10.4 Other Features of Steam and Power Conversion System

10.4.1 Main Condensers

The main condenser functions as the steam cycle heat sink condensing steam from the main turbine or from the turbine bypass system (TBS).

10.4.1.1 Design Basis

The main condenser performs no safety-related function and therefore has no nuclear safety-related design basis.

The main condenser is designed to meet the following functional criteria:

- Condense steam exhausted from the three low-pressure (LP) turbines. Serve as collection point for steam, demineralized water, equipment drains, extracted water and vented air from other systems.
- Accommodate up to 50 percent of the valves wide open (VWO) main steam flow, which is bypassed directly to the main condenser by the turbine bypass system (TBS). Design features such as baffles, flow distributors, and pressure breakdown devices are included in the main condenser design to preclude component or tube failures due to steam blowdown from the turbine bypass system.
- Receive steam dumped from the TBS without exceeding condenser high backpressure turbine trip (TT) pressure.
- Remove non-condensable gases from the condensing steam through the main condenser evacuation system (MCES), as described in Section 10.4.2.

10.4.1.2 System Description

Table 10.4.1-1—Main Condenser Design Data, provides design data. Table 3.2.2-1 provides the seismic design and other design classifications for the main condenser. Section 3.2 describes how the guidance of RG 1.26 is implemented for the U.S. EPR.

The main condenser is a multipressure, three-shell unit. Each shell is located beneath its respective LP turbine. The tubes in each shell are oriented transversely to the turbine generator longitudinal axis.

The three condenser shells are designated as the LP shell, intermediate-pressure (IP) shell and high-pressure (HP) shell. Each shell has two or more tube bundles. Circulating water flows in series through the three single-pass shells, as shown in Figure 10.4.5-1.

The hotwells are partitioned and connected so that condensate cascades from the LP hotwell to the HP hotwell. As described in Section 10.4.7, the condensate pumps take suction from the HP hotwell.

The condenser shells are located below the Turbine Building operating floor and are supported above the Turbine Building foundation.

Each LP turbine outer casing (exhaust hood) and condenser neck is rigidly welded together.

Condenser materials depend upon the circulating water characteristics. For example, titanium tubes and tubesheet overlay are used for seawater, while stainless steel tubes and tubesheet overlay are used for freshwater. The COL applicant that references the U.S. EPR design certification will describe the site-specific main condenser materials.

Methods used to reduce the corrosion and erosion of tubes and components include:

- Use of corrosion resistant tube and tubesheet materials.
- Treatment of circulating water (refer to Section 10.4.5).
- Limitation on design flow velocity in tubes.
- Use of condenser tube cleaning system (refer to Section 10.4.5).
- Control of secondary side water chemistry (refer to Section 10.3.5).

The design pressure of the CWS and condenser water boxes is site-specific. The COL applicant that references the U.S. EPR design certification will describe the site-specific design pressure and test pressure for the main condenser.

10.4.1.2.1 System Operation

During normal plant operation, the main condenser is operated under a vacuum and steam from the exhaust of the low pressure turbines is expanded down into the main condenser shells across the main condenser tubes and is condensed and collected in the hotwells. The main condenser also serves as a collection point for steam, demineralized water, equipment drains, extracted water and vented air from other systems.

Main condenser vacuum is maintained by the MCES. Air inleakage and noncondensable gases contained in the turbine exhaust steam are collected in the main condenser and removed by the MCES as described in Section 10.4.2.

During operations, continuous monitoring of condenser tube leak tightness is accomplished by leakage monitors. The hotwell of each condenser shell is compartmentalized to increase the accuracy of identifying the location of the leakages that are subsequently measured. Control of contaminants, including air leakage, that could enter the main condenser, is described in Section 10.3.5 as part of the secondary side water chemistry program.

Butterfly valves are provided in the circulating water system (CWS) to permit half of the condenser tube bundles to be isolated and removed from service for maintenance.

During anticipated operational occurrences, the main condenser is capable of accepting steam from the TBS while maintaining condenser vacuum, provided the CWS remains in operation and spray water pressure is available if operating conditions require spray water (refer to Section 10.4.4 for a description of the TBS).

The operation of the main condenser supports other system operations within the steam and power conversion system.

10.4.1.3 Safety Evaluation

The main condenser has no nuclear safety-related function.

The design of the main condenser satisfies general design criterion (GDC 60), as it relates to the control of radioactive material releases to the environment. During normal operation and shutdown, the main condenser contains negligible quantities of radioactive contaminants. However, it is possible for the main condenser to become contaminated in the event of primary-to-secondary system leakage.

- Air and non-condensable gases are discharged from the main condenser by the MCES. Radiological activity of the MCES exhaust is monitored (refer to Section 10.4.2). The radiological aspects of primary-to-secondary leakage, which includes anticipated operating concentrations of radioactive contaminants, are addressed in Section 11.5 and Table 11.5-1, Monitor R-3.
- For the U.S. EPR, no hydrogen buildup is anticipated in the main condenser. Dissolved oxygen is present in the condensate and condenser hotwell inventory, but only trace amounts of this oxygen are released in the condenser, and the amounts are negligible compared to the amount of gas and vapor being evacuated by the MCES. There is no potential for explosive mixtures within the main condenser which would result in excessive releases of radioactivity; therefore, the main condenser design satisfies GDC 60 and is not required to be designed to withstand the effects of an explosion.

Failure of the main condenser and the resulting flooding does not prevent the operation of any essential system because no safety-related equipment is located in the Turbine Building.

Main condenser operation does not directly affect the reactor coolant system. If the main condenser performance is degraded, the turbine backpressure increases. This increase in backpressure causes a lowering of turbine cycle efficiency, which requires an increase in reactor power to maintain the demanded electrical power generation level. The reactor power increase is limited by the reactor control system, as described in Section 7.7. The reactor protection system, described in Section 7.2, maintains the plant within safe operation limits. If main condenser performance is sufficiently degraded, the backpressure increases to the turbine trip setpoint and a turbine trip is initiated. A turbine trip is addressed in Section 15.2.2.

10.4.1.4 Inspection and Testing Requirements

The main condenser components are inspected and tested as part of the initial plant startup. Refer to Section 14.2 (test abstract #065) for initial plant startup test program.

Periodic inspections of the main condenser are performed in conjunction with the scheduled maintenance outages.

10.4.1.5 Instrumentation Requirements

The following main condenser protection devices are provided:

- Low-vacuum trip to initiate turbine trip.
- Low-vacuum trip to initiate bypass trip for each condenser.
- The condensate level in the hotwell is indicated and monitored by high- and low-water level alarms in the main control room. Conductivity meters are installed to detect high conductivity. Display of meter readings and associated alarms is provided in the main control room.
- Hotwell level controls and makeup controls are described in Section 10.4.7.

Table 10.4.1-1—Main Condenser Design Data

Condenser Data	
Condenser type	Multi-pressure, single-pass, 3-shell
Hotwell storage capacity	5 minutes between the normal water level and the low alarm level
Design operating pressure (average of all shells)	2.5 in/Hg
Shell pressure (design)	0 in/Hg absolute to 15 psig
Circulating water flow (max)	790,000 gpm
Water box pressure (design)	(Site specific - to be provided by COL applicant)
Waterbox material	Carbon steel with coating or lining
Condenser Tube Data	
Tube material (main section)	Stainless steel (SS) (Note 1)
Tube sheet material	SS or carbon steel clad with SS (Note 2)

Notes:

1. For sea water plants, an equivalent tube material such as titanium may be substituted.

2. If one of the alternate tube materials is used, the tube sheet material shall be carbon steel, clad with the same material as the tubes.

Next File