6.3 EMERGENCY CORE COOLING SYSTEMS

6.3.1 DESIGN BASES AND SUMMARY DESCRIPTION

Section 6.3.1 provides the design basis for the Emergency Core Cooling System (ECCS) systems and a brief summary design description. Detailed system descriptions are provided in Section 6.3.2. Section 6.3.3 contains the results of the performance analysis.

The current ECCS-LOCA analysis was performed using the SAFER/GESTR-LOCA methodology described in References 6.3-5 and 6.3-7 and supplemented by the implementation of the PRIME methodology described in Reference 6.3-15 with updates as discussed in Reference 6.3-15 and Reference 4.1-1. The SAFER/GESTR analysis was performed assuming the thermal power listed in Table 6.3-1 (which bounds the current plant conditions). The results of the original SAFER/GESTR-LOCA are provided in Reference 6.3-6.

This analysis addressed the fuel types that were in operation at the time. However, those 8x8 (e.g., GE9) and 9x9 (e.g., GE11/GE13) fuel designs are no longer in operation and therefore are not considered when evaluating the limiting peak cladding temperature.

An updated SAFER/GESTR-LOCA analysis has been performed for the implementation of GNF2 fuel (10x10 fuel design) and documented in Reference 6.3-10. For the implementation of GNF3 fuel (10x10 fuel design) an updated SAFER/GESTR-LOCA analysis has been performed and documented in Reference 6.3-16. The input parameters used for the current ECCS-LOCA analysis are listed in Table 6.3-1. Table 6.3-2 summarizes the revised operational sequence of ECCS for the design basis LOCA. The licensing basis peak cladding temperature values for GNF2 and GNF3 fuel are provided in Table 6.3-5.

There exist changes or errors that affect the analysis of record PCT calculation. These changes or errors are documented via 10 CFR 50.46 reporting. After accounting for all changes or errors, the licensing basis PCT remains below the 2,200°F limit. Refer to the docketed annual or thirty-day 10 CFR 50.46(a)(3) report for details.

The original ECCS-LOCA analysis was performed using the methodology described in reference 6.3-1. The input parameters used for the original ECCS-LOCA are listed in Table 6.3-1A. Table 6.3-2A contains the operational sequence of ECCS assumed in the original ECCS-LOCA analysis. Tables 6.3-1A and 6.3-2A are retained for historical purposes, because they provide the basis for most of the ECCS performance parameters specified in the current plant Technical Specifications.

6.3.1.1 Design Bases

6.3.1.1.1 Performance and Functional Requirements

The ECCS is designed to provide protection against postulated LOCA's caused by ruptures in primary system piping. The functional requirements (e.g., coolant delivery rates), specified in Table 6.3-1 for the current ECCS-LOCA analysis and in Table 6.3-1A for the original LOCA analysis, are such that the system performance under all LOCA conditions postulated in the design satisfies the requirements of 10CFR50.46, "Acceptance Criteria for Emergency Core Cooling System for Light-Water-Cooled Nuclear Power Reactors." These requirements are summarized in Section 6.3.3.2. In addition, the ECCS is designed to meet the following requirements:

a. Protection is provided for any primary system line break up to and including the double-ended break of the largest line.

b. Two independent phenomenological cooling methods (flooding and spraying) are provided to cool the core.

c. One high pressure cooling system is provided, which is capable of maintaining the water level above the top of the core and preventing Automatic Depressurization System (ADS) actuation for breaks of lines less than 1 inch nominal diameter.

d. No operator action is required until 10 minutes after an accident, to allow for operator assessment and decision.

e. The ECCS is designed to satisfy all criteria specified in this section for any normal mode of reactor operation.

f. A sufficient water source and the necessary piping, pumps, and other hardware are provided so that the containment and reactor core can be flooded for possible core heat removal following a LOCA.

6.3.1.1.2 Reliability Requirements

The following reliability requirements apply:

a. The ECCS conforms to all licensing requirements and to good design practices of isolation, separation, and common mode failure considerations.

b. In order to meet the above requirements, the ECCS network has built-in redundancy so that adequate cooling can be provided, even in the event of specified failures. As a minimum, the following equipment makes up the ECCS:

   1. One HPCI system
   2. Two Core Spray (CS) loops
   3. Four Low Pressure Coolant Injection (LPCI) loops
   4. One ADS

c. The ECCS is designed so that a single active or passive component failure, including power buses, electrical and mechanical parts, cabinets, and wiring, cannot disable the ADS.

d. If there is a break in a pipe that is not a part of the ECCS, no single active component failure in the ECCS, including all common and support components, prevents automatic initiation and successful operation of less than one of the following combinations of ECCS equipment:

   1. Three LPCI loops, one CS loop and the ADS and HPCI (i.e., single diesel generator failure). If the single failure occurs in a diesel generator that supplies power to an ESW pump, the diesel generator in the other unit is needed to support the other ESW pump that supplies that loop.

   2. Four LPCI loops, two CS loops and the ADS (i.e., HPCI failure)

e. If there is a break in a pipe that is a part of the ECCS, no single active component failure in the ECCS, including all common and support components, prevents automatic initiation and successful operation of less than one of the following combinations of ECCS equipment:

   1. Three LPCI loops and the ADS
   2. Two LPCI loops, one CS loop, and the ADS and HPCI

   These are the minimum ECCS combinations which result after assuming any failure (from d. above), and assuming that the ECCS line break disables the affected loop/system.

f. Long-term (later than10 minutes after initiation signal) cooling requirements call for the removal of decay heat via the RHRSW system. In addition to the break which initiated the loss-of-coolant event, the system can sustain one failure, either active or passive, and have at least one low pressure ECCS pump (LPCI or CS) operating for makeup, one RHR pump with a heat exchanger, and 100% RHRSW flow to the heat exchanger operating for heat removal.

g. Offsite ac power is the preferred source of ac power for the ECCS network, and every reasonable precaution is made to assure its high availability. However, onsite safeguard ac power has sufficient diversity and capacity to meet all the above requirements, even if offsite ac power is not available.

h. The onsite diesel fuel reserve is in accordance with IEEE 308 (1974) criteria.

i. The diesel load configuration is one LPCI pump and one CS pump, connected to a single diesel generator (4 sets per unit).

j. Electrical systems which interface with, but are not part of, the ECCS are designed and operated so that failure(s) in the interfacing systems do not propagate to, and/or affect the performance of, the ECCS.

k. 1. Nonsafety-related electrical systems in the accident unit interfacing with the Class 1E buses are automatically shed from the Class 1E buses when a LOCA signal exists.

   2. Nonsafety-related electrical systems in the nonaccident unit will remain connected to the Class 1E buses when a LOCA signal exists in the other unit.

l. No more than one storage battery is connectable to a dc power bus.

m. Each fluid loop/system of the ECCS network, including flow rate and sensing networks, is capable of being tested during shutdown. All active components are capable of being tested during plant operation, including logic required to automatically initiate component action.

n. Provisions for testing the ECCS network components (electronic, mechanical, hydraulic and pneumatic, as applicable) are installed in such a manner that they are an integral and nonseparable part of the design.

o. While a break in a non-ECCS or ECCS pipe concurrent with a single active component failure in an ECCS or support component will result in remaining combinations of ECCS as described in items d. and e. above, certain technical specification limiting conditions for operation (LCOs) are based on ECCS requirements as given in NEDO-24708A. This document, prepared in response to NRC questions arising from licensee responses to I. E. Bulletin 79-08 (Events relevant to boiling water power reactors identified during Three Mile Island incident), specifies the minimum ECCS system requirements to successfully terminate a transient or LOCA initiating event (with scram) assuming multiple failures with realistic conditions. For the postulated suction line breaks (including DBA), one low pressure ECCS (one LPCI pump or one CS loop) and ADS to depressurize thereby allowing the low-pressure ECCS to inject is adequate to reflood the vessel and maintain core cooling sufficient to preclude fuel damage. NEDC-30936P-A, specifically applicable to LGS, references NEDO-24708A and reaffirms that one low pressure ECCS will reflood the vessel and maintain core cooling. It adds the advisory that for a large break LOCA, following 2 hours of LPCI injection, an alternate cooling path may be necessary for long term core cooling. This is because LPCI injecting directly into the core shroud could possible keep the body of water around the core substantially subcooled, quenching any steam cooling effects.

6.3.1.1.3 ECCS Requirements for Protection from Physical Damage

The ECCS piping and components are protected against damage from the effects of movement, thermal-stresses, the effects of the LOCA, and the SSE.

The ECCS is protected against the effects of pipe whip, which might result from piping failures up to, and including, the design basis event LOCA. This protection is provided by separation, pipe whip restraints, or energy-absorbing materials if required. One of these three methods is applied to provide protection against damage to piping and components of the ECCS, which otherwise could reduce ECCS effectiveness to an unacceptable level.

For the purpose of mechanical separation ECCS components are divided into two divisions. The Division 1 ECCS components include the following:

a. Core spray loop A

b. RHR loop A and RHR-LPCI loop C

c. ADS

The Division 2 ECCS components include the following:

a. Core spray loop B

b. RHR loop B and RHR-LPCI loop D

c. HPCI

With the exception of the RHR pumps, each of the ECCS pumps and its associated components are located in individual compartments within the reactor enclosure. The two RHR pumps in each division are located in a common compartment. This compartmentalization ensures that environmental disturbances such as fire, pipe rupture, flooding, etc., affecting one system do not affect the remaining systems. For ECCS mechanical components located outside the pump compartments, such as the outboard containment isolation valves, separation between the different divisions is provided by distance or by locating the components in different compartments.

Electrical separation is described in Sections 7.1 and 8.3.

6.3.1.1.4 ECCS Environmental Design Basis

Each loop/system of the ECCS injection network, except the HPCI system, has a safety-related injection/isolation testable check valve located in piping within the drywell. The HPCI system injects through one of the core spray spargers and through the feedwater sparger, and the (non-ECCS) RCIC system injects through the feedwater system. However, both systems have isolation valves in the drywell portion of their steam supply piping. No portion of the ECCS and RCIC piping is subject to drywell flooding, since water drains into the suppression chamber through the downcomers. The valves are qualified for the following environmental conditions:

a. Normal and upset plant operating ambient temperatures, relative humidities, and pressures as discussed for each area of the drywell in Section 3.11.

b. Envelope-of-accident conditions for temperature, relative humidity, and pressure within the drywell for various time periods following the accident as discussed in Section 3.11.

c. Normal and envelope-of-accident radiation environment (gamma and neutron) as discussed in Section 3.11.

The portions of ECCS and RCIC piping and equipment located outside the drywell and within the secondary containment are qualified for the following environmental conditions:

a. Normal and upset plant operating ambient temperatures, relative humidities, and pressures as discussed in Section 3.11.

b. Envelope-of-accident conditions for temperature, relative humidity, and pressure for various time periods following the accident as discussed in Section 3.11.

c. Normal and envelope-of-accident radiation environment (gamma and neutron) as discussed in Section 3.11.

6.3.1.2 Summary Descriptions of ECCS

The ECCS injection network is comprised of a HPCI system, a low pressure CS system, and the LPCI mode of the RHR system. These systems are briefly described here as an introduction to the more detailed system design descriptions provided in Section 6.3.2. The ADS, which assists the injection network under certain conditions, is also briefly described. BWRs with the same ECCS design are listed in Table 1.3-2.

6.3.1.2.1 High Pressure Coolant Injection System

The HPCI system pumps water into the reactor vessel through one of the CS spargers and through one of the feedwater sparger. The primary purpose of HPCI is to provide sufficient coolant to the reactor vessel following a small break LOCA until reactor pressure is below the pressure at which CS operation or LPCI mode of RHR system operation maintains core cooling. The HPCI system is also required to provide sufficient coolant to the reactor vessel to prevent the actuation of the ADS and maintain reactor level above the top of the reactor core in the event of a small pipe break with a break size of one-inch diameter or less.

6.3.1.2.2 Core Spray System

The two CS system loops pump water into peripheral ring spray spargers, mounted above the reactor core. The primary purposes of the CS loops are to provide inventory makeup and spray cooling during large breaks in which the core is calculated to uncover. Following ADS initiation, CS provides inventory makeup following a small break.

6.3.1.2.3 Low Pressure Coolant Injection Subsystem

LPCI is an operating mode of the RHR system. Four pumps deliver water from the suppression pool to separate vessel nozzles, which lead to direct discharge inside the core shroud region (four loops). The primary purpose of LPCI is to provide vessel inventory makeup following large pipe breaks. Following ADS initiation, LPCI provides inventory makeup following a small break.

6.3.1.2.4 Automatic Depressurization System

The ADS utilizes five of the reactor SRVs to reduce reactor pressure during small breaks or after containment isolation, in the event of HPCI failure. When the vessel pressure is reduced to within the design of the low pressure systems (CS and LPCI), these systems provide inventory makeup so that acceptable postaccident temperatures are maintained.

6.3.1.2.5 Management of Gas Accumulation in Fluid Systems

On January 11, 2008, the NRC issued Generic Letter 2008-01, “Managing Gas Accumulation in Emergency Core Cooling, Decay Heat Removal, and Containment Spray (Reference 6.3-12). Generic Letter 2008-01 requested licensees to evaluate the licensing basis, design, testing, and corrective action programs for the Emergency Core Cooling, Decay Heat Removal, and Containment Spray systems to ensure that gas accumulation is maintained less than the amount that challenges operability of these systems, and that appropriate action is taken when conditions adverse to quality are identified. As a consequence, Limerick performed in-depth system reviews for the RHR, HPCI, Cores Spray, and RCIC systems in accordance with the criteria of GL 2008-01, investigating whether the existing Licensing Basis, Design Basis, actual field configuration, system restoration processes, and operational procedures would introduce or allow the accumulation of a gas (air) void in system piping. Piping locations in each system that are susceptible to air accumulation are periodically monitored to ensure that the piping systems are maintained sufficiently filled with water. The piping systems addressed in the response to Generic Letter 2008-01 have the potential to develop voids and pockets of entrained gases. Maintaining the pump suction and discharge piping sufficiently full of water is necessary to ensure that the system will perform and will inject the flow assumed in the safety analyses into the Reactor Coolant System or containment upon demand. This will also prevent damage from pump cavitation or water hammer, and pumping of unacceptable quantities on non-condensable gas (e.g., air, nitrogen, hydrogen) into the reactor vessel following an ECCS start signal or during shutdown cooling.

6.3.2 SYSTEM DESIGN

More detailed descriptions of the individual systems, including individual design characteristics of the systems, are covered in detail in Sections 6.3.2.2.1 through 6.3.2.2.4. The following discussion provides details of the combined systems, and in particular, those design features and characteristics which are common to all systems.

6.3.2.1 Piping and Instrumentation and Process Diagrams

The P&IDs for the ECCS and the process diagrams which identify the various operating modes of each system are identified in Section 6.3.2.2.

6.3.2.2 Equipment and Component Descriptions

The starting signal for the ECCS comes from at least two independent and redundant sensors of high drywell pressure and low reactor water level. The ECCS is actuated automatically, and is designed to require no operator action during the first l0 minutes following the accident. A time sequence for starting of the systems is provided in Table 6.3-2 for the current ECCS-LOCA analysis, and in Table 6.3-2A for the original ECCS-LOCA analysis.

Electric power for operating the ECCS (except the dc powered HPCI and ADS systems) is from the preferred offsite ac power supply.

Upon loss of the preferred source, operation is from the onsite standby diesel generators. Four diesel generators supplying individual ac buses in a unit have sufficient diversity and capacity so that any three units satisfy minimum ECCS requirements, which are stated in Section 6.3.1.1.2.b. One CS pump (2 loop) and one LPCI loop are powered by each ac bus. Section 8.3 contains a more detailed description of the power supplies for the ECCS.

Regulatory Guide 1.1

Regulatory Guide 1.1 prohibits design reliance on pressure and/or temperature transients expected during a LOCA for assuring adequate NPSH. The requirements of this guide are applicable to the HPCI, CS, and LPCI pumps.

The BWR design conservatively assumes 0 psig containment pressure and maximum expected temperatures of the pumped fluids. Thus, no reliance is placed on pressure and/or temperature transients to ensure adequate NPSH.

Requirements for NPSH at the centerline of the pump suction nozzles for each pump are given in drawings E41-1020-G-002 (HPCI), E21-1020-G-001 (CS), and E11-1020-G-002 (LPCI).

6.3.2.2.1 High Pressure Coolant Injection System

The HPCI system consists of a steam turbine-driven, constant flow pump assembly and associated system piping, valves, controls, and instrumentation. The P&IDs for the HPCI, drawings M-55 and

M-56, show the system components and their arrangement. The HPCI process diagram, drawing E41-1020-G-002, shows the design operating modes of the system.

The principal HPCI equipment is installed in the reactor enclosure. Suction piping comes from both the CST and the suppression pool. Injection water is piped to the reactor via the CS Loop B sparger pipe and through the Loop A feedwater sparger. The steam supply for the turbine is piped from a main steam line in the primary containment. This piping is provided with an isolation valve on each side of the primary containment. Remote controls for valve and turbine operation are provided in the main control room. The controls and instrumentation of the HPCI system are described, illustrated, and evaluated in detail in Section 7.3.

The HPCI system provides coolant to the reactor vessel following a small break LOCA until reactor vessel pressure is below the pressure at which CS operation or LPCI operation maintains core cooling. The HPCI system is also capable of providing sufficient coolant to the reactor vessel to prevent the actuation of the ADS and ensure that the reactor core remains covered in the event of a small pipe break with a break size of one-inch diameter or less. This permits the plant to be shut down, while maintaining sufficient reactor vessel inventory until the reactor is depressurized. For design basis events HPCI needs to operate for a maximum of six hours in order to fulfill its safety functions.

The HPCI system is designed to pump water into the reactor vessel for a wide range of pressures in the reactor vessel. The normal alignment of the HPCI system initially injects water from the CST instead of water from the suppression pool. An alternate alignment to the suppression pool is also available during periods whan the CST is not available. This provides reactor grade water to the reactor vessel. Water is pumped into the reactor vessel through a core spray sparger and a feedwater sparger; this flow split is provided by orificing.

The pump assembly is located below the water levels of the CST and the suppression pool, to ensure positive suction head to the pumps. Pump NPSH requirements are met by providing adequate suction head and adequate suction line size.

The HPCI turbine-pump assembly and piping are protected from the detrimental physical effects of pipe whip, flooding, and high temperature.

The HPCI turbine is driven by steam from the reactor vessel, generated by decay and residual heat. The steam is extracted from a main steam line upstream of the MSIVs. Inboard and outboard HPCI isolation valves in the steam line to the HPCI turbine are normally open. This keeps the piping to the turbine at an elevated temperature to permit rapid startup of the HPCI system. Signals from the HPCI control system open or close the turbine control valve adjacent to the turbine. The outboard isolation valve has a bypass line containing a normally closed valve. This bypass line permits pressure equalization and drainage around the isolation valve, and downstream line warmup prior to opening of the isolation valve.

A condensate drain pot is provided upstream of the turbine stop valve to prevent the HPCI steam supply line from filling with water. The drain pot normally routes the condensate to the main condenser, but upon receipt of a HPCI initiation signal and subsequent opening of the steam supply valve, or a loss of control air pressure signal, isolation valves on the condensate line automatically close.

The turbine power is controlled by a flow controller that senses pump discharge flow and provides a variable signal to the turbine governor to maintain constant pump discharge flow over the pressure range of operation. The turbine control system is capable of limiting speed overshoot to 15% of maximum operating speed on a quick start, while driving only the pump inertia load.

Limit switches are provided on the turbine control (governor) valves(s) to indicate fully open and closed positions. Both lights are "on" in midposition.

As reactor steam pressure decreases, the HPCI turbine throttle valves open further to pass the steam flow required to provide the necessary pump flow. The capacity of the system is selected to provide sufficient core cooling to prevent clad temperatures in excess of the limits (10CFR50.46) while the pressure in the reactor vessel is above the pressure at which CS and LPCI become effective.

Exhaust steam from the HPCI turbine is discharged to the suppression pool. A drain pot at the low point in the exhaust line collects moisture present in the steam. Collected moisture is discharged through an orifice to the barometric condenser.

The HPCI turbine gland seals are vented to the barometric condenser for cooling. Noncondensable gases from the barometric condenser are pumped to the reactor enclosure equipment compartment exhaust filter during normal plant operation and to the RERS during reactor enclosure isolation.

A redundant system of check valves and isolation valves is installed as a vacuum breaker line, which connects the air space in the suppression chamber with the HPCI turbine exhaust line. This eliminates any possibility of water from the suppression pool being drawn into the HPCI turbine exhaust line. The isolation valves in this vacuum breaker line automatically close via a combination of low HPCI steam supply pressure and high drywell pressure. Test connections are provided on either side of the two check valves.

Potential damage from water hammer in the HPCI turbine supply and exhaust lines is prevented by the use of design features such as exhaust line vacuum breakers, drain pots upstream and downstream of the turbine, and a sparger in the turbine exhaust line in the suppression pool. Further discussion of water hammer is provided in Section 1.12.3.

Startup of the HPCI system is completely independent of ac power. Only dc power from the station battery and steam extracted from the nuclear system are necessary.

The various operations of the HPCI components are summarized below.

The HPCI controls automatically start the system and bring it to design flow rate within 60 seconds from receipt of a RPV low water level signal, or a primary containment (drywell) high pressure signal. Refer to Chapter 15 for more analysis details.

The HPCI turbine is directly shut down by any of the following signals:

a. Turbine overspeed: this prevents damage to the turbine.

b. RPV high water level: this indicates that core cooling requirements are satisfied.

c. HPCI pump low suction pressure: this prevents damage to the pump due to loss of flow.

d. HPCI turbine exhaust high pressure: this indicates a turbine or turbine control malfunction.

e. Isolation of either inboard or outboard HPCI isolation valves.

f. Low steam supply pressure.

If an initiation signal is received after the turbine is shut down, the system restarts automatically, if no shutdown signal exists.

Because the steam supply line to the HPCI turbine is part of the RCPB, certain signals automatically isolate this line, causing shutdown of the HPCI turbine. Automatic shutoff of the steam supply is described in Section 7.3. However, automatic depressurization and the low pressure systems of the ECCS act as backup; and automatic shutoff of the steam supply does not negate the ability of the ECCS to satisfy the safety objective.

In addition to the automatic operational features of the system, provisions are included for remote manual startup, operation, and shutdown (provided automatic initiation or shutdown signals do not exist).

HPCI operation automatically actuates the following valves:

a. HPCI pump discharge shutoff valve, if closed (F007)

b. HPCI steam supply shutoff valve (F001)

c. HPCI turbine stop valve

d. HPCI turbine control valves

e. HPCI steam line drain isolation valve (F028, F029)

f. HPCI test valves, if open (F008, F011, F071)

g. Minimum flow bypass valve (F012)

h. HPCI pump discharge injection valves (F006, F105)

i. HPCI lube oil cooling water valve (F059)

j Condensate pump discharge isolation valves, if open (F025, F026)

Startup of the auxiliary oil pump and proper functioning of the hydraulic control system are required to open the turbine stop and control valves. Operation of the barometric condenser components is required to prevent out-leakage from the turbine shaft seals. Startup of the condenser equipment is automatic, but its failure does not prevent the HPCI system from fulfilling its core cooling objective. Prior to startup of the HPCI turbine, the turbine control system is set to maintain the turbine at the low speed design condition. Upon receipt of an initiation signal, a speed ramp generator module automatically runs the control system toward its high speed design point, thereby controlling the transient acceleration of the turbine. The flow controller then automatically overrides the speed ramp generator, and when rated flow is established, the flow controller signal adjusts the setting of the turbine control so that rated flow is maintained as nuclear system pressure decreases.

A minimum flow bypass is provided for pump protection. The bypass valve automatically opens on low flow, provided pump discharge pressure is above a pressure permissive setpoint (indicates pump is running) and automatically closes on high flow, stop valve closure or steam supply valve closure. When the bypass is open, flow is directed to the suppression pool. A line used for system testing leads from the HPCI pump discharge line to the CST. The shutoff valves in this line are sequenced to close by the signal that actuates system operation, and valve F011 is interlocked closed when the F041 valve, suppression pool to pump suction valve, is open. All automatically operated valves are capable of remote manual operation.

The normal alignment of the HPCI system is to initially inject water from the CST. An alternate alignment to the suppression pool is also available when the CST is not available. When the water level in the tank falls below a predetermined level or the suppression pool level is high, the pump suction is automatically transferred to the suppression pool. A vortex breaker is located at the suction nozzle of the CST to prevent vortex formation. A calculation has been performed to demonstrate that air core vortex formation will not occur with the CST level at the transfer level, and with the HPCI pumps operating at 5600 gpm. This transfer may also be made from the main control room using remote controls. When the pump suction has been transferred to the suppression pool, a closed-loop is established for recirculation of water escaping from a break.

To ensure continuous core cooling, general containment isolation signals do not operate any HPCI valves. The HPCI system incorporates a relief valve in the pump suction line to protect the components and piping from inadvertent overpressure conditions.

Level instrumentation for the CST and the HPCI suction line are protected from the effects of cold weather. The HPCI suction line and the CST instrument sensing lines that are exposed to the outdoor environment are provided with heat tracing. Indication is provided in the control room if this heat tracing should become inoperative. The CST level instrumentation for control room monitoring is located in the reactor enclosure. The level instrumentation used to automatically transfer the HPCI pump suction from the CST to the suppression pool is located on the portion of the HPCI line in the reactor enclosure and is not subject to the effects of cold weather.

The HPCI pump and piping are designed and located to avoid damage from the physical effects of DBAs, such as pipe whip, missiles, temperature, pressure, and humidity.

The HPCI equipment and support structures are designed in accordance with seismic Category I criteria (Section 3.9). The system is assumed to be filled with water for seismic analysis.

Provisions are included in the HPCI system which permit the HPCI system to be tested. These provisions are:

a. A full flow test line is provided to route water from and to the CST, without entering the RPV.

b. A bypass flow test line is provided to route water from and to the suppression pool, without entering the RPV.

c. Instrumentation is provided to indicate system performance during normal test operations.

d. All MOVs are capable of manual operation for test purposes. During all modes of manual MOV operation using the handswitch from the main control room, a "dead zone" is present for a portion of the valve travel. The "dead zone" is present when the valve is not fully closed and green light only indication exists. If the valve is stopped in the "dead zone", operator action is required to restart the valve.

e. Drains are provided to leak test the major system valves.

Interlocks for the HPCI system are described in Chapter 7. The operating requirement parameters for the components of the HPCI system, listed below, are shown on the process diagram (drawing E41-1020-G-002).

a. One 100% capacity booster and main pump assembly with accessories

b. Piping, valves, and instrumentation for:

    1. Steam supply to the turbine

    2. Turbine exhaust to the suppression pool

    3. Makeup supply from the CST to the pump suction

    4. Makeup supply from the suppression pool to the pump suction including pump suction strainers described in Section 6.2.2.2.

    5. Pump discharge to the core spray sparger and feedwater line, including a test line to the CST, a minimum flow bypass line to the suppression pool, and a coolant water supply to accessory equipment

The basis for the design conditions is the ASME Section III, "Nuclear Power Plant Components."

A design flow functional test of the HPCI is performed during plant operation by taking suction from the CST, and discharging through the full flow test return line back to the CST. The discharge valve to the core spray and feedwater lines remain closed during the test, and reactor operation is undisturbed. All components of the HPCI system are capable of individual functional testing during normal plant operation. Control system design provides automatic alignment from test to operating mode if system initiation is required. The three exceptions are as follows:

a. The auto/manual station is in "manual" on the flow controller. This feature is required for operator flexibility during system operation.

b. Steam inboard/outboard isolation valves: closure of either or both of these valves requires operator action to properly sequence their opening. An alarm sounds when either of these valves leaves the fully open position.

c. Parts of the system which are bypassed or deliberately rendered inoperable. This is automatically indicated in the control room.

Periodic inspection and maintenance of the turbine-pump unit are conducted in accordance with plant programs and procedures. Other than surveillances required by technical specifications, the types of inspection and maintenance are based on manufacturer's recommendations and industry guidelines and the frequency is based on industry and site specific experience. Valve position indications and instrumentation alarms are displayed in the control room.

6.3.2.2.1.1 NPSH Available with Suction from the CST

The available NPSH is calculated in accordance with Regulatory Guide 1.1. The following data were used in the calculation:

a. Condensate water level is at el 191'- 7.25" at the bottom of the 34 inch section of pipe HCB-105. This level is approximately 27 ft below the static transfer level (i.e. 0 gpm HPCI flow), which is within the CST nozzle.

b. CST water is at 120°F.

c. Atmospheric pressure is assumed above the condensate water level.

d. NPSH = $h_s - h_{vp} - h_f + h_a$

where:

h_s = static head above pump suction nozzle centerline
= 191.6 ft to 182.25 ft = 9.3 ft

h_f = friction head loss = 4.0 ft

h_{vp} = vapor pressure (head loss) = 3.9 ft

h_a = atmospheric head = 34.3 ft

NPSH = 35.7 ft

6.3.2.2.1.2 NPSH Available with Suction from the Suppression Pool

The available NPSH is calculated in accordance with Regulatory Guide 1.1. The following data were used in the calculation:

a. Suppression pool is at the minimum postaccident level reached while the pump is running of el 201'-5.64".

b. Suppression pool water is at its maximum temperature for the given operating mode, 170°F.

c. Atmospheric pressure is assumed over the suppression pool.

d. NPSH = $h_s - h_{vp} - h_f + h_a$

where:

h_s = static head above pump suction nozzle centerline
= 201.47 ft to 182.25 ft = 19.2 ft

h_f = friction head loss (including 2 psi loss across suction strainers) = 11.7 ft

h_{vp} = vapor pressure (head loss) = 14.2 ft

h_a = atmospheric head = 34.8 ft

NPSH = 28.1 ft

6.3.2.2.2 Automatic Depressurization System

If the RCIC system or the HPCI system cannot maintain the reactor water level, the ADS reduces the reactor pressure so that flow from LPCI and/or CS systems enters the reactor vessel in time to cool the core and limit fuel cladding temperature.

The ADS employs five of the nuclear system SRVs to relieve high pressure steam to the suppression pool. The design, number, location, description, operational characteristics, and evaluation of the SRVs and their pneumatic accumulators are discussed in detail in Section 5.2.2. The instrumentation and controls for the ADS are discussed in Section 7.3. Gas supplies for long term operation of ADS are described in Sections 9.3.1.3 and 7.6.

6.3.2.2.3 Core Spray System

Each of the two redundant CS system loops consists of: two 50% capacity centrifugal pumps powered from Class 1E buses; a spray sparger in the reactor vessel above the core (a separate sparger for each CS loop); piping and valves to convey water from the suppression pool to the sparger; and associated controls and instrumentation. A connection to the HPCI system is provided to allow HPCI injection through the CS Loop B vessel connection. The CS P&ID (drawing M-52) presents the system components and their arrangement. The CS process diagram (drawing E41-1020-G-001) shows the design operating modes of the system. A simplified system flow diagram showing system injection into the reactor vessel is included in drawing E41-1020-G-001.

When low water level in the reactor vessel and/or high pressure in the drywell is sensed, and if reactor vessel pressure is low enough, the CS system automatically starts and sprays water into the top of the fuel assemblies to cool the core. The time sequence assumed in the current ECCS-LOCA analysis for CS system operation is given in Table 6.3-2. The time sequence assumed in the original ECCS-LOCA analysis for CS system operation is given in Table 6.3-2A. The CS injection piping enters the vessel, divides, and enters the core shroud at two points near the top of the shroud. A semicircular sparger is attached to each outlet. Nozzles are spaced around the sparger to spray the water radially over the core and into the fuel assemblies.

The CS system is designed to provide cooling to the reactor core only when the reactor vessel pressure is low, as is the case for large LOCA break sizes. However, when CS operates in conjunction with the ADS, the effective core cooling capability of CS is extended to all break sizes because the ADS rapidly reduces the reactor vessel pressure to the CS operating range.

The CS pumps and all MOVs can be operated individually by manual switches located in the control room. Operating indication is provided in the control room by a flowmeter, and valve and pump indicator lights.

To assure continuity of core cooling, signals to isolate the containment do not operate any CS system valves. Suppression pool test return valves isolate on an automatic CS initiation signal.

Loop A and B injection lines are each provided with two isolation valves. One of these valves is a pneumatically-testable check valve located inside the drywell, as close as practical to the reactor vessel. CS injection flow causes this valve to open during LOCA conditions (i.e., no power is required for valve actuation during the LOCA). If the CS line should break outside the containment, the check valve in the line inside the drywell prevents loss of reactor water.

The outer isolation valve on Loop A is a motor-operated gate valve, and the outer isolation valve on Loop B is a pneumatically-testable check valve. These valves are located as close as practicable to the CS discharge line containment penetration. The pneumatically-testable check valve is designed so that air failure will not close the valve against normal flow. Upstream of the HPCI injection connection on Loop B is a motor-operated gate valve which isolates CS Loop B upstream of the valve from HPCI injection pressure. This valve, and the Loop A outer isolation valve are also referred to as the CS injection valves. These valves are capable of opening with the maximum differential pressure across the valve expected for any system operating mode. These valves are normally closed. The containment isolation design of the CS system is discussed in detail in Section 6.2.4.

The CS system piping and components are designed and arranged to avoid unacceptable damage from the physical effect of pipe whip, missiles, high temperature, pressure or humidity. All principal active CS equipment is located outside the primary containment.

A check valve (one per CS pump), flow element, and restricting orifice are provided in the CS discharge line from the pump to the injection valve. The check valve is located below the minimum suppression pool water level, and is provided so that the piping downstream of the valve can be continuously filled with water by the condensate transfer or safeguard piping fill systems (Section 6.3.2.2.6). The flow element is provided to measure system flow rate during LOCA and test conditions, and for automatic control of

the minimum low flow bypass valve. The flow rate is indicated in the main control room. The restricting orifice is sized during preoperational testing of the system to limit system flow to acceptable values, as described on the CS system process diagram.

A low flow bypass line with a motor-operated globe valve connects to the CS discharge line upstream of the check valve on the pump discharge line. The line bypasses water to the suppression pool preventing pump damage when other discharge line valves are closed, or when reactor pressure is greater than the CS system discharge pressure following system initiation. The valve automatically closes when flow in the main discharge line is sufficient.

A normally open motor-operated pump suction valve is provided that can be remote-manually closed to isolate the CS system from the suppression pool should a leak develop in the system. This valve is located as close to the suppression pool penetration as practical. Because the CS system conveys water from the suppression pool, a closed-loop is established for the spray water escaping from the break.

The design pressure and temperature of the system components are based on ASME Section III. The design pressures and temperatures at various points in the system can be obtained from the miscellaneous information blocks on the CS process diagram (drawing E41-1020-G-001).

The CS pumps are located in the reactor enclosure below the water level in the suppression pool, assuring positive pump suction. Pump NPSH requirements are met with the containment at atmospheric pressure. Each CS Pump has a local pressure gauge to indicate the suction head. The pump suction strainers are described in Section 6.2.2.2.

The CS system incorporates relief valves to prevent the components and piping from inadvertent overpressure conditions.

For the CS “A” loop:

- One relief valve located on the pump discharge is set at 500 psig at a capacity of 16 gpm – 10% accumulation to 1340 psig at a capacity of 24 gpm – 10% accumulation.
- One relief valve is located on the suction side of each pump in the “A” loop and is set for 100 psig at a capacity of 10 gpm – 10% accumulation.

For the CS “B” loop:

- One relief valve located on the pump discharge is set at 500 psig at a capacity of 16 gpm – 10% accumulation to 1340 psig at a capacity of 24 gpm – 10% accumulation.
- One relief valve is located on the suction side of each pump in the “B” loop and is set for 100 psig at a capacity of 10 gpm – 10% accumulation.

The CS system piping and support structures are designed in accordance with seismic Category I criteria (Section 3.9). The system is assumed to be filled with water for seismic analysis. The CS system has the capability to be lined up to the CST, with the plant shutdown, to provide a clean water source for pipe flushes, cavity flood-up and as an alternate ECCS make-up volume.

Provisions are included in the design which permit the CS system to be tested. These provisions are:

a. All active CS components are testable during normal plant operation.

b. A full flow test line is provided in each loop of CS to route water to and from the suppression pool without entering the RPV.

c. A suction test line supplying water from the CST is provided to allow the capability to test pump discharge into the RPV during normal plant shutdown.

d. Instrumentation is provided to indicate system performance during normal and test operations.

e. All motor-operated and check valves are capable of operation for test purposes. During all modes of manual MOV operation using the handswitch from the main control room, a "dead zone" is present for a portion of the valve travel. The "dead zone" is present when the valve is not fully closed and green light only indication exists. If the valve is stopped in the "dead zone", operator action is required to restart the valve.

6.3.2.2.4 Low Pressure Coolant Injection Subsystem

The LPCI subsystem is an operating mode of the RHR system. The LPCI subsystem is automatically actuated by low water level in the reactor and/or high pressure in the drywell coincident with low reactor pressure. It uses four motor-driven RHR pumps to draw suction from the suppression pool and inject cooling water flow into the reactor core via separate vessel nozzles and core shroud penetrations.

The LPCI subsystem, like the CS system, is designed to provide cooling to the reactor core only when the reactor vessel pressure is low, as is the case for large LOCA break sizes. However, when LPCI operates in conjunction with the ADS, the effective core cooling capability of LPCI is extended to all break sizes because the ADS rapidly reduces the reactor vessel pressure to the LPCI operating range.

Drawing E41-1020-G-002 shows a process diagram and process data for the RHR system, including the LPCI mode. The RHR system P&ID is shown in drawing M-51.

LPCI operation includes using associated valves, control, instrumentation, and pump accessories. LPCI is normally powered from the preferred ac power source, and from the standby ac power source upon a loss of preferred ac power.

If there is a LOCA, the four loops of the LPCI subsystem inject water into the reactor vessel. Separate power sources are provided for the LPCI injection valves, so that the failure of a single electrical division does not prevent the valves in other divisions from opening.

To ensure continuity of core cooling, signals to isolate the primary containment do not operate any RHR system valves which interfere with the LPCI mode of operation.

The process diagram (E11-1020-G-002) and the P&ID (drawing M-51) indicate that a great many flow paths are available other than the LPCI injection line. However, the low water level and/or high drywell pressure coincident with low reactor pressure signals which automatically initiate the LPCI mode are also used to isolate all other modes of operation and revert other system valves to the LPCI lineup. Inlet and outlet valves from the heat exchangers receive no automatic signals, as the system is designed to provide rated flow to the vessel whether they are open or not. Further discussion of valve logic is provided in Section 7.3.1.1.

A check valve in the pump discharge line is used, together with a discharge line fill system (Section 6.3.2.2.6), to prevent water hammer resulting from starting the pump with a partially drained discharge line.

Further discussion of water hammer is provided in Section 1.12.3.

A flow element in the pump discharge line originates automatic signals for control of the pump minimum flow valve. The minimum flow valve permits a small flow to the suppression pool if sufficient system flow is not available.

There is sufficient system resistance to preclude RHR pump damage due to pump run-out in the LPCI and containment spray operating modes. A combination of valve throttling and flow orifices prevents pump run-out during suppression pool cooling and test modes.

Using the suppression pool as the source of water for LPCI establishes a closed-loop for recirculation of water escaping from a pipe break inside containment.

The design pressures and temperatures at various points in the system, during each LPCI subsystem mode of operation can be obtained from the miscellaneous information blocks on the RHR process diagram (drawing E11-1020-G-002).

LPCI pumps and equipment are described in detail in Section 5.4.7, which also describes the other functions served by the same pumps in other modes of RHR system operation. The RHR heat exchangers are not associated with the emergency core cooling function. The heat exchangers are discussed in Section 5.4.7.2.2. Portions of the RHR system required for accident protection, including support structures, are designed in accordance with seismic Category I criteria (Section 3.9). The LPCI pump characteristic curves are shown in Figure 5.4-15.

The LPCI subsystem incorporates a relief valve on each of the pump discharge lines, which protects the components and piping from inadvertent overpressure conditions. These valves are set as shown in Table 5.4-3.

Provisions are included in the LPCI subsystem to permit testing of the LPCI loops. These provisions are:

a. All active LPCI components are designed to be testable during normal plant operation.

b. A discharge test line is provided for the four pumps to route suppression pool water back to the suppression pool without entering the RPV.

c. Instrumentation is provided to indicate system performance during normal and test operations.

d. All MOVs, AOVs, and check valves are capable of manual operation for test purposes. During all modes of manual MOV operation using the handswitch from the main control room, a "dead zone" is present for a portion of the valve travel. The "dead zone" is present when the valve is not fully closed and green light only indication exists. If the valve is stopped in the "dead zone", operator action is required to restart the valve.

e. Shutdown cooling lines taking suction from the recirculation system permit testing of the pump discharge into the RPV after normal plant shutdown.

f. All relief valves are or will be removable for bench testing during plant shutdown.

6.3.2.2.4.1 NPSH for LPCI Mode

The available NPSH is calculated in accordance with Regulatory Guide 1.1. The following data are used for a typical NPSH calculation:

a. Suppression pool is at its minimum post accident depth, el 199'-11.5".

b. Centerline of pump suction is at el 174'-10.5".

c. Suppression pool water is at its maximum temperature for the given operating mode.

d. Pressure is atmospheric above the suppression pool.

e. Maximum suction strainer losses are 5.0 psi at 11,000 gpm.

NPSH = $h_{ATM} + h_S - h_{VAP} - h_F$

where:

h_{ATM} = atmospheric head

h_S = static head

h_{VAP} = vapor pressure head

h_F = frictional head

Operating modes and conditions are given on the process flow diagram (drawing E11-1020-G-002). NPSH requirements are given on the pump curve (Figure 5.4-15).

<u>Case 1</u> LPCI Pump Run-out (Mode A-2)

Maximum suppression pool temperature is 180°F.

h_{ATM} = 34.94'

h_S = 25.08'

h_{VAP} = 17.85'

h_F = 4.61’

Strainer head loss = 11.85’

NPSH available = 34.94 + 25.08 - 17.85 - 4.61 - 11.85
= 25.71

<u>Case 2</u> RHR Accident Mode B

Maximum suppression pool temperature assumed is 212°F

h_{ATM} = 35.4'

h_S = 25.08'

h_{VAP} = 35.4'

h_F = 3.8’

Strainer head loss at 10,000 gpm = 10.67’

NPSH available = 35.4 + 25.08 - 35.4 - 3.8’ - 10.67’
= 10.61’

6.3.2.2.5 ECCS NPSH Margin and Vortex Formation

NPSH calculations for ECCS pumps, such as that in the previous section, have shown adequate margin to ensure capability of proper pump operation under accident conditions. This capability will be verified during preoperational testing by verifying expected pump operating parameters at specific operating conditions. The absence of air entrainment and vortex formation in the flow approaching the suction strainers in the suppression pool during ECCS pump operation will also be verified during preoperational testing. Pump performance and pump noise will be monitored during these tests to determine if pumps are sensitive to suction flow conditions in the suppression pool.

6.3.2.2.6 Safeguard Piping Fill System

A requirement of the core cooling systems is that cooling water flow to the RPV be initiated rapidly when the system is called upon to perform its function. This quick-start system capability is provided by quick-opening valves, quick-start pumps, and standby ac power sources. The lag between the signal to start the pump and the initiation of flow into the RPV can be minimized by keeping the core cooling pump discharge lines full. Additionally, if these lines are empty when the systems are called for, the large momentum forces associated with accelerating fluid into a dry pipe could cause physical damage to the piping. Therefore, the safeguard piping fill system is designed to maintain the pump discharge lines in a filled condition.

Since the ECCS discharge lines are elevated above the suppression pool, check or stop-check valves are provided near the pumps to prevent backflow from emptying the lines into the suppression pool. Past experience shows that these valves may leak slightly, producing a small backflow that eventually empties the discharge piping. To ensure that the leakage from the discharge lines is replaced and the lines are always kept filled, suppression pool water is provided for each system of the ECCS by the safeguard piping fill system. There are two safeguard fill pump trains, as shown in drawing M-52. Each fill train and its associated ECCS lines are powered from separate Class 1E electrical divisions. Each fill train also provides water to both of the feedwater lines after a LOCA to prevent bypass leakage, as described in Section 6.2.3.2.3.

During normal plant operating conditions, the safeguard piping fill system (SPFS) is on standby and water from the condensate transfer system is used through different connections to keep the ECCS lines full.

The fill system is a safety-related system and is designed to seismic Category I criteria, as described in Section 3.7. Quality group classification is discussed in Section 3.2. A single failure of an active component in one fill system train will prevent that train from performing its intended function, but will not affect the operation of the other train. When the SPFS is in use, the fill pumps operate continuously, with recirculation back to the suppression pool via two core spray pump suction lines. The pumps are powered from the diesel generators during a LOOP. The pumps are operated from the control room and alarms in the control room indicate low fill pump discharge pressure.

As discussed in Section 5.4.7.1.1.5, all of the components comprising the steam condensing mode of the RHR system have either been abandoned in place or physically removed from the plant. Therefore, the mode is no longer functional.

6.3.2.3 Applicable Codes and Classification

The applicable codes and classification of the ECCS are specified in Section 3.2. All piping systems and components (pumps, valves, etc.) for the ECCS comply with applicable codes, addenda, code cases, and errata in effect at the time the equipment is procured. The equipment and piping of these systems are designed to the requirements of seismic Category I. This seismic designation applies to all structures and equipment essential to the core cooling function. IEEE standards applicable to the controls and power supplies are specified in Section 7.1.

6.3.2.4 Materials Specifications and Compatibility

Materials specifications and compatibility for the ECCS are presented in Section 6.1. Nonmetallic materials, such as lubricants, seals, packings, paints and primers, insulation, as well as metallic materials are selected as a result of an engineering review and evaluation for compatibility with other materials in the system and the surroundings, with concern for chemical, radiolytic, mechanical and nuclear effects. Materials used are reviewed and evaluated with regard to radiolytic and pyrolytic decomposition, and attendant effects on safe operation of the ECCS.

6.3.2.5 System Reliability

A single failure analysis shows that no single failure prevents the starting of the ECCS and/or the delivery of coolant to the reactor vessel. The most severe effects of single failures with respect to loss of equipment occur if a LOCA occurs in an ECCS pipe coincident with a LOOP. The consequences of the most severe single failures are shown in Table 6.3-3.

Certain technical specification LCO periods are justified based on NEDO-24708A which states that for postulated LOCAs, one low pressure ECCS (one LPCI pump or one CS loop) and ADS to depressurize is adequate to reflood the vessel and maintain core cooling sufficient to preclude fuel damage. NEDC-30936P-A, specifically applicable to LGS references NEDO-24708A and reaffirms this conclusion, with the advisory regarding the possible necessity of an alternate cooling path following 2 hours of post large-break LOCA LPCI injection into the core shroud.

6.3.2.6 Protection Provisions

Protection provisions are included in the design of the ECCS. Protection is afforded against missiles, pipe whip, and flooding. Also accounted for in the design are thermal-stresses, loadings from a LOCA, and seismic effects.

The ECCS piping and components located outside the primary containment are protected from internally and externally generated missiles by the reinforced concrete structure of the ECCS pump rooms. The layout and protection of the pump rooms are covered in Section 6.2.3.

The ECCS is protected against the effects of pipe whip which might result from piping failures up to, and including, the design basis event LOCA. This protection is provided by separation, pipe whip restraints, and energy-absorbing materials. These three methods are applied to provide protection against damage to piping and components of the ECCS which otherwise could result in a reduction of ECCS effectiveness to an unacceptable level. See Section 3.6 for criteria on pipe whip.

The component supports, which protect against damage from movement and from seismic events, are discussed in Section 5.4.14. The methods used to provide assurance that thermal-stresses do not cause damage to the ECCS are described in Section 3.9.3.

The ECCS relief valves discharge lines that penetrate the primary containment and that have outlets below the surface of the suppression pool are designed to protect against the possibility of water hammer. RHR system valves in this category are: PSV-1(2)06A and PSV-1(2) 06B (Dwg. M-51). Each PSV discharge line connects to a 10 inch line which has been designed and installed with a continuous slope to the suppression pool to preclude water pockets from forming. These design features prevent the occurrence of excessive dynamic loads resulting from water hammer during relief valve actuation, and thereby preclude line cracking or rupture. The dynamic loadings have been included in the piping stress analysis. Supports are designed to ensure that they are capable of withstanding the normal plus dynamic loading resulting from the relief valve opening. Section 1.12.3 contains further discussion of water hammer.

6.3.2.7 Provisions for Performance Testing

Periodic system and component testing provisions for the ECCS are described in Section 6.3.2.2 as part of the individual system descriptions.

6.3.2.8 Manual Actions

The ECCS is actuated automatically, and is designed to require no operator action during the first 10 minutes following the accident. Only limited operator action is required before 20 minutes following a LOCA.

During the long-term cooling period (after 10 minutes), the operator takes action, as specified in Section 6.2.2.2, to place the containment cooling system into operation. This action will ensure that suppression pool temperature limits are not exceeded. This is the only manual action that the operator needs to accomplish for the ECCS during the course of the LOCA.

The operator has multiple instrumentation available in the control room to assist him in assessing the post-LOCA conditions. This instrumentation provides reactor vessel pressure and water level, and containment pressure, temperature, and radiation levels, as well as indicating the operation of the ECCS. ECCS flow indication is the primary parameter available to assess proper operation of the system. Other indications, such as position of valves, status of circuit breakers, and essential power bus voltage are also available to assist in determining system operating status.

All controls required to perform the above manual actions are located in the control room. If the RHRSW radiation monitors are inoperable either due to loss of power or component malfunction/failure, the RHRSW pump trip bypass can also be accomplished from the Control Room. The EOPs written in accordance with the BWROG EPGs have been incorporated into LGS training and procedures. The EOPs, with main sections on reactor control and containment control, specify operator actions based on the symptoms that are occurring. Implementation of these training and procedural measures will ensure that LGS operators are adequately equipped to deal with plant emergencies consistent with the design bases assumptions.

The instrumentation and controls for the ECCS are discussed in detail in Section 7.3. Monitoring instrumentation available to the operator is discussed in more detail in Chapter 5 and Section 6.2.

6.3.2.9 Correct Positioning of Manual Valves

Consideration has been given to the possibility that manual valves in the ECCS might be left in the wrong position when an accident occurs. Remote indication in the control room is not required for all critical ECCS manual valves unless they are located in primary containment and therefore are not accessible for survey during normal plant operation. (Critical ECCS manual valves are those that provide system isolation, other than vent, drain, or test connection valves, or are located in the main flow paths.) The positions of those critical valves that are not provided with remote position indication in the control room are administratively controlled and have the following additional protection features:

a. Manual valves in the main ECCS flow paths and manual system isolation valves for ECCS pump suction piping are physically locked in their normal position; access to the keys is controlled administratively.

b. All other manual ECCS isolation valves are redundant to provide double isolation.

The only manual valves in the RHR system that were evaluated are those associated with LPCI mode. The boundary of the LPCI mode piping also includes all piping associated with the suppression pool cooling mode.

Vent, drain, and test connection valves are valves which are not critical to the ECCS function, and administrative controls such as prestartup valve lineup checks suffice to reasonably ensure that such valves will not degrade ECCS performance. In addition, many of these valves are redundant or locked in position, and test connections are capped.

The position of each manually operated valve will be identified in a valve checkoff list. When verification of system operability is required, performance of the valve checkoff list in conjunction with the applicable lineup procedure is one method which may be used. When operability is verified in this manner, an independent verification of valve lineup will be accomplished by redundant performance of each valve checkoff list used. Use of a lineup procedure with its associated valve checkoff lists will not be the exclusive method available for verification of operability, but can be used in any circumstance and supersedes the other methods discussed below. If valve positions are to be changed for surveillance or maintenance purposes, the procedure or other administrative control will have steps requiring return-to-normal valve lineup prior to completion. The shift supervisor will not consider the system operable until all valves identified within the boundaries of the surveillance/maintenance activities have been returned to the position specified in the valve checkoff list. If valve positions in the ECCS are changed for operational purposes, these changes will be made in accordance with procedures having similar administrative controls.

6.3.3 ECCS Performance Evaluation

The performance of the ECCS is determined through application of the 10CFR50, Appendix K evaluation models, and by conformance to the acceptance criteria of 10CFR50.46. The analytical models are documented in GESTAR II (Reference 4.1-1).

The ECCS performance is evaluated for the entire spectrum of break sizes for postulated LOCAs. The accidents, as listed in Chapter 15, for which ECCS operation is required are located in the following sections:

a.	Feedwater piping breaks outside primary containment	15.6.6
b.	Spectrum of BWR steam system piping failures outside of containment	15.6.4
c.	LOCAs inside primary containment	15.6.5

6.3.3.1 ECCS Bases for Technical Specifications

The maximum average planar linear heat generation rates calculated in this performance analysis provide the bases for Technical Specifications designed to ensure conformance with the acceptance criteria of 10CFR50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light-Water-Cooled Nuclear Power Reactors." Minimum ECCS functional requirements are specified in Sections 6.3.3.4 and 6.3.3.5; and testing requirements are discussed in Section 6.3.4. Limits on minimum suppression pool water level are discussed in Section 6.2.

Certain technical specification LCO periods are justified based on the results of NEDO-24708A and NEDC-30936P-A which state that one low pressure ECCS (one LPCI pump or one CS loop) and ADS is adequate to reflood the vessel and maintain core cooling sufficient to preclude fuel damage following a suction line break (including DBA). NEDC-30936P-A adds an advisory about the possible necessity of an alternate cooling path following 2 hours of post large-break LOCA LPCI injection into the core shroud. The justification provided by these documents is required to provide a basis for the maximum period specified to restore equipment or systems declared inoperable to operable status.

6.3.3.2 Acceptance Criteria for ECCS Performance

The applicable acceptance criteria, extracted from 10CFR50.46, are listed below. For each criterion, applicable parts of Section 6.3.3 (where conformance is demonstrated) are indicated. A description of the methods used to show compliance is contained in GESTAR II (Reference 4.1-1).

Criterion 1, Peak Cladding Temperature:

"The calculated maximum fuel element cladding temperature shall not exceed 2200°F." Conformance to Criterion 1 is demonstrated in Table 6.3-5.

Criterion 2, Maximum Cladding Oxidation:

"The calculated total oxidation of the cladding shall nowhere exceed 0.17 times the total cladding thickness before oxidation." Conformance to Criterion 2 is shown in Table 6.3-5.

Criterion 3, Maximum Hydrogen Generation:

"The calculated total amount of hydrogen generated from the chemical reaction of the cladding with water or steam shall not exceed 0.01 times the hypothetical amount that would be generated if all the metal in the cladding cylinder surrounding the fuel, excluding the cladding surrounding the plenum volume, were to react." Conformance to Criterion 3 is shown in References 6.3-6, 6.3-9, 6.3-10, and 6.3-16.

Criterion 4, Coolable Geometry:

"Calculated changes in core geometry shall be such that the core remains amenable to cooling." As described in section III of Reference 6.3-6, conformance to Criterion 4 is demonstrated by conformance to Criteria 1 and 2.

Criterion 5, Long-Term Cooling:

"After any calculated successful initial operation of the ECCS, the calculated core temperature shall be maintained at an acceptably low value and decay heat shall be removed for the extended period of time required by the long-lived radioactivity remaining in the core." Conformance to Criterion 5 is demonstrated generically for GE BWRs in section III.A of Reference 6.3-1 and confirmed in References 6.3-6, 6.3-9, 6.3-10, and 6.3-16. Briefly summarized, the core remains covered to at least the jet pump suction elevation, and the uncovered region is cooled by spray cooling.

The LGS equipment for long-term cooling following a postulated LOCA includes two complete core spray systems and two RHR systems. System components required for long-term coolant recirculation and decay heat removal are designed to remain operable during and following a LOCA. The redundancy provided is such that maintenance is not expected to be required during the long-term core cooling period (180 days) following a LOCA. However, the RHR and core spray systems are designed with provisions for flushing as shown in drawings M-51 and M-52.

6.3.3.3 Single Failure Considerations

The functional consequences of single failures (including operator errors which might cause any manually controlled electrically operated valve in the ECCS to move to a position which could adversely affect the ECCS) are discussed in Section 6.3.2. All potential single failures are no more severe than one of the single failures identified in Table 6.3-3.

It is therefore only necessary to consider each of these single failures in the ECCS performance analyses. For the original Reference 6.3-1 methodology, failure of one of the diesel generators is, in general, the most severe failure for large break; and a loss of the HPCI system is the most severe failure for small break. For the ECCS analysis performed with SAFER/GESTR-LOCA method (References 6.3-5 and 6.3-7) the limiting failure for all breaks is the division 2 dc (battery) failure.

The worst failure of an ECCS pump seal or valve packing during the long-term cooling mode would produce a leak of less than 50 gpm. The ECCS equipment compartments, located on the lowest elevation of the reactor enclosure, are watertight and equipped with flood alarms. Any passive failure including pump seal or valve packing failure occurring in an ECCS long-term cooling loop can be isolated by turning off the pump and shutting the suction isolation valve. If the packing of the suction isolation valve should fail, the leak could still be isolated because all of the suction isolation valves are gate valves.

6.3.3.4 System Performance During the Accident

In general, the system response to an accident can be described as the following:

a. Receiving an initiation signal

b. A small lag time (to open all valves and have the pumps up to rated speed)

c. Finally, the ECCS flow entering the vessel

Key ECCS actuation setpoints and time delays for all the ECCS are provided in Table 6.3-1 for the current ECCS-LOCA analysis and in Table 6.3-1A for the original ECCS-LOCA analysis. The minimization of the delay from the receipt of signal until the ECCS pumps have reached rated speed is limited by the physical constraints on accelerating the diesel generators and pumps. The delay time due to valve motion in the case of the high pressure system provides a suitably conservative allowance for valves available for this application. In the case of the low pressure system, the time delay for valve motion is such that the pumps are at rated speed prior to the time the vessel pressure reaches the pump shutoff pressure.

The operational sequence of ECCS for the DBA is shown in Table 6.3-2 for the current ECCS-LOCA analysis and in Table 6.3-2A for the original ECCS-LOCA analysis.

Operator action is not required, except as a monitoring function, during the short-term cooling period following the LOCA. The HPCI system is designed to inject water into the reactor vessel for small breaks that do not depressurize the vessel.

If a small break occurs and the HPCI system does not function, the ADS will cause vessel blowdown, and the low pressure systems will then act to restore vessel water level. In either case, no operator action is required to restore reactor water level. To establish decay heat removal, the operator will realign the RHR system to the suppression pool cooling mode. The necessary operator actions are described in Section 6.2.2.2.

If a small break occurs and the HPCI system functions properly, reactor vessel water level will be maintained, and no automatic depressurization will occur. The operator must then manually depressurize the vessel, using a minimum number of ADS valves, and establish long-term cooling as above.

All control switches necessary for ADS operation and realignment of the RHR system are located in the control room. The instrumentation available to monitor RHR pressure and flow, reactor vessel pressure, level and temperature, suppression pool temperature, pump status and relevant valve positions are discussed in Chapter 7.

Direction for accomplishing the above actions are available to the operator in the EOPs and appropriate system operating procedures.

The preceding discussion of operator actions in response to a small break LOCA is applicable even when single active failures and LOOP are assumed.

The available NPSH for the pumps in the HPCI system has been calculated based on minimum postaccident suppression pool level, maximum suppression pool temperature, 50% plugged strainers, and no credit for wetwell pressurization. The available NPSH for the RHR and Core Spray pumps has been calculated based on the same assumptions used for the HPCI except for the criteria for the determination of the dirty strainer pressure drop. The dirty strainer pressure drop for these strainers is based on the entire amount of fibrous debris generated in the drywell during a design basis LOCA (within the zone of influence of the worst case pipe break location) transported to the suppression pool and all debris is available to clog the strainer. The results of these calculations show that available NPSH is greater than the required NPSH by a margin of at least 10 feet for RHR, at least 7 feet for Core Spray, and at least 4 feet for HPCI.

6.3.3.5 Use of Dual-Function Components for ECCS

With the exception of the LPCI and ADS systems, the systems of the ECCS are designed to accomplish only one function: to cool the reactor core following a loss of reactor coolant. To this extent, components or portions of these systems (except for pressure relief) are not required for the operation of other systems which have emergency core cooling functions, or vice-versa. Because either the ADS initiating signal or the overpressure signal opens the SRV, no conflict exists.

The LPCI subsystem, however, uses the RHR pumps, and some of the RHR valves and piping. When the reactor water level is low, the LPCI subsystem has priority, through the valve control logic, over the other RHR modes of operation. Immediately following a LOCA, the RHR system is aligned to the LPCI mode. Further discussion of valve logic is provided in Section 7.3.1.1.

6.3.3.6 Limits on ECCS System Parameters

Refer to GESTAR II (Reference 4.1-1).

6.3.3.7 ECCS Analyses for LOCA

6.3.3.7.1 LOCA Analysis Procedures and Input Variables

Refer to GESTAR II (Reference 4.1-1).

The significant input variables used by the LOCA codes are listed in Table 6.3-1 and Figure 6.3-11, for the current ECCS-LOCA. The significant input variables used for the original ECCS-LOCA analysis are shown in Table 6.3-1A and Figure 6.3-11A.

6.3.3.7.2 Accident Description

The original methodology for analysis of the LOCA is reflected in Reference 6.3-1. Reference 6.3-5 provides a detailed description of the current methodology for analysis of the LOCA. The results of the Reference 6.3-5 and 6.3-7 methods are detailed in References 6.3-6, 6.3-9, 6.3-10, and 6.3-16.

6.3.3.7.3 Break Spectrum Calculations

A complete spectrum of postulated break sizes and locations is considered in the evaluation of ECCS performance.

A summary of the results of the break spectrum calculations is shown in tabular form in Table 6.3-5. Conformance to the acceptance criteria (PCT ≤2200°F, local oxidation <17%, and core-wide metal-water reaction <1%) is demonstrated in the above paragraphs. Details of calculations for specific breaks are included in subsequent paragraphs.

6.3.3.7.4 Large Recirculation Line Break Calculations

The characteristics that determine which is the most limiting large break are:

a. the calculated hot node reflooding time,

b. the calculated hot node uncovery time, and

c. the time of calculated boiling transition.

The time of calculated boiling transition increases with decreasing break size, since jet pump suction uncovery (which leads to boiling transition) is determined primarily by the break size for a particular plant. The calculated hot node uncovery time also generally increases with decreasing break size, as it is primarily determined by the inventory loss during the blowdown. The hot node reflooding time is determined by a number of interacting phenomena such as depressurization rate, counter current flow limiting, and a combination of available ECCS.

The period between hot node uncovery and reflooding is the period when the hot node has the lowest heat transfer. Hence, the break that results in the longest period during which the hot node remains uncovered results in the highest calculated PCT. If two breaks have similar times during which the hot node remains uncovered, then the larger of the two breaks will be limiting as it would have an earlier boiling transition time (i.e., the larger break would have a more severe LAMB/SCAT blowdown heat transfer analysis).

The DBA was determined to be the break that results in the highest calculated PCT in the 1.0 ft^2 to DBA region.

The component areas that comprise the suction and discharge break areas in the LOCA analysis are as follows:

a. Suction Break

Recirculation Suction Line Nozzle/Safe End	3.541 ft^2	
Jet Pump Discharge Nozzles - One Bank	0.548 ft^2	
	Total	4.089 ft^2

b. Discharge Break

Recirculation Pump Minimum Area	1.736 ft^2
Jet Pump Discharge Nozzles - One Bank	0.548 ft^2

Total	2.284 ft^2

6.3.3.7.5 Steam Flow Induced Process Measurement Error

The impact on the ECCS-LOCA analysis of a Steam Flow Induced Error (SFIE) in the Level 3 scram has been evaluated. SFIE is a process measurement error in Reactor vessel level measurement induced by steam flowing in the annulus region between the dryer and vessel wall across the mouth of the instrument reference leg tap during a loss of coolant inventory event. For Limerick, SFIE can result in a level measurement error up to 4.67 inches at extended (20%) Power Uprate (3952 MWt). This error adversely impacts the timing of the Level 3 (L3) scram Analytical Limit (AL) for events resulting in a decrease in coolant inventory. Reference 6.3-13 provides an evaluation of this process error for ECCS-LOCA analysis.

For Limerick, the limiting LOCA analysis (and Licensing Basis PCT) is limited by large breaks. Therefore, the Limiting PCT is not affected by the reduction in the L3 analytical limit.

6.3.3.8 LOCA Analysis Conclusions

Having shown compliance with the applicable acceptance criteria of Section 6.3.3.2, it is concluded that the ECCS will perform its function in an acceptable manner and meet all of the 10CFR50.46 acceptance criteria.

6.3.4 TESTS AND INSPECTIONS

6.3.4.1 ECCS Performance Tests

All systems of the ECCS are tested for their operational ECCS function during the preoperational and/or startup test program. Each component is tested for power source, range, direction of rotation, setpoint, limit switch setting, torque switch setting, etc., as applicable. Each pump is tested for flow capacity for a comparison with vendor data (this test is also used to verify flow-measuring capability). The flow tests involve the same suction and discharge source; i.e., the suppression pool or CST.

All logic elements are tested individually and as a system to verify complete system response to emergency signals, including the ability of valves to revert to the ECCS alignment from other positions.

Finally, the entire system is tested for response time and flow capacity, taking suction from its normal source and delivering flow into the reactor vessel. This last series of tests is performed with power supplied from both offsite power and onsite emergency power.

See Chapter 14 for a thorough discussion of preoperational testing for these systems.

6.3.4.2 Reliability Tests and Inspections

The average reliability of a standby (nonoperating) safety system is a function of the duration of the interval between periodic functional tests. The factors considered in determining the periodic test interval of the ECCS are: the desired system availability (average reliability), the number of redundant functional system success paths, the failure rates of the individual components in the system, and the schedule of periodic tests (simultaneous versus uniformly staggered versus randomly staggered). For the ECCS, the above factors are used to determine safe test intervals, utilizing the methods described in Reference 6.3-2.

All of the active components of HPCI, CS, and LPCI are designed so that they may be tested during normal plant operation. Full flow test capability of each ECCS injection system is provided by test lines back to their suction sources. The full flow test is used to verify the capacity of each ECCS pump loop while the plant remains undisturbed in the power generation mode. In addition, each individual valve may be tested during normal plant operation. Input jacks are provided, and by racking out the injection valve breaker, each ECCS loop can be tested for response time.

The ADS logic is designed so that it may be tested during normal plant operation. The SRVs and associated solenoid valves are all tested at least once during the plant startup following each refueling outage. Those SRVs and their associated solenoid valves, which are overhauled during a plant outage, are tested during the startup following that outage.

Testing of the initiating instrumentation and controls portion of the ECCS is discussed in Section 7.3. The safeguard power system, which supplies electrical power to the ECCS if offsite power is unavailable, is tested as described in Section 8.3. Testing is specified in the Technical Specifications. Visual inspections of all the ECCS components located outside the primary containment can be made at any time during power operation. Components inside the primary containment can be visually inspected only during periods of access to the primary containment. When the reactor vessel is open, the spargers and other reactor vessel internals can be inspected.

6.3.4.2.1 HPCI Testing

The HPCI system can be tested at full flow with CST water at any time during plant operation, except when the reactor vessel water level is low, when the condensate level in the CST is below the reserve level, or when the HPCI F041 valve from the suppression pool to the pump are open. If an initiation signal occurs while the HPCI system is being tested, the system aligns automatically to the operating mode.

A design flow functional test of the HPCI system over the operating pressure and flow range is performed by pumping water from the CST and back through the full flow test return line to the CST. The HPCI system turbine-pump is driven at its rated output by steam from the reactor. The HPCI F041 valve, suction valve from the suppression pool, and the discharge valves to the core spray line remain closed. The HPCI F042 valve, suppression pool to pump suction PCIV remains open. These valves are tested separately to ensure their operability.

The HPCI test conditions are tabulated on the HPCI process flow diagram (drawing E41-1020-G-002).

6.3.4.2.2 ADS Testing

The ADS valves are tested once per fuel cycle. This testing includes simulated automatic actuation of the system throughout its emergency operating sequence, but excludes actual valve actuation.

During plant operation the ADS system can be checked as discussed in Section 7.3.

6.3.4.2.3 CS Testing

The CS pumps and valves can be tested during reactor operation. The injection valve and injection line check valve for the A-loop and the outboard and inboard injection line check valves for the B-loop are normally tested with the reactor shutdown. The injection lines to the reactor can be tested when the reactor is shutdown and the CS suction is lined up to the CST. With the injection valve closed and the return line open to the suppression pool, full flow pump capability is demonstrated. The system test conditions during reactor shutdown are shown on the CS system process diagram (drawing E41-1020-G-001. The portion of the CS system outside the drywell may be inspected for leaks during tests.

If an initiation signal occurs during the test, the CS System aligns to the operating mode. The test return line valves close automatically to ensure that CS pump discharge is correctly routed to the RPV.

6.3.4.2.4 LPCI Testing

Each LPCI loop can be tested during reactor operation. The test conditions are tabulated in drawing E11-1020-G-002. During plant operation, this test does not inject cold water into the reactor, because the injection line check valve is held closed by vessel pressure, which is higher than the pump pressure. The injection line portion can be tested with reactor water when the reactor is shut down, and when a closed system loop is created. This prevents unnecessary thermal-stresses.

To test a LPCI pump at rated flow, the test line valve to the suppression pool is opened, the pump suction valve from the suppression pool is opened (this valve is normally open), and the pumps are started using the remote manual switches in the control room. Correct operation is determined by observing instruments locally and in the control room.

If an initiation signal occurs during the test, the LPCI subsystem aligns to the operating mode. The valves in the test bypass lines close automatically to ensure that the LPCI pump discharge is correctly routed to the RPV.

6.3.5 Instrumentation Requirements

Design details, including redundancy and logic of the ECCS instrumentation, are discussed in Section 7.3.

All instrumentation required for automatic and manual initiation of HPCI, CS, LPCI, and ADS is discussed in Section 7.3.2, and is designed to meet the requirements of IEEE 279 and other applicable standards.

Long-term ADS gas supply instrumentation is addressed in Section 7.6.

The HPCI system is automatically initiated on low reactor water level and/or high drywell pressure. The CS and LPCI loops are automatically initiated on low reactor water level, and/or high drywell pressure (in combination with low reactor pressure). The ADS is automatically actuated by sensed variables for reactor vessel low water level and drywell high pressure plus the indication that at least one CS loop or LPCI pump is operating. HPCI, CS, and LPCI automatically realign from system flow test modes to the emergency core cooling mode of operation following receipt of an automatic initiation signal. The CS and LPCI injection into the RPV begins when reactor pressure decreases to loop discharge shutoff pressure.

HPCI injection begins as soon as the HPCI turbine-pump is up to speed and the injection valve is open, since the HPCI is capable of injecting water at full flow into the RPV at pressures up to the reactor pressure specified in Mode A of drawing E41-1020-G-002.

6.3.6 REFERENCES

6.3-1 "General Electric Company Analytical Model for Loss-of-Coolant Analysis in Accordance with 10CFR50, Appendix K", NEDE-20566-P, (November 1975).

6.3-2 H.M. Hirsch, "Methods for Calculating Safe Test Intervals and Allowable Repair Times for Engineered Safeguard Systems," NEDO-10739, (January 1973).

6.3-3 General Electric Company, "Additional Information Required for NRC Staff Generic Report on Boiling Water Reactors", NEDO-24708A, Revision 1, (December 1980).

6.3-4 General Electric Company, "BWR Owner's Group Technical Specification Improvement Methodology (with Demonstration for BWR ECCS Activation Instrumentation)", NEDC-30936P-A, (December 1988).

6.3-5 General Electric Company Analytical Model for Loss of Coolant Analysis in Accordance with 10CFR50, Appendix K, NEDO-20566A, General Electric Company, September 1986.

6.3-6 GE Nuclear Energy, Limerick Generating Station Units 1 and 2, SAFER/GESTR-LOCA, Rev. 2 Loss-of-Coolant Accident Analysis, NEDC-32170P, Rev. 2, May 1995

6.3-7 General Electric Company, "The GESTR-LOCA and SAFER models for the evaluation of the Loss-of-Coolant Accident, Volume III, SAFER/GESTR Application Methodology," NEDE-23785-1 PA, Rev. 1, (Oct 1984).

6.3-8 Deleted.

6.3-9 Limerick Generating Station Units 1 and 2 ECCS-LOCA Evaluation for GE-14, GE-NE-J1103793-09-01P, DFR J11-03793-09, March 2001.

6.3-10 GE-Hitachi Nuclear Energy, 0000-0111-9078-R0, “Limerick Generating Station Units 1 and 2 GNF2 ECCS-LOCA Evaluation,” February 2011.

6.3-11 Deleted.

6.3-12 Generic Letter 2008-01, “Managing Gas Accumulation in Emergency Core Cooling, Decay Heat Removal, and Containment Spray Systems,” dated January 11, 2008.

6.3-13 GE-Hitachi Nuclear Energy, 0000-0077-4603-R1, "BWR Owners Group Evaluation of Steam Flow Induced Error (SFIE) Impact on the L3 Setpoint Analytic Limit," October 2008.

6.3-14 Letter Report for Exelon, Summary of GEH Transient Anticipated Operational Occurrences (AOO) and Loss of Coolant Accident (LOCA) Analyses with Respect to ASD Modification in Limerick Generating Station Units 1 and 2, 0000-0129-8688-R1, Revision 1, May 2011.

6.3-15 GE Hitachi Nuclear Energy, "Implementation of PRIME Models and Data in Downstream Methods," NEDO-33173, Supplement 4-A, Revision 1, November 2012.

6.3-16 GE Hitachi Nuclear Energy, "Limerick Generating Station Units 1 and 2 GNF3 ECCS-LOCA Evaluation," 005N3990, Revision 0, December 2020.

Table 6.3-1

SIGNIFICANT INPUT VARIABLES USED IN THE SAFER/GESTR-LOCA ANALYSIS

VARIABLE			VALUE			
			GNF2		GNF3	
A.	PLANT PARAMETERS		NOMINAL	APPENDIX K	NOMINAL	APPENDIX K
	•	Core thermal power (MWt)	3622	3694	3515	3528
	•	Vessel steam output (lbm/hr)	15.8x10^6	16.2X10^6	15.8x10^6	N/A
	•	Vessel steam dome pressure (psia)	1060	1063	1060	1063[1]
	•	Maximum recirculation line break area (ft^2)	4.16	4.16	4.174	4.174
B.	ECCS PARAMETERS					
	B.1	LPCI System				
	•	Vessel pressure at which flow may commence	<295 psid (vessel to drywell)		Same as GNF2	
	•	Minimum rated flow at vessel Pressure	32,000 gpm (4 pumps) 20 psid (vessel to drywell)		Same as GNF2	
	•	Initiating signals				
		Low water level (level 1), or	≥366.5 inches above vessel zero		Same as GNF2	
		High drywell pressure	≤2.0 psig			
	•	Maximum allowable time delay from initiating signal to power at injection valves	≤28 sec		13 sec	
	•	Maximum allowable time delay from initiating signal to injection valves full open	≤64 sec		Same as GNF2	
	B.2	Core Spray System				
	•	Vessel pressure at which flow may commence	<289 psid (vessel to drywell)		Same as GNF2	
	•	Minimum rated flow at vessel pressure	5000 gpm/loop 105 psid (vessel to drywell)		Same as GNF2	

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[1] The conclusions of the Limerick GNF3 LOCA analysis for 1063 psia dome pressure remain valid for TS LCO of 1068 psia dome pressure.

Table 6.3-1 (Cont'd)

	VARIABLE	VALUE	
		GNF2	GNF3
•	Initiating signals		
	Low water level (level 1), or	≥366.5 inches above vessel zero	Same as GNF2
	High drywell pressure	≤2.0 psig	Same as GNF2
•	Minimum allowed run-out flow	6250 gpm/loop	
•	Maximum allowed delay time from initiating signal to power at injection valves	≤28.0 sec	13 sec
•	Maximum allowed delay time from initiating signal to injection valve full open	48.0 sec	Same as GNF2
B.3	HPCI/Core Spray Flow Split Characteristics		
•	Minimum flow rate (independent of vessel pressure)	5400 gpm	Same as GNF2
•	Initiating signals		
	Low water level (level 2), or	≥457.5 inches above vessel zero	Same as GNF2
	High drywell pressure	≤2.0 psig	Same as GNF2
•	Maximum allowed delay time from initiating signal to rated flow available and injection valve wide open	≤60.0 sec	Same as GNF2
•	Maximum HPCI flow rate injected through core spray sparger	2890 gpm	Same as GNF2
B.4	Automatic Depressurization System		
•	Total number of relief valves with ADS function	5	Same as GNF2
•	Total minimum flow capacity at a vessel pressure	4.35x10^{6} lbs/hr 1090 x 1.03 psig	Same as GNF2

Table 6.3-1 (Cont'd)

VARIABLE	VALUE	
	GNF2	GNF3
• Initiating signals		
a) Low water level (level 1), and	≥366.5 inches above vessel zero	Same as GNF2
High drywell pressure(1)	≤2.0 psig	Same as GNF2
b) Low water level (level 1), and	≥366.5 inches above vessel zero	Same as GNF2
High drywell pressure bypass timer timed out(2)	≤8 minutes	Same as GNF2
• Delay time from all initiating signals completed to the time valves are open	≤120 seconds	Same as GNF2

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(1) Designed to actuate for breaks inside the drywell.

(2) Designed to actuate ADS when needed for events which do not result in drywell pressurization.

Table 6.3-1A

SIGNIFICANT INPUT VARIABLES USED IN THE LOCA ANALYSIS BASED ON ORIGINAL REFERENCE 6.3-1 METHODOLOGY

VARIABLE	VALUE
A. PLANT PARAMETERS	
• Core thermal power	3430 MWt
• Vessel steam output	14.86x10^6 lb_m/hr
• Corresponding percent of rated steam flow	105%
• Vessel steam dome pressure	1055 psia
• Maximum recirculation line break area	4.1 ft^2
B. ECCS PARAMETERS	
B.1 LPCI System	
• Vessel pressure at which flow may commence	<295 psid (vessel to drywell)
• Minimum rated flow at vessel pressure	40,000 gpm (4 pumps) 20 psid (vessel to drywell)
• Initiating signals	
Low water level (level 1), or	≥1.0 feet above top of active fuel
High drywell pressure	≤2.0 psig
• Maximum allowable time delay from initiating signal to pumps at rated speed	≤40 sec
B.2 Core Spray System	
• Vessel pressure at which flow may commence	<289 psid (vessel to drywell)
• Minimum rated flow at vessel pressure	6250 gpm/loop 105 psid (vessel to drywell)

Table 6.3-1A (Cont'd)

VARIABLE	VALUE
• Initiating signals	
Low water level (level 1), or	≥1.0 feet above top of active fuel
High drywell pressure	≤2.0 psig
• Minimum allowed run-out flow	7000 gpm/loop
• Maximum allowed delay time from initiating signal to pump at rated speed	≤27.0 sec
B.3 HPCI/Core Spray Flow Split Characteristics	
• Minimum flow rate (independent of vessel pressure)	5600 gpm
• Initiating signals	
Low water level (level 2), or	≥8.6 feet above top of active fuel
High drywell pressure	≤2.0 psig
• Maximum allowed delay time from initiating signal to rated flow available and injection valve wide open	≤30.0 sec
• Maximum HPCI flow rate injected through core spray sparger	3000 gpm
B.4 Automatic Depressurization System	
• Total number of relief valves with ADS function	5
• Total minimum flow capacity at a vessel pressure of	4.0×10^6 lbs/hr 1125 psig

Table 6.3-1A (Cont'd)

VARIABLE	VALUE
• Initiating signals	
a) Low water level (level 1), and	≥1.0 feet above top of active fuel
High drywell pressure[1]	≤2.0 psig
b) Low water level (level 1), and	≥1.0 feet above top of active fuel
High drywell pressure bypass timer timed out[2]	≤8 minutes
• Delay time from all initiating signals completed to the time valves are open	≤120 seconds
C. FUEL PARAMETERS	
• Fuel type	Initial Core
• Fuel bundle geometry	8x8
• Lattice	C
• Number of fueled rods per bundle	62
• Peak Technical Specification LHGR	13.4 kW/ft
• Initial minimum critical power ratio	1.2
• Design axial peaking factor	1.4

---

[1] Designed to actuate for breaks inside the drywell.

[2] Designed to actuate ADS when needed for events which do not result in drywell pressurization.

Table 6.3-2

OPERATIONAL SEQUENCE OF ECCS FOR DESIGN BASIS LOCA(1)

TIME (sec)	EVENTS
0	Design basis LOCA is assumed to start; normal auxiliary power is assumed to be lost.
<1	Drywell high pressure is reached. Scram initiated; HPCI is signaled to start, and containment isolates, except for the MSIVs.
Approx 1	Reactor Low Water Level (Level 3) is reached (2). The second scram initiation signal is received.
Approx 4	Reactor low-low water level (level 2) is reached. HPCI receives the second signal to start.
Approx 5	The reactor low-low-low water level (level 1) is reached; MSIVs are signaled to close; the signal to start LPCI and CS is given.
Approx 25	Reactor low pressure is reached. CS and LPCI receive the second signal to start. CS injection valve receives pressure permissive signal to open.
≤54	The CS pumps are at rated flow and the CS injection valves are open, which completes the CS system startup.
≤70	The LPCI pumps are at rated flow and the LPCI injection valves are open, which completes the LPCI system startup.
Approx 130	The core is effectively reflooded, assuming the worst single failure; heatup is terminated.
>10 min	The operator shifts to containment cooling.

---

(1) For the purpose of all but the next to the last entry on this table, all ECCS equipment is assumed to function as designed. Performance analysis calculations consider the effects of single equipment failures (Sections 6.3.2.5 and 6.3.3.3).

(2) The Level 3 Analytical value in this table may be slightly different for various events due to a steam flow induced process measurement error. However, the impact of the change is not significant and the event descriptions or conclusions need not be modified (Section 6.3.3.7.5).

Table 6.3-2A

OPERATIONAL SEQUENCE OF ECCS FOR DESIGN BASIS LOCA (1) BASED ON THE ORIGINAL REFERENCE 6.3-1 METHODOLOGY

TIME (sec)	EVENTS
0	Design basis LOCA is assumed to start; normal auxiliary power is assumed to be lost.
<1	Drywell high pressure (2) and reactor low water level (level 3) are reached (3). All diesel generators are signaled to start; scram initiated; HPCI is signaled to start, and containment isolates, except for the MSIVs.
Approx 2	Reactor low-low water level (level 2) is reached (3). HPCI receives the second signal to start.
Approx 5	The reactor low-low-low water level (level 1) is reached; MSIVs are signaled to close; the signal to start LPCI and CS is given.
Approx 22	Reactor low pressure is reached. CS and LPCI receive the second signal to start. CS injection valve receives pressure permissive signal to open.
Approx 26	LPCI injection valve receives ΔP permissive signal to open.
Approx 32	The HPCI injection valve opens and the pump is at design flow, which completes the HPCI startup.
≤34	The CS pumps are at rated flow and the CS injection valves are open, which completes the CS system startup.
≤50	The LPCI pumps are at rated flow and the LPCI injection valves are open, which completes the LPCI system startup.
Approx 165	The core is effectively reflooded, assuming the worst single failure; heatup is terminated.
>10 min	The operator shifts to containment cooling.

---

(1) For the purpose of all but the next to the last entry on this table, all ECCS equipment is assumed to function as designed. Performance analysis calculations consider the effects of single equipment failures (Sections 6.3.2.5 and 6.3.3.3).

(2) No credit taken in the DBA LOCA analysis for ECCS system initiation on the high drywell pressure signal.

(3) The Level 3 Analytical value in this table may be slightly different for various events due to a steam flow induced process measurement error. However, the impact of the change is not significant and the event descriptions or conclusions need not be modified (Section 6.3.3.7.5).

Table 6.3-3

SINGLE FAILURE EVALUATION(1)(4)

No potential single failure has been identified as more severe than one of the following single failures:

ASSUMED FAILURE	SUCTION BREAK(2) SYSTEMS REMAINING
Division 2 dc source	1 CS loop + 3 LPCI + All ADS
Diesel generator(3)	1 CS loop + HPCI + 3 LPCI + All ADS
LPCI injection valve	2 CS loop + HPCI + 3 LPCI + All ADS
HPCI	2 CS loop + 4 LPCI + All ADS
One ADS valve	2 CS loop + 4 LPCI + HPCI + All ADS minus one

---

(1) Other postulated failures are not specifically considered because they all result in at least as much ECCS capacity as one of the above designated failures.

(2) Systems remaining, as identified in this table, are applicable to all non-ECCS line breaks. For a LOCA from an ECCS line break, the systems remaining are those listed, less the ECCS system in which the break is assumed.

(3) If the single failure occurs in a diesel generator that supplies power to an ESW pump, the diesel generator in the other unit is needed to support the other ESW pump that supplies that loop.

(4) This table demonstrates the performance of safety systems under the single failure criteria. For the minimum system requirements to successfully terminate a transient or LOCA initiating event (with scram), assuming multiple failures with realistic conditions, refer to NEDO-24708.

Table 6.3-4 has been deleted

Table 6.3-5

SUMMARY OF RESULTS OF LOCA ANALYSIS WITH SAFER/GESTR-LOCA USING TABLE 6.3-1 INPUTS

Parameter	Value		10 CFR 50.46 Acceptance Criteria
1. Fuel Type	GNF2	GNF3	N/A
2. Limiting Break	Large Recirc suction DBA(1)	Large Recirc suction DBA(1)	N/A
3. Limiting Single Failure	Division 2 dc source	Division 2 dc source	N/A
4. Licensing Basis Peak Cladding Temperature	1880 °F	≤ 1940 °F	≤ 2200 °F
5. Maximum Local Oxidation	< 3.0%	< 3.0 %	≤ 17 %
6. Core-Wide Metal-Water Reaction	< 0.1 %	< 0.1 %	≤ 1.0 %
7. Coolable Geometry	Item 4 AND Item 5 Satisfied.	Item 4 AND Item 5 satisfied.	Maintain coolable geometry, which is satisfied by meeting PCT ≤ 2200 °F AND Maximum Local Oxidation ≤ 17 %.
8. Long-Term Cooling	Satisfied by EITHER: Core reflooded above TAF OR Core reflooded to the elevation of jet pump suction and one core spray system in operation.	Satisfied by EITHER: Core reflooded above TAF OR Core reflooded to the elevation of jet pump suction and one core spray system in operation.	Core Temperature acceptably low AND long-term decay heat removed.

(1) Includes the area of the bottom head drain line.

Table 6.3-5A has been deleted

Table 6.3-6 has been deleted

Table 6.3-7 has been deleted

6.4 HABITABILITY SYSTEMS

The control room habitability systems are designed to provide safety and comfort for operating personnel during normal operations and during postulated accident conditions. These habitability systems for the control room include radiation shielding, charcoal filter systems, HVAC, storage for food and water, kitchen and sanitary facilities, and fire protection. The habitability systems are designed to meet GDC 19 of 10CFR50, Appendix A.

6.4.1 DESIGN BASES

The design bases of the habitability systems, upon which the functional design is established, are summarized as follows:

a. The control room environmental envelope is designed for continuous occupation on a year-round basis. The occupancy of the operating personnel is ensured for a minimum of 30 days after a DBA.

b. The habitability systems are designed to support 5 people during normal and abnormal station operating conditions. A 5 day emergency supply of food and water is provided within the control room habitability envelope. Supplies of potassium iodide adequate to protect 30 people are maintained onsite.

c. Kitchen and sanitary facilities and medical supplies for minor injuries are provided within the boundary of the control room habitability systems for the use of control room personnel during normal and accident conditions.

d. The radiological effects on the control room personnel that could exist as a consequence of the postulated DBAs described in Chapter 15 do not exceed the guidelines set by GDC 19 of 10CFR50, Appendix A, or the dose limits of 10CFR50.67.

e. The design includes provisions to preclude the effects of a chlorine release accident onsite or offsite from affecting the habitability of the control room.

f. The design includes provisions to preclude the effects of an offsite toxic chemical release from affecting the habitability of the control room.

g. Respiratory and skin protection and emergency breathing apparatus are provided within the control room envelope for control room operators.

h. The control room ventilation system is capable of automatic transfer from its normal operational mode to its accident or isolation mode upon detection of conditions which could result in the introduction of airborne radioactivity into the control room.

i. The control room ventilation system is designed to remain functional during and after an OBE and an SSE.

j. The habitability systems are designed to remain functional following a failure of any one of the HVAC system components.

k. Radiation monitors and offsite toxic chemical detectors continuously monitor the outside air at the control room envelope outside air intake. The detection of high radiation or offsite toxic chemical release is alarmed in the control room, and related protection functions are simultaneously initiated.

l. The control room HVAC system design bases are discussed in Section 9.4.1.

m. The seismic category, quality group classification, and corresponding codes and standards that apply to the design of the habitability systems are discussed in Section 3.2.

n. The guidelines of Regulatory Guide 1.52, Regulatory Guide 1.78, and Regulatory Guide 1.95 apply to the design of habitability systems. Conformance for the analyses associated with Regulatory Guide 1.78 is discussed in Section 2.2.3. Conformance to design aspects of the guides is as follows:

    1. There is partial conformance with Regulatory Guide 1.52 as discussed in Section 6.5.1

    2. The habitability system design for offsite toxic chemical protection conforms with Regulatory Guide 1.78. Differences from the analytic models are discussed in Section 2.2.3.

    3. Regulatory Guide 1.95 (Rev 1), which discusses protection from accidental chlorine release, does not apply to LGS per its implementation section. Nevertheless, the LGS design is in conformance.

The design of the habitability systems with respect to the following areas is discussed in separate sections as indicated:

a.	Protection from wind and tornado effects	Section 3.3
b.	Flood Design	Section 3.4
c.	Missile Protection	Section 3.5
d.	Protection against dynamic effects associated with postulated rupture of piping	Section 3.6
e.	Environmental design	Section 3.11

6.4.2 SYSTEM DESIGN

6.4.2.1 Definition of Control Room Envelope

The control room envelope maintained under habitable conditions following an accident is shown on Figure 6.4-1. The envelope consists of the control room, peripheral offices at the west and east ends, toilet room, and utility room; all on el 269'-0". Steam and air tight doors are provided for ingress and egress.

The volume of the emergency zone served by the HVAC system in the accident mode or the isolation mode is approximately 126,000 cubic feet.

6.4.2.2 Ventilation System Design

The control room HVAC system is discussed in detail in Section 9.4.1. The system is shown schematically in drawing M-78, and major system components are described in Table 9.4-1.

Figure 6.4-2 shows the plant layout, including the location of plant facilities, with respect to the control room outside air intake. The control room arrangement is shown in Figure 6.4-1. The seismic category and quality group classification of components, instrumentation, and ducts are listed in Section 3.2 and shown in drawing M-78.

The control room is common for Units 1 and 2. The principal equipment in the system includes:

a. Two 100% capacity air handling units which include cooling coils, and fans for use during normal plant operation and following a DBA, a chlorine accident, or an offsite toxic chemical accident. Electric humidifiers, electric heaters, and roll filters are provided for use during normal plant operation, during a chlorine accident, or during an offsite chemical accident.

b. Two 100% capacity return air fans for use during normal plant operation and following a DBA, chlorine or offsite toxic chemical accident.

c. Two banks of high efficiency air filtration units consisting of a prefilter, HEPA filter, an electric heating coil, a carbon adsorber, and a second HEPA filter for treatment of recirculated air or outside supply air following a DBA, chlorine, or offsite toxic chemical accident. Two filtration unit fans are provided; one for each filtration unit.

d. A single outside air intake for use during normal plant operation and following a DBA.

6.4.2.3 Leak-Tightness

Control room envelope construction joints and penetrations for cable, pipe, HVAC duct, HVAC equipment, dampers, and steam-tight doors have been designed specifically for leak-tightness. A list of potential leak paths to the control room is provided in Table 6.4-2, along with the type of material, joint, or penetration.

For the onsite chlorine storage discussed in Section 2.2.3, a control room design with a maximum allowable control room isolated air exchange rate of 0.25 air changes per hour is provided. The analysis discussed in Section 2.2.3.1.3 demonstrates that this air exchange rate allows the operators more than 2 minutes to put on their breathing masks.

6.4.2.4 Interaction with Other Zones and Pressure-Containing Equipment

a. Design of the control room envelope boundaries, duct-work and isolation valves minimizes interchange of exterior radioactive gases or toxic vapors into the control room envelope.

   The control room is surrounded by the turbine enclosure, the reactor enclosure, and the cable spreading room and auxiliary equipment room. Each of these areas is separated from the control room by shield walls, floors, and leak-tight doors and is served by the independent HVAC systems described in Section 9.4.

   The HVAC equipment room at el 304' is a part of the control structure. The negative pressure control room duct-work system in the HVAC equipment room is of welded construction and tested for leak-tightness. Dampers on the negative pressure duct-work are of gas-tight construction.

b. Steam lines and central carbon dioxide fire prevention system tanks are not located within the control room envelope.

6.4.2.5 Shielding Design

Control room shielding is discussed in Section 12.3. The shielding is designed for continuous occupancy during a DBA and meets GDC 19 and 10CFR50.67.

6.4.3 System Operational Procedures

6.4.3.1 Normal Operation

During normal operation, one of the two air handling units and one of the two return fans recirculate the control room air. Approximately 2100 cfm of fresh outside air is taken in at the control room ventilation system intake located on the north wall of the control enclosure. By balancing the exhaust and makeup flow rates, the control room is normally maintained at a slightly positive pressure with respect to the surrounding areas. The outside makeup air and recirculated air pass through a roll filter at the inlet of the air handling unit fans. The supply air is cooled or heated by the air handling units as required to maintain the desired temperature. Upon loss of supply or return air flow, the respective standby fans automatically start; the associated fan dampers reposition; and an alarm annunciates in the main control room. The start of standby equipment may also be manually initiated.

The control room is fully air conditioned and will be maintained between 65 and 78^{o}F and between 30 and 90% relative humidity. Control room temperature is sensed by a temperature transmitter which transmits a signal to a temperature indicating controller. The temperature controller maintains the proper temperature by controlling an electric heating coil or cooling coil valve as necessary. Control room minimum humidity is maintained by a return air duct moisture sensor and transmitter, which transmits a signal to the humidity controller which in turn controls an electric humidifier. Excessive humidity is precluded by the cooling coil which condenses excessive moisture.

6.4.3.2 Postaccident Operation

The control room HVAC system is designed to ensure habitability after any of the design basis radiological accidents or a chemical release accident. To provide adequate operator protection in the unlikely event of one of these accidents, three distinct accident modes of operation are included. These modes are referred to as the chlorine isolation mode, the toxic chemical isolation mode, and the radiation isolation mode.

The mode of system operation after each of the individual accidents of concern with the control room HVAC system initially in the normal mode of operation is as follows:

Chlorine accident - Chlorine isolation mode

High radiation accident - Radiation isolation mode

Offsite toxic chemical accident - Toxic chemical isolation mode

In the event of a radiation accident, the control room will be automatically isolated. In the event of an offsite toxic chemical accident, the control room will be remote manually isolated when the predetermined toxic chemical concentrations are detected in the control room air intake plenum and alarmed in the control room.

Note: the possibility exists for a chlorine accident to occur while the control room HVAC system is operating in the radiation isolation mode for testing purposes or as required by the Action statement of an associated Technical Specifications Limiting Condition of Operation, and likewise, a high radiation accident could occur while the control room HVAC system is operating in the chlorine isolation mode for the same purposes. The mode of system operation with the control room HVAC system in these initial system configurations is described in Sections 6.4.3.2.1 and 6.4.3.2.2 below.

The high radiation accident is discussed in detail in Chapter 15 and identification of design basis toxic chemicals including chlorine is discussed in Section 2.2.3.

6.4.3.2.1 <u>Chlorine Isolation Mode</u>

Upon detection or notification of an off-site chlorine spill, operators will initiate a manual chlorine isolation of the control room HVAC system. The following events occur (drawing M-78) to isolate the control room from the outside air when the control room HVAC system is initially in the normal mode of operation.

a. Redundant outside air intake isolation valves close in 3-5 seconds to prevent outside air from entering the control room supply air handling units.

b. For a manual chlorine isolation only, outside air intake isolation valves to the charcoal filter inlets close, if open, in 8-12 seconds to provide isolation to the charcoal filter trains.

c. Control room exhaust isolation valves and control room toilet exhaust isolation valves close in 3-5 seconds.

d. The emergency fresh air charcoal filter recirculation inlet isolation valve opens in 8-12 seconds.

e. The emergency fresh air fan for charcoal filter train A or B starts to establish filtered recirculation of the control room environment.

f. Manual chlorine isolation concentration is indicated and alarmed in the control room.

In the chlorine isolation mode approximately 3000 cfm of the control room atmosphere is recirculated through the charcoal filter train for cleanup.

The normal air handling units continue to recirculate approximately 26,200 cfm of the control room atmosphere, including the charcoal filter train discharge.

Once initiated, the system remains in the isolation mode until the trip switch is manually reset.

6.4.3.2.2 Radiation Isolation Mode

The radiation isolation mode of operation is intended to protect the control room operators if there are design basis radiological accidents.

Upon receipt of an initiating signal, the following automatic functions occur (drawing M-78) when the control room HVAC system is initially in the normal mode of operation:

a. The control room outside air exhaust is isolated.

b. The control room outside air intake, charcoal filter trains, and normal air handling units are aligned, so that all outside air must pass through the charcoal filter trains before it enters the control room.

c. The control room is maintained at a positive pressure (approximately 1/8 inch wg) with respect to the surrounding areas.

d. High radiation is alarmed in the control room.

The control room is now positively pressurized with respect to the surrounding areas. The quantity of outside air taken in at the normal ventilation intake on the north wall of the control structure is mixed with recirculated control room air, and a total of 3000 cfm is passed through the charcoal adsorber filter train for removal of airborne radioactivity.

If the control room HVAC system is initially in the chlorine isolation mode as described in Section 6.4.3.2.1 for any purpose, the system will remain in this mode of operation upon receipt of a high radiation signal, i.e., automatic transfer from the chlorine isolation mode to the radiation isolation mode will not occur. This design recognizes that the infiltration of chlorine into the main control room is a more immediate threat to the operations personnel.

If the control room HVAC system is initially in the chlorine isolation mode as result of maintenance or surveillance testing, the HVAC system can be manually switched to the radiation isolation mode once the operators determine that no chlorine is present.

6.4.3.2.3 Toxic Chemical Isolation Mode

The toxic chemical isolation mode is identical to the chlorine isolation mode as described in Section 6.4.3.2.1, with the exception that toxic chemical detection does not automatically initiate control room isolation.

Upon receipt of a high toxic chemical concentration alarm indicated by the toxic chemical detectors located in the control room outside air intake plenum, the operator manually initiates control room isolation utilizing controls available in the control room in accordance with plant procedures.

High toxic chemical concentration is indicated and alarmed in the control room and the system remains in the isolation mode until the high toxic chemical concentration condition is no longer present and the system is manually reset.

6.4.4 Design Evaluations

The control room habitability system is designed with redundancy and separation of active components to provide reliable operation under normal conditions and to ensure operation under accident conditions. A failure analysis of the system components is shown in Table 6.4-1.

6.4.4.1 Radiological Protection

A detailed discussion of the dose calculation model for control room operators following the postulated DBA is discussed in Section 15.10. The analysis considers both conditions in which the control room HVAC system is initially in the normal mode of operation and the chlorine isolation mode prior to the high radiation accident. The resulting calculated doses for control room ingress, egress, and occupancy (on a rotating shift basis) are less than 5 rem total effective dose equivalent (TEDE). These doses are within the dose limits specified in GDC 19 and 10CFR50.67. The analysis also assumes the installation of a MCR door seal, which ensures zero direct inleakage from the Turbine Enclosure through the MCR doors. Following the DBA LOCA, after the MSIV Leakage Alternate Drain Pathway has been aligned and when a Turbine Enclosure Area Radiation Monitor alarms, a temporary MCR door seal will be erected, to prevent the direct inleakage to the MCR. This action is necessary to prevent a relatively high calculated concentration of Iodine from entering the MCR directly from the Turbine Enclosure.

Control room shielding design, based on the most limiting radiological accident (design basis LOCA) is discussed in Section 12.3. The evaluations in Chapter 12 demonstrate that radiation exposures to control room personnel originate from containment shine, external cloud shine, and containment airborne radioactivity sources. Total exposures resulting from the worst radiological accident are below the dose limits specified by GDC 19 and 10CFR50.67; the portion contributed by containment shine and external cloud shine is reduced to a small fraction of the total by means of the walls which surround the control room.

Two radiation detector units are located in the control room fresh air inlet duct, and another two radiation detector units are located in the auxiliary equipment room HVAC system fresh air inlet duct. All four radiation detectors are situated in duct-work that is directly below the floor penetration level at el 332'. A description of the radiation detector units is provided in Section 7.1.2.1.11.

6.4.4.2 Toxic Gas Protection

The control room HVAC system is designed to satisfy the guidelines of Regulatory Guide 1.78 for toxic chemical protection, and Regulatory Guide 1.95 for chlorine protection (except as discussed in Section 6.4.1). Detection systems are provided for both offsite toxic chemical accidental release and onsite chlorine container accidental release.

Detector design criteria and descriptions and respiratory protection are discussed below.

6.4.4.2.1 Chlorine

The chlorine release accident analysis is described in Section 2.2.3. The control room and isolation system are designed to meet the requirements of a control room that has a maximum allowable isolated air exchange rate of 0.25 air changes per hour.

The analysis considers both conditions in which the control room HVAC system is initially in the normal mode of operation and the radiation isolation mode prior to the chlorine accident.

6.4.4.2.2 Offsite Toxic Chemical System

Three toxic chemical detection systems are provided to detect the offsite toxic chemicals identified in Section 2.2.3, to provide annunciation in the control room, and identification of the chemical and concentration to a control room console.

Each toxic chemical detection system consists of a microcomputer built around a microprocessor and integrated with an infrared spectrometer and a multipoint sampling manifold. Each system is designed to measure and record the concentration of toxic chemicals at one sample location. Each system, located in the control enclosure, monitors the control room outside air intake plenum.

The microcomputer controls the spectrometer, signal averages the infrared transmission measurements at each programmed wavelength, calculates absorbance, and uses a stored coefficient matrix to calculate the concentration of components in the air sample.

During factory calibration, each system is programmed to monitor the toxic gases listed in Table 2.2-6. Calibration coefficients for each gas are stored in the system hard drive.

The sampling program begins with a nitrogen zero gas cycle. Ambient air is collected from the air intake plenum and pumped into the sample cell of the analyzer. The analyzer passes an infrared beam through the sample and measures the amount of light absorbed at each of the analytical wavelengths of a programmed sequence. The computer uses the stored calibration coefficients to calculate the concentration of sample components.

If the concentration of any monitored gas should exceed the selected limits, alarms will be automatically triggered at the analyzer. The toxic chemical high concentration alarm in the control room will be energized when two-out-of-three analyzers alarm. In addition to the concentration alarms, the system will indicate any malfunction related to electronics, optical system, loss of flow by local indication, or a single toxic chemical high concentration alarm.

Three “Inop/Operate” selector switches are installed on the Relay Logic Panel 00-C734, one for each analyzer. Each selector switch allows the associated analyzer, when inoperable, to be placed in the tripped condition. The switch when placed in the "Inop" position bypasses the toxic analyzer trouble annunciator for the affected analyzer and interrupts the data sent to the remote computer and PMS. With one analyzer in the tripped condition, only one of the two operable analyzers are required to alarm to satisfy the two-out-of-three alarm criteria.

A computer display console in the control room can provide an indication of the toxic chemical and its concentration at any given time.

The equipment has built-in test features. A part of the self-test program is automatically performed each time the analyzer is zeroed.

This system has self calibrated features that are always running when the analyzers are in service to keep them within specification or to activate the control room “Trouble” annunciator if any critical parameter is outside its specified range.

Test points are provided on the Relay Logic Panel for each analyzer to facilitate testing of the toxic chemical high concentration alarm relays.

No special maintenance is required.

6.4.4.2.3 Respiratory Protection

Full-faced pressure demand self-contained breathing apparatus rated for 1 hour per cylinder and protective clothing are available for control room operators.

A 6 hour onsite bottled air supply is provided by charged cylinders maintained for backup fire protection and health physics use. Offsite replenishment is provided by compressors (fill capacity greater than 30 cylinders per hour) owned by an offsite vendor, fire company, or another offsite entity.

The number of respiratory devices shall, as a minimum, provide a 6 hour air supply for 6 individuals. Consistent with the provisions of Regulatory Guide 1.95, one extra respiratory device will be provided for every 3 devices needed to meet the minimum capacity.

See Section 13.2 for discussion on Respiratory Protection.

A program for periodic inspection of control room operator respiratory equipment will be established. The program will address inspection for defects, storage conditions, and, as found to be necessary, cleaning, disinfecting, and repairing. In addition, the equipment will be cleaned, disinfected, and inspected after each use. Replacements and repairs will be done only by trained personnel using parts designed for that equipment. The equipment will be stored to protect against dust, sunlight, extreme heat or cold, excessive moisture, and damaging chemicals.

6.4.5 TESTING AND INSPECTION

The control room HVAC emergency system filtration components are tested in a program consisting of the following classifications:

a. Predelivery tests and factory component qualification tests to ensure the quality of the manufactured product.

b. Preoperational tests in accordance with the requirements of Chapter 14.

c. Periodic tests in accordance with the requirements of Chapter 16.

The frequency of tests and inspections is selected to ensure the continued integrity of the system. Charcoal testing frequency is in accordance with Regulatory Guide 1.52 for the efficiency claimed and the bed depth specified. Except that in-place testing and laboratory testing is performed at least once per 48 months as discussed in Table 6.5-2.

Written test procedures establish minimum acceptable values for all tests. Test results are recorded as a matter of performance records, thus permitting early detection of faulty performance.

The predelivery and factory component qualification tests are in accordance with the recommendations and guidelines presented in section C-3 of Regulatory Guide 1.52. HEPA filters have a minimum efficiency of 99.97% when measured with a 0.3 micron DOP aerosol. Carbon lot testing is required and certified by a qualified testing agency to establish gas adsorption efficiency, uniformity of density, ignition temperature, hardness, and impregnate content.

Filter plenums are tested for leakage under positive pressure. Plenums are pressurized to the design pressure with soap bubble tests made at all welds. The maximum permissible leakage rate is 0.05% of the filter plenum rated flow in cubic feet per minute at 125% of the negative design plenum pressure.

Preoperational tests are conducted in accordance with the requirements of Chapter 14. In general, the tests include:

a. Visual inspection

b. Verification of ability to maintain control room pressurization without exceeding outside air makeup design flow rate

c. Airflow capacity verification test

d. Airflow distribution verification test

e. Air/aerosol uniformity test

f. Inplace HEPA test

g. Inplace adsorber test

h. Laboratory test of adsorbent

i. Electric heater test

Periodic tests of the makeup airflow to the control room HVAC system from the emergency fresh air intake are performed in accordance with the requirements of Chapter 16.

Periodic inplace testing of HEPA filters and charcoal adsorbers and laboratory testing of charcoal adsorbers are performed in accordance with the requirements of Chapter 16.

6.4.6 Instrumentation Requirement

Differential pressure indicators are provided locally to measure the pressure drop across each filter element. The overall pressure drop across each filter train is measured and indicated on the local panel and alarmed in the computer on high differential pressure.

Each charcoal adsorber is provided with three temperature switches that actuate alarms in the control room. The alarms provide information to allow the operator to discontinue operation in the event of fire or radioactivity release due to charcoal desorption. The temperature is also indicated in the control room.

The electric heating coils upstream of the filters are controlled by a minimum temperature control and a humidity control to maintain less than 70% relative humidity. In the recirculation mode, the filters are supplied with recirculated control room air at approximately 78°F dry-bulb, 50% relative humidity. Thus, in this mode, if the charcoal adsorber is subjected to less than 70% relative humidity, the heater does not operate, and no additional heat load is imposed upon the control room HVAC system.

Radiation and offsite toxic chemical monitors are provided in the outside air intake duct. Radiation monitors are also provided in the main control room. The monitors alarm in the control room upon detection of high radiation or high toxic chemical conditions.

Differential pressure transmitters are provided which sense the differential pressure between the control room and the outside air and indicate positive pressure differential in the control room.

The hand switches for HVAC equipment required for control room habitability are located in the control room.

The flow of control room air recirculating through the emergency fresh air filter system is indicated in the control room.

Section 9.4 addresses instrumentation requirements for the control room supply and return air systems.

The instrumentation used to provide the initiating signals for control room pressurization are discussed in Sections 7.3 and 7.6.

Table 6.4-1

CONTROL ROOM EMERGENCY HVAC SYSTEM
FAILURE ANALYSIS

COMPONENT	MALFUNCTION	COMMENTS
Emergency fresh air fan	Failure of fan resulting in reduction of air flow	If the operating fan fails, the resultant reduction of air flow actuates an alarm in the control room, automatically starts the standby fan, and opens the standby filter train isolation valves.
Electric heating coil	Failure of coil control resulting in constant coil operation	Maximum capacity of the electric heating coil is not sufficient to cause damage.
	Failure of coil resulting in no heat	The heating coil is not required during emergency operation because the humidity will not exceed 70% relative humidity.
Filter train	Failure resulting in high differential pressure across the filter train	High differential pressure across the filter train is indicated on the local panel and automatically actuates an alarm in the computer. The defective filter train is manually isolated and the standby train is manually placed in service. If the high differential pressure results in low flow the standby fan and filter train will start.
	Failure resulting in high radiation at the discharge	The defective filter train is manually isolated and the redundant filter train is manually placed into operation upon receiving a high radiation signal.
Charcoal Adsorber	High temperature in charcoal bed	Temperature sensors are provided on the leaving air side of each charcoal bed to alarm in the control room

Table 6.4-1 (Cont'd)

COMPONENT	MALFUNCTION	COMMENTS
		on rising charcoal temperature. The charcoal temperature is also indicated in the control room. The deluge fire protection system is manually initiated if required.
Isolation Valve	Failure to close or failure to close completely	A series redundant isolation valve and a closed and capped test port connection provide the required isolation.
Operational Damper	Failure to open	Low flow switch actuates standby fan and filter train.
Air handling units and return air fans	All postulated failures	See Table 9.4-3.

Table 6.4-2

CONTROL ROOM POTENTIAL LEAK PATHS

	POTENTIAL LEAK PATHS	TYPE OF MATERIAL JOINT, OR PENETRATION
a.	Control room walls	3' thick reinforced concrete
b.	Control room ceiling	1½' thick reinforced concrete poured on 16 gauge galvanized steel metal decking
c.	Control room floor	1½' thick reinforced concrete poured on 16 gauge galvanized steel metal decking
d.	Control room construction joints - floor to wall, wall to wall, wall to ceiling, slab to slab	All are poured concrete cold joints
e.	Doors - personnel access	2 each - 3'x7' steam-tight metal doors with elastomer seals and sealing mechanism
f.	Electrical cable penetrations	Kaowool fiber and silicone expansion foam - 9" deep Dow-Corning 36548 RTV and Sylgard 170
g.	HVAC duct penetrations	Embedded metal sleeves through concrete walls - flanged and welded to ducts
h.	Control room HVAC ducts (negative pressure) exterior to control room	Welded galvanized steel
i.	Dampers (frames, shaft penetrations, flanges) in control room ducts (negative pressure) exterior to control room	Gas-tight construction maximum 0.1 cfm/damper from ambient into duct-work.
j.	HVAC isolation valves	Pneumatic or electrohydraulic butterfly valves - bubble-tight
k.	Piping penetrations	Bellows-type expansion joint

Table 6.4-2 (Cont'd)

	POTENTIAL LEAK PATHS	TYPE OF MATERIAL JOINT, OR PENETRATION
l.	Emergency fresh air supply system (filter assembly and fans)	Welded filter - leak tested; welded fan housing-bolted; and gasketed access doors; inlet and discharge connections
m.	Control room supply air fan cabinets	Welded cabinet construction; vaneaxial fan and coil connections - bolted; and gasketed inlet and discharge connections
n.	Test port connection and isolation valve	Capped test port connection and closed globe valve. Pneumatic or electrohydraulic butterfly valve - bubble-tight.

6.5 FISSION PRODUCT REMOVAL AND CONTROL SYSTEMS

6.5.1 ENGINEERED SAFETY FEATURE FILTER SYSTEMS

The following filtration systems, required to perform postaccident safety-related functions are provided:

a. SGTS: In its safety-related mode of operation, this system is used to reduce halogen and particulate concentrations in gases potentially present in the reactor enclosure following a LOCA, and gases present following a postulated fuel handling accident in the refueling area before the gases are discharged to the environment (Section 6.5.1.1). The system exhausts a controlled filtered flow to the atmosphere during isolation to restore and maintain a negative pressure in the affected secondary containment zone. In addition, this system performs the nonsafety-related function of reducing halogen and particulate concentrations in gases purged from the primary containment.

b. CREFAS filter units: This system is used to clean the outside air of halogens and particulates that are potentially present in the air following a postulated accident before introducing the air into the control room HVAC system (Section 6.5.1.2).

c. RERS filter units: This system is used to reduce halogen and particulate concentrations in gases in the reactor enclosures following a LOCA. The RERS is the initial cleanup system (the SGTS is the final cleanup system) before discharge of the gases from the reactor enclosures (Section 6.5.1.3).

6.5.1.1 Standby Gas Treatment System

6.5.1.1.1 Design Bases

As described in Section 9.4.2.1, the secondary containment consists of three ventilation zones. Zones I and II surround the primary containment of Units 1 and 2, respectively, below the floor at el 352'. Zone III consists of the common refueling area above the floor at el 352'.

The SGTS is designed to accomplish the following objectives:

a. Exhaust sufficient filtered air from the reactor enclosure and/or refueling area to maintain a negative pressure of about 0.25 inch wg. in the affected volumes during secondary containment isolation (see Section 9.4.2 for discussion of the secondary containment isolation signals)

b. Filter the air exhausted to remove radioactive particulates and both radioactive and nonradioactive forms of iodine from the following areas:

    1. Reactor enclosure (Zone I and Zone II)

    2. Refueling area (Zone III)

    3. Deleted

    4. Primary containment during purging and ventilating
    5. Discharge from the HPCI barometric condenser, following filtration by the RERS when the reactor enclosure is isolated

c. Ensure that the failure of any component of the filtration train, assuming LOOP, cannot impair the ability of the system to perform its safety function

d. Remain intact and functional in the event of a SSE

e. Automatically start in response to any one of the following signals:

    1. LOCA signal as described in Section 9.4.2.
    2. High radiation level in refueling area exhaust air
    3. High radiation level in reactor enclosure (Zone I or Zone II) exhaust air
    4. Low differential pressure in the reactor enclosure (Zone I or Zone II)
    5. Low differential pressure in refueling area (Zone III)

    (The SGTS fans can also be started manually in the control room by tripping the refueling area isolation system or the reactor enclosure isolation system.)

f. The design bases employed for sizing the filters, fans, and associated duct-work are as follows:

    1. Each filter train is sized and specified for treating the incoming air-steam mixture at 11,000 cfm maximum and 135°F ① for drywell purge (drywell purge is discussed in Section 9.4.5). The SGTS fans are sized for 8400 cfm maximum flow at 20 inches wg. static pressure.
    2. The system capacity is maintained with all filters fully loaded (dirty).
    3. For HEPA filters, maximum free velocity does not exceed 300 fpm with maximum airflow resistance of 1 inch wg. when clean and minimum efficiency of 99.97% by DOP test method.
    4. The charcoal adsorber is rated for 99.0% trapping of radioactive iodine as elemental iodine (I_2) and 99.0% trapping of radioactive iodine as methyl iodide (CH_3I) when passing through charcoal (8 inch bed depth) at 70% relative humidity. The air residence time in the 8 inch charcoal bed is 0.68 seconds considering a maximum total after drawdown leakage rate from Zones I, II, and III of 5764 cfm.

① This information is based on original design conditions. Further evaluation has validated this design for a drywell operating temperature of 150°F.

5. Relative humidity at the charcoal adsorber is limited to 70% by the appropriate heating of air.

6. The SGTS maximum fan capacity is based on the calculated inleakage into secondary containment with the secondary containment maintained at a negative pressure of 0.25 inches of water with reference to the outside atmosphere. The maximum capacity includes an allowance for thermal expansion of the secondary containment air volume due to equipment residual heat transfer to the air during SGTS operation.

6.5.1.1.2 System Description

The SGTS is common to both Units 1 and 2. Each of the two redundant SGTS filter trains consists of an electric air heater, two banks of HEPA filters (upstream and downstream of charcoal adsorber), a vertical 8 inch deep charcoal adsorber bed (with temperature detection sensors and a water flooding system for fire protection), and associated dampers, ducts, instruments, valves, and controls.

For its safety-related mode of operation (Section 6.5.1.a), two redundant 100% capacity SGTS fans are provided for use in conjunction with the SGTS filter trains. Each fan has a controllable capacity of 500 cfm to 8400 cfm, which is sufficient to restore and maintain both reactor enclosures and the common refueling area at the required negative pressure in relation to atmospheric pressure during secondary containment isolation. The air flow varies in response to secondary containment differential pressure controls, which modulate the fan inlet vanes and control dampers in the run-around bypass and discharge ducts provided for each fan. Slide gate dampers with position switches are closed to isolate the SGTS from any secondary containment zone which cannot be isolated and drawn down.

The SGTS is actuated automatically in its safety-related mode of operation. Both SGTS filter trains are maintained in the open position. Upon receipt of a secondary containment isolation signal (Section 6.5.1.1.1.e), both of the SGTS fans are started and the associated controls are activated to open or modulate appropriate dampers and valves so that the system function is accomplished. Following the initial fan start, the operators may elect to place one of the SGTS fans in the standby position.

For its nonsafety-related mode of operation (Section 6.5.1.a), two redundant 100% capacity drywell purge fans are provided for use in conjunction with the SGTS filter trains. Each fan has a capacity of 11,000 cfm which is sufficient for the drywell purge operation.

The SGTS is manually actuated for its nonsafety-related mode of operation.

If one of the SGTS filter train isolation valves fails closed during its safety-related mode of operation, the redundant filter train is automatically placed into service. If one of the SGTS fans fails to establish flow, because of either fan or fan damper failure, the standby SGTS fan automatically starts.

The SGTS is shown schematically on drawing M-76. Specific SGTS component design parameters are shown in Table 6.5-1.

The equipment and materials conform to the applicable requirements and recommendations of the guides, codes, and standards listed in Section 3.2. Conformance with Regulatory Guide 1.52 is discussed in Table 6.5-2.

Components for each SGTS train are designed as discussed in the following paragraphs.

A prefilter is not included in the SGTS filter trains because the SGTS intake is downstream of the recirculation filter system fans so that the air is prefiltered before entering the SGTS filters after RERS start during reactor enclosure isolation. A prefilter is provided in the SGTS duct for air drawn from the refueling area during refueling area isolation. The drywell purge air supply is prefiltered by the reactor enclosure supply air system during the drywell purge mode.

The SGTS fan performance and motor selection are based on the maximum system pressure drop resulting from dirty SGTS filters. The SGTS filter banks are sized for 11,000 cfm drywell purge flow, (see Table 6.5-1 for filter pressure drops).

The charcoal adsorber is a gasketless, welded seam type filled with impregnated activated charcoal that meets the requirements in table 5-1 of ANSI N509 (1980) and Regulatory Guide 1.52 except that laboratory analysis of carbon samples is performed in accordance with ASTM D3803-1989. The bank holds a total of approximately 2400 pounds of charcoal having an ignition temperature of not less than 626°F. The charcoal adsorber is capable of removing not less than 99.0% of elemental iodine and 99.0% of methyl iodide at 70% relative humidity. The maximum loading is 2.5 milligrams of iodine per gram of activated charcoal.

A demister is not required for the SGTS filters. The absence of water droplets in the air stream entering the SGTS filters during post-LOCA isolation, refueling area isolation, and primary containment purging is assured based on the following:

a. The SGTS intake is downstream of the RERS filters and normally exhausts air which has been prefiltered by the RERS filters. However, prior to RERS fan operation (up to 3 minutes post-LOCA), the SGTS can draw air directly through a pressure relief vent located between the RERS and SGTS ducts. This vent is located in an access area on el 283' where there are no significant sources of humidity which can form water droplets. After the RERS fan starts, the vent is maintained at a slight positive pressure with air which has been prefiltered by the RERS filters. The absence of water droplets in the RERS air stream during reactor enclosure isolation is discussed in Section 6.5.1.3.2.

b. There are no sources of water droplets in the refueling area that could enter the duct connection to the SGTS. As discussed below, water droplets from condensation will not reach the SGTS filters during refueling area isolation because of the tortuous flow path and low velocities through the ducts, and low point drains in the ducts. The duct from the refueling area to the SGTS filters passes the Unit 1 reactor enclosure for approximately 260 feet and includes at least 20 bends and turns. If condensation does occur, the amount of condensation would be minor, based on the potential amount of water vapor in the air stream. One inch diameter low point drain is provided for the portion of duct-work in the reactor enclosure to ensure that any condensation will be drained from the duct. When refueling area drawdown begins, the flow rate could reach 2400 cfm or more for a short period of time. As water vapor accumulates in the refueling area, the flow rate will be decreasing. During the period when any significant condensation could occur in the ducts, the flow rate in the duct will be no more than 800 cfm. The air velocity during this period varies from approximately 162 fpm to 325 fpm (1.8 mph to 3.7 mph) for the majority of the duct-work.

c. Water droplets will not reach the SGTS filters during drywell containment purging because of the reasons discussed below.

It is highly unlikely that water droplets will enter the purge lines during drywell purging. As discussed in Section 6.5.1.3.3, the licensee's preventive maintenance program will maintain normal plant leaks to low flow dripping type leakages. Any leakage with spraying water droplets (such as those due to failed seals in pumps and valves) will be identified and corrected as part of the maintenance program. It can be shown that any droplets formed will travel less than 20 feet. There are no potential sources of water droplets within 20 feet of the suppression chamber purge exhaust opening. There are no pumps, and only few valves, within 20 feet of the drywell purge exhaust opening. The closest valve is 8 feet away from the opening. Because the purge system is used during only a limited period of power operation (only open for inerting, de-inerting, pressure control, ALARA or air quality considerations for personnel entry, or Surveillances that require the valves to be open), it is highly unlikely that a valve seal would fail and spray water into the drywell purge exhaust opening during purge system operation.

If water droplets are hypothetically assumed to enter the purge exhaust ducts, or if condensation within the duct-work occurs, the water droplets would not reach the SGTS filters because of the tortuous flow path, the insulated duct-work in the control structure, and the SGTS heaters. Purge air exhausted from the drywell flows approximately 215 feet in the reactor enclosure through three valves, two vertical upward turns, and four additional bends and turns with a flow rate of 11,000 cfm at a velocity of 2240 fpm (25.5 mph) in the duct, and 3731 fpm in the pipe. The purge air from the suppression chamber flows more than 160 feet in the reactor enclosure through valves and six bends and turns with a flow rate of 9750 cfm and a velocity of 1986 fpm (22.6 mph) in the duct, and 6008 fpm in the pipe. At these velocities, if condensation occurs within the duct-work, it is possible for some water droplets to be entrained in the air-steam. Condensation within the reactor enclosure duct-work could occur while purging the suppression chamber, but no significant condensation would occur while purging the drywell because the drywell is maintained at a low relative humidity by the drywell coolers. No significant condensation would occur in the control enclosure duct-work for either purge mode because it is insulated.

The environmental conditions within the reactor enclosure duct-work will be such that only surface type condensation could occur. Droplets will coalesce on the inside surface of the duct creating larger droplets, forming condensate flow on the bottom of the duct. Much of this flow will drain to low points in the duct-work and be removed via drains, and therefore never enters the air stream. Much of the condensate that does become entrained in the air stream is subsequently removed from the air stream due to the any bends and turns in the duct. Water droplets greater than 20 microns in size are removed by the bends and turns, including a square elbow with turning vanes, which act as course moisture separators (Reference 6.5-2). Water droplets less than 20 microns in size may reach the

SGTS heaters. However, analyses have been performed to demonstrate that the SGTS heaters can evaporate all water droplets less than 25 microns in size. Thus, no water droplets will reach the SGTS filters.

The effects of water droplets on the SGTS HEPA filters were evaluated, even though there is no credible way for water droplets to reach the HEPA filters. (Effects on the charcoal filters were not evaluated because the HEPA filters are upstream of the charcoal filters and would collect any water droplets postulated to be in the air stream). When HEPA filters are exposed to high concentrations of liquid, plugging could occur that would decrease air flow through them. Decreased efficiency in collecting particulate matter would not occur unless plugging is severe enough to rupture the HEPA filter. Based on Reference 6.5-2, if the maximum water delivery rate is kept below 0.18 gpm per 1000 cfm of air flow, plugging will not occur. Analyses have been performed to demonstrate that, even if all of the condensation that forms in the duct during the worst case condition of suppression pool purging is hypothetically assumed to reach the HEPA filters in the form of water droplets, the condensate loading is only 8.33×10^{-3} gpm/1000 cfm, which is well below 0.18 gpm/1000 cfm. Thus, plugging of the filters would not occur.

Analyses were performed to demonstrate that the SGTS heaters are capable of reducing the relative humidity of the air during suppression pool purging (9750 cfm for this mode) from 100% relative humidity, with entrained droplets, to less than 70% relative humidity, with no entrained droplets. The SGTS heaters are also capable of reducing the relative humidity of the air during drywell purging (11,000 cfm for this mode), from 100% relative humidity to less than 70% relative humidity.

A water flooding system within the charcoal bed is provided. The water system is connected to the station fire protection system. Valves are mounted outside the charcoal adsorber. Two continuous type thermistors are provided on the leaving air side of the charcoal bed. A rise in the charcoal bed area temperature results in the following:

a. The first temperature setpoint (200°F) actuates an alarm in the control room. The filter train is removed from service until the cause of the alarm has been determined. The operator shall investigate to determine if a fire has occurred and introduce the fire protection water to the charcoal plenum, if necessary, as listed in Item c.

b. The second temperature setpoint (250°F) also actuates an alarm in the control room. The operator shall continue to investigate to determine if a fire has occurred and introduce the fire protection water, if necessary, as listed in Item c. The SGTS charcoal temperature sensor system power trouble alarm is allied with this alarm window.

c. The third temperature setpoint (550°F) actuates an alarm in the control room. The operator shall investigate to determine if a fire has occurred and introduce the fire protection water to the charcoal plenum, if necessary, as follows: The operator manually opens the valves, thus introducing the fire protection water to the charcoal plenum. A drain valve is provided to drain the water from the filter plenum.

Four test canisters are provided for each charcoal adsorber. These canisters contain the same depth of the same charcoal that is in the adsorber. The canisters are mounted so that a parallel flow path is created between each canister and the adsorber. Periodically one of the canisters can be removed and laboratory tested to verify the adsorbent efficiency. Alternate means of sampling (slotted-tube method) may also be used for obtaining representative samples of used activated charcoal per the requirements specified in ANSI N509-1980.

Permanently installed injection and sampling ports are provided for all ESF atmosphere cleanup systems to permit accurate testing in accordance with ANSI N510. Providing fewer charcoal test canisters on the ESF atmosphere cleanup systems than specified in ANSI N509 (1980) section 4.11 results in equal or more frequent replacement of activated carbon. Regulatory Guide 1.52 states that testing of representative samples should be performed (1) initially, (2) at least once per 18 months thereafter for systems in a standby status, or after 720 hours of system operation and (3) following painting, fire, or chemical release in any ventilation zone communicating with the system. However, representative samples of the SGTS are tested at least once per 48 months as discussed in Table 6.5-2. More frequent replacement may result because Regulatory Guide 1.52 further states that when no representative samples are available for testing, the activated carbon should be replaced with new activated carbon.

Access doors, with 30x68 inch openings, to each HEPA filter compartment are provided. An 18 inch access hatch is provided for the charcoal filter compartment.

The HEPA filter and charcoal filter housings are of all-welded construction.

Interior lights with external light switches are provided in the HEPA filter plenums to facilitate inspection, testing, and replacement of components.

The SGTS has been designed to continuously purge the filter plenums with dry instrument air when the filters are not in use. Any amount of dry air continuously purged through the adsorbers and HEPA filters will entrain moisture and maintain moisture levels at a minimum because the duct-work is gas-tight and there is no internal humidity source. (The periodic operation of the ESF atmosphere cleanup (SGTS) train could introduce additional moisture into the system and increase moisture levels above those normally maintained.)

The electric heater maintains the relative humidity below 70% for charcoal adsorber operation by maintaining a constant temperature rise of 15°F across the heater. An analysis of heater capabilities for various entering saturated air conditions up to 150°F (which exceeds any inlet conditions the SGTS system will experience) yields a peak heating requirement of 135,000 Btu/hr, at maximum 11,000 cfm airflow. A 55 kW heater is provided.

The automatic reset cutout (setpoint 260°F) is located inside the heater where the sensed temperature is higher than the actual air temperature downstream of the heater. This heater protection device that was selected and installed by the heater manufacturer. The automatic reset cutout (setpoint 180°F), which is located downstream of the heater, senses the actual temperature of air leaving the heater and causes an alarm signal in the control room when the air temperature exceeds 180°F. Because the SGTS electric heaters operate with a fixed temperature differential of 15°F between the inlet and outlet air temperatures and the maximum inlet temperature is 150°F, the maximum air temperature downstream of the heater should not exceed 165°F. In the event of a heater malfunction, the discharge air automatic reset cutout will shut off the heater when the downstream air temperature exceeds 180°F. The conservatively selected 180°F heater cutout temperature, and an alarm annunciation in the control room to notify the operator if this condition should occur are considered to be equivalent to the 225°F manual heater cutout required by section 5.5 of ANSI N509-76.

6.5.1.1.3 Design Evaluation

The SGTS is designed to preclude direct exfiltration of contaminated air from the secondary containment following a postulated accident or an abnormal occurrence which could result in abnormally high airborne radiation in the secondary containment. Equipment is powered from Class 1E buses, and all power circuits meet IEEE 279 and IEEE 308 requirements to ensure power availability from the standby diesel generator sets in the event of loss of normal offsite ac power. Redundant components are provided where necessary to ensure that a single failure does not impair or preclude system operation. The SGTS is designed to seismic Category I requirements as discussed in Section 3.7 to ensure that the system remains intact and functional in the event of an SSE. Components and materials of the SGTS system have been selected to assure availability of the system under postulated accident conditions. An SGTS failure mode and effect analysis is presented in Table 6.5-3.

6.5.1.1.4 Tests and Inspections

Except for Items D.2 and D.3 of Table 9.4-4, all tests and inspections described in the table apply to the SGTS. Conformance with Regulatory Guide 1.52 is discussed in Table 6.5-2.

ESF atmosphere cleanup systems are accessible during normal operation and during anticipated transients. ESF atmosphere cleanup systems are designed to operate after an accident or during drywell purge. Periodic tests are performed during normal operation on all ESF atmosphere cleanup systems, to ensure that prefilters and HEPA filters are either changed on high pressure readings or checked on abnormal readings.

The system will be preoperationally tested in accordance with the requirements of Chapter 14 and periodically tested in accordance with the requirements of Chapter 16.

6.5.1.1.5 Instrumentation

The SGTS can be actuated manually from the control room. Each SGTS train is designed to function automatically upon receipt of a secondary containment isolation signal. The status of system equipment, which is an indication of pertinent system temperatures and flow rates, is displayed in the control room during both normal and accident operation.

All instrumentation required during and after accident conditions is qualified to meet seismic Category I requirements. Instrumentation conformance with Regulatory Guide 1.52 is discussed in Tables 6.5-2 and 6.5-8.

The following alarms are annunciated in the control room:

a. Fan trouble

b. Heater failure (low temperature rise across the heater)

c. Charcoal filter high temperature alarms

d. Filter system trouble (including valve circuit trouble, charcoal temperature detection system trouble and electric heater trouble)

e. Low pressure differential, referenced to the outside ambient pressure, in the secondary containment ventilation zones being isolated

6.5.1.1.6 Materials

The materials of construction used in or on the SGTS are given in Table 6.5-4.

Materials used in or on the SGTS are selected to ensure that system operability is not affected by radiation, temperature, or other environmental effects. Environmental qualification of the SGTS is discussed in Section 3.11.

By being located in the control structure, the SGTS is protected from extremes of radiation and temperature that could potentially produce radiolytic or pyrolytic decomposition of filter materials. Thus, filter system decomposition products would not be generated.

6.5.1.2 Control Room Emergency Fresh Air Filter Units

6.5.1.2.1 Design Bases

The design bases for the control room emergency fresh air filter units are described in Sections 6.4 and 9.4.1 and as given below.

The design bases employed for sizing the filters, fans, and associated duct-work are as follows:

a. Each filter train is sized and specified for treating incoming air at 3000 cfm at design outdoor temperature.

b. The system capacity is maintained with all filters fully loaded (dirty).

c. For HEPA filters, maximum free velocity does not exceed 300 fpm with maximum airflow resistance of 1 inch wg. when clean and minimum efficiency of 99.97% by the DOP test method.

d. The charcoal adsorber is rated 95.0% for trapping of radioactive iodine as elemental iodine (I_2) and 95.0% trapping of radioactive iodine as methyl iodide (CH_3I) when passing through charcoal (2 inch bed depth) at 70% relative humidity. The air residence time in the 2 inch charcoal bed is not less than 0.25 seconds.

6.5.1.2.2 System Description

The control room emergency fresh air filter system is described in Sections 6.4 and 9.4.1. Conformance with Regulatory Guide 1.52 is discussed in Table 6.5-2.

6.5.1.2.3 Design Evaluation

The control room emergency fresh air filter units work in conjunction with the control room HVAC system to maintain habitability in the control room. The design evaluation is given in Sections 6.4 and 9.4.1. Control room emergency fresh air filter system failure analysis is given in Section 6.4.

6.5.1.2.4 Tests and Inspections

Tests and inspections are described in Sections 6.4 and 9.4.1.

6.5.1.2.5 Instrumentation

Instrumentation requirements are discussed in Section 6.4. Conformance with Regulatory Guide 1.52 is discussed in Tables 6.5-2 and 6.5-8.

6.5.1.2.6 Materials

The materials of construction used in or on the control room emergency fresh air filter systems are given in Table 6.5-5.

Materials used in or on the emergency fresh air filter systems are selected to ensure that system operability is not affected by radiation, temperature, or other environmental effects. Environmental qualification of the system is discussed in Section 3.11.

By being located in the control structure, the emergency fresh air filter systems are protected from extremes of radiation and temperature that could potentially produce radiolytic or pyrolytic decomposition of filter materials. Thus, filter system decomposition products would not be generated.

6.5.1.3 Reactor Enclosure Recirculation System Filter Units

6.5.1.3.1 Design Bases

The RERS is designed to accomplish the following objectives:

a. Filter the air in the reactor enclosures following a LOCA to reduce the concentration of radioactive halogens and particulates potentially present in the reactor enclosures

b. Ensure that failure of any component of the filtration train, assuming loss of offsite power, cannot impair the ability of the system to perform its safety function

c. Remain intact and functional in the event of an SSE

d. Automatically start in response to any one of the following signals (the RERS fans can also be started manually in the control room by tripping the reactor enclosure isolation system):

    1. LOCA signal as described in Section 9.4.2

    2. High radiation level in the reactor enclosure (Zone I or Zone II) exhaust air of the respective unit

    3. Low differential pressure in the reactor enclosure (Zone I or Zone II)

e. The design bases employed for sizing the filters, fans, and associated duct-work are:

1. Each filter train is sized and specified for treating incoming air at 60,000 cfm and 150°F, which exceeds the accident temperature service requirements.
2. The system capacity is maintained with all filters fully loaded (dirty).
3. For HEPA filters, maximum free velocity does not exceed 375 fpm, with maximum airflow resistance of 1 inch wg. when clean and minimum efficiency of 99.97% by DOP test method.
4. The charcoal adsorber is rated for 95.0% trapping of radioactive iodine as elemental iodine (I_2) and 95.0% trapping of radioactive iodine as methyl iodide (CH_3I) when passing through charcoal (2 inch bed depth) at 70% relative humidity. The air residence time in the 2 inch charcoal bed is not less than 0.25 seconds.

6.5.1.3.2 System Description

There are two redundant RERS trains in each reactor enclosure. Each of the RERS trains consists of a bank of prefilters, two banks of HEPA filters (upstream and downstream of the charcoal adsorber), a vertical two inch deep charcoal adsorber bed (with fire detection temperature sensors and a water spray system for fire protection), and associated dampers, ducts, instruments, and controls. The RERS is shown schematically on drawing M-76. Specific RERS component design parameters are provided in Table 6.5-1.

The equipment and materials conform to the applicable requirements and recommendations of the guides, codes, and standards listed in Section 3.2. Conformance with Regulatory Guide 1.52 is discussed in Table 6.5-2.

Each redundant RERS train has a constant capacity of 60,000 cfm, and each is capable of treating the required amount of air from the Unit 1 or Unit 2 reactor enclosure volume being recirculated. Components for each RERS are designed as discussed in the following paragraphs.

The fan performance and motor selection are based on maximum system pressure drop, that is, a pressure drop based on maximum pressure drops across the component filters (3 inches wg. for the first bank of HEPA filters and 4 inches wg. for the second bank). The air flow is maintained at a constant rate by flow control dampers.

The charcoal adsorber is a gasketless, welded seam type filled with impregnated activated charcoal that meets the requirements in table 5-1 of ANSI N509 (1980) and Regulatory Guide 1.52 except that laboratory analysis of carbon samples is performed in accordance with ASTM D3803-1989. The bank holds a total of approximately 13,000 pounds of charcoal having an ignition temperature of not less than 626°F. The charcoal adsorber is capable of removing not less than 95.0% of elemental iodine and 95.0% of methyl iodide at 70% relative humidity.

There are no demisters provided for the RERS. The absence of water droplets in the RERS air stream during reactor enclosure isolation is assured based on the following:

a. The reactor enclosure relative humidity will not exceed 77% during normal operation. This relative humidity will decrease to below 70% post-LOCA due to the increase in heat to the structure.

b. ESF system leakage will be held to a minimum because LGS will follow the guidelines of NUREG-0737 Item III.D.1.1, i.e., provide periodic surveillance tests to minimize system leakage.

c. The RERS is not required to mitigate the consequences of a HELB or a moderate energy line break. Therefore this line break is not considered a source of water that could enter the RERS air stream.

d. The RERS will not communicate with the refueling area during reactor enclosure isolation or refueling area isolation. Therefore humidity from the fuel pool is not considered a source of water that could enter the RERS air stream. As indicated in Table 6.5-2, the SGTS, which will drawdown the refueling area upon refueling area isolation, will be provided with a prefilter in accordance with Regulatory Guide 1.52.

A water spray system within the charcoal bed is provided. The spray system is connected to the fire protection system. A valve is mounted outside the charcoal adsorber. A continuous type thermistor is provided on the leaving air side of the charcoal bed. A rise in the charcoal bed area temperature results in the following:

a. The first temperature setpoint (200°F) actuates an alarm in the control room. The filter train is removed from service until the cause of the alarm has been determined. The operator shall investigate to determine if a fire has occurred and introduce the fire protection water to the charcoal plenum, if necessary, as listed in item c.

b. The second temperature setpoint (250°F) also actuates an alarm in the control room. The operator shall continue to investigate to determine if a fire has occurred and introduce the fire protection water, if necessary, as listed in item c. The RERS charcoal temperature sensor system power trouble alarm is allied with this alarm window.

c. The third temperature setpoint (550°F) actuates an alarm in the control room. The operator shall investigate to determine if a fire has occurred and introduce the fire protection water to the charcoal plenum, if necessary, as follows: The operator manually opens the valve, thus introducing the fire protection water to the charcoal plenum. A drain valve is provided to drain the water from the filter plenum.

Six test canisters are provided for each charcoal adsorber. These canisters contain the same depth of the same charcoal that is in the adsorber. The canisters are mounted so that a parallel flow path is created between each canister and the adsorber. Periodically one of the canisters can be removed and laboratory tested to verify the adsorbent efficiency. Alternate means of sampling (slotted-tube method) may also be used for obtaining representative samples of used activated charcoal per the requirements specified in ANSI N509-1980.

Access doors, with 20x50 inch openings, are provided in each filter compartment in the RERS plenum.

The RERS filter plenum housing is of all-welded construction.

Interior lights with external light switches are provided between all train components to facilitate inspection, testing, and replacement of components.

Each charcoal train is continuously purged with 1 cfm of dry instrument air; however, any amount of dry air continuously purged through the adsorbers and HEPA filters will entrain moisture and maintain moisture levels at a minimum because the duct-work is gas-tight and there is no internal humidity source. (The periodic operation of the ESF atmosphere cleanup train could introduce additional moisture into the system and increase moisture levels above those normally maintained.)

The RERS is actuated either automatically (safety-related mode) or manually for routine system operability testing (nonsafety-related mode). The automatic actuation is originated by the reactor enclosure isolation signal (Section 6.5.1.3.1.d).

During normal operation the RERS trains are maintained in a lead/lag mode of operation. Upon receipt of an automatic isolation signal the RERS train in lead will automatically start to accomplish the system functions. The RERS train in lag will remain in standby. In the event of a single active failure associated with the operating RERS train, the RERS train in standby will automatically start, following a time delay, to perform the system functions and will operate for the duration of the Design Bases Event.

6.5.1.3.3 Design Evaluation

The RERS is designed for filtration of contaminated air in the reactor enclosure following a postulated accident or abnormal occurrence which could result in abnormally high airborne radiation in the reactor enclosure. Equipment is powered from Class 1E buses and all power circuits meet IEEE 279 and IEEE 308 requirements to ensure uninterruptible operation in the event of loss of normal offsite ac power. Redundant components are provided where necessary to ensure that a single failure will not impair or preclude system operation. Operating the RERS trains in a lead/lag mode will assure compliance with the design bases since a single RERS train is sufficient to perform all of the required RERS safety functions and the time delay associated with the shutdown of the lead RERS train and standby start of the lag RERS train will have a negligible effect on the Reactor Enclosure differential pressure, the post-LOCA mixing function and the on-site/off-site dose analyses. The RERS is designed to seismic Category I requirements as discussed in Section 3.7 to ensure that the system remains intact and functional if there is an SSE. Components and materials of the RERS have been selected to assure availability of the system under postulated accident conditions. A RERS failure mode and effect analysis is presented in Table 6.5-6.

An analysis was conducted to calculate the maximum post-LOCA time period for which the relative humidity at the inlet of the RERS charcoal filters could exceed 70%. It was found that within 15 minutes after isolation of the reactor enclosure secondary containment, the relative humidity will decrease from an initial maximum condition of 76.2% to below 70%. The following conservative rationale was used for this analysis:

a. The reactor enclosure supply air system uses unconditioned outdoor air to provide once-through ventilation to cool the reactor enclosure during normal plant operation.

b. On a design basis summer day of 95°F (Db), the reactor enclosure ventilation system is designed to maintain the reactor enclosure at a nominal 104°F. The outdoor air is sensibly heated from 95°F to 104°F as it passes through the reactor enclosure supply fans and from internal reactor enclosure heat loads such as the primary containment, MCCs, load control centers, motors, lights, cable trays, and piping.

c. Assuming outdoor air conditions of 95°F (Db) and 95°F (Wb) (100% relative humidity) exist, the same air when heated to 104°F (Db) will have a relative humidity of 76.2%. This is the basis for the initial reactor enclosure relative humidity conditions when isolation occurs due to a LOCA.

d. Based on the ASHRAE 1981 Handbook of Fundamentals, less than 1% of the total hours during the months of June through September will exceed a 93°F (Db) or 77°F (Wb) in Philadelphia. Therefore the outdoor air conditions used in this analysis are improbable.

e. Other outdoor air conditions at lower dry-bulb and wet-bulb temperatures, which are more probable from a meteorological standpoint, can also result in an initial reactor enclosure relative humidity condition exceeding 70%. However, the initial relative humidity for these cases will be less than 76.2% because cooler air contains less moisture and the 9°F temperature rise from operating equipment has a greater effect on lowering the relative humidity.

f. After isolation occurs, an increase in the bulk reactor enclosure temperature from 104°F to 107°F will lower the relative humidity to 70% in accordance with basic psychrometric principles. At lower reactor enclosure temperatures, the initial relative humidity is closer to 70%, and a smaller temperature rise after isolation is needed to lower the relative humidity to 70%.

g. Only internal reactor enclosure heat loads that were determined to exist for the duration of the transient were considered to provide air heat-up. The heat load from seismic Category II motors was considered to decay instantly because loss of their internal motor ventilating fans would prevent efficient residual heat removal from the motor casings. The lighting load was also considered to decay to zero instantly because the small mass and therefore residual heat stored in this equipment would be small.

h. The heat loss of the air into the cooler exterior and interior walls and floor slabs of the reactor enclosure was calculated using a conservative heat transfer model.

i. The cooling effect of outdoor air inleakage into the reactor enclosure due to SGTS operation was considered.

j. Because the bulk reactor enclosure temperature 15 minutes post-LOCA will always exceed any outdoor air temperature by at least 12°F (107°F versus 95°F for worst case analysis), the relative humidity will not rise above 70% for the duration of RERS operation.

k. Internal sources of moisture resulting from operation of the ECCS pumps were evaluated. The additional moisture was found to be small and will not have a significant effect on relative humidity.

The RERS charcoal filter efficiency is not expected to be adversely affected by this temporary condition. Although the initial relative humidity of the reactor enclosure is 76.2% at the time of the LOCA, the RERS does not operate for the first 3 minutes. Therefore, the time period in which the relative humidity exceeds 70% and the RERS operates is between 3 minutes and 15 minutes when the average relative humidity will be approximately 73%. Reference 6.5-2 recommends a charcoal efficiency for methyl iodine removal of 95% for relative humidities of 85% and less as a conservative design basis. It also states that "Trapping of elemental radioiodine involves physical adsorption only, and the efficiency of nearly any good grade of activated carbon, impregnated or not, will be at least 99% (DF = 100) under any combination of temperature and humidity that would be encountered in a nuclear air cleaning system." Evidence that these efficiency values are realistic and conservative has been identified in the following sources:

a. The ANSI N509 (1980) activated carbon performance test requirements and acceptance values are more stringent than the recommended efficiency values of Reference 6.5-2. LGS RERS charcoal is being supplied in accordance with the ANSI N509 requirements.

b. Figure 4.6 of Reference 6.5-3 plots the test results of 65 different methyl iodine penetration tests as a function of relative humidity. In no cases was the penetration found to be greater than 4% when the relative humidity was less than 85%. Figure 4.7 of Reference 6.5-3, based on 7 different tests, indicates a generally low penetration (less than 1%) for elemental iodine for all relative humidity conditions.

It was also determined that demisters were not necessary for the RERS. This conclusion is based on the following analysis of a postulated situation in which water droplets are assumed to be formed from system leakage and the possible migration paths of this leakage to the RERS filters.

The estimated leakage from the drywell/suppression pool to the reactor enclosure is limited by several mechanisms. These are:

a. The limit of 0.5% per day air leakage imposed by the containment leak test Technical Specification, the periodic integrated leak rate test, and individual valve leak tests. The 0.5% per day leak rate corresponds to approximately 1.4 cfm, which dictates only pinhole-size leak paths. These small leak paths serve to condense moisture and preclude droplet formation.

b. The programs of preventive maintenance implemented by NUREG-0737, Item III.D.1.1 to minimize system leakage. This program includes helium leak detection for gaseous systems and liquid detection/inspection for liquid-containing systems.

c. The postulated passive failure of an RHR pump seal and resulting release of liquid. The licensee's preventive maintenance program will maintain normal plant leaks to low flow dripping type leakages. Any leakages with spraying water droplets will be identified and corrected as part of the maintenance program. However, for the purpose of this discussion, a postulated passive failure of an RHR pump seal is assumed (SRP 15.6.5, Appendix B). This assumption results in a 5 gpm leak of suppression water at less than 212°F (Figure 6.2-9) and may produce water spray into the air. Because the water is below the boiling point, the airborne water will fall to the floor and subsequently into the floor drains with little or no flashing.

If water should be sprayed from the passive failure, it can be shown that any droplets formed travel less than 20 feet, based on analyses of spray systems where the nozzles are designed to maximize the development of water droplets (Reference 6.5-1). These analyses have shown that 1000 micron droplets would travel no more than 20 feet in a horizontal direction with an initial velocity of 3000 ft/sec. The travel distance from the RHR pump seal to the local RERS exhaust vents is approximately 29 feet vertically and 10 feet horizontally. No droplets will reach the exhaust duct.

Another factor virtually eliminating the potential for water droplets to travel as far as 20 feet is the effect of the unit coolers in the ECCS rooms. These coolers have flow rates of 9000 cfm to 22,000 cfm. The major objective of the unit coolers is to ensure cool ambient air in the RHR room and to condense excess water vapor. The RHR pump rooms have unit coolers, each operating at 21,800 cfm. The unit cooler air flow competes with the 310 cfm RERS exhaust air flow. Over 95% of the moisture in the air will go through the unit coolers and not into the duct-work.

If it is hypothetically and nonmechanistically assumed that airborne droplets are available, those water droplets entering the exhaust duct must make an immediate 90° turn. A 155 fpm (1.8 mph) RERS exhaust air velocity is not sufficient to overcome the force of gravity to impart a vertical upward velocity to any water droplets. Over 400 feet of RERS ducting containing valves and dampers and numerous bends and turns (at least 15) exist between the exhaust and the prefilters. This tortuous path results in droplets either falling back or impacting on the walls of the ducting where it will evaporate due to the less than 100% humidity in the air flow.

Furthermore, any water droplets suspended in the small air flow (310 cfm) from the RHR room are diluted by 59,700 cfm entering the RERS from other parts of the reactor enclosure. Because the calculated maximum humidity is less than 76.2%, water droplets carried with the air stream would be evaporated.

Even if water droplets were to reach the RERS filters, the droplets must first pass through the prefilter and the HEPA filters before impacting the charcoal medium. Both of these filters are more efficient at removing water droplets from air than demisters. Water removed would be evaporated in the air due to the maximum humidity being less than 76.2%.

Given these physical conditions and the lack of a significant source of water droplets, there is no need to install a demister on the RERS.

These contributions to the DBA/LOCA are considered in the Section 15.6.5 analysis and in SRP 15.6.5, Appendices A and B.

d. Deleted

6.5.1.3.4 Tests and Inspections

Tests and inspections are described in the applicable items (2, 3, and 7 through 13) in Table 9.4-4. Conformance with Regulatory Guide 1.52 is discussed in Table 6.5-2. The system is preoperationally tested in accordance with the requirements of Chapter 14 and periodically tested in accordance with the requirements of Chapter 16.

6.5.1.3.5 Instrumentation

The RERS can be actuated manually from the control room by tripping the reactor enclosure isolation system. Each RERS train is designed to function automatically upon receipt of a reactor enclosure isolation signal. The status of system equipment, which is an indication of pertinent system pressure drops and temperatures, is displayed in the control room during both normal and accident operation.

All instrumentation required during and after accident conditions is designed to seismic Category I requirements. Instrumentation conformance with Regulatory Guide 1.52 is discussed in Tables 6.5-2 and 6.5-8.

The following alarms are annunciated in the control room:

a. Fan trouble (including valve circuit trouble and charcoal temperature detection system trouble)

b. Charcoal filter high temperature alarms

ESF atmosphere cleanup systems are accessible during normal operation and during anticipated transients. ESF atmosphere cleanup systems operate only after an accident or during drywell purge. This allows operation on all ESF atmosphere cleanup systems, which ensures that prefilters and HEPA filters are either changed on high pressure readings or checked on abnormal readings.

6.5.1.3.6 Materials

The materials of construction used in or on the RERS are given in Table 6.5-7.

Materials used in or on the RERS are selected to ensure that system operability is not affected by radiation, temperature, or other environmental effects. Environmental qualification of the RERS is discussed in Section 3.11.

Filter materials used will not decompose due to radiation during the specified useful life of the filter.

6.5.2 CONTAINMENT SPRAY SYSTEM

The containment spray cooling subsystem, which is one of the five modes of operation of the RHR system, is not designed to perform a fission product removal function following a DBA. The containment cooling subsystem is described in Section 6.2.2.

6.5.3 FISSION PRODUCT CONTROL SYSTEMS

6.5.3.1 Primary Containment

The primary containment structure is in the form of a truncated cone (the drywell) over a cylindrical section (the suppression chamber). Its pressure-suppression concept is the GE Mark II design. The primary containment is made of reinforced concrete, and it is lined with welded steel plate and provided with a steel domed head. The structural design of the primary containment is discussed in Section 3.8. Plan and elevation views of the primary containment are shown in Figures 3.8-1 through 3.8-8.

The primary containment walls, liner plate, mechanical penetrations, isolation valves, hatches, and locks function to limit release of radioactive materials, subsequent to postulated accidents, so that the resulting offsite doses are less than the dose limits of 10 CFR 50.67. Primary containment parameters affecting fission product release accident analyses are given in Section 6.2.1. Fission product removal systems are discussed in Section 6.5.1. Operation of the primary containment purge system during normal conditions is described in Section 9.4.5.1. This system isolates as described in Section 6.2.4. As discussed in Section 6.2.5, a low volume containment purge capability is provided as a backup to the containment hydrogen recombiner system. If placed into operation, the ESF filtration systems (RERS and SGTS) would process the low volume purge exhaust flow prior to its release.

6.5.3.2 Secondary Containment

The secondary containment completely encloses both primary containments and is provided to contain leakage from the primary containments so that any such leakage can be processed by filtration systems prior to release to the environment. The secondary containment boundary is formed by the exterior walls of the reactor enclosures and the refueling area, with the exception of the fan rooms on el 313' and el 331'. These fan rooms are not within the secondary containment, and the interior walls which separate them from the remainder of the reactor enclosure form a portion of the secondary containment boundary. The design of the secondary containment is discussed in Section 3.8.4, and plan and elevation views of the reactor enclosure are shown in drawings M-116, M-117, M-118, M-119, M-120, M-121, M-122, M-123, M-131, M-132, M-133, M-134, M-135, M-136, M-137, and M-138.

Two systems are provided for removal of fission products from reactor enclosure air following a DBA. These systems are the RERS and the SGTS, both of which are described in Section 6.5.1. Drawdown of the reactor enclosures by the SGTS following a postulated accident to establish a negative relative pressure with respect to the outside is discussed in Section 6.2.3.

The SGTS also provides for the drawdown of the refueling area to a negative relative pressure with respect to the outside following a fuel handling accident. As described in the LGS Technical Specifications, SGTS is only required to be aligned to the refueling area during handling of recently irradiated fuel and during water inventory control actions.

Section 9.4.2.1.3 gives details of secondary containment isolation modes (REIS, RAIS) versus the various secondary containment isolation signal inputs.

6.5.4 ICE CONDENSER AS A FISSION PRODUCT CLEANUP SYSTEM

LGS does not have an ice condenser system.

6.5.5 REFERENCES

6.5-1 Sprayco Co., Catalog "1713A Nozzle for Nuclear Containment Vessels," Spray Engineering Co., Burlington, MA, includes: Article from Nuclear Technology Vol. 1, "Droplet Size Distribution and Spray Effectiveness," W.F. Pasedag and J.I. Gallagher, (April 10, 1971).

6.5-2 ERDA 76-21, "Nuclear Air Cleaning Handbook", pp. 64-65.

6.5-3 "American Air Filter Topical Report", AAF-TR-7102, (September 1, 1972).

Table 6.5-1

ENGINEERED SAFETY FEATURE FILTER SYSTEMS DESIGN PARAMETERS

ITEM	SGTS[(1)]	RERS[(1)]
Type	Built-up unit	Built-up unit
Number of units	2	2
Flow rate, each (cfm)	SGTS: 500 to 8400; Drywell purge: 11,000 max	60,000
COMPONENTS		
Fan	SGTS/Drywell purge	
Type	Centrifugal	Vaneaxial
Drive	Direct	Direct
No. of fans per unit	1/1	1
No. of running fans	1/1	1
Total pressure (in wg.)	20/28	15.3
Motor power each (hp)	40/100	200
Air Heater		
No. of coils per unit	1	-
Heating capacity (kW)	55	-
Prefilters	Refueling Area	
Quantity, per unit	4	40
Size, each (in)	24x24x12	24x24x12
Pressure drop (in wg.)		
Clean	0.17 @ 2400 cfm	0.55
Dirty	0.25 @ 2400 cfm	1
Efficiency [(2)](%)	80	80
HEPA filter, upstream[(3)]	SGTS/Drywell Purge	
Size, each (in)	24x24x12	24x24x12
Pressure drop (in wg.)		
Clean	0.77/1.0	1.0
Dirty	1.53/2.0	3.0
Efficiency [(4)] %	99.97	99.97
Charcoal filter	SGTS/Drywell Purge	
Type	Vertical bed	Vertical bed
Depth (in)	8	2

Table 6.5-1 (Cont'd)

ITEM	SGTS(1)	RERS(1)
Filter media	Impregnated Activated charcoal	Impregnated activated charcoal
Pressure drop (in wg.)	6.0/10.5	1.2
Assigned efficiency(5), 70% relative humidity		
Removing elemental iodine (%)	99.0	95.0
Removing organic iodine (%)	99.0	95.0
Residence time (sec)	0.68 (when using SGTS fans at 3 zone maximum leakage rate of 5764 cfm)	0.25

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(1) SGTS: Standby gas treatment system
RERS: Reactor enclosure recirculation system

(2) Dust spot test on atmospheric dust in accordance with ASHRAE 52-68

(3) All design parameters for the downstream HEPA filter are the same as the upstream HEPA filter, except in the drywell purge mode, the pressure drop when dirty is 4 in wg.

(4) By MIL Standards 282 DOP test method on 0.3 micron particles

(5) Efficiency designated by Regulatory Guide 1.52 for use in release analyses.

Table 6.5-2

COMPLIANCE WITH REGULATORY GUIDE 1.52 OF LIGHT-WATER-COOLED NUCLEAR POWER PLANTS (REV 2)(1)

REGULATORY POSITION	(SGTS)	(RERS)	CREFAS
C.1. Environmental Design Criteria			
Position a	Conforms	Conforms	Conforms
Position b	Conforms The LGS system design is based on a total integrated dose over the 40 year plant life. The magnitude of the dose is dependent on location and includes the effect of a DBA. The design is more stringent than the regulatory guide guideline.	Conforms	Conforms
	Conforms with the shielding requirement: The system is shielded from other engineered safeguard features or components. There is no essential service located near the filters.	(Same as SGTS)	(Same as SGTS)
Position c	Conforms	Conforms	Conforms
Position d	Not applicable. There is no primary containment atmospheric cleanup system for LGS.	(Same as SGTS)	(Same as SGTS)
Position e	Conforms	Conforms	Conforms

Table 6.5-2 (Cont'd)

REGULATORY POSITION	(SGTS)	(RERS)	CREFAS
C.2. System Design Criteria			
Position a	Partially conforms. Demisters are not included; there are no water droplets in the air stream. Air heaters are included to control humidity.	Partially conforms. Demisters are not included; there are no water droplets in the air stream. Air heaters are not included to control humidity.	Partially conforms. Demisters are not included; there are no water droplets in the air stream.
	Filter trains and fans are redundant, but duct-work is not: These systems are designed on a single active component failure basis.	(Same as SGTS)	(Same as SGTS)
Position b	Partially conforms. The filters are physically separated, but the fans are not: There will be no missiles from equipment failure or natural phenomenon.	(Same as SGTS)	Does not conform. There will be no missiles from equipment failure or natural phenomenon.
Position c	Conforms	Conforms	Conforms
Position d	Not applicable to systems outside the primary containment.	(Same as SGTS)	(Same as SGTS)
Position e	Conforms	Conforms	Conforms
Position f	Partially conforms. HEPA filters are arranged 3 wide by 4 high and are serviced by a stepladder. The plenum design provides easy access to the HEPA filters.	Does not conform. Due to space restrictions(1), recirculation system filter train is rated at 60,000 cfm. HEPA filters are arranged 8 wide by 5 high. Platforms are provided in the plenums to service the filters.	Conforms

Table 6.5-2 (Cont'd)

REGULATORY POSITION	(SGTS)	(RERS)	CREFAS
Position g	Partially conforms. Instruments are provided to indicate and alarm overall pressure drop across the entire filter train. Local pressure indicators are provided for each filter component. No recorders are provided, because the filters are able to be changed on high pressure readings.	(Same as SGTS)	(Same as SGTS)
	Flow rate is indicated in the control room.	Flow rate is indicated locally. Low flow activates alarm in control room.	Flow rate is indicated locally. Low flow activates alarm in control room.
Position h	Conforms	Conforms	Conforms
Position i	Conforms	Conforms	Conforms
Position j	Conforms	Partially conforms. Design meets intent of this paragraph. Because of space restrictions[(1)], filter plenum cannot be removed as a complete module or segmented sections.	Conforms
Position k	Not applicable. No outdoor air intake	Not applicable. No outdoor air intake	Conforms

Table 6.5-2 (Cont'd)

REGULATORY POSITION	(SGTS)	(RERS)	CREFAS
Position l	Does not conform. Allowable leak rate: (1) filter housing, 0.1% of rated flow at 125% negative pressure, which complies with the 1973 original version of Regulatory Guide 1.52; (2) fan discharge gas-tight duct-work, 0.1% scheduled air flow, multiplied by ratio of the volume of duct being tested to the total volume of the duct run; (3) fan suction duct, 1% of scheduled air flow, multiplied by ratio of the volume of duct being tested to the total volume of the duct run. The system is considered not to be in a high radiation zone.	Does not conform. Allowable leak rate: (1) filter housing, 0.05% of rated flow at 125% negative design pressure, which complies with the 1973 original version of Regulatory Guide 1.52; (2) gas-tight duct-work, 0.1% of scheduled air flow, multiplied by ratio of volume of duct being tested to the total volume of the duct run; (3) standard duct, 1% of scheduled air flow, multiplied by ratio of the volume of duct being tested to the total volume of the duct run. The system is considered not to be in a high radiation zone.	Does not conform. Allowable leak rate: (1) filter housing, 0.05% of rated flow at 125% negative pressure, which complies with the 1973 original version of Regulatory Guide 1.52; (2) duct-work, 0.1% of scheduled air flow, multiplied by ratio of the volume of duct being tested to the total volume of the duct run. The system is considered not to be in a high radiation zone.
C.3. Component Design Criteria and Qualification Testing			
Position a	Not applicable. Demisters are not included.	(Same as SGTS)	(Same as SGTS)
Position b	Partially conforms. Two automatic reset cut-outs set at 180°F and 260°F.	Not applicable. Heaters are not included.	Conforms
Position c	Conforms[(3)]	Conforms	Conforms

Table 6.5-2 (Cont'd)

REGULATORY POSITION	(SGTS)	(RERS)	CREFAS
Position d	Partially conforms. HEPA filters meet requirements in this paragraph. However, testing will not be performed in ERDA test facilities. Shop tests and field tests are considered adequate.	(Same as SGTS)	(Same as SGTS)
Position e	Conforms	Conforms	Conforms
Position f	Partially conforms. HEPA filters are arranged 3 wide by 4 high and are serviced by a stepladder.	Does not conform. Because of space restrictions(1), the system is rated at 60,000 cfm. HEPA filters are arranged 8 wide by 5 high. Platforms are provided in the plenum to service the filter.	Partially conforms. Filter arrangement meets general guideline, except that service aisles between filter banks are narrower than recommended.
Position g	Partially conforms. Housing design generally conforms with ANSI N509 (1976) section 5.6, except that view ports are not included.	(Same as SGTS)	(Same as SGTS)
Position h	Conforms	Conforms	Conforms
Position i	Partially Conforms(2) (5)	Conforms(2)	Conforms(2)
Position j	Conforms	Conforms	Conforms
Position k	Conforms	Conforms	Conforms
Position l	Conforms	Conforms	Conforms
Position m	Conforms	Conforms	Conforms

Table 6.5-2 (Cont'd)

REGULATORY POSITION		(SGTS)	(RERS)	CREFAS
	Position n	Conforms	Conforms	Conforms
	Position o	Conforms	Conforms	Conforms
	Position p	Conforms	Conforms	Conforms
C.4.	Maintenance			
	Position a	Conforms	Conforms	Conforms
	Position b	Conforms	Does not conform. Because of space restrictions(1), distance between filter banks is less than recommended.	(Same as RERS)
	Position c	Partially conforms. There are 4 charcoal test canisters provided rather than 6.	Conforms	Conforms
	Position d	Does not conform. SGTS trains continuously purged when the filters are not in use with dry instrument air to prevent build-up of moisture.	(Same as SGTS)	(Same as SGTS)
	Position e	Conforms	Conforms	Conforms
C.5.	In-Place Testing Criteria			
	Position a	Conforms(4)	Conforms(4)	Conforms(4)
	Position b	Conforms(4)	Conforms(4)	Conforms(4)
	Position c	Partially conforms. (4) HEPA filters are tested to requirements of this paragraph. However, testing will be performed at least once per 48 months rather than 18 months.	(Same as SGTS)	(Same as SGTS)
	Position d	Partially conforms.(4) Activated carbon adsorber sections are tested to requirements of this paragraph. However, testing will be performed at least once per 24 months rather than 18 months.	(Same as SGTS)	(Same as SGTS)

Table 6.5-2 (Cont'd)

REGULATORY POSITION	(SGTS)	(RERS)	CREFAS
C.6. Laboratory Testing Criteria for Activated Carbon[2]			
Position a	Partially conforms. The Laboratory analysis of new and used carbon samples is performed in accordance with ASTM D3803-1989.	(Same as SGTS)	(Same as SGTS)
Position b	Partially conforms. Activated carbon adsorber sections are tested to requirements of this paragraph. However, testing will be performed at least once per 24 months rather than 18 months. Additionally, the laboratory analysis of carbon samples is performed in accordance with ASTM D3803-1989.	(Same as SGTS)	(Same as SGTS)

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(1) The LGS air filter systems were designed before the issuance of Regulatory Guide 1.52 in 1973. The filter design details have been studied in accordance with the regulatory guide and it was found that the filter performs satisfactorily although the design is not in strict conformance with the regulatory guide.

(2) Each original or replacement batch of impregnated activated charcoal used in the adsorber section meets the qualification and batch test results of ANSI N509 (1980). Laboratory tests of charcoal samples meeting the requirements of Position C.6 of Regulatory Guide 1.52 can be performed in accordance with ANSI N509 (1980) except that the laboratory analysis of carbpon samples is performed in accordance with ASTM D3803-1989.

(3) The prefilters in the RERS act as prefilters for the SGTS during reactor enclosure isolation. The prefilters in the SGTS duct from the refueling area act as prefilters for the SGTS during refueling area isolation.

(4) To ANSI/ASME N510 (1980) testing criteria.

(5) The air residence time in the 8 inch bed is 0.68 seconds considering a maximum total post inleakage rate from Zones I, II, and III of 5764 cfm.

Table 6.5-3

STANDBY GAS TREATMENT SYSTEM FAILURE MODES AND EFFECTS ANALYSIS

PLANT OPERATING MODE	SYSTEM COMPONENT	COMPONENT FAILURE MODE	EFFECT OF FAILURE ON THE SYSTEM	FAILURE MODE DETECTION	EFFECT OF FAILURE ON PLANT OPERATION
Emergency	Power supply	Total LOOP	None. All units are powered from separate standby diesel generators.	Alarm in the control room	No loss of safety function
Emergency (LOCA or LOCA & LOOP)	Exhaust fans	Loss of one fan	The standby fan automatically starts.	Low flow indication in the control room	No loss of safety function
Emergency (LOCA or LOCA & LOOP)	Electric heaters	Loss of electric heater	Efficiency of of charcoal adsorber may decrease if the relative humidity is above 70%. The operator may manually switch to the standby train.	Temperature indication in the control room	No loss of safety function
Emergency (LOCA or LOCA & LOOP)	Upstream & downstream HEPA filters .	High differential pressure across the filter bank.	The fan recirculation dampers modulate in sequence to maintain airflow. However, if the system flow rate drops below the setting of the fan flow switch, the standby fan automatically starts and the filter train is manually switched to standby train	Low flow indication in the control room	No loss of safety function

Table 6.5-3 (Cont'd)

PLANT OPERATING MODE	SYSTEM COMPONENT	COMPONENT FAILURE MODE	EFFECT OF FAILURE ON THE SYSTEM	FAILURE MODE DETECTION	EFFECT OF FAILURE ON PLANT OPERATION
Emergency (LOCA or LOCA & LOOP)	Charcoal adsorbers	High-high-high temperature	At ignition temperature setting the fire protection system is manually actuated.	Temperature indication in the control room.	No loss of safety function
Emergency (LOCA or LOCA & LOOP)	RERS to SGTS transfer valves	Valve fails to open	None. Valves are redundant and parallel. Normally closed valves fail open.	SGTS flow indication in the control room	No loss of safety function
Emergency (LOCA or LOCA & LOOP)	Fans inlet dampers	Damper fails closed	None. These dampers are redundant - standby unit will operate.	Flow indication and damper position indication in the control room	No loss of safety function
Emergency (LOCA or LOCA & LOOP)	Charcoal filter inlet valves and outlet valves	Valve fails closed	None. The valves are redundant - the standby unit will operate.	Flow indication in the control room	No loss of safety function
Emergency (LOCA or LOCA & LOOP)	Fans recirculation dampers	Dampers fail closed	None. These dampers are designed to fail closed. If the damper fails, this will increase a demand for more makeup air, and fans will attempt to deliver maximum flow.	Flow indication in the control room.	No loss of safety function
Emergency (LOCA or LOCA & LOOP)	Refueling Area to SGTS transfer valve	Valve fails open(1)	None. The refueling area is automatically isolated. The SGTS will drawdown both the reactor enclosure and refueling area.	Flow indication in the control room	No loss of safety function
Emergency (Fuel Handling Accident)	Refueling Area to SGTS transfer valve	Valve fails to open	None.Valves are redundant and parallel. Normally closed valves fail open.	SGTS flow indication in the control room	No loss of safety function

Table 6.5-3 (Cont'd)

PLANT OPERATING MODE	SYSTEM COMPONENT	COMPONENT FAILURE MODE	EFFECT OF FAILURE ON THE SYSTEM	FAILURE MODE DETECTION	EFFECT OF FAILURE ON PLANT OPERATION
Emergency (Fuel Handling Accident)	RERS to SGTS transfer valve	Valve fails open(1)	None. The corresponding reactor enclosure is automatically The SGTS will drawdown the refueling area and that Unit's reactor enclosure.	Flow indication in the Control isolated.	No loss of safety function Room
Emergency (Unit LOCA or LOOP)	The other Unit RERS to SGTS transfer valve	Valve fails open(1)	None. The other Unit reactor enclosure is automatically isolated. The SGTS will drawdown both reactor enclosures.	Flow indication in the Control Room	No loss of safety function

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Note: The SGTS is a common system.

(1) Any combination of valve failures which result in either a 2 or 3 zone isolation will not affect SGTS operation. The SGTS has a design flow of 8400 cfm which is adequate to restore and maintain the required pressure in both reactor enclosures and common refueling area.

Table 6.5-4

MATERIALS USED IN THE STANDBY GAS TREATMENT FILTER SYSTEM

COMPONENT	MATERIAL
Housing	
Structural steel	
Channel	CS ASTM A36
Plate	CS ASTM A36 SS ASTM A240 304 CS ASTM A36
Angle	CS ASTM A106 Grade B
Piping	CS ASTM A53 Grade B CS ASTM A105 Grade 1 or 2 CI ASTM A126 SS ASTM A312 TP304 CS ASTM A197
Internal structure	
Filter supports	
Plate	SS ASTM A240 304 CS ASTM A36
Angle	SS ASTM A276 304 CS ASTM A36
Fasteners	CS ASTM A307 CS ASTM A325 CS ASTM A449
Gaskets	ASTM D1056
Filter elements	
HEPA	
Frame	Cadmium Plated or Stainless Steel per ASME AG-1
Filter media	Glass Fiber per MIL-F-51079A or ASME AG-1
Electric heating coil	Nickel-chrome alloy wire with metal sheathing

Table 6.5-4 (Cont'd)

COMPONENT	MATERIAL
Carbon adsorber filter media	Activated impregnated coconut base charcoal per ANSI N509 (1980), table 5-1 and Regulatory Guide 1.52 except that laboratory analysis of carbon samples is performed in accordance with ASTM D3803-1989
Prefilter	(1)
Paint	
Interior	Carboline CarboZinc 11 primer with Carboline 3912 finish coat
Exterior	PPG 6-205 primer with PPG Lavax Machinery Enamel No. 23-61

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(1) Prefilters for the refueling area to SGTS alignment are installed in the refueling area duct-work. The filter elements consist of galvanized carbon steel frames and fiberglass media. Each filter has a UL Class I flame retardant rating. Prefiltering for the reactor enclosure to SGTS alignment is provided by the RERS filter train.

Table 6.5-5

MATERIALS USED IN THE CONTROL ROOM EMERGENCY FRESH AIR FILTER SYSTEM

COMPONENT	MATERIAL
Housing	
Structural steel	
Plate	CS ASTM A36
Angle	CS ASTM A36
Bar-stock	CS ASTM A36
Piping	CS ASTM A120 SS ASTM A312 TP304 CS ASTM A105 SS ASTM A182 F304
Internal structure	
Filter supports	
Plate	SS ASTM A240 304
Sheet	SS ASTM A240 304
Angle	SS ASTM A240 304
Bar-stock	SS ASTM A276 304
Studs	CS ASTM A108 SS AISI 166 304
Filter elements	
Prefilter	
Frame	Fire retardant particle board
Filter media	Glass fiber
HEPA	
Frame	Chromized or Stainless Steel per ASME AG-1
Filter media	Glass Fiber per MIL-F-51079A or ASME AG-1
Carbon adsorber filter media	Activated impregnated coconut base charcoal per table 5-1 of ANSI N509 (1980), and Regulatory Guide 1.52 except that laboratory analysis of carbon samples is performed in accordance with ASTM D3803-1989.

Table 6.5-5 (Cont'd)

COMPONENT	MATERIAL
Paint	
Interior	Carboline Carbo Zinc 11
Exterior	Mobil Val-Chem Zinc Chromate Primer, red base 13-R-56B with finish coat Mobil Val-Chem Hi-Build Epoxy 89 Series.

Table 6.5-6

REACTOR ENCLOSURE RECIRCULATION SYSTEM FAILURE MODES AND EFFECTS ANALYSIS (Typical for Zone I or Zone II)

PLANT OPERATING MODE	SYSTEM COMPONENT	COMPONENT FAILURE MODE	EFFECT OF FAILURE ON THE SYSTEM	FAILURE MODE DETECTION	EFFECT OF FAILURE ON PLANT OPERATION
Emergency	Power supply	Total LOOP	None; each of the redundant fans and associated dampers is powered from separate standby diesel generators.	Alarm in the control room	No loss of safety function
Emergency (LOCA or LOCA & LOOP)	Recirculation fans	Loss of one fan	The standby fan automatically starts.	Pressure differential indication in the control room	No loss of safety function
Emergency (LOCA or LOCA & LOOP)	Valves on duct from recirculation system to SGTS	One valve failed closed	None; the other valve installed in parallel remains open.	SGTS flow indication in the control room	No loss of safety function
Emergency (LOCA or LOCA & LOOP)	Valves on duct from reactor enclosure equipment compartment exhaust system to supply plenum of recirculation system	One valve failed closed	None; the other valve installed in parallel remains open.	Valve position indication on local panel C101	No loss of safety function
Emergency (LOCA or LOCA & LOOP)	Valves on duct from reactor enclosure exhaust system to supply plenum of recirculation	One valve failed at last position	None; the other valve installed in parallel remains open.	Valve position indication on local panel C101	No loss of safety function
Emergency (LOCA or LOCA & LOOP)	Valves on duct from discharge plenum of recirculation system to reactor enclosure supply system	One valve failed closed	None; the other valve installed remains open.	Valve position indication on local panel C101	No loss of safety function

Table 6.5-6 (Cont'd)

PLANT OPERATING MODE	SYSTEM COMPONENT	COMPONENT FAILURE MODE	EFFECT OF FAILURE ON THE SYSTEM	FAILURE MODE DETECTION	EFFECT OF FAILURE ON PLANT OPERATION
Emergency (LOCA or LOCA & LOOP)	Upstream & downstream HEPA filters	High differential pressure across the filter bank	None; the filter discharge flow control dampers will modulate to maintain constant airflow. However, if the pressure differential rises above a selected maximum value the operator may manually switch to the standby filter train.	Filter bank pressure differential indication in the control room	No loss of safety function
Emergency (LOCA or LOCA & LOOP)	Charcoal absorbers	High-high-high temperature	At ignition temperature setting the fire protection system is manually actuated.	Temperature indication in the control room	No loss of safety function
Emergency (LOCA or LOCA & LOOP)	Filter train inlet & outlet dampers	Damper fail close	Low flow on the flow switch will cause automatic switch-over to the standby train.	Filter differential pressure indication in the control room. Damper position indication in the control room	No loss of safety function

Table 6.5-7

MATERIALS USED IN THE REACTOR ENCLOSURE RECIRCULATION FILTER SYSTEM

COMPONENT	MATERIAL
Housing	
Structural Steel	
Plate	CS ASTM A36
Angle	CS ASTM A36
I-Beams	CS ASTM A36
Bar-stock	CS ASTM A36
Piping	CS ASTM A105 SS ASTM A312 TP304 SS ASTM A182 F304
Internal Structure	
Filter Supports	
Plate	SS ASTM A240 304
Sheet	SS ASTM A240 304
Angle	SS ASTM A276 304
Studs	CS ASTM A193 B7 CS ASTM 193 B8
Filter elements	
Prefilter	
Frame	Fire retardant particle board
Filter media	Glass fiber
HEPA	
Frame	Chromized or Stainless Steel per ASME AG-1
Filter media	Glass Fiber per MIL-F-51079A or ASME AG-1
Carbon adsorber filter media	Activated impregnated coconut base charcoal per table 5-1 of ANSI N509 (1980), and Regulatory Guide 1.52

Table 6.5-7 (Cont'd)

COMPONENT	MATERIAL
Paint	
Interior	Carboline Carbo Zinc 11
Exterior	Mobil Val-Chem Zinc Chromate Primer, red base 13-R-56B with finish coat Mobil Val-Chem Hi-Build Epoxy 89 Series.

Table 6.5-8

INSTRUMENTATION FOR ESF ATMOSPHERE CLEANUP SYSTEMS

GUIDELINES PER SRP Table 6.5.1-1			INSTRUMENTATION PROVIDED IN LGS DESIGN(1)		
SENSING LOCATION	LOCAL READOUT/ALARM	CONTROL ROOM PANEL	SGTS	RERS	CREFAS
Unit inlet or outlet	Flow rate (indication)	-	Not provided(2)	Flow rate indication at outlet	Flow Rate indication at outlet
Unit inlet or outlet	-	Flow rate (recorded indication, high and low alarms	Flow indication at outlet Low flow alarm (2)(3)(4)	Low flow alarm(3)(5)	Low flow alarm (3)(6)
Electrical heater	Status indication	-	Status indication in the control room	N/A	Not provided (Trouble alarm in the control room)(7)
Space between heater and prefilter	Temperature (indication high and low alarm signals)	-	Indication only(8)	N/A	Indication only(8)
Space between heater and prefilter	-	Temperature (indication high and low alarms, trip alarm signals)	Provided	N/A	Not provided(9)
Prefilter	Pressure drop (indication, high alarm signal)	-	Indication only (8)(10)	Indication only(8)(10)	Indication only(8)(10)
First HEPA	Pressure drop (indication, high alarm signal)	-	Indication only(8)(10)	Same as SGTS(8)(10)	Same as SGTS(8)(10)
First HEPA	-	Pressure drop (recorded indication)	Not provided(10)	Not provided (10)	Not provided(10)
Space between adsorber and second HEPA	Temperature (two-stage high alarm signal)	-	Not provided(8)	Not provided (8)	Not provided(8)
Space between adsorber and second HEPA	-	Temperature (two-stage high alarm signal)	Three-stage high alarm and indication	Same as SGTS	Same as SGTS

Table 6.5-8 (Cont'd)

GUIDELINES PER SRP Table 6.5.1-1			INSTRUMENTATION PROVIDED IN LGS DESIGN[1]		
SENSING LOCATION	LOCAL READOUT/ALARM	CONTROL ROOM PANEL	SGTS	RERS	CREFAS
Second HEPA	Pressure drop (indication, high alarm signal)	-	Indication only [8][10]	Same as SGTS[8][10]	Same as SGTS[8][10]
Fan	(Optional hand switch and status indication)	-	Not provided	Not provided	Not provided
Fan	-	Hand switch, status indication	Provided	Provided	Provided
Valve/damper operator	(Optional status indication)	-	Not provided	Not provided	Not provided
Valve/damper	-	Status indication	Provided	Provided	Provided
Deluge valves	-	-	Manual valves Indication only	Same as SGTS	Same as SGTS
Deluge valves	-	-	Alarm[11]	Same as SGTS[11]	Same as SGTS[11]
System inlet to outlet	-	Summation of pressure drop across total system, high alarm signal.	Provided	Provided	Provided

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[1] Regulatory Guide 1.52, ANSI-N509, and SRP Table 6.5.1-1 were originally issued after the LGS system design and therefore were not specifically considered in the design.

[2] The SGTS flow rate is variable to draw down and maintain the reactor enclosure/refueling area at a negative 0.25 in wg. Local flow indication does not provide meaningful information in terms of system operability. Flow indication is provided in the control room where this information, in addition to the reactor enclosure/refueling area pressure differential indicators, is available for operator evaluation of system performance.

[3] Low flow switch operates on loss of flow only.

Table 6.5-8 (Cont'd)

(4) Maximum SGTS flow occurs only during drawdown. As thermodynamic equilibrium is approached within the reactor enclosure and/or refueling area during isolation, the SGTS flow decreases to the design inleakage rate.

(5) The RERS does not operate during normal plant operation. The RERS flow is recirculated within the reactor enclosure during isolation and is not directly released to the environment.

(6) Outdoor air requirements are governed by the control room leak-tightness needed to maintain a positive pressure. High flow through the filtration system due to the failure of FD-C-78-011A in an open position will result in additional recirculation flow rather than additional unfiltered outdoor air. Control room pressure differential is indicated in the control room.

(7) Electric heater does not operate continuously during EFA system operation. Local temperature and humidity indicator controllers are provided to assess system operation.

(8) Local panels are not continuously manned to observe alarm signals.

(9) The Emergency Fresh Air system air is made up of approximately 90% recirculation air from the control room and 10% outdoor air to maintain the control room at a positive pressure. If the heater fails to operate, the temperature of the resultant air mixture will be similar to the control room even during winter conditions. Therefore, a low temperature alarm is not essential. The Emergency Fresh Air heaters are provided with automatic and manual high temperature cutouts to prevent overheating of the heater elements. Radiation monitors are provided downstream of the Emergency Fresh Air system filters and will alarm on high radiation in the event of unacceptable air quality.

(10) ESF systems do not operate continuously, and routine system testing will ensure that filter changeout requirements will be met.

(11) General trouble alarm for local panel OOC926 when any deluge valve is opened.

6.6 PRESERVICE/INSERVICE INSPECTION OF CLASS 2 AND 3 COMPONENTS

The construction permits for the LGS Units 1 and 2 were issued in June 1974. Based on this date, 10CFR50.55a required that the PSI program for the Class 2 and 3 components meet the examination requirements set forth in ASME Section XI, 1971 edition with addenda through Winter 1972 or alternatively, the examination requirements of the subsequent editions and addenda, subject to the limitations and modifications listed in 10CFR50.55a. The LGS PSI programs followed the alternative requirements.

Specifically, the Unit 1 Class 2 and 3 component PSI program (except operability testing of safety-related pumps and valves) meets the requirements of ASME Section XI, 1974 edition with addenda through Summer 1975, as modified by Appendix III of the Winter 1975 Addenda and paragraph IWA-2232 of the Summer 1976 Addenda.

At the time the LGS PSI program commenced, the latest edition of the code permissible for use was the Summer 1975 Addenda. In an effort to take advantage of improved UT methods, Appendix III of the Winter 1975 Addenda and paragraph IWA-2232 of the Summer 1976 were used. Although these items are not specifically referenced by 10CFR50.55a, they are equivalent to the comparable portions of the subsequently approved ASME Section XI of Summer 1978 Addenda as long as Section XI Appendix III indications greater than 50% DAC are recorded. The LGS ISI procedures do record such indications.

Supplement 7 of Appendix III permits the use of Appendix III for austenitic piping welds with certain modifications. It is our position, consistent with the PSI/ISI industry, that Appendix III (at 50% DAC recording) is more appropriate for austenitic piping weld examination than Article 5 of ASME Section V. Thus for austenitic piping welds:

a. All of the Supplement 7 modifications are being used.

b. Examination sensitivity is ensured through the calibration process.

c. Where one-sided access only occurs and penetrations cannot be confirmed, a one-sided access limitation is noted in the data package for that weld.

When using Section XI, Appendix III for either ferritic or austenitic piping welds, the following applies:

a. All indications showing signal amplitudes equal to or in excess of 20% of the reference response are evaluated to the extent that the level II or level III examiner can determine their true nature.

b. The owner evaluates and takes corrective action for the disposition of any indication investigated and found to be other than geometrical or metallurgical in nature.

The Unit 2 Class 2 and 3 component PSI program and Units 1 and 2 programs for the preservice testing of safety-related pumps and valves meet the requirements of the Section XI Code, 1980 edition with addenda through Winter 1981.

For certain ASME Section XI requirements that have been determined to be impractical in the course of inspecting the components, the licensee has submitted and will submit requests for relief from the requirements to the NRC in accordance with the provisions of 10CFR50.55a.

In accordance with 10CFR50.55a, throughout the service life, Class 2 and 3 components (including supports) will meet the ISI requirements, except design and access provisions and preservice examination requirements, set forth in the ASME Section XI edition and addenda that become effective, to the extent practical within the limitations of design, geometry, and materials of construction of the components. In accordance with 10CFR50.55a, inservice examinations of components, inservice tests to verify operational readiness of safety-related pumps and valves, and system pressure tests conducted during the initial 10 year inspection interval will comply with ASME Section XI edition and addenda in effect 12 months prior to the date of issuance of the operating license. In accordance with 10CFR50.55a, the initial 10 year inspection interval commences with commercial operation. The successive 10 year inspection intervals will comply with ASME Section XI edition and addenda in effect 12 months prior to the start of the 10 year inspection interval.

6.6.1 COMPONENTS SUBJECT TO EXAMINATION

LGS piping was originally designed to ANSI B31.7. For inservice inspection, ANSI B31.7 Classes II and III are considered equivalent to ASME Section III, Classes 2 and 3. The PSI/ISI program includes figures showing the systems or portions of systems within the scope of the Section XI Code. The applicable PSI/ISI programs are described in References 6.6-1 through 6.6-7. Any necessary requests for relief are addressed in these documents.

There is a Risk Informed Categorization and Treatment Program at Limerick which is based on 10 CFR 50.69. This regulation provides an alternative approach for establishing requirements for treatment of SSCs using a risk-informed method of categorizing SSCs according to their safety significance. Specifically, for SSCs categorized as low safety significant, alternate treatment requirements may be implemented rather than treatments chosen by the ISI program. Refer to Section 13.5.5 for further information.

6.6.2 ACCESSIBILITY

a. Sufficient space is provided for personnel and equipment so that examinations of Class 2 and Class 3 piping and components can be performed, as required by the Code.

    1. Piping welds - The access provided for Class 2 system components depends on whether ultrasonic, surface, or visual examinations are performed.

    2. Pumps and valves - Space is provided to disassemble and reassemble the pump or valve. For visual examination, sufficient lighting and access space is provided to permit examination of the inner surface. For ultrasonic examination, access for equipment is provided, depending on the specific design of the weld.

    3. Supports - Access provisions for supports requiring examination are provided and depend on the specific type and design detail of the support.

4. Pressure welds - Access is provided for the inspection of pressure-retaining welds, vessel supports, and pressure-retaining bolting.

b. Capability for the removal and temporary storage of structural members, shielding components, and insulation is provided.

c. Hoists and other handling machinery necessary to support ISI are provided.

d. Equipment and personnel for alternative examinations that may be required will be provided.

e. Repair and replacement operations are provided for system components and parts, where necessary.

6.6.3 EXAMINATION TECHNIQUES AND PROCEDURES

a. The techniques and procedures for surface, visual, and volumetric examinations are in compliance with IWA-2200 of the Section XI Code.

b. Alternate examination methods are acceptable, provided that the results are equal or superior to the methods of IWA-2200. The acceptance criteria for alternate examination methods are in accordance with IWA-3100 of the Section XI Code.

6.6.4 INSPECTION INTERVALS

The examinations required by IWC-2400 for Class 2 system components and by IWD-2400 for Class 3 system components will be performed on the basis of a 10 year interval, hereafter known as the inspection interval.

6.6.5 EXAMINATION CATEGORIES AND REQUIREMENTS

The PSI/ISI program provides a listing of the Class 2 and 3 components or parts including the Section XI Code item number, examination category, the required method of examination, and the extent and frequency of examination. The applicable PSI/ISI programs are identified in References 6.6-1 through 6.6-7.

6.6.6 EVALUATION OF EXAMINATION RESULTS

The standards for evaluation of results and repair procedures are in accordance with Articles IWB-3000 and IWA-4000. Where acceptance standards are still in preparation, IWA-3100 shall apply. The ISI program for the first and successive inspection intervals will use the articles in IWC and IWD as they are issued and approved. Summary reports for the RPV and piping PSI were submitted 90 days after commercial operation, in accordance with subarticle IWA-6220.

6.6.7 SYSTEM PRESSURE TESTS

The system pressure tests will be performed in accordance with the general requirements of IWA-5000 and the specific requirements of IWC-5000 and IWD-5000 for Class 2 and 3 components, respectively.

6.6.8 AUGMENTED INSERVICE INSPECTION TO PROTECT AGAINST POSTULATED PIPING FAILURES

Class 2 and 3 components will receive augmented inservice inspection in accordance with the documents listed below to the extent specified in the applicable PSI/ISI programs identified in References 6.6-1 through 6.6-7.

a. NUREG-0313, Revision 1, July 1980, "Technical Report on Material Selection and Processing Guidelines for BWR Coolant Pressure Boundary Piping" (see resolution of USI A-42, Section 1.12.2). Revision 1 of this NUREG is applicable prior to issuance of Generic Letter 88-01.

   In accordance with Generic Letter 88-01, the criteria of NUREG-0313, Revision 2, January 1988 are applicable for LGS Units 1 and 2. The ISI Program for weldments in piping shall be performed in accordance with the NRC staff positions and criteria addressed in Generic Letter 88-01 and BWRVIP-75-A, "BWR Vessel and Internals Project Technical Basis for Revisions to Generic Letter 88-01 Inspection Schedule." Details for schedule, methods, personnel, and sample expansion shall be included as augmented inspection requirements. Response to the Generic Letter 88-01 was provided per letter from S.J. Kowalski (PECo) to F.J. Miraglia, Jr. (NRC), dated August 2, 1988. The ISI Program for weldments in piping shall be performed in accordance with the NRC staff positions and criteria addressed in Generic Letter 88-01. Details for schedule, methods, personnel, and sample expansion shall be included as augmented inspection requirements.

b. BTP MEB 3-1 (NUREG-0800) addresses high energy piping between containment isolation valves and first outboard restraint for which no breaks are postulated

In addition, high energy fluid system piping between containment isolation valves will receive an augmented examination as follows:

a. Protective measures and structures are located, to the greatest extent possible, so as not to prevent access for inservice inspections.

b. High energy fluid system piping between containment isolation valves is required to be either 100% volumetrically examined (both circumferential and longitudinal welds) during each examination interval or examined in accordance with the Risk Informed Inservice Inspection Program as applied to these welds.

c. High energy piping requiring ISI receives a baseline (preservice) examination to establish the integrity of the original condition of the welds.

d. Augmented examination for high energy piping is maintained out to outboard restraints.

e. Welds between outboard containment isolation valves and piping restraints will be included in the PSI and the ISI plans.

6.6.9 REFERENCES

6.6-1 Document 8031-M246AQA-59, Preservice Inspection Program Plan for the LGS Unit 1 Nuclear Piping Systems

6.6-2 Program Document ML-008, Limerick Generating Station Units 1 and 2, “IST Program Plan” and “IST Basis Document”

6.6-3 ER-LG-330-1001 through 1006, Limerick ISI Program Documents

6.6-4 Deleted

6.6-5 Document 8031-P-504, LGS Unit 2 Preservice Inspection Program

6.6-6 Document 8031-P-505, LGS Unit 2 Preservice Inspection Examination Plan for Nuclear Piping Systems

6.6-7 Document 8031-P-507, LGS Unit 2 Testing Plan for Safety-Related Pumps and Valves

6.7 MSIV LEAKAGE ALTERNATE DRAIN PATHWAY

The MSIV Leakage Alternate Drain Pathway prevents a direct release of fission products that could leak through the closed MSIVs after a LOCA. The pathway provides control by providing a hold-up volume for the MSIV leakage before release to the atmosphere. This is accomplished by directing the leakage through existing Main Steam Drain Lines to the High Pressure Shell of the Main Condenser.

6.7.1 DESIGN BASES

6.7.1.1 Safety Criteria

The following criteria represent pathway design, safety, and performance requirements imposed on the MSIV Leakage Alternate Drain Pathway.

a. The MSIV Leakage Alternate Drain Pathway is evaluated to have sufficient capacity and capability to control the leakage from the MSIVs, consistent with containment leakage limits imposed for the conditions associated with a postulated design basis LOCA. Specifically, a complete severance of a recirculation line does not permit an offsite dose to exceed the requirements of 10CFR50.67.

b. The MSIV Leakage Alternate Drain Pathway has been evaluated to demonstrate that the main system piping and equipment are seismically rugged and meet the requirements of 10CFR Part 100, Appendix A.

c. The MSIV Leakage Alternate Drain Pathway is capable of performing its safety function following a LOCA with Loss of Offsite Power. The Pathway is not single failure proof, but there are alternate unanalyzed pathways which will serve to direct any MSIV leakage to allow for reducing the offsite dose.

d. The MSIV Leakage Alternate Drain Pathway is manually actuated, and designed to permit actuation within about 20 minutes, but no earlier than 10 minutes, after a postulated design basis LOCA. This time period is considered to be consistent with loading requirements of the Class 1E electrical buses and with reasonable times for operator action.

6.7.1.2 Regulatory Acceptance Criteria

The piping and the components of the MSIV Leakage Alternate Drain Pathway have been evaluated to confirm the capability of the main steam piping and condenser to serve as an alternate leakage pathway. Seismic verification walkdowns have been performed to assure that the MSIV, the steam drain lines, the condenser and interconnecting piping and equipment that are not seismically analyzed fall within the bounds of the design characteristics of the seismic experience database as discussed in reference 1.

6.7.2 SYSTEM DESCRIPTION

The MSIV Leakage Alternate Drain Pathway is credited in the Radiological Dose Calculations for Limerick Generating Station. The pathway serves as a "hold-up" volume for processing of a potential release of fission products that could leak through the closed MSIV's during a Loss of Coolant Accident (LOCA). This pathway limits the calculated doses from the MSIV Leakage to within the requirements of 10CFR50.67 for offsite releases and GDC 19 for local area access. The system has been evaluated to adequately handle the Technical Specification allowed MSIV leakage.

The design boundaries of the MSIV Leakage Alternate Drain Pathway are defined as follows. The designated boundary (block) valves (HV-1(2)08, HV-1(2)09, HV-1(2)11, HV-1(2)50, Main Turbine Stop Valves (MSTV), and Main Turbine Bypass Valves (MTBV)) will function to contain the MSIV leakage in the drain pathway. The boundary valves also identify the functional and design boundary of the "MSIV Leakage Alternate Drain Pathway." All other lines which interface with the designated drain pathway are shown in the applicable drawings and UFSAR Figures (drawings M-01, M-41, M-49, M-55, and Figure 10.4-4) will either be described below as a drain pathway, or lead back through Seismic Category I/IIA piping back into containment (primary or secondary) and as such do not represent potential leakage pathways.

There are three potential leakage pathways. These pathways are as follows:

1) Flow from all four Main Steam lines directly after the outboard MSIVs, through 2 inch EBB-1(2)05, into 3 inch EBB-1(2)05, into 3 inch EBD-1(2)08, into 4 inch EBD-1(2)08, discharging into the H.P. Condenser.

2) Flow from the above seat drain on the Main Stop Valves through 1 inch EBD-*, into 2 inch EBD-1(2)15, into 4 inch EBD-1(2)08, discharging into the H.P. Condenser.

3) Flow from all four Main Steam lines directly before the Main Stop Valves through 1 inch EBB-1(2)01(2,3,4), into 2 inch EBD-1(2)14, into 2 inch EBD-1(2)15, into 4 inch EBD-1(2)08, discharge into the H.P. Condenser.

Although all three drain pathways are capable of directing leakage to the H.P. Condenser the only credited drain line is item 1). This is based on the fact that the other drain lines are either not sized properly to ensure adequate flow or require the opening of non-class 1E valves. The primary drain pathway has one normally closed valve in the line (HV-041-1(2)F021). This valve is required to be opened to establish the drain pathway.

The remainder of the system shown in attachment 1 of reference 2, identifies the total scope of the potential pathways which was evaluated during a seismic walkdown, and was in a Design Analysis contained in reference 1 for "Seismic Ruggedness" specified in reference 2.

6.7.3 SYSTEM EVALUATION

An evaluation of the capability of the MSIV Leakage Alternate Drain Pathway to control the release of radioactivity from the MSIVs during and following a LOCA has been conducted. A summary of the evaluation is contained in reference 2. In addition, the results of the radiological evaluations are contained in section 15.6.5.

6.7.4 INSTRUMENTATION REQUIREMENTS

There are no specific instrumentation requirements for this pathway since there are no automatic actions required. The operational requirements of the pathway only require the capability to reposition one valve identified in section 6.7.2 .

6.7.5 Inspection And Testing

The valves required to be repositioned are tested in accordance with the requirements of the Inservice Testing Program.

6.7.6 REFERENCES

1. NEDC-31585P, Revision 2, BWROG Report for Increasing MSIV Leakage Rate Limits and Elimination of Leakage Control System, dated September 1993.

2. 10CFR50.90 Technical Specification Change Request 93-18-0, for removal of MSIV-LCS, dated January 14, 1994.

Table 6.7-1 has been deleted