Westinghouse Technology Systems Manual

Section 14.3

Condenser Circulating Water System

TABLE OF CONTENTS

LIST OF FIGURES

14.3 CONDENSER CIRCULATING WATER SYSTEM

Learning Objective:

1. State the purpose of the Condenser Circulating Water System.

14.3.1 Introduction

The primary purpose of the condenser circulating water system is to supply cooling water to the condensers of the main turbines. This system also provides water for auxiliary cooling equipment and provides an efficient means of rejecting waste heat from the power generation cycle into the ambient surroundings. In addition, due to its capacity and convenience, this system is used to dilute and disperse the potentially low-level radioactive waste from the blowdown of the steam generators.

14.3.2 System Description

The condenser circulating water system, as shown in Figure 14.3-1, consists of three circulating water pumps that take suction on the pumping station forebay. The circulating water passes under a skimmer wall. The skimmer wall prevents trash from entering the intake channel and allows cooler subsurface water to flow into the forebay. The circulating water flows into the intake structure through trash racks and then through a traveling screen. The traveling screen has 3/8-inch square openings to trap smaller pieces of trash that may have gotten by the skimmer wall and the trash racks.

The intake structure has three pits. Each condenser circulating water pump has its own pit from which to take suction and discharges through an 84-inch conduit pipe. The individual conduits combine to form a 13'6'' by 13'6" concrete supply conduit that runs to the condenser. The water makes one pass through the condenser with a resulting maximum temperature rise of 29.5°F, which is the limit imposed by environmental Technical Specifications.

From the condenser, water flows from individual discharge lines into a 13'6" by 13'6" concrete discharge conduit that dumps the water into the discharge pond. The flow is then directed to the cooling towers via the cooling tower lift pumps, or bypasses the lift pumps and is directed into the diffuser pond. From this point the water is directed back to the ultimate heat sink.

14.3.3 Component Descriptions

14.3.3.1 Circulating Water Pumps and Valves

The circulating water pumps are slow-speed (250 rpm), vertical, single-stage pumps rated at 1750 horsepower. Each pump has a design capacity of 187,000 gpm, with a design discharge head of 30 feet. The pump motors are powered from 4160-Vac busses. The discharge valves are 84-inch butterfly valves. To prevent overheating

the circulating water pump motors (overheating will occur if a pump is operated against its shut-off head for greater than one minute), the discharge valves are interlocked with the condenser circulating water pump start switches. Therefore, when a circulating water pump is started, its associated discharge valve opens.

14.3.3.2 Condenser

The main condenser is described in Section 7.2. A vacuum-priming system takes suction on the condenser shell water boxes to remove any noncondensible gases that may have accumulated in the upper region of the water box. This system is used to ensure that the uppermost condenser tubes are completely filled with water.

14.3.3.3 Cooling Towers

The shape of the cooling tower stack is circular in plan, and hyperbolic in profile. From a strictly thermodynamic point of view, the tower shape does not have to be hyperbolic. It could be cylindrical in shape. The momentum of entering air forms a vena contracta (as a fluid or gas flows past an orifice plate, the flow achieves its narrowest cross section somewhat downstream of the plane of the plate), the dimensions of which vary with the ratio of the tower's diameter to the height of the air inlet of the base. Cooling tower designers taper the shell of the cooling tower to follow the diameter of the vena contracta, producing considerable savings in material and cost. Also, the hyperbolic shape stiffens the concrete shell against wind forces.

Air flow through the hyperbolic tower is produced by differences in air density. In operation, heavier outside air is drawn in from around the base of the cooling tower. This air displaces the lighter saturated air in the tower, forcing it up and out the top of the tower. In fact, the cooling tower works like a conventional chimney, except that water saturation rather than heat causes the changes in air density that are responsible for the air movement.

Unlike a mechanical-draft cooling tower whose fan moves a fixed volumetric flow rate of air regardless of its density, a hyperbolic unit's air flow varies with changing atmospheric conditions. Optimum performance is obtained when the air humidity is high: the higher the relative humidity, the cooler the outlet water. Operation is satisfactory at a low relative humidity, but there is an economic limit to the lower level of application: about 35 percent relative humidity for design conditions. Below this relative humidity value, the size and the cost of the tower increase dramatically.

Many nuclear units use natural-draft cooling towers to provide cooling for the condenser circulating water and the service water systems. In addition, to the cooling towers, water must be pumped into the basin of the cooling towers. This is accomplished with cooling tower lift pumps. These pumps (usually three or four pumps per cooling tower) are capable of supplying 187,000 gpm per pump.

14.3.4 System Features and Interrelationships

14.3.4.1 Condenser Tube Cleaning

The condenser tubes are cleaned by an Amertap system. This system, which includes a nonclogging centrifugal pump, strainer screens, distribution piping, and a removable visual inspection port (for checking, removing, and adding new balls), maintains the condenser tubes in a clean, polished form at all times. Elastic sponge rubber balls (slightly larger in diameter than the condenser tubes) are pumped into the condenser supply water boxes, forced through the condenser tubes, and then collected via screen traps in the discharge water boxes of the condenser. The balls are about the same density as water, so they are evenly distributed among all the tubes. When the balls are too small to effectively clean the tubes, they are systematically removed from the system. During normal operation, approximately 250 - 350 balls are replaced on a weekly basis. The total number of balls in the system is selected so that each condenser tube receives a ball on an average of every five minutes with a single ball making approximately four passes per minute through the condenser.

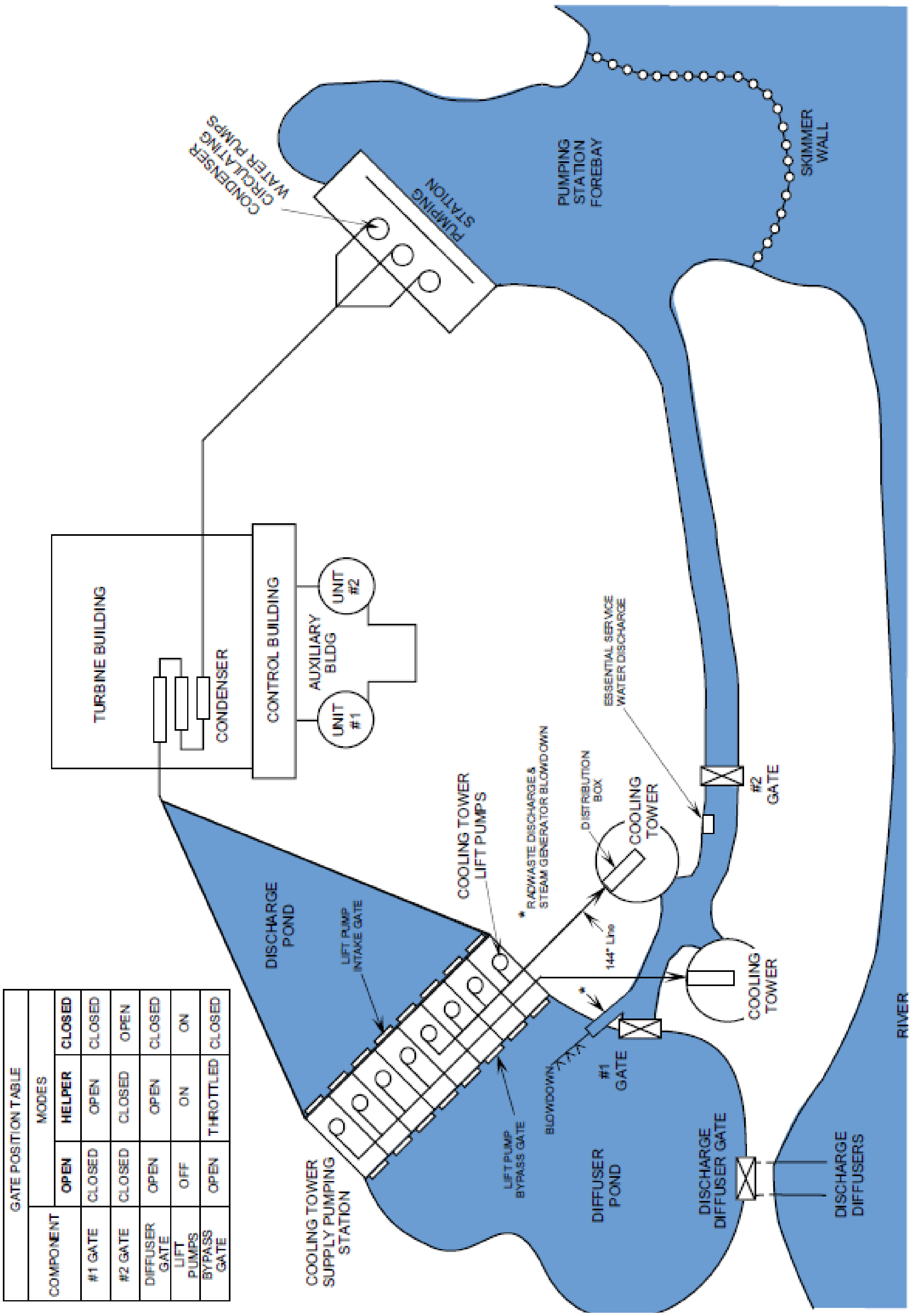
14.3.4.2 Modes of Operation

Due to Environmental Protection Agency guidelines, the temperature of the water returned to the ultimate heat sink cannot be 5.4°F greater than the temperature of the water taken from the ultimate heat sink. With these guidelines in effect, the condenser circulating water system is operated in one of the following three modes; open, closed, or helper. (See Figure 14.3-1.)

In the open mode, circulating water bypasses the cooling towers and enters the diffuser pond for release directly to the river. Gates number 1 and 2 are closed, while the diffuser sluice gate is open. Water is discharged from the diffuser pond to the ultimate heat sink via a corrugated metal discharge diffusion pipe. For a two-unit site, there would be two diffusion pipes. Two sluice gates are provided, which allow one diffuser pipe to be closed off when only one unit is in operation.

In the closed mode, circulating water is sent to the cooling towers. From the cooling towers water flows through gate number 2 back to the pumping station forebay. Gate number 1 and the diffuser sluice gate are closed. In addition, when the system is operating in this mode, liquid radioactive waste cannot be discharged into the canal.

Finally in the helper mode, a portion or all of the circulating water is sent to the cooling towers before entering the diffuser pond. Gate number 2 is closed, while gate number 1 and the diffuser sluice gate are open.



GATE POSITION TABLE

COMPONENT	MODES		
	OPEN	HELPER	CLOSED
#1 GATE	CLOSED	OPEN	CLOSED
#2 GATE	CLOSED	CLOSED	OPEN
DIFFUSER GATE	OPEN	OPEN	CLOSED
LIFT PUMPS	OFF	ON	ON
BYPASS GATE	OPEN	THROTTLED	CLOSED

Figure 14.3-1 Circulating Water System