US Army Corps
of Engineers
Waterways Experiment
Station

Zebra Mussel Research Technical Notes

March 1995

Use of Thermal Treatment at Shawnee Fossil Fuel Plant

Background

In early April 1994, the Tennessee Valley Authority (TVA) conducted a test of a zebra mussel thermal treatment process on the condenser circulating water (CCW) intake tunnel and pump pit of Unit 9 at its Shawnee Fossil Fuel Plant near Paducah, KY. The Zietren process, developed by First Thermal Systems (FTS), Inc., of Chattanooga, TN, was selected as the process to be tested. The purpose of this technical note is to describe the field test and its results.

Additional information

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Zietren process

The intake tunnel of Unit 9 at the TVA Shawnee Fossil Fuel Plant was thermally treated using the Zietren process. The Zietren process is a controlled-heat sourcing process that can be installed onsite for any situation in which the water volume can be isolated. Zietren is a specially formulated thermal fluid that acts as the heat transfer medium. It is continually circulated through the helical coil of a Villam high- efficiency helical coil heater. The heat developed in the Villam is transferred to the intake water at a temperature above the lethal limits of the zebra mussel.

Temperature tolerances of zebra mussels

Two strategies exist for thermal mitigation of zebra mussel macrofouling of raw water systems. The first strategy involves maintaining the temperature of a water system at a constant lethal level for an extended period, inducing 100-percent kill among zebra mussel infestations. The second strategy entails raising water temperatures at a constant rate, until an instantaneously lethal temperature for 100-percent mussel mortality is reached. The temperature required for 100-percent mortality in each strategy is considered the chronic temperature and acute temperature, respectively.

Prepared and published by the Zebra Mussel Research Program, U.S. Army Engineer Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199.

The intent of the field test was to raise the water temperature in the intake tunnel from an approximate initial temperature of 60 ºF to 105 ºF, above the zebra mussel's acute upper lethal temperature (AULT). Using the equation given in McMahon and others (1993), the acute temperature for zebra mussels acclimated to approximately 55 ^{o}F was determined to be at most 97 ^{o}F. It is speculated that as water temperature rises and nears the AULT, zebra mussels release their byssal threads from the substrate to which they are attached and find a more "suitable" environment. This approach makes posttreatment inspection simpler and alleviates cleaning.

Temperature of intake tunnel

Treatment area

The CCW intake tunnel to be treated begins at the CCW pump discharge valve and ends in the condenser waterboxes. The intake tunnel of Unit 9 traverses a length of approximately 938 ft, beginning with a 6.5-ft-diam circular tunnel, 613 ft long, terminating in a 325-ft-long tunnel 6.5 by 5.5 ft. When sealed at the pump discharge valve and condenser waterboxes, the tunnel holds 347,093 gal of water.

Pretreatment inspection

Before treatment, the intake was completely drained for inspection. The previous dewatering occurred approximately 18 months earlier. Zebra mussel concentrations as high as three per square inch were found during this inspection. The mean zebra mussel shell length was 0.612 in. with a minimum length of 0.118 in. and maximum of 1.23 in. The highest concentration of infestation occurred near the end of the intake tunnel where the water enters a larger cavity as a precourse to entering the condenser intake waterboxes.

No zebra mussels were found in the initial portion of the intake tunnel. This is attributed to the fact that water velocities are higher through the narrower, circular section of the tunnel. The condenser waterboxes had been dewatered long enough to have killed any zebra mussels in the upper sections.

Retrofication

Following inspection, the intake tunnel was sealed and retrofitted to accommodate the Zietren process. The setup is illustrated in Figure 1. A pump was used to draw water out of a condenser waterbox and return it to the heat exchanger. Rubber hoses and polyvinyl chloride piping were used for the other connections. FTS' trailer-mounted heat source was stationed outside the facility. Four thermometers to measure the water temperature were installed in the rectangular tunnel through a manway at depths of 6, 28, 49, and 70 in. (measured from the tunnel floor).

Treatment process

Upon completion of the retrofication and setup, the intake tunnel was filled with water. The unique shape of the intake tunnel, decreasing in elevation from the intake structure to the entrance of the condenser waterboxes, allowed only the infested area to be filled with water. This decreased the volume of water to be heated to 83,000 gal, reducing treatment time and cost. Cooler water was drawn out the terminus end (entrance to the waterbox) of the tunnel and pumped to the heat source. Heated water exited the Villam and was returned to the water volume toward the entrance of the tunnel, to aid in water mixing.

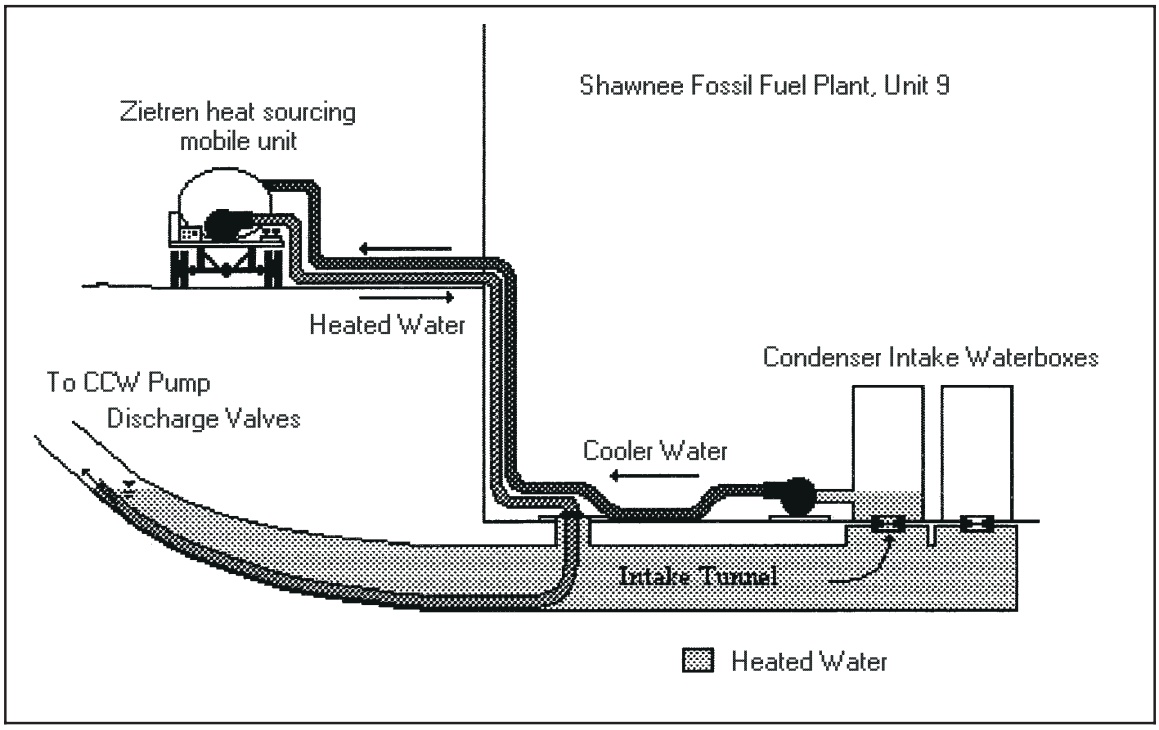

Figure 1. Schematic of thermal treatment of the condenser circulating water intake tunnel

The initial water temperature within the intake tunnel ranged from 58 to 85 ^{o}F. Within 2 hr, water temperatures exiting the Villam heat chambers had reached 125 ^{o}F. Figure 2 illustrates the change in water temperature recorded by the four thermometers over time. As illustrated by the figure, surface water temperatures in the intake tunnel continued to heat while the deeper water levels remained cooler. Through approximately 2 hr of thermal treatment, the thermometer readings were 55, 59, 98, and 111 ^{o}F, respectively. A decision was made to discontinue the heating process and slowly drain the water, gradually exposing the zebra mussels to the hotter surface water and causing the zebra mussels to either release from the walls or die.

As illustrated in Figure 2, the lower depths of the tunnel were exposed to water temperatures above the lethal limit of the zebra mussels as the water drained. Thermometers left exposed after the water drained recorded the temperature of the warm humid air resulting from the treatment, approximately 91 ^{o}F.

Posttreatment inspection and results

On April 7, 1994, the drained tunnel was inspected. No zebra mussels were found alive. Zebra mussels that were found on the tunnel walls and ceiling were gaping and held in place by algae growth, not byssal threads. This indicates that as the water temperatures rose, the zebra mussels had released themselves prior to dying. Many dead zebra mussels were found on the floor of the tunnel.

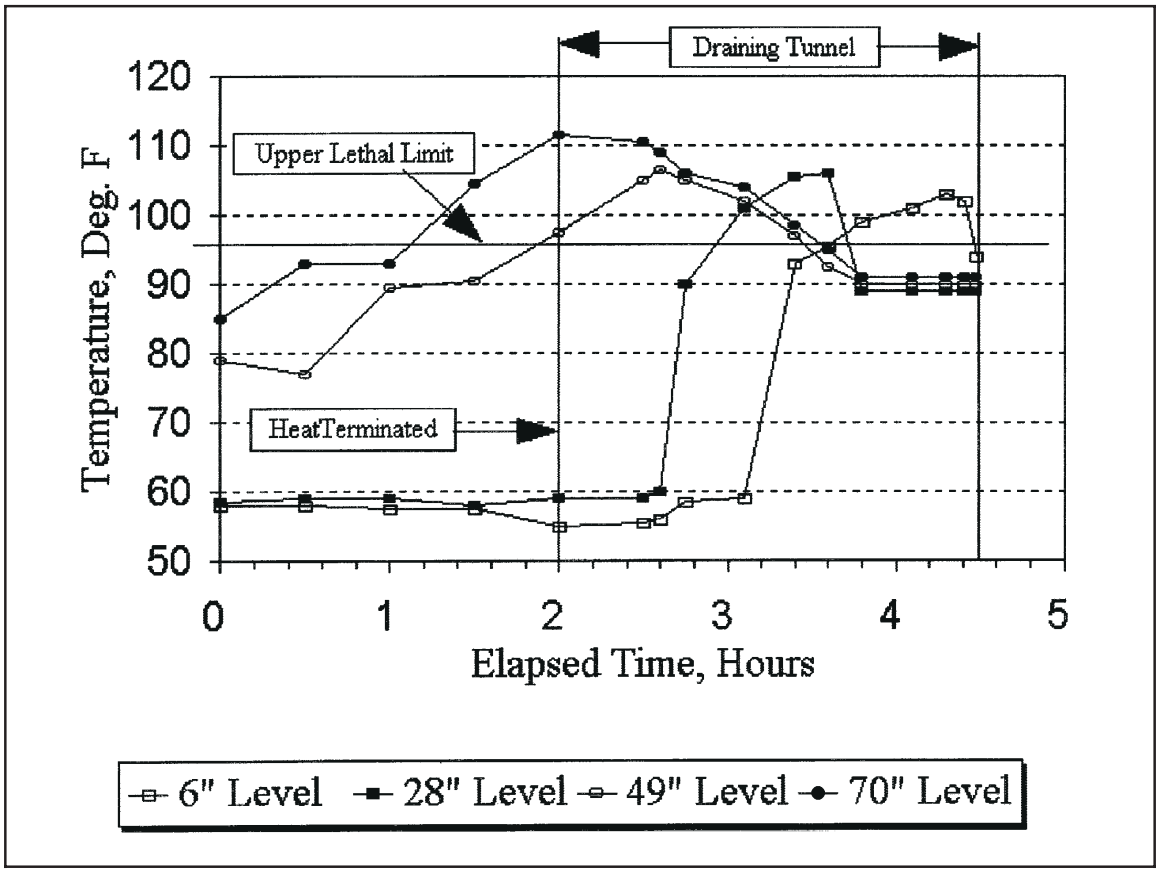

Figure 2. Temperature change over time at four depths in the condenser circulating water intake tunnel (measured from the tunnel floor)

Treatment of pump pits

The CCW pump pit 9 receives raw water directly from the Ohio River and pumps it to the Unit 9 condenser circulating waterbox via the condenser circulating intake tunnel. The pump pit is 27 ft long and 15.6 ft wide, with its depth dependent on river elevation. Normal river elevation is 300 ft, resulting in a depth of 23.5 ft. On April 14, 1994, the river level was approximately 25 ft above normal levels, resulting in a pump pit depth of 52.5 ft. The volume of the pump pit was approximately 285,000 gal.

On April 7, the Zietren mobile unit was moved into position to treat the pump pit, and the preliminary piping connections were completed. After cleaning and setting the stop logs, an attempt was made to drain the pit using the circulating pumps. The high water level and a valve not completely closed contributed to leaks which prevented drainage of the pump pit. Treatment was delayed for a week to allow divers time to properly set the stop logs and complete the closing of the valve.

On April 13, little improvement was gained in attempting to drain the pump pits, and application of the thermal process with the present state of the pits was unsuccessful. On April 14, the valve was closed using an air motor but continued to leak. Thermal treatment was again initiated. Following 18 hr of application, the water discharge temperature leaving the Villam heat source unit had reached and leveled off at 101 ^{o}F. Subsequent heating would not be effective, as the heat input was in balance with the heat loss. The top 4 ft of water in the pump pit had increased from 64 to 89 ^{o}F.

Summary The thermal treatment of the CCW intake tunnel for the eradication of zebra mussels was considered a success. Zebra mussels had released their byssal threads prior to dying, which allowed many of the organisms to be flushed out with the draining water. In the posttreatment tunnel, a few dead zebra mussels were left attached to the walls.

The inability to completely isolate the water volume in the CCW pump pit made thermal treatment ineffective. Heat gains were balanced by heat losses through the leaking valve and stop logs. To conduct successful thermal treatments, the components needed to isolate and drain a section for treatment must be in good operating condition.

Reference

McMahon, R. F., Ussery, T. A., Miller, A. C., and Payne, B. S. 1993. "Thermal Tolerance in Zebra Mussels (*Dreissena polymorpha*) Relative to Rate of Temperature Increase and Acclimation Temperature," *Proceedings: Third International Zebra Mussel Conference, 1993*, pp 97-118.