger loads for the reactor feedwater pumps and heat exchangers were checked. The review was based on the design package rather than the final reconciled stress analysis since the latter was not complete.

The following revised nozzle and hanger loads on the RFW system were checked:

RFW-HX-6A	inlet A nozzle
RFW-HX-6B	inlet A nozzle
RFW-P-1A	suction and discharge nozzles
RFW-P-1B	suction and discharge nozzles
RFW-HGR-24	hanger
RFW-HGR-944N	hanger
RFW-HGR-943N	hanger
RFW-HGR-21	hanger
RFW-HGR-17	hanger.

For each nozzle or hanger, a detailed check which compared analysis output to data sheet entries was completed. Two design requirement documents, the status as-built pipe stress calculation, and three detailed hanger calculations were reviewed.

3.4.5.1 Heat Exchangers

No vendor allowables were available for the heat exchangers, so B&R's Tech Memo 1271 was the governing document. The design verification consisted of checking the computer printout against the nozzle qualification calculation per Tech Memo 1271. Both nozzles met the Tech Memo criteria.

No PFR's were issued.

3.4.5.2 <u>Hanger Load Verification</u>

The transmittal of hanger load design data was checked by tracking the hanger loads from the piping stress analysis to the hanger design package. All forces and moments were transmitted correctly.

No PFR's were issued.

3.4.5.3 <u>Reactor Feedwater Pump Nozzles</u>

The piping stress calculation was checked to determine that the pump nozzle loads were compiled correctly. Letters transmitting the loads to the vendor were also checked to determine if the latest nozzle loads were approved. One PFR resulted from this review.

<u>PFR-NL-1</u>, classified as an observation, was issued as a result of this review. This observation noted that B&R transmitted the latest loads to the vendor for approval, but the memo from the vendor confirmed only the thermal portion of the loads. It was determined that the nozzle loads were nearly enveloped by a previous vendor transmittal; therefore, that it was reasonable to wait for the final calculation to be completed prior to resubmittal of the nozzle loads to the vendor. The PFR was referred to project engineering for information. B&R has been requested to resubmit the thermal and dead weight loads to the vendor for final reconciliation. A B&R program for acceptance of nozzle loads was planned and is functioning. The problem identified by this PFR would have been identified prior to final nozzle load approval. Consequently, no further action is considered necessary.

3.4.6 COMPONENT ON-SITE INSPECTIONS

To assure that the reactor feedwater system was installed in conformance with design criteria and installation requirements, an as-built inspection was performed by each discipline on all components selected for reverification (see Table 3-8).

The as-built inspection consisted of a physical examination of the installed components using previously prepared checklists. The inspection items included nameplate data, equipment piece numbers, equipment location and orientation, accessibility for maintenance and clearance required for operation, disassembly and, where required, laydown.

The as-built inspection information was then compared to the component design, specification, and installation requirements to verify correct installation. All documents used to verify the components' as-built status were the latest revisions available at the time of the inspections.

3.4.6.1 Mechanical Components (As-Built Inspection)

The mechanical components inspected and the type and number of documents used are listed below:

Mechanical Components	Type of Documents Reviewed	Number of Documents Reviewed
RFW-RV-116A:	drawings (B&R)	1
	manuals	1
RFW-RV-32A:	drawings	
	B&R	2
	vendor	1
RFW-V-65A:	drawings	
	B&R	2
	vendor	1

Mechanical Components	Type of Documents Reviewed	Number of Documents Reviewed
RFW-P-1A:	drawings	
	B&R	2
	vendor	1
RDW-HX-6A:	drawings	
	B&R	4
	vendor	1
	manual (vendor)	1
	specification (B&R)	1
COND-HX-5A:	drawings	
	B&R	4
	vendor	1
	manual (vendor)	1
	specification (B&R)	1

The as-built inspection results verified the correct installation for six of the seven mechanical components. Inspection of the feedwater recirculation flow control valve (RFW-FCV-15) could not be performed due to continuing construction in the area. This particular control valve is being replaced and an as-built inspection will be performed as part of the acceptance test of the installation. No additional inspection of the valve installation as part of the reverification program is considered necessary.

No PFR's were generated as a result of the mechanical component as-built inspection.

3.4.6.2 Electrical Components (As-Built Inspection)

The electrical components inspected and the type and number of documents used are listed below:

Electrical Components	Type of Documents Reviewed	Number of Documents Reviewed
RFW-MO-65A:	drawings	
	B&R	2
	vendor	2
	data sheets	0
RFW-MO-112A:	drawings	
	B&R	2
	vendor	1
RFW-MO-109:	drawings	
	B&R	2
	vendor	1
RFW-M-MOPA:	drawings	
	B&R	2
	vendor	1
RFT-M-TNGA:	drawings	
	B&R	2
	vendor	2
RFW-CBL-1M7A/160:	drawings	
	B&R	6
	vendor	
RFW-CBL-AM1B/190:	drawings	
	B&R	6
	vendor	
RFW-42-7A3C:	drawings	
	B&R	4
	vendor	

Electrical Components	Type of Documents Reviewed	Number of Documents Reviewed
RFW-42-1B3B:	drawings	
	B&R	3
	vendor	

The as-built inspection results verified the correct installation for all nine electrical components examined.

No PFR's were generated.

3.4.6.3 Instrument and Control Components (As-Built Inspection)

The instrument and control components inspected and the type and number of drawings used are listed below:

Instrumentation and Control Components	Type of Documents Reviewed	Number of Documents Reviewed
RFW-dPT-803A:	drawings	5
	data sheets	1
	CVI, manuals	1
RFW-dPT-4A:	drawings	3
	data sheets	1
	CVI, manuals	2
RFW-FT-802A:	drawings	3
	data sheets	1
	CVI, manuals	1
RFW-TT-602A:	drawings	3
	data sheets	2
	CVI, manuals	2

Instrumentation and Control Components	Type of Documents Reviewed	Number of Documents Reviewed
RFW-E/P-10:	drawings	3
	data sheets	0
	CVI, manuals	1
RFW-FT-15:	drawings	2
	data sheets	1
	CVI, manuals	1
RFW-SQRT-15:	drawings	1
	CVI, manuals	1
RFW-FIC-15:	drawings	1
	CVI, manuals	1
	contract spec.	1
RFW-E/P-15:	drawings	2
	CVI, manuals	1
	misc. documents	2
RFW-FE-1A	drawings	8
	data sheets	2
	CVI, manuals	1
	miscellaneous	3
RFW-FE-15:	drawings	1
	CVI, manuals	1
	design criteria	1
RFW-TE-41A:	drawings	3
	CVI, manuals	2
	miscellaneous	1

Instrumentation and Control Components	Type of Documents Reviewed	Number of Documents Reviewed
RFW-V-32A:	drawings	3
	CVI, manuals	1
	contract specs	1

Instrument tubing from RFW-E/P to RFW-FCV-2B.

The tubing was for the most part inaccessible for actual visual inspection. The instrument line has been adequately tested. Since it is a Quality Class II Seismic Category II line, no as-builts were required by Johnson Controls and only tubing routing drawings were issued.

The as-built inspections identified one area where the installation was not in accordance with the approved for construction drawings (PFR-RFW-1). In addition, PFR-RFW-3 and 17 noted labeling errors and PFR-RFW-8 identified a potential interference with a valve operator linkage.

PFR-RFW-1, classified as an observation, noted improper terminal connections for temperature element RFW-TE-41A. The design documents were correct and the wires properly identified. It was concluded that the improper connections would have been detected and corrected during the normal startup testing program; hence, the error would have had no impact. The PFR was referred to project construction to correct the error.

PFR-RFW-3, classified as an observation, noted that the cables to temperature element RFW-TE-41A were incorrectly labeled. The installation was correct and all documentation shows consistent labeling. It was concluded that this error had no impact and that no further checks were necessary in view of the extensive cable labeling checks being performed as part of the project review of electrical separation. This PFR was referred to project engineering for consideration in the context of the ongoing program.

PFR-RFW-8 was classified as an observation. This PFR identified a potential interference between the operator linkage for valve RFW-V-32A and a branch pipe. At the time of the inspection, the valve was not yet fully assembled. It was concluded that the interference was of such a nature that it would have been identified and corrected upon final assembly and testing of the air operator. A startup deficiency report was initiated to eliminate the interference. Interferences of this type are normally identified during final assembly and testing; therefore, no further action is considered necessary.

PFR-RFW-17, classified as an observation, noted in the inspection of RFW-dPT-803A that the individual leads coming to instrument rack termination strips were not labeled in accordance with specification. Further evaluation disclosed that divisional identification tags were originally installed by the contractor, but many have been randomly lost or removed. Start-up has a program for systematic replacement of missing tags. In addition, proper operation (thus termination) is routinely verified during test and start-up activities. Based on these considerations, the PFR was provided to the project and closed.

3.5 SYSTEM INTERACTION REVERIFICATION REVIEWS

3.5.1 INTERACTIVE REVIEW APPROACH

A frequent source of problems in any large project is where independent work functions interface. The potential for changes in assumptions, loads, environmental profiles, analytical results, etc., to fail to reach all affected functions is high. The evaluation of interactive systems was included to check the effectiveness of interface control on WNP-2.

Rather than evaluate the progression of processes to procedures to work within the limited definitions of interface control (i.e., an interface control study), it was decided to perform design reverification on systems and/or work packages which were known to involve multi-discipline input and output interaction.

The areas selected for design reverification in the "Interactive Studies" category were:

1. Fire Protection

2. Pipe Breaks, Missile Evaluation/Jet Impingement/Falling Objects/Flooding

3. Qualification of Safety Related Equipment for Environmental Conditions and Seismic Loads

4. Structural Members

5. A/E-Specified, Pre-Purchased Class I Instrument Racks.

The work areas were selected for interactive review based on the review team's experience with nuclear design together with recommendations from

Technical Audit Associates. The five categories were deemed to be representative of the various interactive design activities encountered in the WNP-2 design process.

The design reverification approach used for the interactive studies was similar to that used for the system reviews. The five major areas were treated by selecting specific physical plant items for each area and applying a bounding design review, both vertically and horizontally. This approach reinforced the system reviews as well as evaluating representative interface/interactive elements.

A reverification plan was developed for the major areas detailing the review activities to be conducted, the physical plant items to be evaluated, a checklist of review questions, requirements, commitments, and schedule and manpower estimates for the review.(12 13 14 15)

3.5.2 SUMMARY OF SYSTEM INTERACTION REVIEW RESULTS

Detailed design reverification utilizing design review checklists, alternate calculations and plant walkdowns were conducted in the five system action areas discussed in the preceeding section. Approximately 675 documents were examined in the review and more than 2,000 checklist items addressed. Twenty four alternate calculations were performed.

Table 3-9 provides a summary of the review areas, the PFR's issued and their classification for the five system interaction reviews. Thirty PFR's were issued during the interaction reviews. Ten were classified as findings and 14 were observations. The remaining six were invalid.

Five of the findings (EQ-11, -13, -14, -15 and -16) related to the generic problems associated with the environmental calculations performed by the Supply System. To correct these problems, all design-related Supply System calculations were redone or rechecked and procedural improvements were implemented to assure adequacy of future Supply System work.

TABLE 3-9

SUMMARY OF POTENTIAL FINDING REPORTS
(System Interaction)

Review Area	Number of Review Questions	Number of Documents Reviewed	PFR's Issued	Classification: Not Valid	Classification: Observation	Classification: Finding
3.5.3 Fire Protection		195				
3.5.3.1 Fire Protection Commitments	22		None			
3.5.3.2 Intruding Cable Review - 9 cables	2		FP-4		X	
3.5.3.3 Protected Cable Review - 16 cables	4		FP-1		X	
3.5.3.4 Suppression Systems Review	3		None			
3.5.3.5 Fire Barrier Review	9		None			
3.5.3.6 As-built Inspection	16		FP-2	X		
			FP-3	X		
3.5.4 Pipe Break/Missile Evaluation/Jet Impingement/Falling Objects/Flooding						
3.5.4.1 HPCS Pipe Break		22				
A. Break Locations and Forces	6		None			
B. Pipe Whip Support PWS-2-1	11		PB-1			X
			PB-4	X		
C. Potential Target Identification	2 + walkdown		PB-2		X	
D. Safe Shutdown Analyses	7 + 8/20 targets		PB-3			X
E. Potential Target Resolution	9		PB-7			X
3.5.4.2 RWCU Pipe Break		19				
A. Break Locations and Forces	6		None			
B. Potential Target Identification	2 + walkdown		PB-6		X	
C. Safe Shutdown Analyses	7 + 8/27 targets		PB-7			X
D. Potential Target Resolution	9		None			
3.5.4.3 RPS Motor-Generator Missiles		18				
A. Potential Target Identification	8		None			
B. Safe Shutdown Analyses	10		None			
C. Missile Barrier Adequacy	12		None			
3.5.4.4 RHR-P-2B Missiles	8/4 targets	6	None			
3.5.5 Qualification of Safety Related Equipment for Environmental Conditions and Dynamic Loads		100				
3.5.5.1 Equipment Classification Reviews	8/51 Components		EQ-3		X	
			EQ-17		X	
3.5.5.2 Component Dynamic Loading and Environmental Conditions Review	15/51 Components		EQ-1		X	
			EQ-4	X		
			EQ-2		X	
			EQ-9		X	
3.5.5.3 Component Qualification Review	14/8 Components		None			
3.5.5.4 Deferred Qualification Status Components Review	5/4 Components		None			
3.5.5.5 Review of Equipment Which Can Fail Without Affecting Safe Shutdown	5/6 Components		None			
3.5.5.6 Review of High Energy Line Break Calculations	51	75	EQ-7		X	
			EQ-10		X	
			EQ-11			X
			EQ-12	X		
			EQ-13			X
			EQ-14			X
			EQ-15			X
			EQ-16			X
3.5.6 Structural Members	24	150				
3.5.6.1 Verification of Wall Loads - 2 Walls			WL-3		X	
			WL-5	X		
3.5.6.2 Check of Design Calculations - 2 Walls			WL-1		X	
			WL-2			X
			WL-4		X	
3.5.6.3 Review of Drawings - 2 Walls			None			
3.5.6.4 Amplification of Floor Responses			None			
3. lass I Instrument Racks		90				
3.5. Design Documents	7/racks 19		None			
3.5.7.2 As-Built Inspection	4/racks 15		None			
TOTALS	2,090	675	30	6	14	10

Four findings (PFR-1, -3, -6 and -7) were issued in the pipe break/missile review area. PFR's PB-1 and -3 identified calculational errors that required correction but did not result in hardware modifications. PFR's PB-6 and -7 identified problems with correct target determination during pipe break walkdowns. These two findings resulted in implementation of corrective actions to improve procedures and training, to be implemented for the final WNP-2 pipebreak calculations.

One finding (PFR-WL-2) identified a calculational error in the wall loading computations. The error did not require any plant modifications. The wall loading review also resulted in the implementation of a wall loading calculation closure process to ensure that "hung loads" and final loads are adequately evaluated.

With expection of these problems, the reviews described in this section show that an adequate process existed and was adequately implemented for consideration of system interactions.

The overall trending of findings and observation, corrective actions associated with generic issues and overall conclusions regarding WNP-2 design are covered in Section 1.2 and 1.3.

3.5.3 FIRE PROTECTION

The general requirements for fire protection are defined in General Design Criterion 3 of Appendix A to 10CFR50. These requirements have been expanded by Branch Technical Position APCSB 9.5-1 Appendix A, dated 1976 and Appendix R to 10CFR50, dated 1979.

The WNP-2 fire protection system is designed to meet current requirements. Details are contained in the WNP-2 Fire Hazards Analysis report and in Appendix F of the WNP-2 Final Safety Analysis Report.

This review covers those features of fire protection committed to in Appendix F of the FSAR that relate to the Suppression Pool Cooling Mode of the RHR system. Approximately 195 drawings were reviewed, including general arrangements, piping layouts, heating and ventilating layouts, fire detection layouts, architectural drawings and cable tray and conduit drawings.

Fire protection features for WNP-2 are directed at providing protection for a dedicated shutdown path which includes RHR Loop B. This review concentrated on establishing that RHR Loop B is located either in separate fire areas or is protected when in a common fire area, and that this location/protection arrangement will provide assurance that this dedicated path is available for hot shutdown.

The six review areas listed below were covered in the fire protection interactive reverification:

1. Fire Protection Commitments Review
2. Intruding Cable Review
3. Protected Cable Review
4. Suppression Systems Review
5. Fire Barrier Review
6. As-Built Inspection

The results of the reverification reviews in each of these review areas are discussed in the sections that follow.

3.5.3.1 Fire Protection Commitments Review

This review was to reverify that the fire protection features described in the FSAR, Appendix F, were incorporated into the plant as designed.

Appendix F lists the features of each fire area. Fire Area R-IV, RHR Pump Room for Loop B, and RC-II (the cable spreading room) were selected as representative of redundant and common fire areas.

Comparison of the drawings to Appendix F of the FSAR verified that the physical features listed were included in the design. This review verified that the RHR Loop A and B equipment, piping, cable, etc., were located as described and that the fire protection design description (fire barriers, detectors, etc.) was accurate.

No potential finding reports were issued as a result of this review.

3.5.3.2 Intruding Cable Review

Fire Area R-IV is a redundant fire area containing RHR Loop B equipment (Division 2). Appendix F lists all Division 1 cables that intrude into this area and also lists all Division 2 associated circuits.

Assuming a fire in Area R-IV would destroy all cables within the area, 100% of the Division 1 cables and Division 2 associated circuit cables were reviewed for loss of function.

It was concluded that loss of RHR Loop B and all RHR Loop A cables in Area R-IV due to a fire would not affect the capability to achieve safe shutdown with RHR Loop A.

PFR FP-4, classified as an observation, observed that Note 7 on Drawing M521, Sheet 2, does not apply to Valve RHR-V-40. The WNP-2 Project indicated that this drafting error will be corrected on the drawing. The actual installation is correct.

3.5.3.3 Protected Cable Review

Fire Area RC-II, the cable spreading room, is a common fire area containing RHR-Loop A and B cables (Divisions 1 and 2). Appendix F lists all Division 1 and 2 cables in the area that must be protected, including dedicated RHR cables.

The purpose of this review was to examine RHR cables that exist in a common fire area where protection by barriers is relied upon, to provide assurance that cable protection is provided. All of the RHR cables in the cable spreading room were examined and found to be thermally protected.

PFR-FP-01, classified as an observation, reported several drafting errors on Drawing E948 which lists cable tray nodes and the cables passing through them. In all cases, adjacent nodes showed the cables and, in the case of a missing node number, common cables passed through adjacent nodes. Field installation is correct; there are no safety implications.

3.5.3.4 Suppression Systems Review

This review was conducted to verify that activation of the fire protection systems would not prevent both trains of the RHR from performing their required functions.

Fire Area RC-II was examined for effects in the RHR system of activation of the fire suppression function.

The cable tray and conduit drawings were examined for possible electrical panels, boxes, racks, etc., that exist in Fire Area RC-II, which could have an adverse affect on the RHR system if they were inadvertently sprayed by water from the automatic water suppression system.

No panels, racks, or boxes from the RHR system were found to exist in RC-II.

In addition, all RHR system cables listed in Appendix F that exist in fire area RC-II were traced and found to pass through the area unbroken (no terminals); providing additional assurance that there is no RHR System connection point in RC-II that could be adversely affected.

Automatic water suppression systems exist only in fire areas RC-II, RC-III, the corridor of TG-1, in the three diesel generator rooms, and over the charcoal filters in the Radwaste Building. Fire areas RC-II and RC-III contain only cable and the TG-1 corridor does not contain any RHR equipment.

Fire Area RC-II and the elevations directly below were reviewed to verify that all possible openings between the elevations are sealed and that curbs exist at the room entrances to prevent water in the stairwells from running into the fire areas at lower elevations.

It was concluded that sufficient design features are included to prevent water from Area RC-II from flowing into the elevations below.

No potential finding reports were issued.

3.5.3.5 Fire Barrier Review

This review was conducted to examine the fire barriers installed to provide assurance that their existence will not adversely affect the cables that they are designed to protect.

The test reports used to establish thermal derating factors were examined and found to be consistent with the ICEA (NEMA-WC-51-1972) methods of derating cables. The test reports also indicated that the tests themselves were representative of cable tray loading at WNP-2 and are applicable to this plant.

Cable sizing calculations were examined and did not indicate references to thermal derating; however, Burns and Roe advised that this was in process. Accordingly, hand calculations were made for representative 5000 Volt power cables that are enclosed in thermally protected trays. The cables reviewed were found to be acceptable. Hand calculations for 1000 volt power cables confirmed that four 1000 Volt power cables must be resized as was indicated by the in-process work.

Cable tray loading for protected trays was spot checked at three locations in the corridor between the Radwaste and Reactor Building and found to be satisfactory.

It was concluded that fire barriers provided will not of themselves adversely affect cable performance.

No potential finding reports were issued in this review area.

3.5.3.6 As-built Inspection

This review was performed to assure by on-site inspection that the fire protection features reviewed in the design documents are incorporated into the plant as built.

In some areas of the inspection, it was found that cable tray fire barrier work had just started (RC-II and R-I). This was not unusual since Thermo-lag fire protection of cable trays can only reasonably be done after all cables in an area are completed. The corridor between the Reactor and Radwaste Buildings was complete and it was found that the installation did agree with the design drawings. On the basis of the inspection, it is reasonable to assume that fire barrier installation in R-I and RC-II will be done in accordance with the design drawings.

The inspection found that physical fire area boundaries, fire detectors, sprinkler systems and intruding cables were in accordance with design documentation.

Inspection of fire area R-IV HVAC duct fire dampers was performed and fire area RC-II was inspected for curbs around floor penetrations. Installed curbs were found to agree with structural drawings.

It was concluded that the as-built plant incorporates the design features for fire protection.

No valid findings or observations result from the as-built inspections.

3.5.4 PIPE BREAK/MISSILE EVALUATION JET IMPINGEMENT/FALLING OBJECTS/FLOODING

The primary interactive design consideration for pipe break/missile/jet impingement/flooding/falling object involves demonstrating that the plant can be brought to and kept in a safe shutdown mode, including prevention of offsite radiological consequences, assuming an additional single active component failure as specified in 10CFR50, Appendix A, Criteria 4. The reverification effort focused on determining if the intent of that criteria has been met by the WNP-2 pipe break and missile studies. The following items were reviewed:

(1) Pipe Break Locations. Verified that postulated pipe break locations comply with the criteria identified in the FSAR using the latest stress analyses for two high energy lines--the HPCS injection line inside containment and the RWCU pump discharge to the RWCU heat exchanger outside containment.

(2) Pipe Break Effects. The two lines chosen for break location review were also used to investigate the effects of postulated damage. The B&R evaluation of potential damage from pipe whip and the consequences of the event were reviewed.

(3) Evaluation of Credible Missiles and Falling Objects. This review verified that the design methodology for determining credible missiles is consistent with general industry practice and that 10 CFR50, Appendix A, Criteria 4 are met. It also verified, through walkdown and a review of analyses, that the following two missile sources were adequately addressed to ensure plant safe shutdown:

a) RPS Motor-Generator Sets (RPS-M/Gen-1 and 2) and associated missile protection barriers.

b) RHR Pump (RHR-P-2B) in RHR Pump Room (Loop B). Additionally, the RHR Pump Room was surveyed for potential missile generation by falling objects.

3.5.4.1 HPCS Pipe Break Inside Containment

The HPCS system pipe break analysis reverification concentrated on pipe break studies on the high energy piping extending from the HPCS nozzle of the reactor vessel to the vessel isolation check valve HPCS-V-5.

Twenty-two documents were reviewed in performing the reverification of the HPCS pipe break analysis. The HPCS system in the drywell was inspected several times to identify potential targets, including a joint walkdown with B&R to resolve differences and arrive at a common potential target list.

A. Pipe Break Locations and Reaction Forces Reverification

Pipe break requirements were verified by alternate calculations. As indicated in Standard Review Plan SRP-3.6.1, breaks were postulated at terminal ends and at the required number of intermediate locations. Because the subject piping layout involves only one change in direction, only one required intermediate break location was considered. Circumferential and longitudinal breaks as well as axial splits were postulated at the required break locations.

The conclusions reached with this phase of the reverification study are in general agreement with those of the original Burns and Roe design calculation 5.49.050 Revision 1, "Pipe Break Analysis, WNP-2, Inside Containment". All required break locations were considered by the original analysis, break types were postulated correctly, whip characteristics determined adequately and pipe stability conclusions made properly.

No PFR's were written against the postulated break reviews.

B. Pipe Whip Support PWS-2-1

Pipe whip restraint PWS-2-1 design adequacy was reviewed against the imposed loadings. The primary function of a pipe whip restraint is to control pipe motion upon the occurrence of a circumferential or longitudinal break. As used in this context, a pipe whip restraint is considered to be different from a pipe support. Pipe whip restraints are designed for one-time usage, and as such are allowed to have greater distortion, plastic deformation, etc., than is permitted for pipe support designs.

The imposed pipe whip restraint design loads are comprised of the following components:

a) Equivalent static loads on the structure generated by the reaction of the broken high energy pipe during the postulated break

b) Jet impingement equivalent static loads on the structure generated by the postulated break

c) Missile impact equivalent static loads on the structure generated by or during the postulated break, as from pipe whipping. The effects of dynamic loading on the structural behavior of restraint members was also considered.

Alternate calculation ME-02-83-06 Revision 0, 02/25/83, details the design verification of pipe whip restraint PWS-2-1. One valid finding resulted from this review as discussed below.

PFR-PB-1, classified as a finding, reported that the independent reviewer could not determine the basis for stress allowables utilized by B&R in calculation 8.01.52. This calculation was the basis for the design of pipe whip support PWS 2-1. Further evaluation revealed that the design of the installed pipe whip supports is adequate; however, the calculation was in error in that it reflected incorrect materials and incorrect allowables. All pipe whip support calculations were revised to reflect correct materials and correct methodology for determining allowable stresses.

C. Potential Target Identification Reverification

Field walkdowns were conducted to verify potential target locations, given the previously postulated breaks and subsequent pipe reactions. Targets identified are addressed by the shutdown analysis studies, which serve to verify plant adequacy following an assumed accident condition.

Twenty distinct targets were identified during this reverification study for the five subject postulated breaks. The Burns and Roe original design calculation 5.49.051 for the same assumed breaks found 15 potential targets. The five differences include three items of relatively minor significance, and two of more potential importance. One PFR resulted from this difference in potential target identification.

PFR-PB-2, classified as an observation, noted that during the walk-down of the HPCS piping and compartment, several different potential targets were identified than had been used in the original B&R calculation 5.49.051, Rev. 1. B&R response BRWP-RO-83-313 satisfactorily addressed the reviewer's specific concerns. The generic issue concerning training and procedures for target identification is addressed in the description of PFR-PB-6.

D. Safe Shutdown Analyses Reverification

Post-accident damage sequences were reviewed for all postulated pipe breaks, given the pre-determined whip characteristics of the pipe and the relative strengths and weaknesses of potential targets. Generally, agreement was found with the B&R design calculation 5.49.050 Revision 1, with the following exceptions. The post accident scenarios following circumferential breaks in the vertical riser containing valves HPCS-V-5 and HPCS-V-51 were in slight disagreement. Jet impingement loads were found to potentially cause partial crimping of CRD lines in the B&R design calculation, while the reverification study determined these not to be potential targets. Also, the weld strength of four shear lugs on the vertical riser was overestimated in the original B&R design calculation. Consideration of the proper weld shear capacity resulted in failure of these lugs and a slightly varied post-accident damage sequence.

One PFR resulted from this variation. Although the postulated post-accident damage scenario differed, plant shutdown capability would not be impaired by the differences noted.

PFR-PB-3, classified as a finding, noted an error in B&R calculation 5.49.030, page 9, which indicates that the shear capacity of fillet welds for structural attachments was 47,850 psi. Supply System alternate calculations determined the value to be only 35,000 psi. B&R performed alternate calculations showing that the existing design is adequate and committed to formally revise the original calculation. The Burns and Roe corrective action included a review of all calculations in which credit was taken for the resistance of hangers, snubbers, or steel structures to limit the travel of the ruptured pipe. This item will be tracked to completion as Letter No. BRWP-RO-83-258.

All safety-related equipment in the drywell is qualified to tolerate accident conditions including inadvertent actuation of the drywell spray headers. All drywell leaks will run into the wetwell if sufficient water accumulates to run over the lips of the downcomers (1 inch). Therefore, the HPCS pipe break will not compromise any additional equipment because of flooding. The total system is adequately designed to accommodate pipe break flooding inside the drywell.

E. Potential Target Resolution Reverification

Review of B&R draft target resolution calculation 5.49.052, Rev. 0, resulted in questions regarding resolution of ADS control cables identified as potential targets for the HPCS line break. PFR-PB-7 was issued to document the deficiencies observed.

PFR-PB-7, classified as a finding, noted several discrepancies in draft B&R calculation 5.49.056, Rev. 0, (the inside containment pipe breaks target calculation). This calculation was not finalized at the time of the independent review; therefore, the problems noted may have been corrected by B&R in the final calculation. Since the calculations were not final, it could reasonably be argued that it is not a valid finding. However, because of the potential safety significance of the observed deficiencies and the need for generic corrective action, the PFR was classified as a finding by the Findings Review Committee. A corrective action plan to eliminate the observed deficiencies was established by the Project. The generic issues of improving target determination procedures and training are discussed in connection with PFR-PB-6.

3.5.4.2 RWCU Pipe Break Outside Containment

The RWCU System pipe break analysis reverification concentrated on the pipe break studies of the portion of RWCU piping entitled Part A of RWCU Analysis Group 24. The subject piping extends from the regenerative heat exchanger RWCU shell inlet and outlet nozzles to actual anchors RWCU-181 and RWCU-901N.

Nineteen documents were reviewed in performing the RWCU pipe break analysis reverification activity. The RWCU system piping in the area of the postulated breaks was walked down and inspected several times to identify potential targets, including a joint walkdown with B&R to resolve differences and arrive at a common potential target list.

A. Pipe Break Locations and Reaction Forces Reverification

Pipe break location requirements were verified by alternate calculation. The analysis was performed using the guidelines for high energy piping.

From Standard Review Plan SRP-3.6.1, breaks were postulated at terminal ends and at a minimum of two intermediate locations, where it is predicted that maximum pipe whip and jet impingement will result. Based on a review of provided piping analyses, total system stresses never exceed .8 (Sh + Sa); therefore, the chosen two intermediate points represent only areas of high relative stress.

Burns and Roe Design Calculation 5.51.050, Revision 1, conservatively postulated the occurrence of four intermediate breaks plus two additional intermediate locations. Damage studies and target determinations were reviewed as part of this reverification effort for the two required intermediate breaks only. No adverse effects were found as a result of this increased Burns and Roe conservatism.

The conclusions reached with this phase of the reverification study are in general agreement with those of original Burns and Roe Design Calculation 5.51.050 RWCU Analysis Part A. All required break locations were considered by the original analysis, break types were postulated correctly, whip characteristics determined adequately and pipe stability conclusions made properly.

No PFR's were written against the RWCU postulated break reviews.

B. Potential Target Identification Reverification

Field walkdowns were conducted in order to verify potential target locations, given the previously postulated breaks and subsequent pipe reactions. Targets identified are addressed within the shutdown analysis studies which serve to verify plant adequacy following an assumed accident condition.

All potential targets were identified, whether they were impacted by a whipping pipe, or impinged upon by a postulated jet. Jets were assumed to follow the whipping pipe to a steady state location, all intermediate targets were therefore considered. Jet dispersion follows 10^{0} half angles; impingement on small piping, tubes and conduit was considered capable of destroying the function of the impacted component. Impingement on large pipes or equipment was considered incapable of causing pressure boundary damage.

A total of 27 distinct targets were identified during this reverification study for the six subject postulated breaks. The Burns and Roe original Design Calculation 5.51.051 Revision 1, for the same assumed breaks found 11 potential targets.

One PFR resulted from this disparity.

PFR-PB-6, classified as a finding, noted that the field walkdown of the RWCU piping and compartments revealed several more potential targets than were cited in the original B&R calculation, 5.51.051. Based on this PFR and similar findings in PFR-PB-2 and PFR-PB-7, B&R was requested to formalize their pipe break target evaluation procedures and improve the training of engineers utilizing these procedures. They agreed to do so since their analyst had not considered moving jets outside of containment. BRWP-RO-83-347 tracks this activity which is scheduled to be complete during October, 1983.

C. Safe Shutdown Analyses Reverification

The B&R "Safe Shutdown" analyses were reviewed for the identified potential targets to ensure that the ability of the plant to safely shutdown following the postulated high energy line break and one additional active failure is not compromised by loss of targets impacted by the whipping pipe or jet impingement.

The blowdown from the RWCU pipe break event was calculated to be about 60,000 lbs in 80 seconds. This is equivalent to about 8,000 gallons of water. No equipment that would be rendered inoperable by water spray was identified in the jet impingement zone nor in runoff areas. The building floor drain sumps and pumps are of adequate capacity to handle this volume of water. No flooding impacts were identified for this event.

No PFRs were identified in this review area. PFR-PB-7 does relate to the safe shutdown calculation for pipe breaks RWCU-10A and 10B and is described previously in Section 3.5.4.2.E.

D. Potential Target Resolution Reverification

The B&R target resolution calculations for the RWCU pipe break targets have not been completed and were not reviewed as part of this reverification process.

3.5.4.3 RPS Motor-Generator Sets Potential Missiles

The RPS Motor-Generator sets are located in the critical DC switchgear rooms in the Radwaste Building. Structural failure of the 1800 rpm flywheel during operation would produce missiles with the potential to damage nearby systems, components and structures in their paths.

Eighteen documents were reviewed during the reverification of the RPS Motor-Generator missile analysis. The area was also inspected to determine potential targets in the flight path of flywheel missiles, and a joint walkdown with B&R was performed to resolve differences and arrive at a common potential target list.

A. Potential Target Identification Reverification

Flywheel missiles are postulated to leave the motor generator sets distributed along a plane perpendicular to the flywheel axis, with the missiles exiting a maximum of ten degrees from the perpendicular plane. Secondary missiles are not considered to be credible.

The potential targets identified for the motor-generator sets were determined by field walkdown. This list of targets differs from the original B&R target identification in B&R calculation 5.50.051 dated 6/25/82. However, the joint walkdown resulted in a common potential target list. The final B&R as-built walkdown had not taken place at the time this reverification activity was performed, so some deviation due to changes during construction are expected.

No PFR's were written as a result of the potential target identification reverification.

B. Safe Shutdown Analyses Reverification

There are several vital components of both electrical Divisions I and II in the area of the RPS Motor-Generator sets that could be impacted by flywheel missiles. Therefore, a missile barrier for each set is provided as indicated in the WNP-2 FSAR. The missile barriers are designed to prevent damage to any safety-related component from flywheel missiles.

No PFR's were written as a result of this part of this reverification review.

C. Missile Barrier Adequacy Reverification

The RPS Motor-Generator sets missile barriers were reviewed to ensure that they would absorb the postulated flywheel missile kinetic energy and protect the safety-related components identified as potential missile targets.

An alternate calculation was completed to verify the missile barrier structural adequacy. Twelve documents were reviewed during its preparation.

The alternate calculation was based on a conservative approach which assumed that the potential energy of the missile was not reduced by the postulated rupture of the flywheel housing or by collapse of the crushable hexcel barrier liner. Therefore, all potential energy was applied to the barrier structural attachments. The loads and stresses in the barrier members were determined and compared to dynamic allowables. All members were acceptable as designed.

No PFR's were issued as a result of verifying this review area.

3.5.4.4 RHR-P-2B Potential Missile Reverification

RHR-P-2B, located in the Reactor Building basement, was reviewed to determine whether this piece of high speed rotating equipment was a credible missile source, and whether any further missile protection from potential pump missiles was required.

Six documents were reviewed while performing this reverification activity. The area around the RHR-P-2B was inspected to identify potential missile targets, and a joint walkdown with B&R performed to resolve differences and arrive at a common potential target list.

The inspection revealed that any impeller missiles generated by structural failures in the pump would be retained in the pump suction pit. The missiles were postulated to project with a 10^{o} half-angle cone perpendicular to the rotating impeller. As described for the RPS motor-generator sets, secondary missiles are not considered to be credible sources of damage.

The only potential targets in the path of RHR-P-2B missiles are RHR lines in the pump pit. Loss of function of these lines would not further impact the ability of the plant to safely shutdown.

No PFR's were written as a result of the review of missiles from RHR-P-2B.

3.5.5 QUALIFICATION OF SAFETY RELATED EQUIPMENT FOR ENVIRONMENTAL CONDITIONS AND DYNAMIC LOADS

The Supply System has undertaken a thorough equipment qualification program to assure all Class 1E and safety-related mechanical equipment is qualified to NUREG-0588, Category II. This program includes development of WNP-2 specific hydrodynamic loads, environmental conditions, qualification document retrieval, re-evaluation of past tests and analysis, justification of methods used, and retesting or supplemental analysis where necessary. The program, including the results as of September 1982, was submitted to NRC in the WNP-2 Dynamic Qualification Report for Safety-Related Equipment([16]) and the WNP-2 Environmental Equipment Qualification Report for Safety-Related Equipment.([17])

The scope of this design reverification was to assure adequate implementation of the equipment qualification program for the HPCS and RHR safety systems. Review areas included within the scope of this reverification effort include:

1. Equipment Classification Review--Verification that the equipment used is included in the Class 1E and safety-related equipment lists

2. Component Dynamic Loading and Environmental Condition Review--Verification that proper dynamic loads and/or environmental conditions have been used as input to the qualification evaluation of selected components

3. Component Qualification Review--Verification that the component qualification evaluation was properly performed

4. Deferred Qualification Status Components Review--Check of several HPCS and RHR components from the deferred qualification list to determine if they are required as part of the qualified shutdown path

5. Review of Equipment Which Can Fail Without Affecting Safe Shutdown--Check of several HPCS and RHR components from Table D of the Justification for Interim Operation (JIO) to determine if failure of these components due to harsh environment exposure would adversely affect safe shutdown.

6. Review of High Energy Line Break Calculations--Review of the calculations and assumptions which define the auxiliary steam

line break environment to verify High Energy Line Break (HELB) accident conditions since this case gave the limiting environmental conditions for equipment in both the HPCS and RHR systems. Based on findings uncovered during the initial review, this scope was expanded to include review of all twelve Supply System calculations which evaluated high energy line break environments outside containment plus three supporting B&R calculations.

Each of these review areas is discussed in the following sections.

3.5.5.1 Equipment Classification Reviews

Equipment in the High Pressure Core Spray (HPCS) and the Residual Heat Removal (RHR) Systems that must be qualified includes all Class 1E electric equipment as defined in IEEE-323, 1974, plus the instrumentation required by the operator to follow the course of an accident. It also includes all HPCS and RHR safety-related mechanical equipment that is essential to the performance of these systems and the instrumentation identified by Reg. Guide 1.97. For WNP-2, this equipment is listed in the Class 1E Electric Equipment List and the Safety-Related Mechanical (SRM) Equipment List. Each one of the HPCS and RHR system components selected for reverification (Table 3-10) was evaluated to verify its function, safety status, plant location (i.e., mild or harsh environment), its inclusion in the Class 1E or SRM list, and that the actual component installed in the plant is the same or a similar component that is documented as being qualified in the two qualification reports. These areas evaluated were:

A. What is the component function?

B. Is the function essential?

C. Is the component located in harsh environment?

TABLE 3-10

List of Components Evaluated in Sections 3.5.5.3 and 3.5.5.4

HPCS		RHR	
1.	HPCS-P-1	1.	RHR-P-2B
2.	HPCS-M-1	2.	RHR-HX-1B
3.	HPCS-CB-HPCS	3.	RHR-V-3B
4.	HPCS-V-4	4.	RHR-V-24B
5.	HPCS-MO-4	5.	RHR-V-47B
6.	HPCS-42-4A5B	6.	RHR-FE-14B
7.	HPCS-M-3	7.	RHR-FCV-64B
8.	HPCS-42-4A7C	8.	RHR-FIS-10B
9.	HPCS-CB-4-2	9.	RHR-FT-1
10.	HPCS-CB-4DG3	10.	RHR-FI-5
11.	HPCS-ST-2	11.	RHR-PS-16B
12.	HPCS-V-5	12.	RHR-42-8BB5B
13.	HPCS-V-23	13.	RHR-42-8BA2C
14.	HPCS-RO-4	14.	RHR-42-8BA4B
15.	HPCS-V-710	15.	RHR-42-8BA3D
16.	HPCS-RV-35	16.	RHR-CB-RHR2B
17.	HPCS-V-12	17.	RHR-M-2B
18.	HPCS-P-2	18.	RHR-MO-3B
19.	HPCS-LS-1A	19.	RHR-MO-4B
20.	HPCS-LS-2A	20.	RHR-MO-24B
21.	HPCS-FT-5	21.	RHR-MO-64B
22.	HPCS-DPIS-9		
23.	HPCS-FIS-6		
24.	HPCS-PS-12		
25.	HPCS-FE-7		
26.	DE-F-1		
27.	SA-C-2C		
28.	DG-ENG-1C		
29.	DO-TK-4		
30.	DCW-HX-1C		

D. If the answer to B is yes, is the component on the Class 1E or SRM List?

E. Is the component manufacturer, model number and location identified on the list, the same as that for the installed component?

The component function and whether or not the function is essential to the proper operation of the safety system, was determined by reviewing the HPCS and RHR System design specifications, data sheets, and process flow diagrams. If the failure of the component to perform its function prevented the HPCS and RHR Systems from performing their plant safety function(s) during an accident condition, then the component was considered "essential". The component was considered to be in a harsh environment if it is located within the reactor building or the primary containment (and not within an environmentally controlled room). All other locations are considered to have mild environments where no environmental qualification is required. If the component is essential, then the component should be included in either the Class 1E or Safety-Related Mechanical (SRM) List. A check of these lists was made to ascertain that this was true.

Fifty-one components were reviewed. All HPCS-selected components were listed in the Class 1E and SRM Equipment lists. All RHR-selected components except RHR-FI-5 were likewise listed. RHR-FI-5 was classified as non-essential and was thus not required to be listed.

No potential finding reports were issued as a result of this review.

A review was made to determine if the manufacturer's model numbers shown in the Class 1E/Safety-Related lists accurately reflect those for the equipment installed in the plant for the 51 components reviewed. In all but ten cases the manufacturer-provided information agreed with that found either on the component during the plant walkdown inspection or from information extracted from the vendor information files. Those components with discrepancies are as follows:

1. DSA-C-2C
2. DCW-HX-1C
3. RHR-FCV-64B
4. RHR-FIS-10B
5. RHR-FT-1
6. RHR-42-8BA2C
7. RHR-42-8BA3D
8. RHR-42-8BA4B
9. RHR-42-8BB5B
10. HPCS-42-4A7C

PFR-EQ-3 and PFR-EQ-17 were issued to document these deficiencies.

PFR-EQ-17, classified as an observation, was issued to document model number discrepancies for components 1-9 listed above. A review to determine if item 1, DSA-C-2C, is essential to plant safety disclosed that the component need not be included on the Safety-Related Mechanical (SRM) list. The Project initiated action to remove this component from the list. Review of the qualification files showed that the qualification of item 2 has not yet been completed. It has been determined for items 3 through 9, that the actual components installed in the plant are adequately addressed by the qualification file and the components are qualified. Upon completion of the qualification program for item 2, all discrepancies documented by PFR-EQ-17 will be corrected.

PFR-EQ-3, classified as an observation, noted what appeared to be a lack of qualification records for rack 7C of MC-4A. MC-4A was procured from one vendor, qualified, given a Qualification Identification (QID) number, and given an Equipment Piece Number (EPN). Later, a seventh rack (free standing) for the Motor Control Center (MCC) was obtained from a second vendor, qualified, given a second QID number but the same EPN; therefore, two QID's for one EPN which resulted in issuance of a PFR. The equipment is properly qualified and the documentation is in place. The MCC containing Rack 7C was renumbered to permit proper tracking. A review of other MCC's indicates this to be a unique occurrence.

3.5.5.2 Component Dynamic Loading and Environmental Conditions Review

Each one of the selected components in the HPCS and RHR systems (Table 3-10) was evaluated with respect to the dynamic loadings (both seismic and hydrodynamic) and environmental conditions (including pressure, temperature, humidity and radiation).

The dynamic qualification loads for which all 21 RHR system selected components are qualified exceed their corresponding required input loads except for the following two components where no information was provided:

A. RHR-FT-1 - qualification of this component has been deferred and is included in the JIO list.

B. RHR-FI-5 - No qualification is required since this component has been classified as a non-Class 1E component.

All but three of the pipe-mounted RHR components have had their final pipe input loads reconciled with the interim loads used in the dynamic qualification evaluation. These three components, RHR-MO-4B, RHR-V-24B, and RHR-MO-24B, are included on the safety-related mechanical equipment list and hence the dynamic qualification will be completed when the final loads are established by B&R.

The environmental qualification profile to which the components are qualified exceeds the corresponding requirements for all selected RHR components that are required to be environmentally qualified. Five components, located in a mild environment, do not require environmental qualification. Two components, RHR-HX-1B and RHR-FE-14B are not active mechanical components; therefore, they do not require environmental qualification. As noted above, RHR-FT-1 is deferred and RHR is a non-Class 1E component for which no qualification is required.

The dynamic qualification for eleven of the 30 HPCS components selected for review was still under evaluation or determined to be unacceptable by the Environmental Qualification Group; therefore, they were not further evaluated in this segment of the review. The final dynamic loads for qualification of HPCS-RV-25 were not available for reconciliation; however, as discussed previously for the RHR system, qualification of this component is in progress. For the remaining 19 components, the review of the qualification records confirmed that fifteen met or exceeded the applicable requirements.

Three potential finding reports (PFR-EQ-1, PFR-EQ-2 and PFR-EQ-9) were issued, related to the dynamic qualification of HPCS components.

PFR-EQ-1, classified as an observation, reported that a valve motor operator for which seismic qualification was required was not included on the qualified equipment list. Further evaluation concluded that the motor operator was indeed qualified. The motor operator has been added to the qualification list and qualification status properly indicated.

PFR-EQ-2, classified as an observation, reported that the seismic qualification file design certification submitted does not include HPCS-RO-4. The environmental qualification group was requested to correct the QID. The file has been corrected.

PFR-EQ-9, classified as an observation, reported a discrepancy between the required and as-tested values used for the seismic qualification of HPCS-LS-2A which appeared on the Class 1E list as qualified. The error occurred during the generation of the Class 1E list. The qualification status of HPCS-LS-2A has been corrected and a line-by-line review of the Class 1E list against the QID files has been instituted to conform the two lists.

3.5.5.3 Component Qualification Evaluation Review

Four components in each of the HPCS and RHR systems were selected from the Class 1E or SRM lists for reverification of their qualification (both dynamic and environmental). These components are listed in Table 3-11.

The components are a pump, two valves, a motor, a motor operator, a heat exchanger and two pressure sensors. The review of the dynamic qualification of each component included the qualification method (analysis or test), performance of function and criteria for its acceptance (if tested), structural deformations, if any, and resonant frequencies determined. When the dynamic qualification method was by analysis, the calculated stresses due to seismic and/or hydrodynamic excitation were compared to the maximum allowable stresses. The calculated stem deflections (for valves) due to seismic or hydrodynamic excitation were compared to allowables for operability purposes.

Table 3-11

Components Reviewed in Component Qualification Evaluation (Section 3.5.5.5)

	HPCS		RHR
1.	HPCS-V-4	1.	RHR-FIS-10B
2.	HPCS-P-1	2.	RHR-M-2B
3.	HPCS-MO-4	3.	RHR-FCV-64B
4.	HPCS-PS-12	4.	RHR-HX-1B

The environmental qualification review for each component included the method of qualification (test or analysis), performance of function during any test, including acceptance criteria met and margin demonstrated during the qualification. Documents reviewed include seismic test reports and analyses, environmental material evaluations and test reports and other qualification material found in the WNP-2 qualification documentation files.

All mechanical components were dynamically qualified by static and/or dynamic analysis methods.

All electric components were dynamically qualified by testing the actual or a similar component. Each properly performed its function before, during and after the dynamic qualification tests, thus meeting the prescribed acceptance criteria. No structural deformation was observed and all electric components were mounted on the vibration table or test fixture in the same manner as installed in the plant.

All eight HPCS and RHR selected components are located in the reactor building; therefore, they are exposed to a harsh environment.

The three active mechanical components were environmentally qualified by analysis of their non-metallic materials. The heat exchanger (a passive mechanical component) did not require environmental qualification per paragraph 4.5 of the WNP-2 Environmental Equipment Qualification Report for Safety-Related Equipment. (Mechanical equipment whose process fluid conditions are equal to or more severe than accident conditions are considered environmentally qualified.)

The review concluded that the four electric components reviewed in this phase of the qualification reverification program were subjected to correct qualification methods and were tested in a proper manner, including performance of function during and after the tests. However, a valve operability test remains to be performed on RHR-FCV-64B. The requirement for this test is being appropriately tracked by the Project. Margins were considered in the qualification of all eight components.

No PFR's were issued as a result of this review.

3.5.5.4 Deferred Qualification Status Components Review

Documentation of the qualification of all safety-related equipment in accordance with NUREG-0588, Category II, will not be complete prior to fuel load. Therefore, a Justification for Interim Operation (JIO) has been prepared and submitted to the NRC.

The review activity defined for the reverification program included defining four components in each of the HPCS and RHR systems that are in the deferred qualification status and reviewing their functions in the system to determine if they are or are not required as part of the qualified shutdown path and located in a harsh environment. These components are listed in Table 3-12. Since no HPCS components were listed in the JIO, four RHR components were selected for review. Documents reviewed to ascertain their function in the RHR system were the System Design Specification, data sheets, and process flow diagrams.

Table 3-12

Components Selected for Review from the Deferred Qualification List (Section 3.5.5.6)

HPCS	RHR
No HPCS components are in Table C of JIO.	1. RHR-FIS-10B
	2. RHR-FT-1
	3. RHR-PS-16B
	4. RHR-V-75B

This review concluded that these four components are properly classified as components whose qualification can be deferred with no affect on plant safety.

No potential finding reports were issued as a result of this review.

3.5.5.5 Review of Equipment Which Can Fail Without Affecting Safe Shutdown

A Failure Modes and Effects Analysis (FMEA) was performed for all safety-related equipment that need not function to achieve essential safety functions. All components whose failure was determined to have no adverse effect on plant safety or accident mitigation need not be qualified for any harsh environment. The FMEA analysis included determining the justification for classifying the components that need not be environmentally qualified for a harsh environment. These components are listed in the JIO. In order to perform a reverification of this component selection, four components in the RHR system, and two in the HPCS system were selected for a review of their system function to determine if their failure due to harsh environment exposure will adversely affect the qualified shutdown path. These selected components are listed in Table 3-13.

Table 3-13

Review of Equipment Which Can Fail Without Affecting Safe Shutdown (Section 3.5.5.7)

HPCS	RHR
1. HPCS-POS-V/51	1. RHR-PT-26B
2. HPCS-POS-V/76	2. RHR-CE-25
	3. RHR-SRV-65B
	4. RHR-POS-V/111B

Documents reviewed in this reverification include the HPCS and RHR design specifications, data sheets and process flow diagrams along with the B&R plant layout drawings used to determine component location.

All six components are located in the reactor building; therefore, they are exposed to a harsh environment. The four RHR components have functions that are used only when the plant is in a shutdown condition. Malfunctions of these components at normal plant operation due to the harsh environmental conditions brought on by an accident (HELB, etc.) will have no effect on accident mitigation or safe plant shutdown or on the safety functions of the RHR system. The HPCS components are valve position switches indicating the open or closed status of the manually-operated valves. These valves are either locked-open or closed during normal plant operation. Their failure due to the harsh environment will not affect the proper operation of the HPCS system.

This review concluded that these six components are properly classified as components whose failure due to harsh environment exposure will not adversely affect the qualified shutdown path.

No potential finding reports were issued as a result of this review.

3.5.5.6 Review of High Energy Line Break Calculations

This review was conducted to verify the high energy line break (HELB) calculations which determine the accident qualification conditions for the WNP-2 reactor building. As part of the overall WNP-2 Reverification Program, these reviews assure that the HELB environmental conditions specified for equipment qualification were calculated in accordance with the Category II requirements of NUREG-0588.

The WNP-2 HELB accident environmental conditions are presented as a series of temperature versus time profiles with associated specifications for pressure and relative humidity for each safety related equipment room or area of the reactor building affected by the postulated high energy pipe breaks. Thirteen different break locations in the three dominant high energy systems were analyzed.

The design review was based on the requirements of NUREG-0588 and SRP Sections 3.6.1 and 6.2.1.2, and addresses three major areas of review; 1) pipe break blowdown calculations, 2) HELB subcompartment pressure, temperature and relative humidity calculations and 3) reactor building environmental zone conditions.

Based on the results of initial review of the calculations and assumptions which define the auxiliary steam line break environment, the review scope (i.e., sample size) was expanded to include review of all 12 Supply System calculations which were performed to define high energy line break environments outside of containment plus three supporting B&R calculations.

Seven potential finding reports were issued as a result of these reviews.

PFR-EQ-7, classified as an observation, noted that the reviewer was unable to confirm the existence of isolation alarms and corresponding operating procedures to isolate the auxiliary system on low pressure. Further evaluation established that the Project identified the action as a deferred change and that the review process was not complete when the potential finding was identified. The remaining steps include a B&R review for technical adequacy/licensability and a review by the Design Change Review Board (DCRB). While this PFR identified two areas in which the deferred change process should be strengthened, the FRC concluded that there was no process breakdown. In response to this observation the Project has indicated that appropriate improvements in the DCRB procedures will be implemented. No further action on this observation is considered necessary.

PFR-EQ-10, classified as an observation, noted that the computer output runs for HELB cooldown calculations are not in the calculation files. The responsible design organization indicated that they will place the outputs for runs not superceded in the files.

PFR-EQ-11, classified as a finding, noted that the blowdown mass energy release rates for the analysis used to model the break in 6" RWCU (1)-4 (B&R Calculation 5.07.20.2) in Room R-510 appear to be low. This calculation was used as input to the room pressurization calculation (B&R Calculation 5.07.62). Since the blowdown calculation did not take credit for a flow restrictor in the system, the correction of the calculation will not invalidate the results or the adequacy of the design. Two general concerns identified by this PFR are the number of nodes used for the RELAP modelling and the effect of penetration sealing for fire protection on room vent area on the pressure response. The Project provided a corrective action plan for resolution of these concerns which involve reevaluations by B&R (utilizing IMPELL calculations) of all of their room pressure calculations. The corrective action plan was reviewed and accepted. Tracking of remaining action is accomplished through B&R Task No. 5180.

PFR-EQ-13, classified as a finding, noted that a nonconservative isolation valve closure characteristic was assumed for the RCIC gate valves in the HELB environmental calculations. Proper valve closure characteristics were incorporated into the revised HELB calculations. In each case, this omission in the affected calculation resulted in a relatively minor peak temperature increase and did not exceed conditions for which equipment was qualified. As a result of those changes and other problems identified during the system interaction reviews, a complete revision of all HELB calculations is underway by IMPELL for the Project. The results will be evaluated against affected equipment qualification data prior to fuel load. Earlier calculations will be superseded. Completion of this action is tracked on the licensing commitment log.

PFR-EQ-14, classified as a finding and reportable under 10CFR50, Part 21, found that leak detection system temperature sensors were not located in Rooms R313, R408 and R509 where RWCU breaks are postulated. Redundant leak detection sensors are being added to the plant to provide timely isolation of the affected system. Implementation of this activity is by PED and it is tracked on both the WNP-2 Master Work List (MWL) and the licensing commitment log.

PFR-EQ-15, classified as a finding, noted that the worst case single failure effects may not have been considered for the HELB calculations for equipment qualification. The HELB environmental calculations are being revised in consideration of the worst case single active failures for blowdown or for other critical parameters. In areas where HELB are not considered, B&R is evaluating moderate energy pipe break effects for bounding environmental effects. This activity is being tracked to completion via the licensing commitment log.

PFR-EQ-16, classified as a finding, noted that the calculations to predict the HELB environments for equipment qualification took credit for normal, unqualified HVAC to reduce the high temperatures following the accidents. In correcting the calculations, the reactor building HVAC is not assumed to function. Fire protection damper positioning and ductwork integrity are also being evaluated by IMPELL with regard to credible venting/blockage. Event combinations and single failure rules consistent with the FSAR are being used. Closure is being tracked on the licensing commitment log.

The number and nature of the findings and observation from this review indicated a generic problem requiring substantive corrective actions. Generic corrective actions that were implemented include:

(1) All high energy line break calculations performed by the Supply System were redone or rechecked.

(2) All other design related calculations performed by the Supply System were redone or rechecked.

(3) An independent review of the Supply System/Burns and Roe design interface is ongoing and actions are being initiated to strengthen this interface for future work.

3.5.6 STRUCTURAL MEMBERS

This review was performed to determine if loads applied to structural members were adequately considered in the design process.

The design of the north wall of the main steam tunnel extension, a wall in the reactor building (outside containment) at elevation 471'-0", and a steel framed floor at elevation 444'-0" in the Reactor Building (outside containment) was examined in detail, not only to determine the adequacy of the walls, but to see if generic problems exist in the reconciliation of mechanical loads.

Flooring systems were investigated to determine if seismic inertia loads used to design floors remain valid after large masses, which cause a reduction in natural frequency, are attached to them. The impact of floor amplification on equipment mounted on the floor was also checked.

3.5.6.1 Verification of Wall Loads

One of the major objectives of this review is to determine if loads from attachments were properly included in the design process.

The loading combinations which must be considered are shown in Table 3.8-15 of the FSAR and in the Engineering criteria Document. Many of these loads, such as wind, flood, or test pressure do not act on these walls. The loads which must be considered include dead loads, live loads, seismic loads, accident pressure loads, operating and accident temperatures, loads from pipe, cable tray, and duct supports during normal and accident conditions, and those resulting from pipe breaks.

The magnitudes of the loads used for calculations for the two walls selected were reviewed.

The review showed that attachment loads were not included in the design of the main steam tunnel. In this case the attachment loads were so small that it would be reasonable to ignore them in the overall evaluations of the wall. A second wall (2W11 at elevation 471 ft. in the reactor building) was selected which had larger attachment loads. The attachment loadings were not included in the design of this wall either.

A review to determine why the attachment loads were not included in the specific wall design disclosed that the Burns and Roe procedure for designing walls evaluated typical walls to determine their load carrying capacity. Individual walls were assessed by determining the total loads, excepting attached loads, on a wall and comparing them to the calculated capacity of the typical wall. If the loading was less than the capacity of the typical wall, the wall was designed to be identical to the typical wall.

This results in a conservative design for most walls. If the wall had a loading greater than the capacity of the typical wall, a specific design was performed.

Independent design calculations were performed to determine the adequacy of both of the walls reviewed. These calculations included all the latest loads and followed the methodology and load combinations described in the FSAR. The calculations demonstrated that the existing wall designs are adequate to resist combinations of loads including impact from whipping pipes without experiencing excessive deflection (as defined by the FSAR), and to resist all other load combinations with stresses remaining within the limits of the ACI-318 (1971) code.

One PFR resulted from this review.

PFR-WL-3, classified as an observation, reported that in the design of the main steam tunnel north wall (Calculation SIII, Vol. 18), none of the loads from attached small bore pipe supports, duct supports, and pipe whip restraint were considered. B&R responded to the FRC concerns with a plan to verify the acceptability of the loads hung on walls, Task No. 1680.

3.5.6.2 Check of Design Calculations

Two calculations were reviewed which apply to the main steam tunnel extension north wall. One defined the required amount of reinforcing steel in the wall; the second verified the adequacy of the wall under pipe rupture impact loading.

All loads of significance were considered in these calculations with the exception of attachment loadings as previously discussed; however, all of the loading combinations shown in Table E, Section B, of the Engineering Criteria Document were not evaluated. Specifically, combination 8 from the FSAR table, which includes a factor of 1.0 on the accident pressure

(Pa) and 1.0 on the SSE acceleration (E'), was used. Combination 7, which includes a factor of 1.25 on the accident pressure and 1.0 on the OBE acceleration (E), would be more severe.

No specific design calculation was prepared by Burns and Roe for wall 2W11. The "typical" wall comparison approach discussed previously (Section 3.5.6.1) was applied.

New independent calculations were performed to verify the adequacy of the walls using the latest load data. The existing wall designs are adequate.

This review concluded that:

- o The correct material properties were used in the design calculations.
- o The correct codes were used in the design calculations.
- o The assumptions made in the calculations are acceptable.
- o The procedures used in the design calculations are acceptable.

PFR-WL-01, PFR-WL-02 and PFR-WL-04 were issued during this review.

PFR-WL-1, classified as an observation, noted in the design of the main steam tunnel north wall, that not all of the load combinations in Table E, Subsection 5.21, Section B of the BRI engineering criteria document were evaluated. An alternate calculation demonstrated that the wall is adequate. This was also resolved in the BRI revised response which determined that the missing 25 percent increase in Pa of load combination 7 would not affect the results calculated using load combination 8.

PFR-WL-2, classified as a finding, noted that the elastic deflection of the main steam tunnel north wall at ultimate load was calculated using a moment of inertia based on a partially cracked concrete section. The deflection due to other loads was calculated using an uncracked concrete section which leads to an overestimate of the amount of energy the wall can absorb during pipe whip impact. Due to the potential generic implications of this discrepancy, BRI reviewed all walls exposed to a pressure of 5 or more psi. It was determined that the effects of using a cracked vs. uncracked section for the dynamic deflection does not change the final acceptability of the structures. Hence, no changes to existing structures are required.

PFR-WL-4, classified as an observation, noted that the percentage of steel in the steam tunnel north wall does not meet those shown in Table 3.6.1 of the FSAR pipe whip loads. It was determined that the unusually thick wall, 5 feet, does meet the requirements of the ACI Code even though it conflicts with the table. An FSAR change (BRSCN-83-52) was prepared to correct the table. No changes to the wall were required.

3.5.6.3 Review of Drawings

The design drawings for the two walls discussed above were reviewed and were found to be adequate; thus, no PFR's were issued.

3.5.6.4 Amplification of Floor Responses

Flooring systems were investigated to determine if seismic inertia loads used to design the floors remain valid after large masses, which would cause a reduction in natural frequency, are attached to them. The concrete floors in the reactor building were found to have short spans and sufficient thickness so that no significant change results from the attached systems. Structural steel floors however are more flexible, have a lower natural frequency and are affected by the addition of large masses.

A portion of the structural steel floor (including the attachments to the steel beams) at Elevation 444'-0" in the Reactor Building was examined. An estimate of the natural frequencies of the floor was made. The frequency above which no amplification occurs (i.e., rigid range) is about 20 Hz, and the floors have natural frequencies below 10 Hz when the added masses of the attachments are considered.

Design calculations for the floor were reviewed which evaluated the applicable load combinations. It was found that the governing load combination does not include seismic loadings. The load combination, which governs the design, includes dead load, live load and operating pressure, but no seismic loads. A second load combination includes dead load, operating pressure, and OBE loads, but not live load. There is no operating pressure load on this floor. Since the live loads are very large compared to the OBE loads, the combination (1.0 D + 1.0 L + 1.0 Po) will be more severe than (1.0 D + 1.0 Po + 1.0 E), even if the seismic accelerations are amplified to the maximum amount possible.

One of the load combinations used (which is a factored load condition) includes both live load and SSE. However, the allowable stresses for this load combination for this condition are much higher than for the first combination (i.e., 1.0 D + 1.0 P.) which governs the design, even if SSE accelerations are increased substantially.

Based on the above considerations, it was concluded that amplification due to floor flexibility is not a concern.

Although review of the effect of seismic floor amplification on floor mounted piping and equipment was not included in the original scope of the reverification plan, Burns and Roe was asked to demonstrate that the frequency response of the reactor building floors are not significant to the seismic design of decoupled floor mounted piping and equipment. As a result, the steel floor at reactor building elevation 444 ft. was selected for coupled analyses of the floor and the attached piping and equipment. All other reactor building floors outside containment need not be considered since they are of a highly rigid concrete design. The steel floor coupled analyses showed that in any horizontal direction the floor fundamental frequency is well above the seismic cutoff frequency and therefore no horizontal floor response amplification which could affect floor mounted equipment would occur. The steel floor vertical coupled analysis yielded a minimum frequency response just below the seismic cutoff frequency; which resulted in less than a 0.2g increase based on the bounding Safe Shutdown Earthquake spectra. Since the bounding seismic load increase is quite small and represents only one component (i.e., vertical) of the total square root of the sum of the squares seismic response, Burns and Roe concluded that no piping or equipment design margin would be adversely affected and that the existing seismic analysis techniques are valid. The Supply System,as part of the design reverification program,will complete a review of Burns and Roe's calculations to ensure that the study and its conclusions are correct. The results of the Supply System review will be reported in the RHR addendum to this report.

3.5.7 REVIEW OF A/E SPECIFIED PRE-PURCHASED CLASS 1E INSTRUMENT RACKS

The review of Class 1E instrument racks was included in the interactive studies review to supplement the prepurchased components reviews within each system and to provide a separate and distinct review of the A/E process for specifications and design control of prepurchased, plant-specific components.

The review covered the seismic design of the rack structure for 19 Class 1E instrument racks procured by Burns and Roe.

3.5.7.1 Design Documentation Review

The Class 1E instrument racks were supplied by Circle AW Products Company. The purchase specification was written by Burns and Roe and covers both Class 1E and Class II racks. A subvendor, Wyle Laboratories, provided a seismic analysis and performed the seismic test of two of the worst case racks. Subsequent to the test, additional seismic calculations were done by Circle AW on modifications made to the racks before shipment.

Approximately 90 documents were examined, including the Burns and Roe specification, Burns and Roe drawings for the rack arrangement, building general arrangement, rack structural support, vendor rack outline drawings, vendor test report, and vendor correspondence. The equipment environmental and seismic qualification report was also reviewed.

The instrument rack design documentation review showed that the seismic design by the vendor and the Burns and Roe review were adequate. The vendor chose to make all of the racks rigid (natural frequency greater than 33 cps) and to stiffen each of them based upon tests of the worst case racks. An allowance for future modifications that would add 20% more equipment, as required by the specification, was accounted for in the vendor seismic analysis and test. This conservative design resulted in very low seismic stresses compared to the allowables and means that rack location does not significantly affect the seismic qualification.

One of the load combinations used (which is a factored load condition) includes both live load and SSE. However, the allowable stresses for this load combination for this condition are much higher than for the first combination (i.e., 1.0 D + 1.0 L + 1.0 P.) which governs the design, even if SSE accelerations are increased substantially.

Based on the above considerations, it was concluded that amplification due to floor flexibility is not a concern. Concrete floors were found to have short spans and sufficient thickness to remain rigid under attached loads. The effect of. amplification was found to have negligible effect on steel floors when load combinations were reviewed.

No PFR's were issued for this review.

The review also showed that the Burns and Roe rack mounting details were adequate and that instrument component changes within a given rack by Burns and Roe after installation did not alter the seismic qualification of the racks.

Thus the technical design review showed that the vendor's seismic design and Burns and Roe's subsequent review, installation, and post-installation changes are satisfactory.

No potential finding reports were generated during this design review.

3.5.7.2 As-Built Inspection

The as-built inspection consisted of a physical examination of the installed instrument racks. The inspection items involved a comparison with the installation drawings and included the equipment piece number, the rack location and orientation, the mounting method, and the quantity and type of instruments within the racks.

The as-built inspection verified the correct installation for the 15 instrument racks that were examined. Four racks were not inspected.

The racks were all found to be mounted as required. No rack structural changes were found. Although some racks had instrument component changes, they were all well within the 20% allowance accounted for in the seismic qualification.

No potential finding reports were generated as a result of the as-built inspection.

4.0 REFERENCES

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(2) WNP-2 Plant Completion Plan, Rev. 8, August 15, 1983.

(3) WNP-2 Plant Verification Report, Supply System, Nuclear Project No. 2, Rev. 1, October 1982.

(4) Letter, G. D. Bouchey, Supply System, to H. R. Denton, NRC, "Nuclear Project No. 2 - Verification of Design and Construction Adequacy," dated October 22, 1982.

(5) Letter, R. L. Ferguson, Supply System, to W. J. Dircks, NRC, "WNP-2 Plant Verification Program," dated November 24, 1982.

(6) Letter, H. R. Denton, NRC to R. L. Ferguson, Supply System, "Design Verification Program for WNP-2", dated December 28, 1982.

(7) Letter, G. D. Bouchey, Supply System, to A. Schwenzer, NRC, "Nuclear Project No. 2 Qualification of Engineers Assigned to the WNP-2 Design Reverification Reviews", dated January 13, 1983.

(8) "WNP-2 Design Requirements Reverification Report, Revision 0, August 1983.

(9) High Pressure Core Spray System Design Reverification Plan, Revision 1, February 22, 1983.

(10) Residual Heat Removal System Design Reverification Plan, Revision 1, February 22, 1983.

(11) Reactor Feedwater System Design Reverification Plan, Revision 1, February 22, 1983.

(12) Systems Interactive Design Reverification Plan for Fire Hazards Evaluation - RHR System (Suppression Pool Cooling Mode), February 16, 1983.

(13) Systems Interactive Design Reverification Plan for Pipe Breaks/ Missile Evaluation/Jet Impingement/Falling Objects/Flooding, February 16, 1983.

(14) Systems Interactive Design Reverification Plan for Qualification of Safety Related Equipment for Environmental Conditions and Dynamic Loads, April 1, 1983.

(15) Systems Interactive Design Reverification Plan for Structural Members, May 1983.

(16) WNP-2 Environmental Qualification Report for Safety Related Equipment, September 1982.

(17) WNP-2 Dynamic Qualification Report for Safety Related Equipment, September 1982.