PEPSE® Application Experiences

by

F. Davis Rees
Senior Engineer
Baltimore Gas & Electric Company
Baltimore, Maryland

Presented at the Annual PEPSE® User's Group Meeting, Sponsored by Energy Incorporated and Virginia Electric Power Company, November 2 and 3, 1983 at Richmond Virginia

ABSTRACT

Baltimore Gas & Electric Company is a new user of PEPSE and is going through a learning process in the development of a knowledgeable group of users. It is our hope that we may help, and be helped, by discussing some of the applications we have attempted.

Several applications of the PEPSE Code have been exercised with mixed levels of success. We will discuss three of those applications; all of them being models of portions of the turbine cycle. Two of the models deal with condenser performance. The effects of removed tubes and retubing with titanium alloy were considered. The results indicate that condenser retubing is primarily a preventive maintenance tool for reliability, as there is little effect on heat rate. A moisture separator-reheater was examined to determine the effect of retubing on heat rate. This analysis led to an accelerated maintenance effort.

INTRODUCTION

At the Baltimore Gas & Electric Company the PEPSE code is currently used by engineers in the Test Engineering Unit whose function is to monitor and interpret performance of mechanical components and systems in power plants. To this end, PEPSE is being used primarily in the performance mode as an engineering tool. It is a logical extension of those resources which have been historically available. This new dimension in a mechanical testing program permits full analysis and development, but eliminates none of the traditional steps:

Equipment Designed for Test Instrumentation
Instrument Selection
Data Acquisition and Reduction
Calculations
Results Interpretation

It is through PEPSE, that ease and thoroughness of interpretation is clearly enhanced. Further, rapid feedback to operating personnel, designers, maintenance planners, etc. can have signficant effect on the financial results of operations. We will illustrate with a few examples.

MOISTURE SEPARATOR - REHEATER

The two units at Calvert Cliffs Nuclear Power Plant generate 60% of this utility's electric production. The contribution of the Moisture Separator-Reheaters in Unit 2 toward generation and toward heat rate has been an on-going concern. Each of the MSR's three sections: moisture separation and two reheater stages, have been the object of scrutiny. This study addressed only the first and second stages of

A performance test was conducted on each of four moisture separator-reheaters associated with Unit 2. The average TTD was found to be 59.6°F in the second stage and 48.6°F in the first stage. These numbers, along with the original design TTD's of 25°F in each stage and a proposed reheater design which would improve TTD's to 17°F in each stage were input sequentially to the PEPSE base case for the unit. Table 1 tabulates the PEPSE results when "heat supplied" was held constant.

TABLE 1
EFFECT OF MOISTURE SEPARATOR-REHEATER TTD
ON UNIT HEAT RATE AND UNIT CAPACITY

	Current Test Case	Design Case	Improved Design
Second Stage TTD °F	59.6	25.0	17.0
First Stage TTD °F	48.6	25.0	17.0
Gross Generation MW	894.5	900.5	902.0
Gross Heat Rate BTU/KWH	9959	9894	9877

Considering only Purchased Fuel and Energy to replace lost megawatts, the payback period for restoring design conditions is less than one year with a projected savings over ten years of $5.7 million. Even greater savings would be realized by utilizing the improved reheater design. The maintenance forces have been mobilized to replace the tube bundles in two heaters in spring of 1984. In an additional report issued by the Test Engineering Unit, a review of the Equipment Design for test instruments was conducted. Recommendations have been made so that analyses of the important MSR parameters may be conducted in greater depth after repairs to the reheaters have been completed.

CONDENSER PERFORMANCE - RETUBING

Calvert Cliffs presented a second opportunity to utilize PEPSE. All condensers at the station had been constructed with 70/30 CuNi 20 BWG tubes. Due to a generalized errosion/corrosion condition, there was an unacceptable frequency of condenser tube leaks. As a result the condensers were retubed last year; Number 1 Unit with AL-6X stainless steel 20 BWG and Number 2 with Titanium 22 BWG.

Both sets of new condenser tubes are expected to resist corrosion well, however the actual cost to operations was subject to question. PEPSE's capability to easily relate condenser effectiveness to heat rate proved to be useful in this situation.

PEPSE has defined heater effectiveness as

$$\varepsilon = \frac{q}{w\,(h_{Thin} - h_{Tcin})}$$

where q = heat absorbed by fluid being heated, BTU/hr.

w = flow, lbm/hr.

h = enthalpy BTU/lbm

at T_{hin} = hot fluid temperature in

T_{cin} = cold fluid temperature in

Sensitivity runs of the PEPSE code were made using data from the acceptance heat rate test and from a recent test of condenser conditions. The condenser effectiveness was shown to decrease from .948 to .946. A decrease of 300 KW of capacity and an increase of 5 BTU/KWH in Heat Rate resulted. These deviations represent a operations cost near $25,000 per year; however that is a small fraction of costs associated with a condenser leak and the associated forced load reduction.

Although the above short test and evaluation was of interest, we should note that definitive evaluation was not achieved. Cleanliness factor tests were not conducted during the unit acceptance test nor in the recent review. Therefore, it must be said that PEPSE, as a performance tool, still depends on the basic steps of performance testing.

CONDENSER PERFORMANCE - TUBE REMOVAL

C.P. Crane Station consists of two 202 MW coal-fired units. The Engineering Test Unit was asked to conduct a sensitivity investigation into the realized cost of plugged condenser tubes. Each condenser contained 14184 tubes in the condensing section. We evaluated costs for the following conditions; 288 tubes plugged; 1000 tubes plugged; and 2000 tubes plugged. Additionally, the series was also conducted with various fouling factors. The Standard Handbook of Engineering Calculations (pg. 3-438); provided the "worst case" fouling factor while the least severe was an extension of observed plant operating data.

PEPSE calculations were conducted in two parts. First the condenser was modeled as illustrated in Appendix 2 and run in PEPSE's design mode. The resultant figures for back pressure were then inserted into the base case of the unit model. Heat Rates vs. Back Pressure is plotted in Table 2 where existing operating conditions implied to us that use of a fouling factor of 0.0002 was appropriate. Assuming that the full load rating would be required for 3000 hours per year, the annual cost of plugging 1000 condenser tubes would be over $20,000/year. Overall, that is an acceptable cost when compared to condenser retubing cost in the area of $500,000. These results are also not definitive in that no cleanliness factor tests were conducted. The degradation of Heat Rate associated with high fouling factors is included in Table 2 to emphasize the importance of that parameter.

CRANE NO.2

CONDENSER BACK PRESSURE VS. HEAT RATE

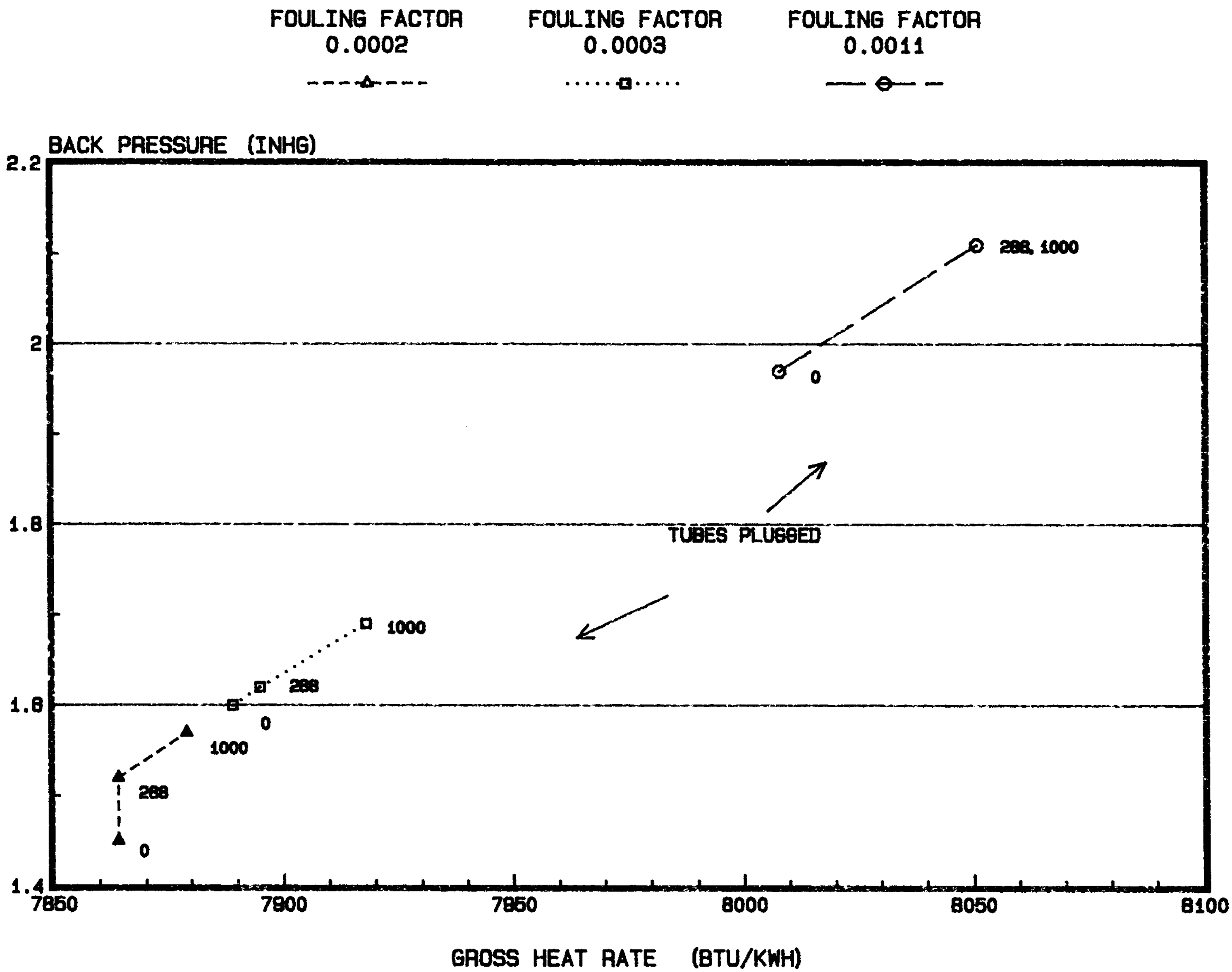


TABLE 2

SUMMARY

Despite locally immature development of the use of PEPSE; we have been quickly made aware of the economic value at hand. Each of three situations considered had potential for influencing planning for future operations and maintenance. Moisture Separator-Reheater investigation led to an accelerated maintenance effort. Retubing a condenser with new metals was demonstrated not to have a great effect on cycle efficiency. Plugging of condenser tubes up to the level of 10%, could not be used as justification for inserting retubing into the near-term maintenance plan.

PEPSE, as an analytical tool, has demonstrated its worth in these situations.

ACKNOWLEDGEMENTS

The basic work for this discussion was accomplished as indicated:

Moisture Separator - Reheater
John Strauch - Associate Engineer

Condenser Performance - Retubing
John Strauch - Associate Engineer

Condenser Performance - Tube Removal
Carnell Williams - Engineer

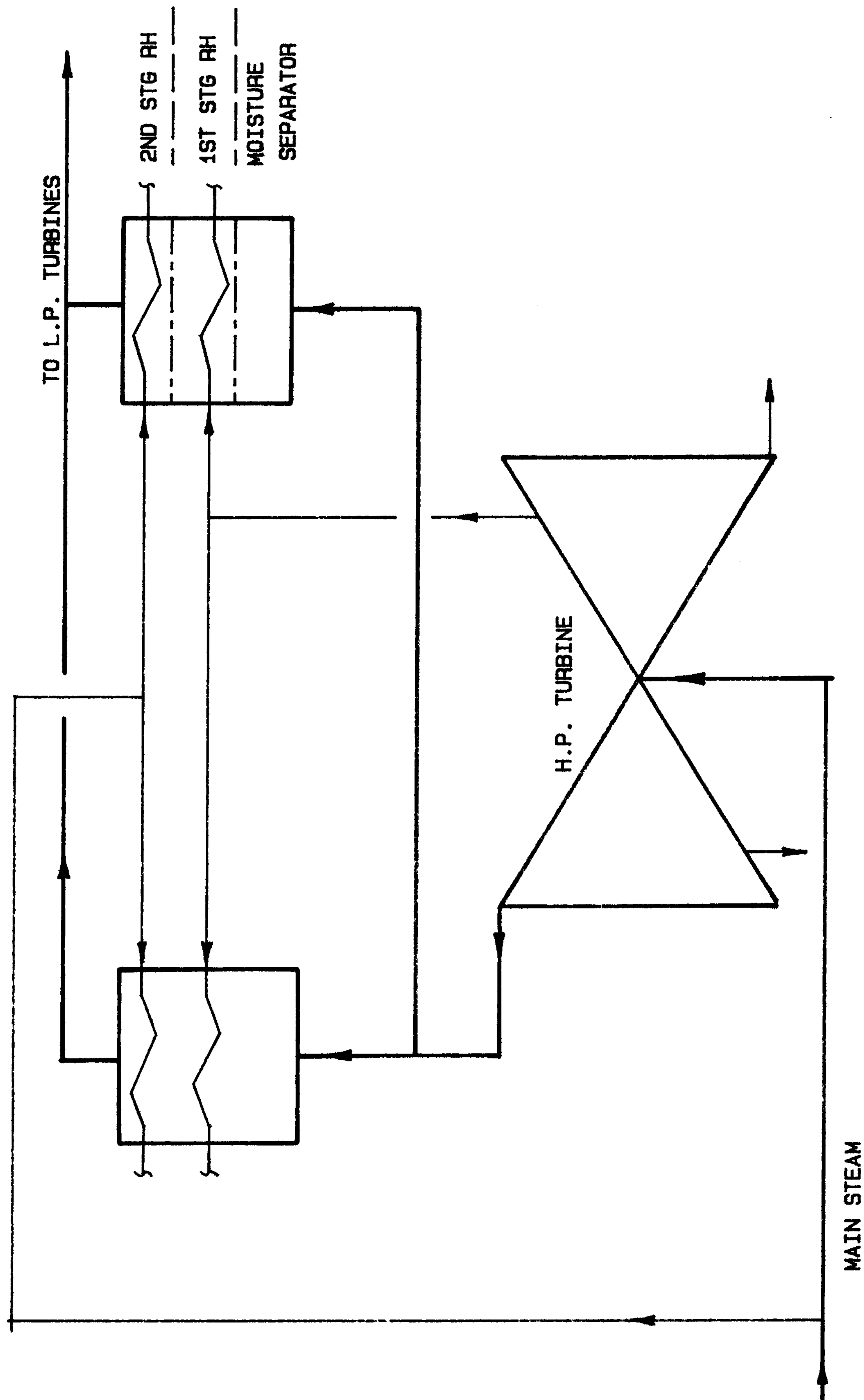
Additional Support:

Paul Maloney - Engineer

Richard Stokoe - Associate Engineer

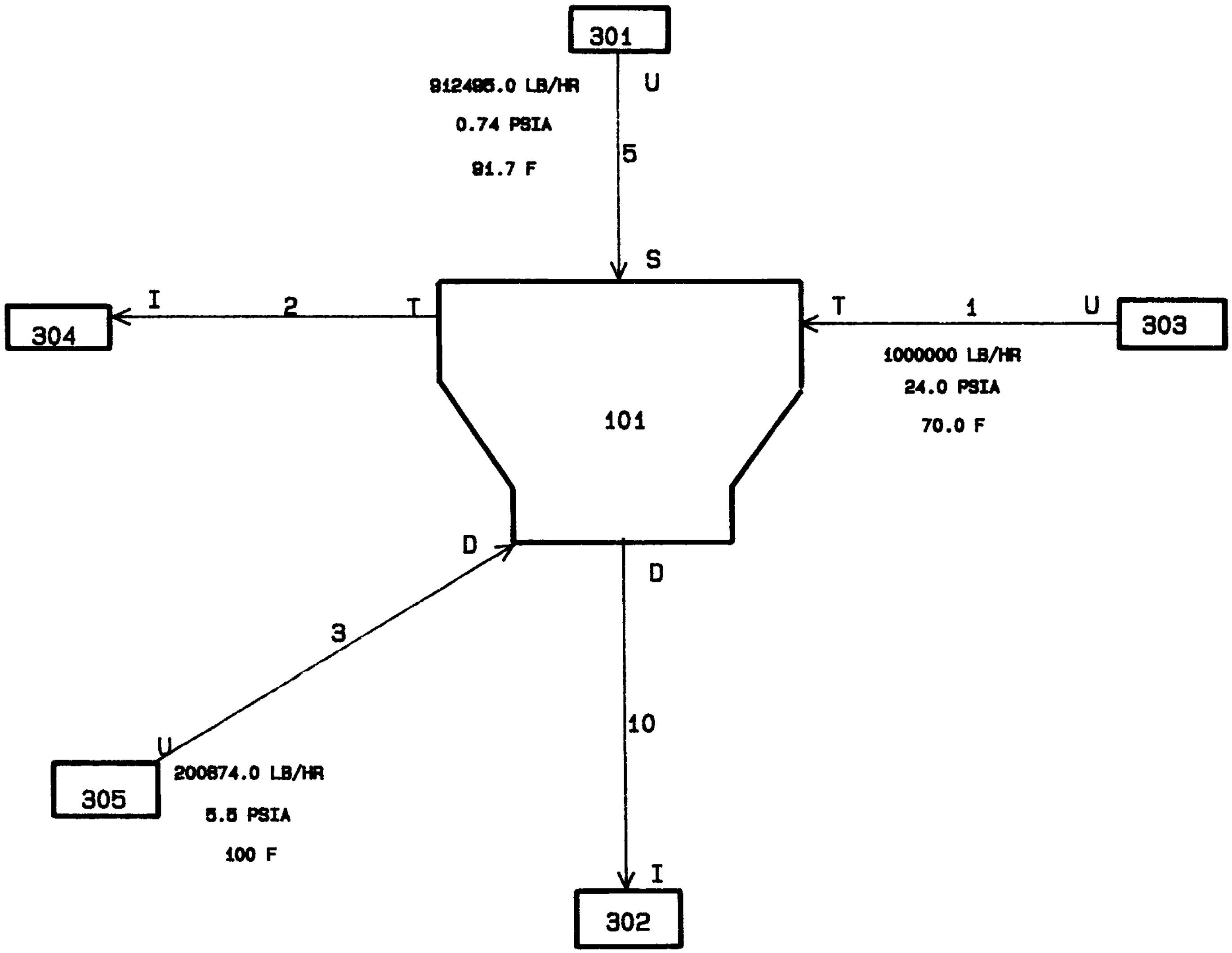
CALVERT CLIFFS NO.2

MOISTURE SEPARATOR-REHEATER



APPENDIX 1

CRANE NO.2
CONDENSER STUDY



APPENDIX 2