# *Comparison of Turbine Vendor Correction Curves with PEPSE® Generated Correction Curves at the Comanche Peak SES*

*Joe Wooten*

*Texas Utilities*

COMPARISON OF TURBINE VENDOR CORRECTION CURVES WITH PEPSE GENERATED CORRECTION CURVES AT THE COMANCHE PEAK SES

The purpose of this paper is to discuss the differences between the vendor supplied correction curves, especially the condenser pressure correction curves, and those generated by the PEPSE model of each unit. Comanche Peak is a two unit Westinghouse PWR with Siemens turbine generators rated at 1163 MWe at a steam pressure of 975 psia and 95 Deg F circulating water temperature. During the analysis of test data it was noticed that the turbine did not meet the design power output and that the condenser pressure correction curves did not give consistent results. The corrected MWe undulated in a manner similar to the rise and fall of the circulating water temperature (Fig 6). Management attention at this time was focused entirely on keeping Unit 1 online and getting Unit 2 started up, so correcting this problem was a low priority. In early 1994, I started attacking this problem.

The first problem was to determine a reference point. The reporting we do for GADS wanted us to reference to the wintertime low circulating water temperature. INPO (Institute of Nuclear Power Operations) has a TPI (Thermal Performance Indicator) that suggests using the vendor corrections. During the process of setting up the efficiency program I polled the different plants that had an existing program and perused the available literature. After much consideration, I chose the MWE accounting method. This method is better suited a baseline nuclear plant than heat rate, since fuel cost is trivial and the desire is to maximize output within the constraints of the operating license. To simplify reporting requirements, the winter high MWe (low circ water temperature) point was chosen as the reference point.

The next task was to build a model that accurately reflected the actual configuration and performance of the plant. The first model used Type 8 turbines, using the data from the vendor heat balance at 100% rated reactor power. Type 8 turbines were used due the fact that Siemens HP turbines are full arc admission reaction machines. The feedwater heaters were in simplified design mode and the other components were in performance mode. Test data was used to tune the model by inserting actual pressure drops for components and piping, pump discharge pressures, extraction pressures, and main pressure. The condenser was changed to use the HEI calculations for a titanium tube condenser and the cleanliness factor changed until the hotwell temperature and circ water outlet temperature matched the actual data. Next the LP turbines were changed to Type 3. Special Option #5 was used to shape the expansion line to match the actual line. A schedule was created for the throttle valve pressure drop as a function of main steam pressure that was based on actual data. The feedwater heaters were tweaked until the TTD's and DCA's matched actual values from the test data. Comanche Peak also has a leading edge flowmeter (LEFM), a high accuracy (+/- 0.9%) ultrasonic flowmeter, which was used to input accurate data for steam flow. Steam flow in a PWR is simply the steam generator blowdown flow subtracted from the feedwater flow. Also, a moisture carryover test was performed to give an accurate indication of main steam moisture content. After all the above was put into the model, the generator output calculated by PEPSE was within 0.25 MWe of the actual value measured during the testing.

The vendor curves for the condenser correction included lines for 25%, 50%, 75% and 100% reactor power. Since Comanche Peak is a baseload unit optimized for operation at 100% power, it made little sense to create correction curves at lower power levels. Therefore, Special Option #4 was used to set the thermal power at 3425 MWth. Then a set of 15 stacked cases was set up in which only the circulating water temperature was the only parameter changed. The output data, heat rate and MWe output, were plotted using Lotus 123R5W (Figures 1 and 2). Another set of stacked cases was set up for operation with 3 circulating water pumps and plotted on the same curve. Another plot was made to compare the PEPSE calculated heat rate to the vendor calculated heat rate for comparison (Fig 3). The next curve to be plotted was heat rate and MWe vs main steam pressure. Again a set of stacked cases was set up where steam pressure was the only parameter changed. The results are shown on Fig. 4 . The same was done for reheater TTD (Fig 5).

It is obvious from the attached charts that there are significant differences between the vendor predictions and the PEPSE data for the condenser and main steam corrections. For the megawatt accounting, a full set of curves for the condenser, reheater, and main steam corrections were constructed using MWe change instead of heat rate change. Equations were derived using the Eureka program and put into a Lotus spreadsheet. Each day, 24 hour data taken each hour is downloaded from the plant computers onto the LAN. This data consists of gross MWe, hotwell and circ water inlet temperatures, reactor power, and steam pressure and is then taken automatically into the aforementioned spreadsheet. This data is plugged into the equations and a corrected MWe is calculated and plotted. The corrections include values for known losses from cycle isolation valves and equipment damage. If the difference between the calculated corrected MWe and the baseline MWe is more than 1.5 MWe, then a closer look is warranted. A file consisting of 146 data points and a user defined calorimetric are started for a two hour run on the plant computer. When the data run is completed, it is inputted into another spreadsheet for analysis. In addition, the average steam pressure, reactor power, and circulating water inlet temperature calculated from this two hour data are inputted into PEPSE using Special Option #6, along with all known cycle isolation losses. Using both the spreadsheet and PEPSE, we are able to narrow the search area for lost megawatts. By using these tools, we are able to keep unknown MWe losses to less than 0.5 MWe. The data files also provide a handy trending tool for the system engineers and to keep track of changes in important parameters affecting the accuracy of the PEPSE model.

The Monthly calculations of TPI for INPO are also more realistic using the new correction curves. Previously, the design values and corrections were used. The TPI calculated from these numbers seemed to show that TU did not care about thermal efficiency, when in actually management had a strong commitment to thermal performance (Fig 6). The old TPI required that each plant use the design heat rate and design condenser correction curves. In response to

# MWe vs CIRCULATING WATER TEMPERATURE

**FROM PEPSE MODEL**

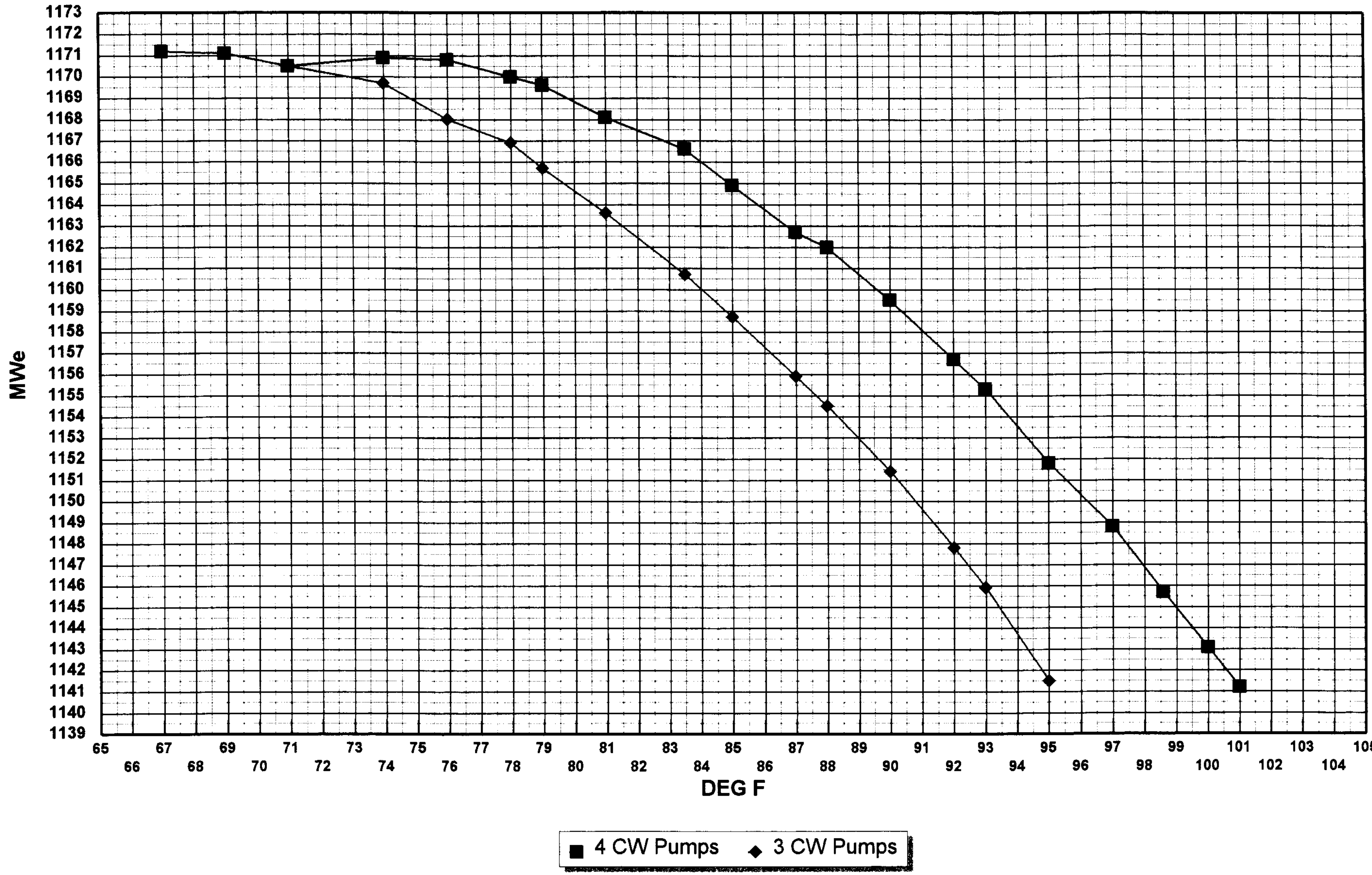


FIGURE 1

## HEAT RATE vs CW TEMPERATURE

*From PEPSE Model*

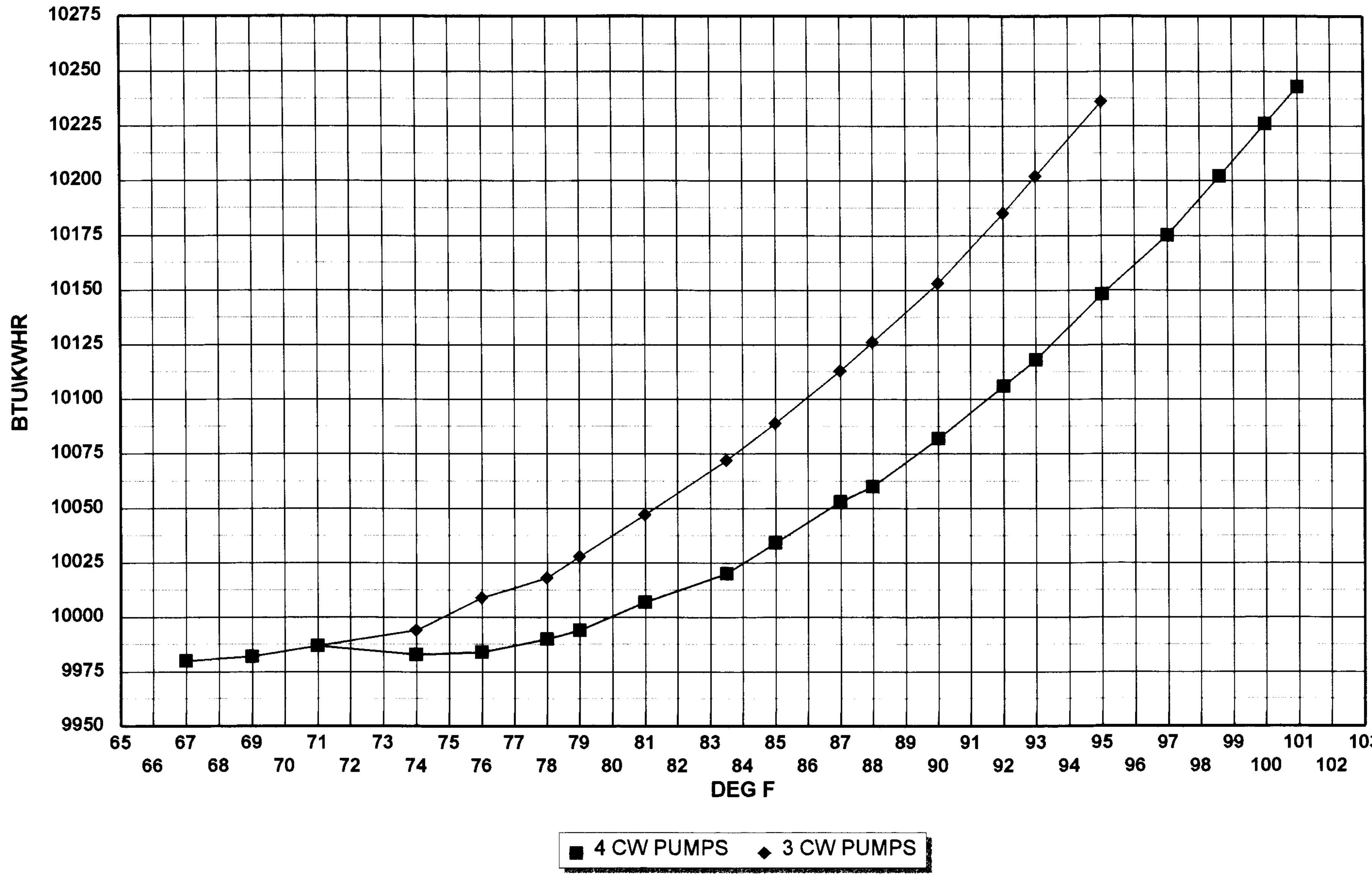


Figure 2

## VENDOR vs PEPSE CALCULATED HEAT RATES

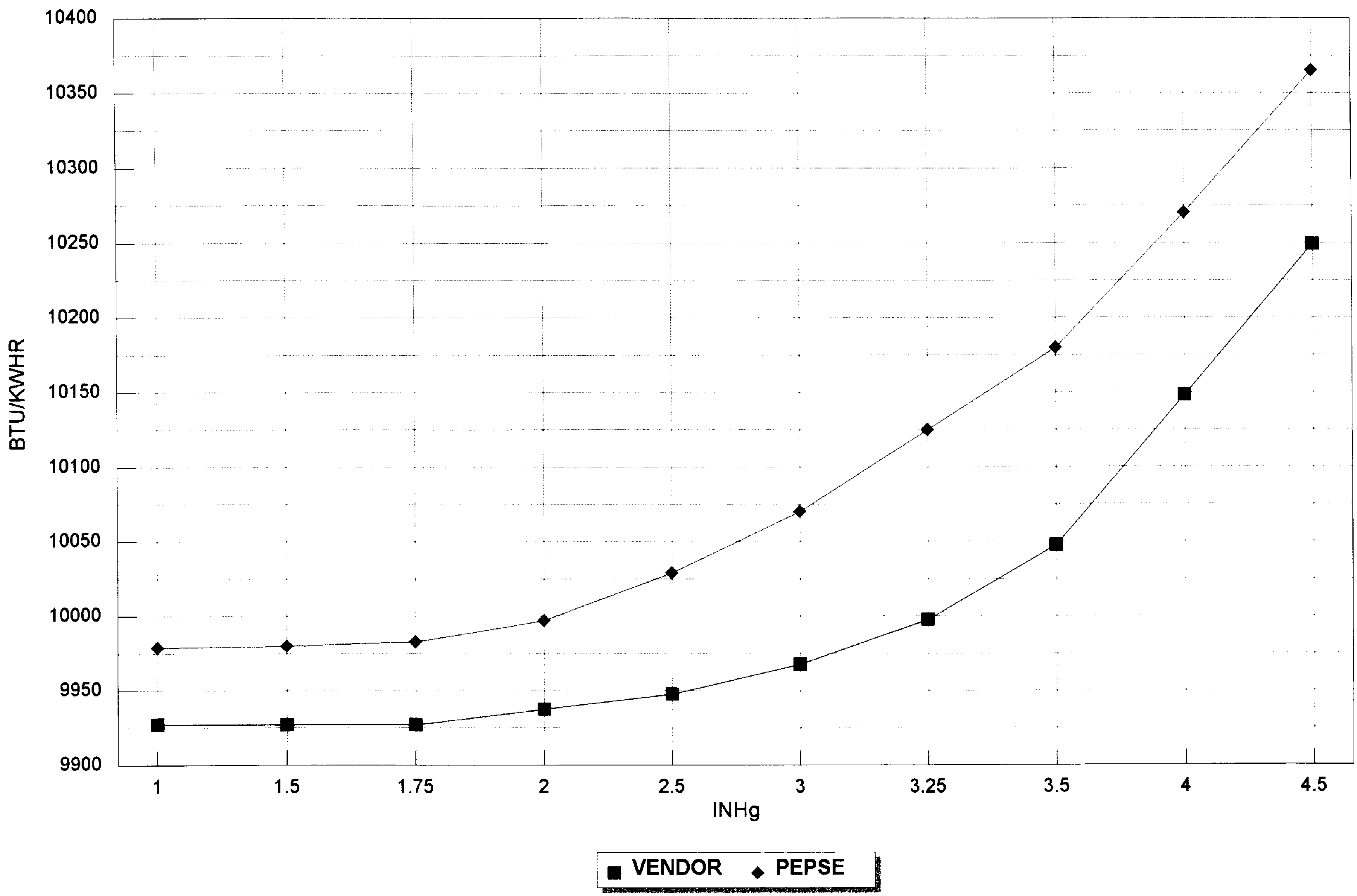


FIGURE 3

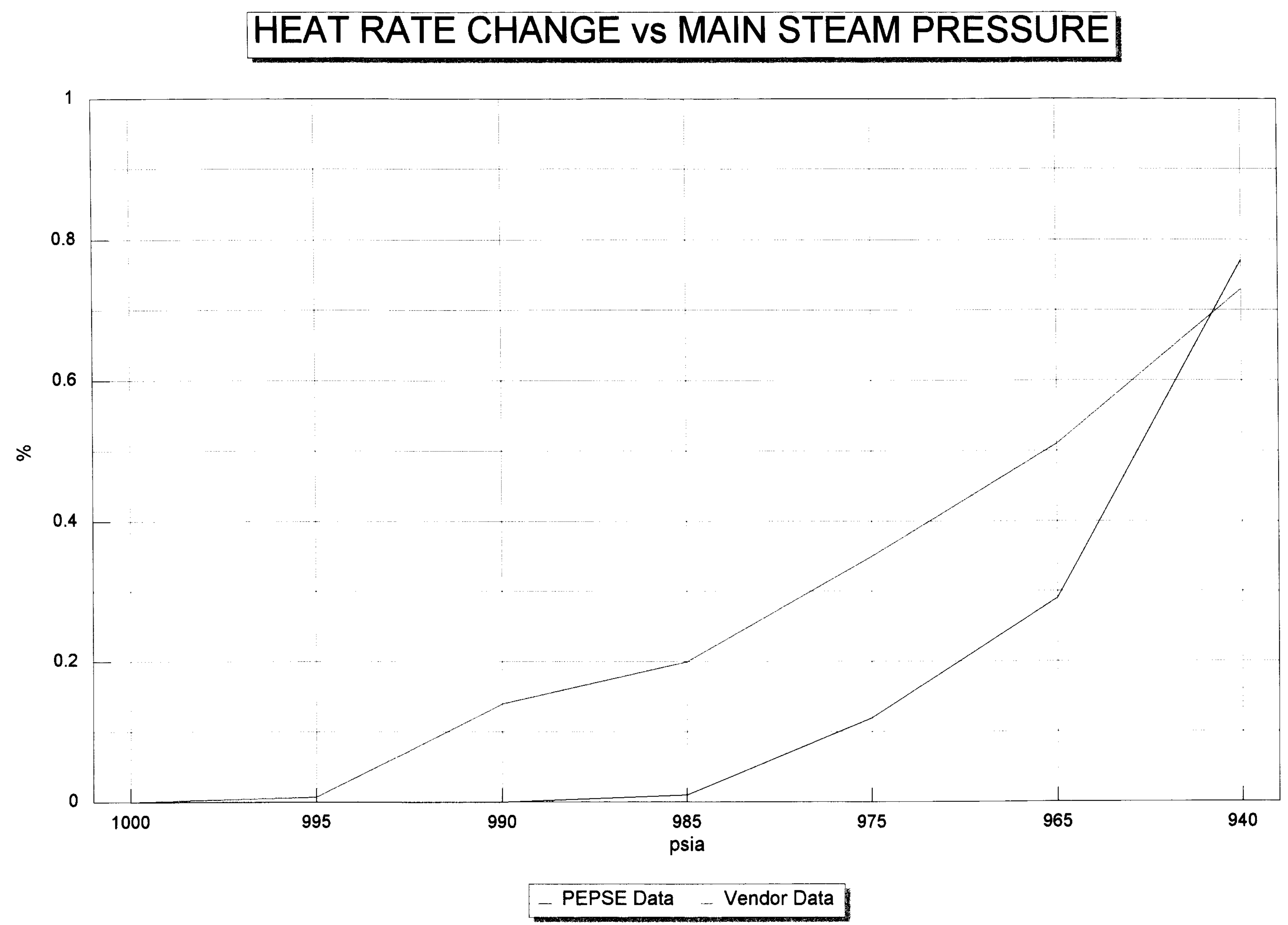
HEAT RATE CHANGE vs MAIN STEAM PRESSURE
%
1
0.8
0.6
0.4
0.2
0
1000
995
990
985
975
965
940
psia
PEPSE Data
Vendor Data

FIGURE 4

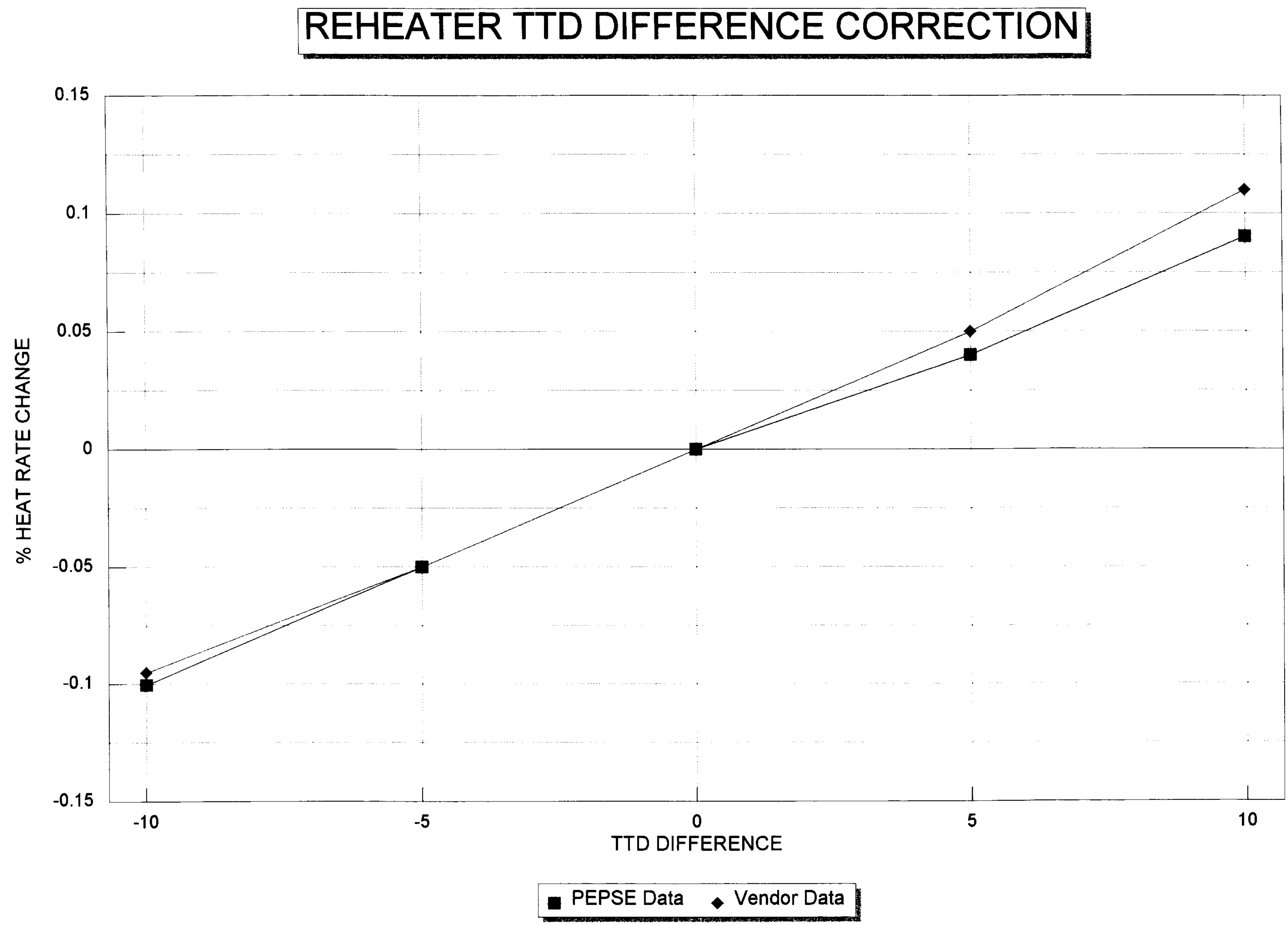
REHEATER TTD DIFFERENCE CORRECTION
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
% HEAT RATE CHANGE
-10
-5
0
5
10
TTD DIFFERENCE
PEPSE Data
Vendor Data

FIGURE 5

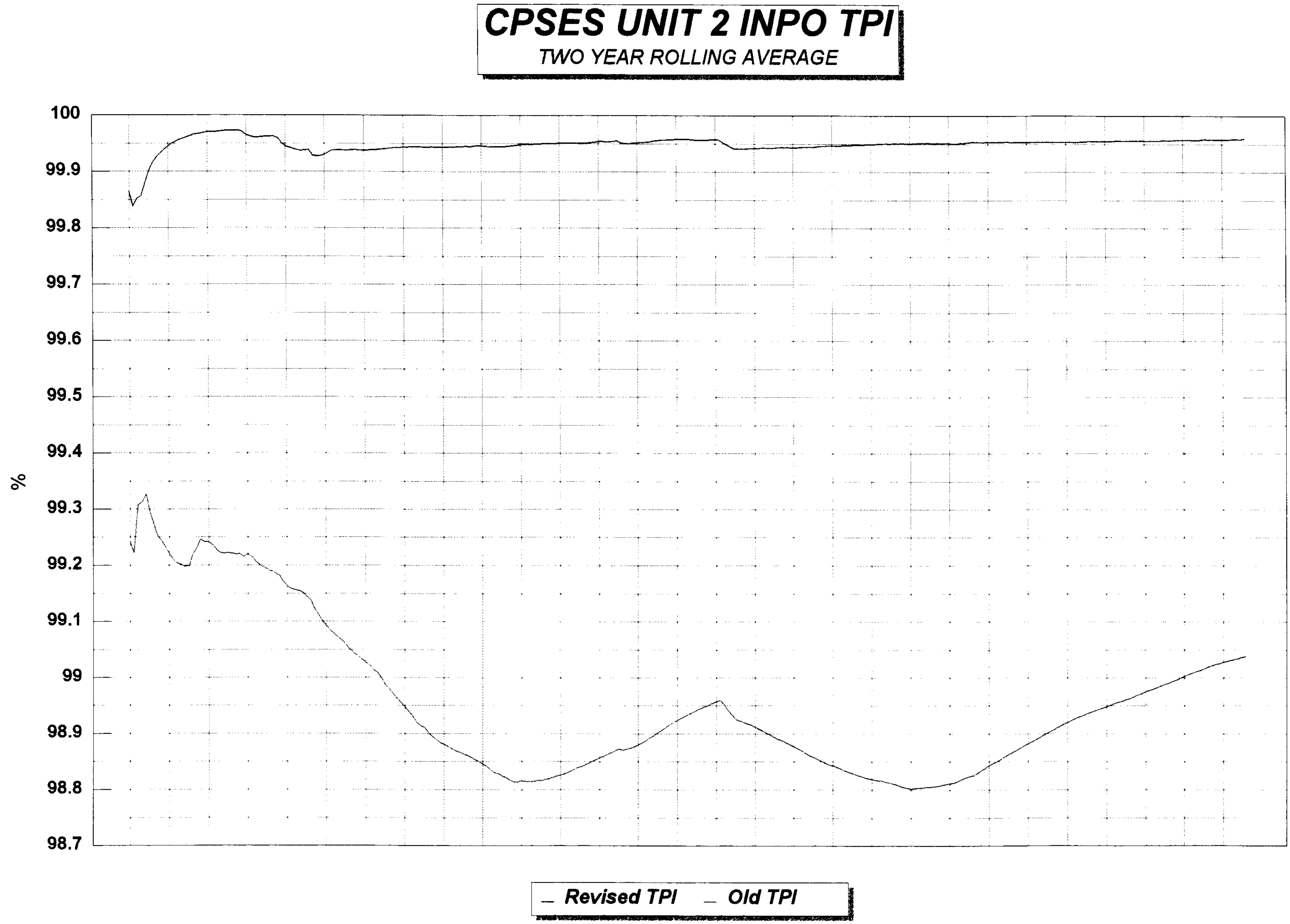
CPSES UNIT 2 INPO TPI
TWO YEAR ROLLING AVERAGE
100
99.9
99.8
99.7
99.6
99.5
99.4
99.3
99.2
99.1
99
98.9
98.8
98.7
%
Revised TPI
Old TPI

FIGURE 6

complaints from engineers at many plants, INPO issued the revised TPI in 1995 and it became the official TPI in January 1997. The revised TPI allowed each plant to use test data or modeling to determine a Best Achievable Heat Rate (BAHR) and new condenser correction curves, if warranted. Comanche Peak used test data to build a PEPSE model that was then used to determine the BAHR and new condenser correction curves. Our TPI ranking jumped from the middle of the bottom quartile to the top of the top quartile, which more accurately reflects the commitment of CPSES management to thermal efficiency.