

# Condenser cleanliness program saves electric utility over \$1 million



## BACKGROUND

In today's energy market, projects that bring a condenser close to the Carnot Efficiency – the theoretical maximum efficiency – mean lower generating costs and higher output.

There is no single, perfect methodology for condenser performance monitoring. It is best to use several methodologies to gauge performance.

- Condenser Pressure Differential
- Discharge Temperature
- Hotwell Temperature
- Generation Output
- Cleanliness Factor
- Condenser Backpressure

## SITUATION

Nine Mile Point Nuclear Station is located on Lake Ontario in Scriba, New York just outside Oswego. The plant operates two boiling water reactors (BWR's) generating about 1,700 MW per year.

Nine Mile Point has a once-through, parallel flow condenser with two water boxes. The unit draws cooling water



**Figure 1** - Nicolas Carnot, the French physicist who developed the theoretical basis of modern thermodynamics. His ideal heat engine defines the maximum efficiency of a reversible thermodynamic process, the Carnot Efficiency.

from Lake Ontario, which varies from about 35°F (2°C) to approximately 75°F (24°C) (Monthly Average Temperature), as shown in Figure 2.

In the cooler months, when lake temperatures are at their lowest, condenser fouling impact is low. As lake temperatures rise, the impact of existing fouling increases. Biological activity also increases during the summer months. As shown in Figure 3, the condenser fouling factor varies throughout the year, in response to changing temperatures.

## CUSTOMER IMPACT

Gained 20 MW of generating capacity



## ECONOMIC RESULTS

Economic recovery of \$1.05 million



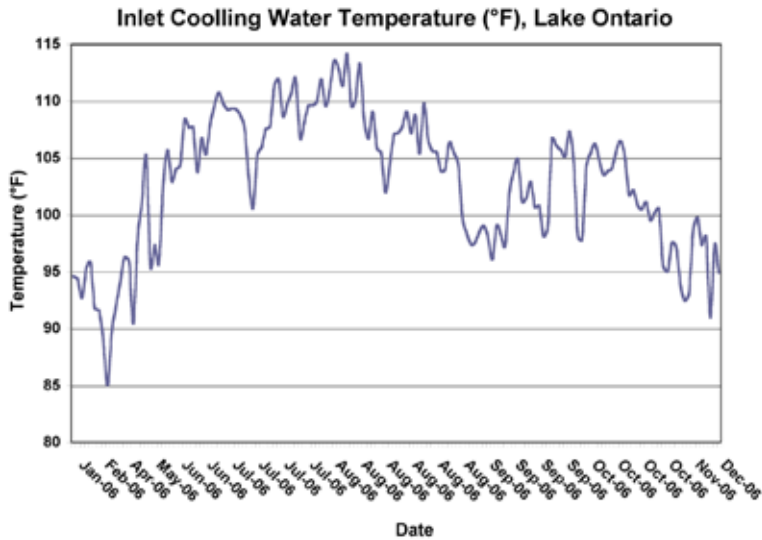


Figure 2 - Cooling Water Temperature varied throughout the year.

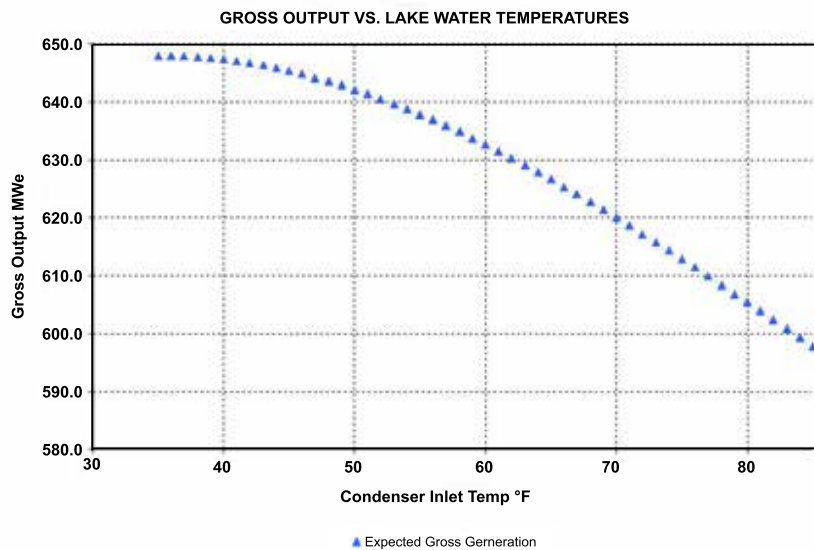
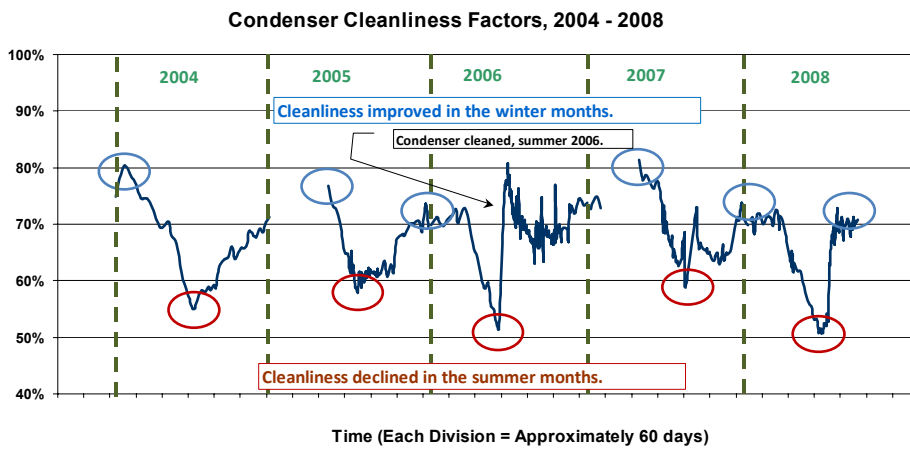


Figure 3 - Gross Output vs. Lake Temperature

The impact of condenser fouling was greatest during the even years, the second year of each two-year refueling cycle. This, coupled with high temperatures during the summer months, resulted in condenser back pressures and discharge temperatures approaching, respectively, their manufacturer and state-mandated limits.

Figure 4 shows the output curves for the years prior to the de-silting of Unit 1's condenser. In the second week in June 2006, Unit 1's condenser was cleaned to avoid problems caused by excessive back pressures predicted for August. Following the cleaning, periodic chemical treatments were started. Their frequency increased over time. Cleaning, in conjunction with chemical injection, improved plant performance for the remainder of the cycle. This improvement in generation continued through the first half of the cycle started in 2007. In 2008, the cycle started to repeat and back pressure curves predicted that operations would again face challenges during high lake temperature months.



**Figure 4** - Condenser Cleanliness Factors varied with the seasons.

### SOLUTION

The efficacy of a cleaning program was proven, but holding the gains from any cleaning required follow-on maintenance. A team formed to address the issue developed an online condenser cleaning program designed to restore condenser performance by removing the maximum amount of fouling deposits in the shortest period of time. A maintenance dispersant program would hold the gains.

Organic material and microbial deposits bind inorganic material like silt, iron oxides and other solids into amorphous, insulating deposits. High-level halogenation, using bleach, oxidised the microbial deposits and made the cleaning environment more alkaline. The bleach was followed up with bromine, which improved microbial kill and penetrated the deposits. A bio-detergent was added to disperse and flush the deposits from the system.

Following the chemical cleaning, Total Residual Halogen (TRO) was reduced – using sodium bisulfite – to meet the plant’s discharge requirements.

Holding the gains achieved by the chemical cleaning required new technology. 3D TRASAR™ Technology, part of the comprehensive OMNI Condenser Performance program, combines an inert, fluorescent signal with a fluorescent functionality attached to a polymer backbone – a chemical “tag” which reacts to stress on the dispersant polymer – to deliver superior dispersion and deposit control.

Measured using a multi-channel fluorometer, the inert material acts as a benchmark, a measure of total polymer present. The chemical tag, measured by a different channel in the fluorometer, registers the amount of active polymer present. Comparing the concentrations of inert and active polymer – and the rates at which they change – delivers dispersant control based on the amount of dispersant needed at any given time.

### RESULTS

The Condenser Fouling Factor, calculated using The Heat Exchanger Institute’s methodology, provides a direct indicator of condenser performance. It is the ratio of the existing to the expected overall heat transfer coefficient.

$$CF = U_m/U_o$$

The overall heat transfer coefficient is derived from the heat balance across the condenser.

$$U_m = Q/A(LMTD)$$

Where:

$U_m$  = Measured heat transfer coefficient Btu/hr-ft<sup>2</sup>-°F

$U_o$  = Expected heat transfer coefficient Btu/hr-ft<sup>2</sup>-°F

$A$  = Effective heat transfer surface ft<sup>2</sup>

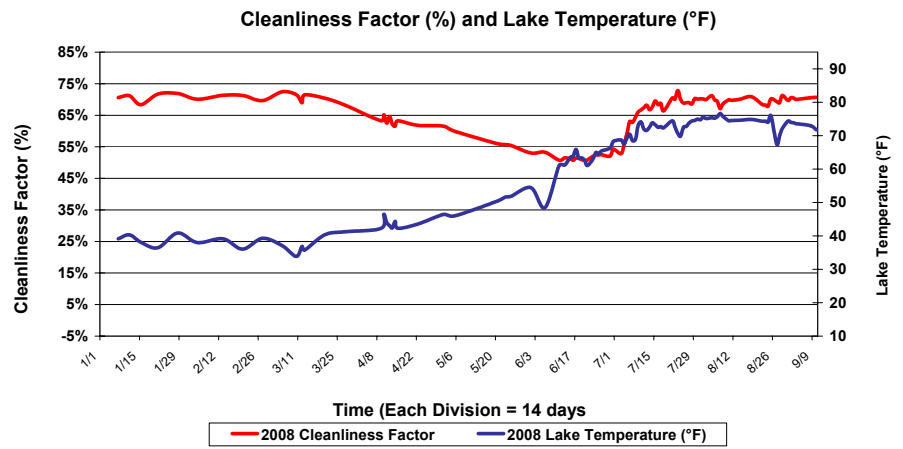
LMTD = Log mean temperature difference °F

$Q$  = Heat rejection rate, Btu/hr

The results were dramatic. Figure 5 tells the story. Lake temperatures increased in 2008 as expected and, also as expected, condenser cleanliness declined.

In June 2008, the new treatment program was initiated, but instead of condenser cleanliness continuing to decline as the lake temperature increased, cleanliness factors increased, clearly demonstrating the efficacy of the program.

The financial implications were also significant. During the first two days of treatment— during the hottest part of the year, when electricity demand (and electricity prices) are highest – the plant saw an increase of 16 MW in generating capability. Over the next week, this improvement increased to 20 MW. After 60 days using the new treatment program, the plant realised an economic recovery of approximately \$1.05 million.



**Figure 5** - New program improved condenser performance, even under high stress, summer operating conditions.

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