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REDUNDANT DECAY HEAT REMOVAL CAPABILITY, KEWAUNEE NUCLEAR POWER PLANT

NRC Research and/or Technical Assistance Report

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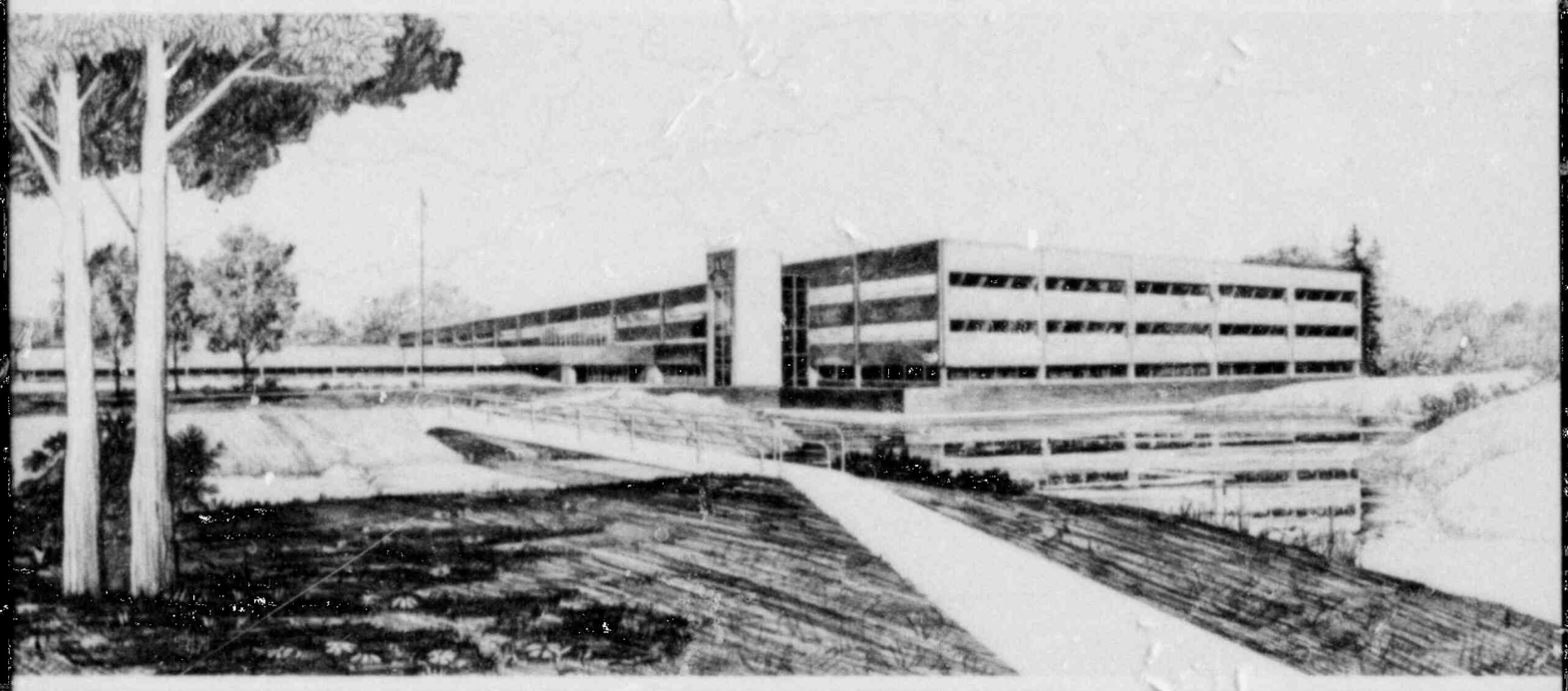
PRELIMINARY

U.S. Department of Energy
Idaho Operations Office • Idaho National Engineering Laboratory



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INTERIM REPORT

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REDUNDANT DECAY HEAT REMOVAL CAPABILITY

KEWAUNEE NUCLEAR POWER PLANT

April 1982

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EG&G Idaho, Inc.

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ABSTRACT

This EG&G Idaho, Inc. report reviews the technical specifications to establish the redundancy and the diversity of systems available for the removal of decay heat at the Kewaunee Nuclear Power Plant.

FOREWORD

This report is supplied as part of the "Selected Operating Reactors Issues Program (III)" being conducted for the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Division of Licensing, by EG&G Idaho, Inc., Reliability and Statistics Branch.

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CONTENTS

REDUNDANT DECAY HEAT REMOVAL CAPABILITY

KEWAUNEE NUCLEAR POWER PLANT

1.0 INTRODUCTION

A number of events have occurred at operating Pressurized Water Reactor (PWR) facilities where decay heat removal capability has been seriously degraded due to inadequate administrative controls during shutdown modes of operation. One of these events, described in IE Information Notice 80-20,[1] occurred at the Davis-Besse Station, Unit No. 1, on April 19, 1980. In IE Bulletin 80-12[2] dated May 9, 1980, licensees were requested to immediately implement administrative controls which would ensure that proper means are available to provide redundant methods of decay heat removal. While the function of the bulletin was to effect immediate action with regard to this problem, the NRC considered it necessary that an amendment be made to each license to provide for permanent long term assurance that redundancy in decay heat removal capability will be maintained. By the letter dated June 11, 1980,[3] all PWR licensees were requested to propose technical specification changes that provide for redundancy in decay heat removal capability in all modes of operation; to use the NRC model technical specifications to provide an acceptable solution to the concern; to include an appropriate safety analysis as a basis; and to submit the proposed technical specification changes along with the bases by October 11, 1980.

Wisconsin Public Service Corporation (WPS) responded to the NRC request for amended technical specifications[3] for the Kewaunee Nuclear Power Plant with a letter dated July 13, 1981.[4] This refered to an earlier requested amendment to technical specifications dated June 15, 1979.[5] WPS replied to IE Bulletin 80-12 on June 20, 1980.[6] WPS indicated that the existing and previously proposed technical specifications satisfied the NRC requirements of assuring decay heat removal for every mode of reactor operation.

2.0 REVIEW CRITERIA

The review criteria for this task are contained in the June 11, 1980, letter from the NRC to all PWR licensees. The NRC provided the model technical specifications[7] which identify the normal required redundant coolant systems and the required actions when redundant systems are not available for a typical four loop plant (Appendix A). The general review criteria are:

1. Two independent methods for decay heat removal are required in the units' technical specifications for each operating mode.

2. Periodic surveillance requirements should insure the operability of the systems.

The specific sections of the Standard Technical Specifications[7] for a Westinghouse unit that apply to this task are as follows:

3/4.4	Reactor Coolant System
3/4.4.1	Reactor Coolant Loops and Coolant Circulation

Startup and Power Operation (modes 1 & 2)

3.4.1.1	Limiting Conditions for Operation
4.4.1.1	Surveillance Requirement

Hot Standby (mode 3)

3.4.1.2	Limiting Conditions for Operation
4.4.1.2.1	Surveillance Requirement
4.4.1.2.2	Surveillance Requirement

Shutdown (modes 4 & 5)

3.4.1.3	Limiting Conditions for Operation
4.4.1.3.1	Surveillance Requirement

4.4.1.3.2 Surveillance Requirement
4.4.1.3.3 Surveillance Requirement
4.4.1.3.4 Surveillance Requirement

Refueling Operations (mode 6)

3.9.8.1 Limiting Condition for Operation
3.9.8.2 Limiting Condition for Operation
4.9.8.1 Surveillance Requirement
4.9.8.2 Surveillance Requirement

3.0 DISCUSSION AND EVALUATION

The Kewaunee Nuclear Power Plant is a two primary coolant loop Westinghouse PWR unit. The existing technical specifications for this unit vary from the NRC model developed from Westinghouse standard technical specifications (for a four loop unit). The following discussion reviews the differences between the two different technical specifications (Standard and Kewaunee). Kewaunee uses slightly different nomenclature for operating modes. The nomenclature for the standard operating modes will be used in the following discussion.

3.1 Startup and Power Operation--Modes 1 and 2

The standard technical specifications require that both reactor coolant loops and all coolant pumps be in operation. If these conditions are not met, the reactor is to be in hot standby (Mode 3) within 1 hour. The standard technical specifications require verification that the required reactor coolant loops are in operation at least once per 12 hours.

The Kewaunee technical specifications, Section 3.1a,[5,8a] require the use of both reactor coolant pumps in the operating (power operation) mode of operation. There is no requirement that both reactor coolant loops be operational, however, both steam generators are required to be on line at greater than 10% of rated reactor power, and one steam generator is required whenever the reactor coolant temperature is greater than 350°F. Kewaunee's

operating mode does not require two complete reactor coolant loops between 2 and 10% of rated reactor power. Kewaunee's hot standby (startup) mode of operation does not require both reactor coolant pumps or reactor coolant loops. However, a reactor trip will occur on either 1) low reactor coolant flow in either loop or reactor coolant pump breaker open or 2) power supply voltage or frequency low or 3) low-low steam generator water level (Section 2.3a.4 & 5).[8] This enforces the surveillance requirements and the component requirements of the standard technical specifications, even though the limiting conditions of operation are discrepant.

3.2 Hot Standby--Mode 3

The standard technical specifications require two coolant loops, composed of a steam generator and a coolant pump, to be operable and at least one of the coolant loops to be in operation during this operating mode.[a] If the two coolant loops are not operable and cannot be restored to operable status in 72 hours, the standard technical specifications require the unit to be in hot shutdown (Mode 4 & 5) in 12 hours. With no reactor coolant loop in operation the licensee is to suspend all operations involving a reduction in boron concentration in the coolant system and to initiate corrective action to return the inoperable coolant loop to operation. The standard technical specifications require verification that at least one coolant pump is operable once per 7 days and at least one cooling loop is in operation at least once per 12 hours.

The Kewaunee technical specifications require only one steam generator to be operable during the hot standby (hot shutdown) mode of operation. It does not require any steam generator to be operating. This does not conform with standard technical specifications. There is no requirement that any reactor coolant pump be operating if there is no change being made in the

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a. All reactor coolant pumps may be de-energized for up to 1 hour provided (1) no operations are permitted that would cause dilution of the reactor coolant system boron concentration, and (2) core outlet temperature is maintained at least 10°F below saturation temperature.

boron concentration of the reactor coolant. If the boron concentration is changing, one reactor coolant pump is required to be operating. This agrees with the standard technical specifications. There is no requirement to verify operation of a reactor coolant loop or to verify the operable status of the non-operating pumps or of the steam generators, or to return a loop to operation if neither loop is operating. This assessment can be tempered by the ability of the Kewaunee reactor to operate at up to 10% power under natural circulation; however, the availability, operation and surveillance of the steam generators is not required in the Kewaunee technical specifications.

3.3 Shutdown--Modes 4 & 5[a]

The standard technical specifications for the shutdown modes require at least two loops that are capable of removing decay heat to be operable. Either two reactor coolant loops (including at least one of their associated coolant pumps and their associated steam generators) or the two residual heat removal loops or one loop of each type must be operable.[b] The technical specifications also require one of the above loops to be operating.[c] If this criteria is not met and immediate corrective action does not restore the loop(s) to operable or operational status, the reactor is to be in Cold Shutdown within 20 hours and reduction of boron concentration operations are to be suspended (if no loop is in operation).

The Kewaunee technical specifications[8a,b] require only one steam generator to be operable when the average reactor coolant temperature is

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a. A reactor coolant pump shall not be started w th one or more of the RCS cold leg temperatures less than or equal to (275°F) unless: (1) the pressurizer water volume is less than (___) cubic feet or (2) the secondary water temperature of each steam generator is less than (__)°F above each of the RCS cold leg temperatures.

b. The normal or emergency power source may be inoperable in MODE 5.

c. All reactor coolant pumps and residual heat removal pumps may be de-energized for up to 1 hour provided: (1) no operations are permitted that would cause dilution of the reactor coolant system boron concentration, and (2) core outlet temperature is maintained at least 10°F below saturation temperature.

above 350°F. This would apply to the hot shutdown (intermediate shutdown) mode of operation. It does not apply to the cold shutdown mode of operation. It does not require the steam generator to be operating in either mode. It does not establish that a redundant heat removal system is available. This does not conform with standard technical specifications. A reactor coolant pump or a residual heat removal pump is required to be in operation when a reduction in the boron concentration of the reactor coolant is being made. It does not verify that a complete system for the removal of decay heat is operating nor that a redundant decay heat removal system is available. This does not conform with the standard technical specifications.

3.4 Refueling--Mode 6

The standard technical specifications require at least one shutdown cooling loop to be in operation. This is to be verified every 12 hours. With less than one shutdown cooling loop in operation, an increase in decay heat load is not permitted, nor is a reduction of boron concentration in the reactor coolant permitted. An exception is permitted for certain core alterations, where the shutdown coolant loop may be removed from operation for one hour out of an eight hour period. All containment atmosphere to outside atmosphere penetrations (purge and vent valves) must be closed within 4 hours of the loss of the required shutdown cooling loop. In this mode, both shutdown cooling loops are to be determined to be operable whenever the water level above the top of the reactor pressure vessel flange is less than 23 feet, with immediate corrective action required if one loop is not operable.

The Kewaunee technical specifications[8c] require at least one residual heat removal pump to be operable for this mode of operation. It does not require at least one residual heat removal loop to be operating. This is not in conformance with the standard technical specifications. The water level above the vessel flange is required to be maintained above 23 feet. The Kewaunee technical specification do not provide surveillance to insure

proper operation, but they do restrict refueling operation, prevent increasing of core reactivity and initiate corrective action.

4.0 CONCLUSION

WPS has not proposed modifications to techncial specifications. The existing technical specifications for the Kewaunee Nuclear Power Plant do not ensure redundancy in decay heat removal capacity for all modes of reactor operation, nor do they provide surveillance to insure continued availability of the redundant systems.

5.0 REFERENCES

1. NRC IE Information Notice 80-20, May 8, 1980.
2. NRC IE Bulletin 80-12, May 9, 1980.
3. NRC Letter, D. G. Eisenhut, To All Operating Pressurized Water Reactors (PWR's), dated June 11, 1980.
4. WPS letter, E. R. Mathews to D. G. Eisenhut, NRC, July 13, 1981, NRC-81-113.
5. WPS letter, E. R. Mathews to Division of Operating Reactors, NRC, "Letter to Mr. A. Schwencer from Mr. E. W. James transmitting Proposed Technical Specification Amendment No. 35," June 15, 1979.
6. WPS letter, E. R. Mathews to J. G. Keppler, NRC Region III, "IE Bulletin 80-12, Decay Heat Removal System Operability," June 20, 1980.
7. Standard Technical Specifications for Westinghouse Pressurized Water Reactors, NUREG-0452, Rev. 3, Fall 1980.
8. Technical Specifications and Basis, Kewaunee Nuclear Power Plant:
   a) Order dated April 20, 1981.
   b) Proposed Amendment No. 35, June 14, 1979.
   c) Amendment 16, March 25, 1977.

APPENDIX A

MODEL TECHNICAL SPECIFICATIONS FOR REDUNDANT DECAY HEAT REMOVAL FOR WESTINGHOUSE PRESSURIZED WATER REACTORS (PWR's)

3/4.4 REACTOR COOLANT SYSTEM

3/4.4.1 REACTOR COOLANT LOOPS AND COOLANT CIRCULATION

STARTUP AND POWER OPERATION

LIMITING CONDITION FOR OPERATION

3.4.1.1 All reactor coolant loops shall be in operation.

APPLICABILITY: MODES 1 and 2.*

ACTION:

With less than the above required reactor coolant loops in operation, be in at least HOT STANDBY within 1 hour.

SURVEILLANCE REQUIREMENT

4.4.1.1 The above required reactor coolant loops shall be verified to be in operation and circulating reactor coolant at least once per 12 hours.

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* See Special Test Exception 3.10.4.

REACTOR COOLANT SYSTEM

HOT STANDBY

LIMITING CONDITION FOR OPERATION

3.4.1.2 a. At least two of the reactor coolant loops listed below shall be OPERABLE:

1. Reactor Coolant Loop (A) and its associated steam generator and reactor coolant pump,

2. Reactor Coolant Loop (B) and its associated steam generator and reactor coolant pump,

3. Reactor Coolant Loop (C) and its associated steam generator and reactor coolant pump,

4. Reactor Coolant Loop (D) and its associated steam generator and reactor coolant pump.

b. At least one of the above coolant loops shall be in operation.*

APPLICABILITY: MODE 3

ACTION:

a. With less than the above required reactor coolant loops OPERABLE, restore the required loops to OPERABLE status within 72 hours or be in HOT SHUTDOWN within the next 12 hours.

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* All reactor coolant pumps may be de-energized for up to 1 hour provided (1) no operations are permitted that would cause dilution of the reactor coolant system boron concentration, and (2) core outlet temperature is maintained at least $10^{o}F$ below saturation temperature.

b. With no reactor coolant loop in operation, suspend all operations involving a reduction in boron concentration of the Reactor Coolant System and immediately initiate corrective action to return the required coolant loop to operation.

SURVEILLANCE REQUIREMENT

4.4.1.2.1 At least the above required reactor coolant pumps, if not in operation, shall be determined to be OPERABLE once per 7 days by verifying correct breaker alignments and indicated power availability.

4.4.1.2.2 At least one cooling loop shall be verified to be in operation and circulating reactor coolant at least once per 12 hours.

REACTOR COOLANT SYSTEM

SHUTDOWN

LIMITING CONDITION FOR OPERATION

3.4.1.3 a. At least two of the coolant loops listed below shall be OPERABLE:

1. Reactor Coolant Loop (A) and its associated steam generator and reactor coolant pump,*

2. Reactor Coolant Loop (B) and its associated steam generator and reactor coolant pump,*

3. Reactor Coolant Loop (C) and its associated steam generator and reactor coolant pump,*

4. Reactor Coolant Loop (D) and its associated steam generator and reactor coolant pump,*

5. Residual Heat Removal Loop (A),**

6. Residual Heat Removal Loop (B).**

b. At least one of the above coolant loops shall be in operation.***

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* A reactor coolant pump shall not be started with one or more of the RCS cold leg temperatures less than or equal to (275)^{o}F unless 1) the pressurizer water volume is less than ____ cubic feet or 2) the secondary water temperature of each steam generator is less than ____ ^{o}F above each of the RCS cold leg temperatures.

** The normal or emergency power source may be inoperable in MODE 5.

*** All reactor coolant pumps and decay heat removal pumps may be de-energized for up to 1 hour provided 1) no operations are permitted that would cause dilution of the reactor coolant system boron concentration, and 2) core outlet temperature is maintained at least 10^{o}F below saturation temperature.

REACTOR COOLANT SYSTEM

APPLICABILITY: MODES 4 and 5.

ACTION:

a. With less than the above required loops OPERABLE, immediately initiate corrective action to return the required loops to OPERABLE status as soon as possible; be in COLD SHUTDOWN within 20 hours.

b. With no coolant loop in operation, suspend all operations involving a reduction in boron concentration of the Reactor Coolant System and immediately initiate corrective action to return the required coolant loop to operation.

SURVEILLANCE REQUIREMENT

4.4.1.3.1 The required residual heat removal loop(s) shall be determined OPERABLE per Specification 4.0.5.

4.4.1.3.2 The required reactor coolant pump(s), if not in operation, shall be determined to be OPERABLE once per 7 days by verifying correct breaker alignments and indicated power availability.

4.4.1.3.3 The required steam generator(s) shall be determined OPERABLE by verifying secondary side level to be greater than or equal to ( )% at least once per 12 hours.

4.4.1.3.4 At least one coolant loop shall be verified to be in operation and circulating reactor coolant at least once per 12 hours.

REFUELING OPERATIONS

3/4.9.8 RESIDUAL HEAT REMOVAL AND COOLANT CIRCULATION

ALL WATER LEVELS

LIMITING CONDITION FOR OPERATION

3.9.8.1 At least one residual heat removal (RHR) loop shall be in operation.

APPLICABILITY: MODE 6

ACTION:

a. With less than one residual heat removal loop in operation, except as provided in b. below, suspend all operations involving an increase in the reactor decay heat load or a reduction in boron concentration of the Reactor Coolant System. Close all containment penetrations providing direct access from the containment atmosphere to the outside atmosphere within 4 hours.

b. The residual heat removal loop may be removed from operation for up to 1 hour per 8 hour period during the performance of CORE ALTERATIONS in the vicinity of the reactor pressure vessel (hot) legs.

c. The provisions of Specification 3.0.3 are not applicable.

SURVEILLANCE REQUIREMENT

4.9.8.1 At least one residual heat removal loop shall be verified to be in operation and circulating reactor coolant at a flow rate of greater than or equal to (2800) gpm at least once per 4 hours.

REFUELING OPERATIONS

LOW WATER LEVEL

LIMITING CONDITION FOR OPERATION

3.9.8.2 Two independent Residual Heat Removal (RHR) loops shall be OPERABLE.*

APPLICABILITY: MODE 6 when the water level above the top of the irradiated fuel assemblies seated within the reactor pressure vessel is less than 23 feet.

ACTION:

a. With less than the required RHR loops OPERABLE, immediately initiate corrective action to return the required RHR loops to OPERABLE status as soon as possible.

b. The provisions of Specification 3.0.3 are not applicable.

SURVEILLANCE REQUIREMENT

4.9.8.2 The required Residual Heat Removal loops shall be determined OPERABLE per Specification 4.0.5.

* The normal or emergency power source may be inoperable for each RHR loop.

BASES

3/4.4.1 REACTOR COOLANT LOOPS AND COOLANT CIRCULATION

The plant is designed to operate with all reactor coolant loops in operation, and maintain DNBR above 1.30 during all normal operations and anticipated transients. In MODES 1 and 2 with one reactor coolant loop not in operation this specification requires that the plant be in at least HOT STANDBY within 1 hour.

In MODE 3, a single reactor coolant loop provides sufficient heat removal capability for removing decay heat; however, single failure considerations require that two loops be OPERABLE.

In MODES 4 and 5, a single reactor coolant loop or RHR loop provides sufficient heat removal capability for removing decay heat; but single failure considerations require that at least two loops be OPERABLE. Thus, if the reactor coolant loops are not OPERABLE, this specification requires two RHR loops to be OPERABLE.

The operation of one Reactor Coolant Pump or one RHR pump provides adequate flow to ensure mixing, prevent stratification and produce gradual reactivity changes during boron concentration reductions in the Reactor Coolant System. The reactivity change rate associated with boron reduction will, therefore, be within the capability of operator recognition and control.

The restrictions on starting a Reactor Coolant Pump with one or more RCS cold legs less than or equal to (275)^{o}F are provided to prevent RCS pressure transients, caused by energy additions from the secondary system, which could exceed the limits of Appendix G to 10 CFR Part 50. The RCS will be protected against overpressure transients and will not exceed the limits of Appendix G by either (1) restricting the water volume in the pressurizer and thereby providing a volume for the primary coolant to expand into, or (2) by restricting starting of the RCPs to when the secondary water temperature of each steam generator is less than ( )^{o}F above each of the RCS cold leg temperatures.

3/4.9.8 RESIDUAL HEAT REMOVAL AND COOLANT CIRCULATION

The requirement that at least one residual heat removal (RHR) loop be in operation ensures that (1) sufficient cooling capacity is available to remove decay heat and maintain the water in the reactor pressure vessel below 140 F as required during the REFUELING MODE, and (2) sufficient coolant circulation is maintained through the reactor core to minimize the effect of a boron dilution incident and prevent boron stratification.

The requirement to have two RHR loops OPERABLE when there is less than 23 feet of water above the core ensures that a single failure of the operating RHR loop will not result in a complete loss of residual heat removal capability. With the reactor vessel head removed and 23 feet of water above the core, a large heat sink is available for core cooling. Thus, in the event of a failure of the operating RHR loop, adequate time is provided to initiate emergency procedures to cool the core.