4.7 REACTOR CORE ISOLATION COOLING SYSTEM

4.7.1 Power Generation Objective

The Reactor Core Isolation Cooling System (RCICS) provides makeup water to the reactor vessel during shutdown and isolation from the main heat sink to supplement or replace the normal makeup sources and operates automatically in time to obviate any requirement for the Core Standby Cooling Systems (see Chapter 6, “Emergency Core Cooling Systems”).

4.7.2 [Deleted]

4.7.3 Power Generation Design Basis

1. The system shall operate automatically in time to maintain sufficient coolant in the reactor vessel so that the Core Standby Cooling Systems are not required.

2. Provision shall be made for remote-manual operation of the system by an operator.

3. The power supply for the system shall be provided by immediately-available energy sources of high reliability in order to provide a high degree of assurance that the system shall operate when necessary.

4. Provision shall be made so that periodic testing can be performed during plant operation, in order to provide a high degree of assurance that the system shall operate when necessary.

4.7.4 Safety Design Basis

Piping and equipment, including support structures, shall be designed to withstand the effects of an earthquake without a failure which could lead to a release of radioactivity in excess of the guideline values given in 10 CFR 50.67.

4.7.5 Description

The RCICS consists of a steam-driven, turbine-pump unit and associated valves and piping capable of delivering makeup water to the reactor vessel. A summary of the design requirements of the turbine-pump unit is shown on Table 4.7-1. The transient analyses are based on a RCIC flow rate of 540 gpm (pre-uprated) and 600 GPM (uprated). A system diagram is shown in Figures 4.7-1a, 4.7-1c, and 4.7-1e.

The steam supply to the turbine comes from the main steam line from the reactor vessel. The steam exhaust from the turbine dumps to the pressure suppression pool. The pump takes suction from the condensate header, or from the pressure suppression pool header, via a core spray pump supply header. The pump discharges either to the feedwater line or to a full-flow return test line to the condensate storage tanks. A minimum-flow bypass line to the pressure suppression pool is provided for pump protection. The makeup water is delivered into the reactor vessel through a connection to the feedwater line and is distributed within the reactor vessel through the feedwater sparger. The connection to the feedwater line is provided with a thermal sleeve. Cooling water for the RCICS turbine lube-oil cooler and gland-seal condenser is supplied from the discharge of the pump (see Figures 4.7-1b, 4.7-1d, and 4.7-1f). Whenever RCIC is lined up to take suction from the condensate storage tank, the discharge piping of the RCIC is periodically vented from the high point of the system and water flow observed in accordance with Technical Specifications surveillance frequency requirements for system operability.

Following any reactor shutdown, steam generation continues due to heat produced by the radioactive decay of fission products. Initially the rate of steam generation can be as much as approximately 6 percent of rated flow, and is augmented during the first few seconds by delayed neutrons and some of the residual energy stored in the fuel. The steam normally flows to the main condenser through the turbine bypass or, if the condenser is isolated, through the main steam relief valves to the pressure suppression pool. The fluid removed from the reactor vessel can be entirely made up by the feedwater pumps if the main steam line isolation valves are open or partially made up from the Control Rod Drive System which is supplied by the control rod drive feed pumps. If makeup water is required to supplement these sources of water, the RCICS turbine-pump unit either starts automatically upon receipt of a Reactor Vessel Water Level - Low Low, Level 2 signal or is started by the operator from the control room by remote-manual controls. The RCICS delivers its design flow within 30 seconds after actuation. To limit the amount of fluid leaving the reactor vessel, a Reactor Vessel Water Level - Low Low Low, Level 1 signal also actuates the closure of the main steam isolation valves.

For events other than pipe breaks, RCICS has a makeup capacity sufficient to prevent the reactor vessel water level from decreasing to the level where the core is uncovered without the use of Core Standby Cooling Systems (see Section 14.0, "Plant Safety Analysis"). The pump suction is normally lined up to the condensate storage tanks through the condensate supply header. Other systems which use the same tanks for condensate, and could jeopardize the availability of this reserve quantity, are restricted by a standpipe to the use of water in the upper portion of the tanks. About 135,000 gallons are below the standpipe in each condensate tank. This quantity represents the conservatively calculated amount of water required to maintain reactor vessel level for at least 8 hours in hot shutdown conditions (MODE 3).

The backup supply of cooling water for the RCICS is the pressure suppression pool Ring Header. The turbine-pump assembly is located below the level of the condensate storage tank and below the minimum water level in the pressure suppression pool to ensure positive suction head to the pump. Pump NPSH requirements are met by providing adequate suction head and adequate suction line size.

All components normally required for initiating operation of the RCICS are completely independent of auxiliary AC power, plant service air, and external cooling water systems, requiring only DC power from a unit battery to operate the valves, vacuum pump, and condensate pumps. The power source for the turbine-pump unit is the steam generated in the reactor pressure vessel by the decay heat in the core. The steam is piped directly to the turbine, and the turbine exhaust is piped to the pressure suppression pool.

If for any reason the reactor vessel is isolated from the main condenser, pressure in the reactor vessel increases but is limited by automatic or remote-manual actuation of the main steam relief valves. Main steam relief valve discharge is piped to the pressure suppression pool. Throughout the period of RCICS operation, the exhaust from the RCICS turbine and main steam relief valve discharge being condensed in the pressure suppression pool results in a temperature rise in the pool. During this period RHR heat exchangers are used to control pool water temperature, if normal AC power is available for operation of the RHR system. Assuming a 1/2-hour delay in initiating pool cooling, the maximum pool temperature of (approximately) 162°F would be reached at about 4 hours into the event.

The RCICS turbine-pump unit is located in a shielded area to ensure that personnel access areas are not restricted during RCICS operation. An analysis of the possibility of the failure of the RCIC turbine has been performed. Stresses in the turbines are sufficiently low, such that wheel failure is not predicted, even at the theoretical run-away condition of twice rated speed. Even though similar results were obtained for the analysis of the HPCI turbine, the HPCI and RCIC turbines are located in separate concrete rooms within the Reactor Building. An assumed failure of either turbine could not cause sufficient damage to prevent safe shutdown of the plant. The turbine controls provide for automatic trip of the RCICS turbine upon receiving any of the following signals:

a. Turbine overspeed--to prevent damage to the turbine and turbine casing,

b. Pump low-suction pressure--to prevent damage to the turbine-pump unit due to loss of cooling water,

c. Turbine high-exhaust pressure--indicating turbine or turbine control malfunction, and

d. Automatic isolation signal-indicating RCIC steam line rupture.

Since the steam supply line to the RCICS turbine is a primary containment boundary, certain signals automatically isolate this line causing shutdown of the RCICS turbine. Automatic shutdown of the steam supply is described in Subsection 7.3, "Primary Containment and Reactor Vessel Isolation Control System."

The turbine control system is positioned by the demand signal from a flow controller, and satisfies a twofold purpose:

a. Limit the turbine pump speed to its maximum normal operating value, and

b. Position the turbine governor valve(s) as required to maintain constant pump discharge flow over the pressure range of system operation.

The RCICS piping within the drywell up to and including the outer isolation valve is designed in accordance with the USA Standard Code for Pressure Piping, USAS B31.1.0, 1967 edition, and the applicable GE design and procurement specifications, which were implemented in lieu of the out dated B31 Nuclear Code Cases-N2, N7, N9, and N10, plus ASME Boiler and Pressure Vessel Code, Section I, 1965 edition. Other piping is designed in accordance with the USAS B31.1.0, 1967 edition, as applicable. The thermal sleeve (liner) in the feedwater line is designed as a nonpressure-containing liner and is provided to protect the pressure-containing piping tee from excessive thermal stress.

4.7.6 Safety Evaluation

The safety design basis is satisfied by design of the RCICS containment function to seismic Class I specifications (see Appendix C).

4.7.7 Inspection and Testing

A design flow functional test of the RCICS is performed during plant operation by taking suction from the condensate header and discharging through the full flow test return line back to the condensate storage tank. The discharge valve to the feed line remains closed during the test and reactor operation is undisturbed. Testing of the pump discharge valve is accomplished in accordance with Subsection 4.12, Inservice Inspection and Testing. Control system design provides automatic return from test to operating mode if system initiation is required during testing. Periodic inspection and maintenance of the turbine-pump unit are based on manufacturer's recommendations and sound maintenance practices. Valve position indication, as well as instrumentation alarms, is displayed in the control room.