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THERMOPHASE

Pittsburgh Chemical Solutions LLC is the exclusive patent holder for THERMOPHASE. THERMOPHASE is a patented non-biocide/non-hazardous product. It is a nano-coating that prevents fouling and improves thermal efficiency. We have applied to various heat exchangers such as condensers, chillers, plate and frames, etc. We have also applied to membrane filters as well and has shown reduced differential pressure across the membrane and improved fluid flow. Details of this below as well.

An example of success on the power side includes data presented in conjunction with the DOE/NETL. It should be noted that the analysis is data directly from plant historical (DCS) and includes 5 years of operation prior to THERMOPHASE and 2 years of operation with THERMOPHASE. The summary in the chart below is just a partial story. (1.3 billion gallons of water saved, 136 million lbs of CO2 not emitted, $3.35M in fuel costs saved. Note, does not include SOx and lime reductions, NOx and Ammonia reductions, Hg and ACI reductions, less ash produced, less chemistry for water used and water discharged). The product also showed to reduce cooling tower fill fouling during the application. There is a DOE link to the report for this application on the OSTI.GOV website.

Application of Heat Transfer Enhancement (HTE) System for Improved Efficiency of Power Plant Condensers (Technical Report) | OSTI.GOV

THERMOPHASE 2-Year Savings per Plant

	Estimate ± 95% C.I.				
Savings Type	Longview Power Plant	Average Coal Plant	Average Natural Gas Plant	All U.S. Coal Plants	All U.S. Natural Gas Plants
Water Withdrawl	1,287 ± 750.8 Mgal	972 ± 486.1 Mgal	29 ± 14.4 Mgal	222,622 ± 111,311 Mgal	58,094 ± 29,047 Mgal
CO_2 Emissions	136 ± 79.3 Mlbs	103 ± 51.3 Mlbs	10 ± 5.0 Mlbs	23,504 ± 11,752. Mlbs	20,176 ± 10,088 Mlbs
Fuel Cost (in Millions)	$3.35 ± 1.68	$2.53 ± 1.27	$0.53 ± 0.26	$579.76 ± 289.88	$1,062.15 ± 531.08 Note: There are 229 coal plants with an average combined annual output of 800 million MWh and there are 2,020 natural gas plants with an average annual output of

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1,600 million MWh. Longview Power Plants annual output is estimated to be ~ 5.4 million MWh and is more efficient than the average plant by 15%.

Payback for the product in this case can be measured in hours not weeks and years.

The EPRI (Electric Power Research Institute) has also tested THERMOPHASE and looked at to improve condenser heat transfer and performance. This report is very positive for THERMOPHASE.

Analysis of the data:

- The test was for heat transfer capabilities in condenser tubes. Not a biofouling test.
- Of the 8 internal coating products they tested only 3 were promising and one had to be coated internally and externally so theoretically only 2 products that internally coated were successful. THERMOPHASE and showed clear success.
- The test was a short duration and THERMOPHASE was the only internal coating that showed improvement during the test time frame. This is consistent with the DOE/NETL testing at Longview 770MW facility which ran for over 2 years and showed improvement in heat transfer as time went on. There was a significant increase from the THERMOPHASE over time.

All-in-all EPRI validated THERMOPHASE's heat transfer success that we have seen in heat exchangers, chillers and condensers on industrial and utility installations including the 770MW DOE/NETL funded multi-year test data. Other benefits from THERMOPHASE we have seen such as fouling prevention (significant data from other tests) and cooling tower fouling prevention (as seen at 770MW unit) were not a part of the EPRI testing but it was stated they could not get the tubes to foul with THERMOPHASE in the EPRI testing.

There is a detailed paper on the chillers on the TS Kennedy ship in partnership with the Department of Transportation's Maritime Administration that applied THERMOPHASE. This paper explains many of the details of how the product works. It shows borescope details of identical sea water chillers. The chiller without THERMOPHASE has significant fouling and the chiller with THERMOPHASE is so clean where you can still see the riffling on the tube. This paper can be provided.

Another impressive example comes from UPMC Children's Hospital where the borescope shows major fouling in 12 months without THERMOPHASE and with THERMOPHASE really none for 2 years!

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Figure 1: Borescope Image Fouled Chiller Tube 1 Year after Operation

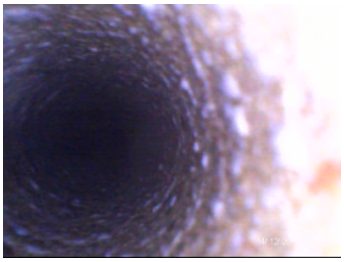
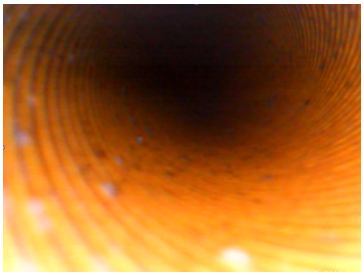


Figure 2: Borescope Image of Chiller Tube 1 Year after THERMOPHASE application Without Cleaning



A recent update on THERMOPHASE is that we are doing work for the Department of Interior Bureau of Reclaimation. We have a side by side comparison of Dupont Filmtec Reverse Osmosis Membrane Filters. We treated one filter with THERMOPHASE and the other was untreated. After running seawater in an enhanced fouling environment thru these filters the side with THERMOPHASE had half the DP. At the same pressures on both sides the side with THERMOPHASE had 50% more flow thru them.

Summary

The THERMOPHASE product is an inexpensive easy applied product that can benefit a facility. Applying to the condenser alone will improve the plant heat rate and provide quick payback. It can be applied to other heat exchangers, cooling system and other heat transfer components. With recent developments THERMOPHASE can also be applied to membranes allowing reduced differential pressure (energy and operation/maintenance savings) and improved throughput. Note: A recent shipment to a utility in the Midwest was provided for application in their unit's condenser, 3 closed cooling water heat exchangers, 3 plate and frame heat exchangers on their vacuum pumps and application in their 3.3 million water clarifier tank where they were exhibiting MIC.

The amount of THERMOPHASE for an application is dependent on the component treated and amount of fluid that it is applied to. The product can be shipped in buckets (small applications), barrels or totes.