Close

Nuclear Plant Efficiently Removes Calcium Carbonate From Condenser Tubes

Teresa Hansen, Section Editor

The South Texas Project (STP) Nuclear Power Plant in Wadsworth, Texas, was put into operation in 1988. The plant has two condenser units, acting as heat exchangers to condense the steam back into a liquid state after it passes through the turbines. It is imperative that the water/steam in its closed-loop system remain free of any contaminants to maintain integrity. Likewise, the 96,234 titanium condenser tubes in each of the two units should be kept as clean as possible to ensure optimal condensing efficiency. Makeup water for the circulating water system is pumped from the nearby Colorado River and sent to the facility's 7,000-acre, 18-foot-deep holding reservoir adjacent to the plant.

STP's 7,000 acre reservoir with inlet pipes to the condensers are pictured here. Photo courtesy of Conco Systems Inc.

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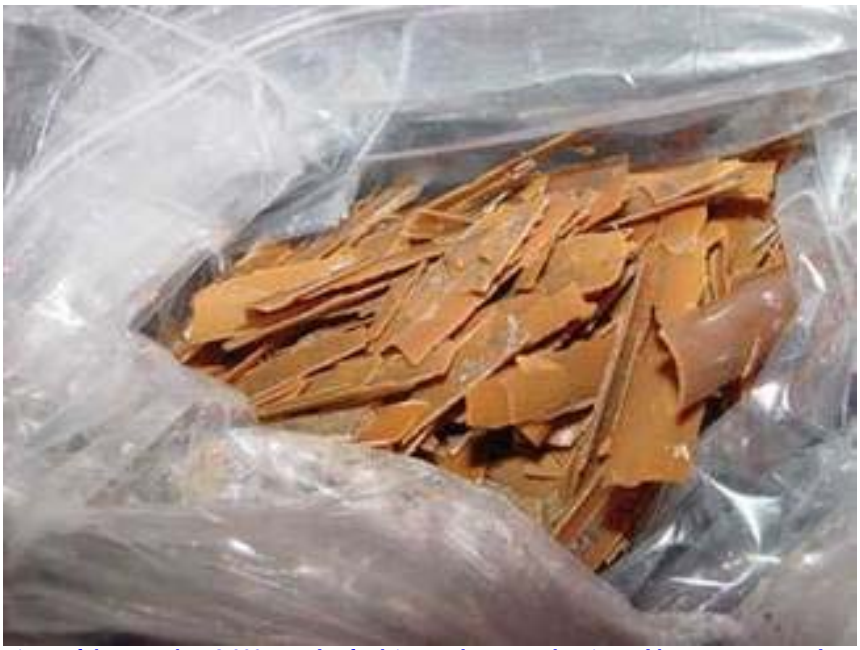
The reservoir was constructed on top of what had been farmland; the sides were formed from a mixture of sand and cement called "soil cement." A stair-step pattern that runs from the bottom of the reservoir to the top of the side walls helps keep the lake's waves from eroding the walls. A system of two traveling screens removes debris

from the water. One screen removes debris from the water that is pumped from the river and the other screen removes debris from the water pumped from the reservoir to the condensers, with a return flow of the now-heated water back to the reservoir. The circulation of the reservoir water itself is designed to keep the entering and exiting condenser water separate for proper cooling, as well as distance it from the river water entrance to allow adequate settling of matter drawn in through the pumping station with the river water.

Studies show that poor condenser performance is one of the single largest causes of energy loss in power generation; therefore, condenser maintenance cannot be ignored. Maintenance of STP's two condenser units includes annual inspection and condenser tubesheet cleaning. In the early 1990s, STP personnel determined that the Unit 1 condenser tubes required cleaning. Plant personnel made two cleaning attempts using technology available at that time, one by hydrolazing/hydroblasting and the other with metal bladed scrapers. Neither of these methods worked, so plant personnel tried chemical cleaning with an acid bath, which was successful. In 2001, STP cleaned the Unit 1 tubes again, this time with a mechanical tube shooting method, using nylon brushes. Shortly after the Unit 1 cleaning, STP used this same method, except with metal-bladed scrapers, to remove debris from Unit 2's condenser tubes.

In September 2006, STP personnel inspected some of the Unit 1 tubes and found scale deposit inside the tubes that proved on analysis to be a tenacious form of calcium carbonate, or calcite ($CaCO_3$). While tube fouling itself is detrimental to plant performance and turbine backpressure, at STP it usually consists of various degrees of sediment and biologic growth. This can include algae to bryozoa, and clams and mussels, the removal of which is not especially difficult.

Calcium carbonate scale, however, poses a serious problem that, until recently, defied standard removal procedures. It is a crystalline compound found in such materials as limestone and marble. At STP, personnel tested 20 tube samples and determined the thickness of the calcium carbonate ranged from 7.6 mils to 31.2 mils, with an average of 19.06 mils. Some tubes were blocked completely.



Pieces of the more than 8,000 pounds of calcium carbonate scale, pictured here, were removed from the tubes of STP's two condenser units. Photo courtesy of Conco Systems Inc.

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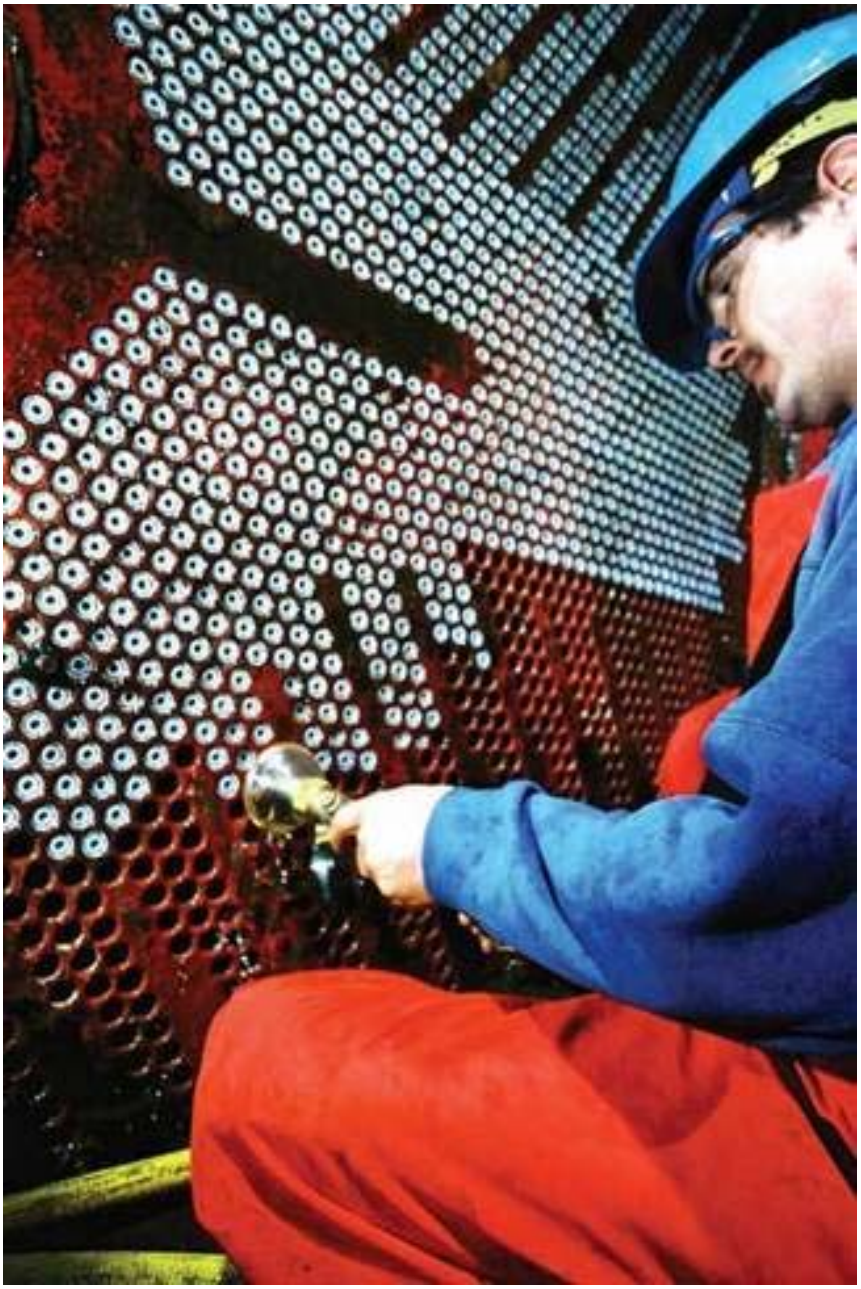
William Moye, an STP systems engineer responsible for the circulating water system, noted that condenser performance was continuing to deteriorate due to the increasing scale on the inside diameter (ID) of the tubes, as well as debris clogging the tubes. Some erosion of the outlet tubesheets was also noted. Moye prepared a plan of action that included bringing in a contractor who could remove the scale and meet the plant's time restraints. The selection process required the bidding contractors to perform test cleaning of several tubes to ensure each one's process was capable of removing the scale. This also helped personnel establish a time line for cleaning all of the tubes. The contractor would provide water powered tube cleaners, specially designed scale cutters, tube drilling equipment, qualified personnel and other tools needed to thoroughly clean and open the tubes. Because it was extremely difficult and expensive to clean-up and dispose of the waste chemicals, STP did not consider chemical cleaning.

Following a bidding process, STP's management selected Conco Systems Inc. Conco Systems arrived on-site with a team of trained personnel and a supply of mechanical tube cleaners called "Cal-Busters," designed to break the stratified calcium carbonate deposits. The cleaner has two rows of four carbide wheels mounted through its circumference. These wheels act like glass cutters when they come into contact with the calcium carbonate scale.



A technician shoots Conco "Cal-Buster" calcium carbonate cutting tube cleaners through the condensor tubes. Photo courtesy of Conco Systems Inc.

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The unit itself has six water boxes, each containing more than 16,000, 55-foot-long, 3/4-inch titanium tubes. An initial test cleaning was conducted in the first water box with inspection showing that $CaCO_3$ scale had reduced the inside tube dimensions to a range of 0.655 inches to 0.673 inches. The inside tube diameter by design should be 0.694 inches. In addition, almost 20 percent of the tubes were blocked with sediment and scale to the point where there was little or no flow evident.

The team determined that the best cleaning procedure was going to be one pass with undersized Conco C4S metal-bladed cleaners, followed by multiple passes of various sized Conco Cal-Buster calcium carbide cutting cleaners, which are stepped in seven sizes for inside diameters ranging from 0.620 inches to 0.694 inches. After the scale had been fractured by the calcium carbide cutting cleaners, a final pass was made in each tube by a 0.694 inch metal-bladed Conco C4S mechanical cleaner to remove the fractured scale. After cleaning all the tubes in the water box, the team conducted a light inspection, which involved shining a bright spotlight down the tubes while performing a visual inspection from the opposite end. If the light was not evident, the tube in question was re-shot until it was fully open to water flow or it was marked accordingly for map plotting. During the light inspection, the team discovered that most tubes were clean, with little or no sign of scale and only a few tubes required plotting for future attention.

Conco "Cal-Buster" calcium carbonate tube cleaner, Conco standard C4S type metal-bladed tube cleaner and calcium carbonate scale removed from one of the condenser tubes is pictured here. Photo courtesy of Conco Systems Inc.

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Working in teams of eight operators per 12-hour shift, around the clock, it took approximately five-and-a-half days to clean each water box. Each team used four Conco Model 200B two-gun water pump systems that shot the tube cleaners with 200 to 300 psi water pressure. Three pumps were used on the inlet side and one was used on the outlet side when back-and-forth shooting was required to free the occasionally stuck cleaner.

The next two water boxes were similarly cleaned, but the fourth water box presented an additional problem. In the

fourth water box, more than 50 percent of the tubes were completely blocked in the top 20 rows. The team determined that these tubes could be cleaned, but additional time would be required to drill and flush them prior to shooting the cleaners. Personnel used a flexible shaft drilling system with a 0.650-inch drill to remove enough of the deposit so that the calcium carbonate cutting tube cleaners would be effective. Because of the calcium carbonate scale, the upper tube inside diameter measurements ranged from 0.583 inch to 0.690 inch. After cleaning with the calcium carbonate cutting cleaners and metal-bladed follow-up cleaners, light inspection showed the tubes were clean and scale free. The team successfully cleaned the remaining water boxes using the two types of tube cleaners. They occasionally had to perform flexible-shaft drilling to gain access in tubes that had been completely blocked.

In all, seven-and-a-half cubic yards of calcium carbonate, weighing more than 5,000 pounds, was removed from the 96,234 condenser tubes in Unit 1. Shortly after, the same number of condenser tubes in Unit 2 were cleaned using the same method, and more than four cubic yards of calcium carbonate-weighing a little more than 3,000 pounds-was removed. STP personnel believe the tubes in Unit 2 were less fouled because they had been cleaned with metal-bladed mechanical tube cleaners in 2001, while the tubes in Unit 1 had been cleaned with nylon brushes that left ridges inside the tubes, promoting faster build-up of debris and scale.

As a result of the condenser tube cleaning and removal of the calcium carbonate scale, STP reports significant improvement in power production. STP plans to establish a preventive maintenance cleaning regimen utilizing one pass of standard metal-bladed tube cleaners to prevent the severe fouling that was observed and slow the buildup of scale.
