CHAPTER 10

STEAM AND POWER CONVERSION

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CHAPTER 10

STEAM AND POWER CONVERSION

10.1 SUMMARY DESCRIPTION

This section of the referenced DCD is incorporated by reference with the following departures and/or supplements.

10.1.3 COMBINED LICENSE INFORMATION ON EROSION - CORROSION MONITORING

Add the following text at the end of DCD Subsection 10.1.3.

10.1.3.1 Erosion-Corrosion Monitoring

STD COL 10.1-1 The flow accelerated corrosion (FAC) monitoring program analyzes, inspects, monitors and trends those nuclear power plant components that are potentially susceptible to erosion-corrosion damage such as carbon steel components that carry wet steam. In addition, the FAC monitoring program considers the information of Generic Letter 89-08, EPRI NSAC-202L-R3, and industry operating experience. The program requires a grid layout for obtaining consistent pipe thickness measurements when using Ultrasonic Test Techniques. The FAC program obtains actual thickness measurements for highly susceptible FAC locations for new lines as defined in EPRI NSAC-202L-R3 (Reference 201). At a minimum, a CHECWORKS type Pass 1 analysis is used for low and highly susceptible FAC locations and a CHECWORKS type Pass 2 analysis is used for highly susceptible FAC locations when Pass 1 analysis results warrant. To determine wear of piping and components where operating conditions are inconsistent or unknown, the guidance provided in EPRI NSAC-202L is used to determine wear rates.

10.1.3.1.1 Analysis

An industry-sponsored program is used to identify the most susceptible components and to evaluate the rate of wall thinning for components and piping potentially susceptible to FAC. Each susceptible component is tracked in a database and is inspected, based on susceptibility. Analytical methods utilize the results of plant specific inspection data to develop plant specific correction factors. This correction accounts for uncertainties in plant data, and for systematic discrepancies caused by plant operation. For each piping component, the analytical method predicts the wear rate, and the estimated time until it must be re-inspected, repaired, or replaced. Carbon steel piping (ASME III and B31.1) that is used for single or multi-phase high temperature flow is the most susceptible to erosion-corrosion damage and receives the most critical analysis.

10.1.3.1.2 Industry Experience

Review and incorporation of industry experience provides a valuable supplement to plant analysis. Industry experience is used to update the program by identifying susceptible components or piping features.

10.1.3.1.3 Inspections

Wall thickness measurements establish the extent of wear in a given component, provide data to help evaluate trends, and provide data to refine the predictive model. Components are inspected for wear using ultrasonic techniques, radiography techniques, or by visual observation. The initial inspections are used as a baseline for later inspections. Each subsequent inspection determines the wear rate for the piping and components and the need for inspection frequency adjustment for those components.

10.1.3.1.4 Training and Engineering Judgement

The FAC program is administered by both trained and experienced personnel. Task specific training is provided for plant personnel that implement the monitoring program. Specific non-destructive examination (NDE) is carried out by personnel qualified in the given NDE method. Inspection data is analyzed by engineers or other experienced personnel to determine the overall effect on the system or component.

10.1.3.1.5 Long-Term Strategy

This strategy focuses on reducing wear rates and performing inspections on the most susceptible locations.

10.1.3.2 Procedures

10.1.3.2.1 Generic Plant Procedure

The FAC monitoring program is governed by procedure. This procedure contains the following elements:

- A requirement to monitor and control FAC.
- Identification of the tasks to be performed and associated responsibilities.
- Identification of the position that has overall responsibility for the FAC monitoring program at each plant.
- Communication requirements between the coordinator and other departments that have responsibility for performing support tasks.
- Quality Assurance requirements.

- Identification of long-term goals and strategies for reducing high FAC wear rates.
- A method for evaluating plant performance against long-term goals.

10.1.3.2.2 Implementing Procedures

The FAC implementing procedures provide guidelines for controlling the major tasks. The plant procedures for major tasks are as follows:

- Identifying susceptible systems.
- Performing FAC analysis.
- Selecting and scheduling components for initial inspection.
- Performing inspections.
- Evaluating degraded components.
- Repairing and replacing components when necessary.
- Selecting and scheduling locations for the follow-on inspections.
- Collection and storage of inspections records.

10.1.3.3 Plant Chemistry

The responsibility for system chemistry is under the purview of the plant chemistry section. The plant chemistry section specifies chemical addition in accordance with plant procedures.

10.1.4 REFERENCES

201. EPRI NSAC-202L-R3, *Recommendations for an Effective Flow-Accelerated Corrosion Program (NSAC-202L-R3)*, Electric Power Research Institute (EPRI) Technical Report 1011838, Palo Alto, CA, 2006.

10.2 TURBINE-GENERATOR

This section of the referenced DCD is incorporated by reference with the following departures and/or supplements.

10.2.2 SYSTEM DESCRIPTION

Add the following sentence at the end of the second paragraph of DCD Subsection 10.2.2.

STD SUP 10.2-1 Subsection 3.5.1.3 addresses the probability of generation of a turbine missile for AP1000 plants in a side-by-side configuration.

Add the following statement at the end of DCD Subsection 10.2.2.

STD SUP 10.2-4 Preoperational and startup tests provide guidance to operations personnel to assure the proper operability of the turbine generator system.

10.2.3 TURBINE ROTOR INTEGRITY

Add the following statement at the end of DCD Subsection 10.2.3.

STD SUP 10.2-5 Operations and maintenance procedures mitigate the following potential degradation mechanisms in the turbine rotor and buckets/blades: pitting, stress corrosion cracking, corrosion fatigue, low-cycle fatigue, erosion and erosion-corrosion.

10.2.3.6 Maintenance and Inspection Program Plan

Add the following at the end of DCD Subsection 10.2.3.6.

STD SUP 10.2-3 The inservice inspection (ISI) program for the turbine assembly provides assurance that rotor flaws that lead to brittle fracture of a rotor are detected. The ISI program also coincides with the ISI schedule during shutdown, as required by the ASME Boiler and Pressure Vessel Code, Section XI, and includes complete inspection of all significant turbine components, such as couplings, coupling bolts, turbine shafts, low-pressure turbine blades, low-pressure rotors, and high-pressure rotors. This inspection consists of visual, surface, and volumetric examinations required by the code.

10.2.6 COMBINED LICENSE INFORMATION ON TURBINE MAINTENANCE AND INSPECTION

Replace the text in DCD Subsection 10.2.6 with the following:

STD COL 10.2-1 A turbine maintenance and inspection program will be submitted to the NRC staff for review prior to fuel load. The program will be consistent with the maintenance and inspection program plan activities and inspection intervals identified in DCD Subsection 10.2.3.6. Plant-specific turbine rotor test data and calculated toughness curves that support the material property assumptions in the turbine rotor analysis will be available for review after fabrication of the turbine and prior to fuel load.

10.3 MAIN STEAM SUPPLY SYSTEM

This section of the referenced DCD is incorporated by reference with the following departures and/or supplements.

10.3.2.2.1 Main Steam Piping

Add the following at the end of DCD Subsection 10.3.2.2.1.

STD SUP 10.3-1 Operations and maintenance procedures include precautions, when appropriate, to minimize the potential for steam and water hammer, including:

- Prevention of rapid valve motion
- Process for avoiding introduction of voids into water-filled lines and components
- Proper filling and venting of water-filled lines and components
- Process for avoiding introduction of steam or heated water that can flash into water-filled lines and components
- Cautions for introduction of water into steam-filled lines or components
- Proper warmup of steam-filled lines
- Proper drainage of steam-filled lines
- The effects of valve alignments on line conditions

10.3.5.4 Chemical Addition

Add the following at the end of DCD Subsection 10.3.5.4.

STD SUP 10.3-2 An alkaline chemistry supports maintaining iodine compounds in their nonvolatile form. When iodine is in its elemental form, it is volatile and free to react with organic compounds to create organic iodine compounds, which are not assumed to remain in solution. It is noted that no significant level of organic compounds is expected in the secondary system. The secondary water chemistry, thus, does not directly impact the radioactive iodine partition coefficients.

10.3.6.2 Material Selection and Fabrication

Add the following at the end of DCD Subsection 10.3.6.2.

STD SUP 10.3-3 Appropriate operations and maintenance procedures provide the necessary controls during operation to minimize the susceptibility of components made of stainless steel and nickel-based materials to intergranular stress-corrosion cracking by controlling chemicals that are used on system components.

10.4 OTHER FEATURES OF STEAM AND POWER CONVERSION SYSTEM

This section of the referenced DCD is incorporated by reference with the following departures and/or supplements.

10.4.1.2 System Description

Add the following sentence at the end of the first paragraph of DCD Subsection 10.4.1.2.

WLS CDI Table 10.4-201 supplements the data in DCD Table 10.4.1-1.

10.4.2.2.1 General Description

Revise the first sentence of the third paragraph of DCD Subsection 10.4.2.2.1 to remove the brackets.

WLS CDI The circulating water system (CWS) provides the cooling water for the vacuum pump seal water heat exchangers.

10.4.2.2.2 Component Description

Revise the fourth sentence of the first paragraph of DCD Subsection 10.4.2.2.2 to remove the brackets.

WLS CDI Seal water flows through the shell side of the seal water heat exchanger and circulating water flows through the tube side.

DCD

10.4.5 CIRCULATING WATER SYSTEM

Subsection 10.4.5 is modified using full text incorporation to provide site-specific information to replace the DCD conceptual design information.

10.4.5.1 Design Basis

10.4.5.1.1 Safety Design Basis

The CWS serves no safety-related function and therefore has no nuclear safety design basis.

10.4.5.1.2 Power Generation Design Basis

WLS CDI The CWS supplies cooling water to remove heat from the main condensers. The CWS and/or makeup water from the raw water system (RWS) supplies cooling water to the turbine building closed cooling water system (TCS) heat exchangers and the condenser vacuum pump seal water heat exchangers under varying conditions of power plant loading and design weather conditions.

DCD

10.4.5.2 System Description

10.4.5.2.1 General Description

Classification of components and equipment in the circulating water system is given in Section 3.2.

WLS COL 10.4-1 The CWS and the cooling towers provide a heat sink for the waste heat exhausted from the steam turbine. Additional cooling is supplied from the CWS through a tap in the main supply header for the TCS heat exchangers and the condenser vacuum pump seal water heat exchangers. CWS design parameters are provided in Table 10.4-202.

WLS CDI The CWS consists of four 33-1/3-percent-capacity circulating water pumps, two mechanical draft cooling towers, and associated piping, valves, and instrumentation.

DCD Makeup water to the CWS is provided by the raw water system (RWS). In addition, water chemistry is controlled by a local chemical feed system.

10.4.5.2.2 Component Description

Circulating Water Pumps

WLS CDI The four circulating water pumps are vertical volute, dry pit, single-stage, mixed-flow pumps driven by electric motors. Three pumps are normally operating with one pump on standby. The pumps are mounted in a pump house with each pump in an individual pump bay. The pumps are connected to the cooling towers by discharge flumes. The four pump discharge lines combine in a single main header, at the pump house, with two discharge lines to the turbine building which connect to the two inlet water boxes of the condenser and supplies cooling water to the TCS and condenser vacuum pump seal water heat exchangers. Each pump has a discharge motor operated butterfly valve and stop logs for suction isolation. This permits isolation of each pump for maintenance.

Cooling Towers

The two mechanical draft cooling towers are round counter-flow type cooling towers with an impingement-type drift eliminator system, and a bypass system capable of passing approximately one half of the design circulating water flow to each tower directly to the cooling tower basin. Each cooling tower has 16 induced draft fans located on the top deck of the cooling tower. The cooling tower hot water distribution system has the capability to isolate each tower cell.

Each cooling tower has a diameter of approximately 360 feet and a height of approximately 85 feet. The cooling towers are located on plant grade. The cooling towers are designed to cool the water to 88°F with a hot water inlet temperature of 113°F.

The cooling tower basins serve as storage for the circulating water inventory and allow bypassing of the cooling tower during cold weather operations. The cooling tower nearest to the Unit 1 safety-related structures, systems and components (SSCs) is located over 700 ft. west of the Unit 1 auxiliary building. The cooling tower nearest to the Unit 2 safety-related SSCs is located over 600 ft. east of the Unit 2 containment building. The cooling tower basins are below grade such that a basin failure will not result in migration of water across the site. The site is graded to direct surface water flow away from the nuclear islands. A break in the cooling tower basin or the associated CWS piping will not have an adverse effect on safety-related SSCs resulting from external plant flooding. The grading of the site combined with the location and below-grade elevation of the cooling tower basins and the associated CWS piping will preclude adverse interactions with safety-related SSCs.

Cooling Towers Makeup and Blowdown

DCD The circulating water system makeup is provided by the raw water system.

WLS CDI Makeup to and blowdown from the CWS is controlled by the makeup and blowdown control valves. These valves, along with a local chemical feed system, provide chemistry control in the circulating water in order to maintain a nonscale-forming condition and limit biological growth in CWS components.

DCD Piping and Valves

WLS CDI The underground portions of the CWS piping are constructed of prestressed concrete piping. The remainder of the piping is carbon steel.

WLS COL 10.4-1 Condenser water box drains allow the condenser to be drained to the turbine building sumps.

DCD Motor-operated butterfly valves are provided in each of the circulating water lines at their inlet to and exit from the condenser shell to allow isolation of portions of the condenser.

WLS CDI Control valves provide regulation of cooling tower blowdown and makeup.

DCD The circulating water system is designed to withstand the maximum operating discharge pressure of the circulating water pumps.

WLS CDI Piping includes the expansion joints, butterfly valves, condenser water boxes, and tube bundles. The maximum pressure of the system is 90 psig.

DCD Circulating Water Chemical Injection

Circulating water chemistry is maintained by a local chemical feed skid at the CWS cooling tower.

WLS CDI CWS chemical feed equipment injects the required chemicals into the circulating water at the CWS cooling tower basin area.

DCD This maintains a noncorrosive, nonscale-forming condition and limits the biological film formation that reduces the heat transfer rate in the condenser and the heat exchangers supplied by the circulating water system.

WLS COL 10.4-1 The specific chemicals used within the system are determined by the site water conditions and are monitored by plant chemistry personnel.

DCD The chemicals can be divided into six categories based upon function: biocide, algaecide, pH adjuster, corrosion inhibitor, scale inhibitor, and a silt dispersant. The pH adjuster, corrosion inhibitor, scale inhibitor, and dispersant are metered into the system continuously or as required to maintain proper concentrations. The biocide application frequency may vary with seasons.

WLS COL 10.4-1 Raw water treatment requirements are highly dependent on the water quality of the raw water supply which also experiences seasonal variations. The Broad River provides the source of make-up water for the CWS. The Lee Nuclear Station utilizes oxidizing chemistry (e.g., sodium hypochlorite, sodium bromide, etc.) for the control of bio-fouling and the growth of algae. Sulfuric acid is added, as necessary, to adjust the pH of the CWS. During periods of high river water turbidity or other conditions when deposition may lead to an increase in microfouling, silt dispersants such as polyacrylate may be used to minimize deposition within the CWS. Based on the materials of construction for the CWS, Lee Nuclear Station has not identified a need for a corrosion inhibitor. Based on an effective pH control program and the constituency of the dissolved and suspended solids found in the Broad River no need for a scale inhibitor has been identified.

Duke Energy operates the Catawba Nuclear Station which draws its intake water from Lake Wylie on the Catawba River. The Catawba River drains the water shed immediately to the East of the Broad River Basin. Based on a similarity of the water chemistry produced by the two water sheds and the similarity in construction of the cooling towers for these plants, Catawba Nuclear Station was used as a model for the design of the chemical treatment program for the CWS at Lee Nuclear Station.

DCD

Addition of biocide and water treatment chemicals is performed by local chemical feed injection metering pumps and is adjusted as required.

WLS CDI

Chemical concentrations are measured through analysis of grab samples from the CWS. Cooling tower blowdown and pH control are utilized to maintain chemistry conditions that will minimize scaling and corrosion.

DCD

Residual chlorine is measured to monitor the effectiveness of the biocide treatment.

WLS CDI

Chemical injections are interlocked with each circulating water pump to prevent chemical injection when the circulating water pumps are not running.

10.4.5.2.3 System Operation

WLS CDI

The three normally operating circulating water pumps take suction from the cooling tower basin and circulate the water through the tube side of the main condenser with smaller flows to the TCS, the condenser vacuum pump seal water heat exchangers, and back through the piping discharge network to the cooling towers. See Figure 10.4-201. The mechanical draft cooling towers cool the circulating water by discharging the water over a network of baffles in each tower. The water then falls through fill material to the basin beneath the tower and, in the process, rejects heat to the atmosphere.

The flow to the cooling towers can be diverted directly to the basin, bypassing the cooling towers internals. This is accomplished by opening the bypass valve while operating one of the circulating water pumps. The bypass is normally used only during plant startup in cold weather or to maintain CWS temperature above 40°F while operating at partial load during periods of cold weather.

The RWS supplies makeup water to the basins of the cooling towers to replace water losses due to evaporation, wind drift, and blowdown. A separate connection is provided between the RWS and CWS to initially fill the CWS piping. This line connects to the CWS downstream of the CWS pump isolation valves.

DCD

A condenser tube cleaning system is installed to clean the circulating water side of the main condenser tubes.

WLS CDI

Blowdown from the CWS is taken from the discharge of the CWS pumps and is discharged to the blowdown sump and then to the Broad River.

DCD

The circulating water system is used to supply cooling water to the main condenser to condense the steam exhausted from the main turbine.

WLS CDI

If the circulating water pumps, the cooling towers, or the circulating water piping malfunction such that condenser backpressure rises above the maximum allowable value, the main condenser will no longer be able to adequately support unit operation.

DCD

Cooldown of the reactor may be accomplished by using the power-operated atmospheric steam relief valves or safety valves rather than the turbine bypass system when the condenser is not available.

Passage of condensate from the main condenser into the circulating water system through a condenser tube leak is not possible during power generation operation, since the circulating water system operates at a greater pressure than the condenser.

WLS CDI

Turbine building closed cooling water in the TCS heat exchangers is maintained at a higher pressure than the circulating water to prevent leakage of the circulating water into the TCS.

Cooling water to the condenser vacuum pump seal water heat exchangers is supplied from the CWS. Cooling water flow from the CWS is normally maintained through all four heat exchangers to facilitate placing the spare condenser vacuum pump in service.

DCD

Isolation valves are provided for the condenser vacuum pump seal water heat exchanger cooling water supply lines to facilitate maintenance.

Small circulating water system leaks in the turbine building will drain into the waste water system. Large circulating water system leaks due to pipe failures will be indicated in the control room by a loss of vacuum in the condenser shell. The effects of flooding due to a circulating water system failure, such as the rupture of an expansion joint, will not result in detrimental effects on safety-related equipment since there is no safety-related equipment in the turbine building and the base slab of the turbine building is located at grade elevation. Water from a system rupture will run out of the building through a relief panel in the turbine building west wall before the level could rise high enough to cause damage. Site grading will carry the water away from safety-related buildings.

WLS CDI

The cooling towers are located so that collapse of the towers have no potential to damage equipment, components, or structures required for safe shutdown of the plant.

DCD

10.4.5.3 Safety Evaluation

The circulating water system has no safety-related function and therefore requires no nuclear safety evaluation.

10.4.5.4 Tests and Inspections

Components of the circulating water system are accessible as required for inspection during plant power generation. Performance, hydrostatic, and leakage tests associated with preinstallation and preoperational testing are performed on the circulating water system. The system performance and structural and leaktight integrity of system components are demonstrated by continuous operation.

10.4.5.5 Instrumentation Applications

WLS CDI

Instrumentation provided indicates the open and closed positions of motor-operated butterfly valves in the circulating water piping. The motor-operated valve at each pump discharge is interlocked with the pump so that the pump trips if the discharge valve fails to reach the open position shortly after starting the pump.

Local grab samples are used to periodically test the circulating water quality to limit harmful effects to the system piping and valves due to improper water chemistry.

Pressure indication is provided on the circulating water pump discharge lines.

DCD

A differential pressure transmitter is provided between one inlet and outlet branch to the condenser. This differential pressure transmitter is used to determine the frequency of operating the condenser tube cleaning system (CES).

WLS CDI

Temperature indication is supplied on the individual branch CWS inlet headers to the TCS heat exchanger trains. This temperature is also representative of the inlet cooling water temperature to the main condenser.

A flow element is provided on the common discharge line from the TCS heat exchangers to allow monitoring of the total flow through the TCS heat exchangers. Flow measurement for the raw water makeup to the cooling towers and for the blowdown for the cooling towers is also provided.

Level instrumentation provided in the circulating water cooling tower basins activates makeup flow from the RWS to the basins of the cooling towers when required. Level instrumentation also annunciates a low-water level in the pump structure and a high-water level in the basins of the cooling towers.

WLS COL 10.4-1

The circulating water chemistry is controlled by the cooling tower blowdown and chemical addition, to maintain the circulating water with an acceptable Stability Index range of approximately 6 to 7. The system accomplishes this by regulating the blowdown valve.

DCD

The control approach is to allow the makeup water to concentrate naturally to its upper limit. Provisions are made to add chemicals for pH control.

WLS CDI

The cycles of concentration at which the cooling towers are operated is dependent on the quality of the cooling tower makeup water. The blowdown of the cooling towers is discharged to the blowdown sump and ultimately to the Broad River.

DCD

Monitoring of the circulating water system is performed through the data display and processing system. Control functions are performed by the plant control system. Appropriate alarms and displays are available in the control room. See Chapter 7.

10.4.7.2.1 General Description

Replace the last sentence of the sixth paragraph of DCD Subsection 10.4.7.2.1 as follows.

WLS COL 10.4-2 The oxygen scavenger agents are hydrazine and carbohydrazide. The pH control agents are dimethylamine and methoxypropylamine.

STD SUP 10.4-2 Oxygen scavenging and ammoniating agents are selected and utilized for plant secondary water chemistry optimization following the guidance of NEI-97-06, "Steam Generator Program Guidelines" (Reference 201). The EPRI Pressurized Water Reactor Secondary Water Chemistry Guidelines are followed as described in NEI 97-06.

Add new paragraph at the end of DCD Subsection 10.4.7.2.1:

STD SUP 10.4-1 Operations and maintenance procedures include precautions, when appropriate, to minimize the potential for steam and water hammer, including:

- Prevention of rapid valve motion
- Process for avoiding introduction of voids into water-filled lines and components
- Proper filling and venting of water-filled lines and components
- Process for avoiding introduction of steam or heated water that can flash into water-filled lines and components
- Cautions for introduction of water into steam-filled lines or components
- Proper warmup of steam-filled lines
- Proper drainage of steam-filled lines
- The effects of valve alignments on line conditions

10.4.12 COMBINED LICENSE INFORMATION

10.4.12.1 Circulating Water System

WLS COL 10.4-1 This COL Item is addressed in Subsection 10.4.5.2.

10.4.12.2 Condensate, Feedwater and Auxiliary Steam System Chemistry Control

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WLS COL 10.4-2 This COL Item is addressed in Subsection 10.4.7.2.1.

10.4.12.3 Potable Water

Replace the existing paragraph with the following:

WLS COL 10.4-3 The potable water is being supplied by the municipal water system of Draytonville Water District for domestic and human consumption, as specified in FSAR Subsection 9.2.5.2.1. No additional onsite treatment is required for this supply of water.

10.4.13 REFERENCES

201. Nuclear Energy Institute, "Steam Generator Program Guidelines," NEI 97-06, Revision 2, May 2005.

TABLE 10.4-201
SUPPLEMENTAL MAIN CONDENSER DESIGN DATA

	Condenser Data	
WLS CDI	Circulating water flow	600,000 gpm

Note: This table supplements DCD Table 10.4.1-1.

WLS COL 10.4-1

TABLE 10.4-202
DESIGN PARAMETERS FOR MAJOR CIRCULATING WATER SYSTEM COMPONENTS[(a)]

Circulating Water Pump	
Quantity	Four per unit (includes one spare)
Flow rate (gal/min)	210,000
Mechanical Draft Cooling Towers	
Quantity	Two per unit
Approach temperature (°F)	9
Inlet temperature (°F)	113
Outlet temperature (°F)	88
Approximate temperature range (°F)	25
Flow rate (gal/min)	614,600
Heat Transfer (Btu/hr)	$7,624 \times 10^6$
Wind velocity design (mph)	110
Seismic design criteria per Uniform Building Code	

a) This table replaces DCD Table 10.4.5-1.