AEP's Use of PEPSE® For Main Frame Graphics

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American Electric Power Service Corporation

ABSTRACT

American Electric Power System is an electric utility company headquartered in Columbus, Ohio. It is a holding company for seven operating company subsidiaries located in seven east central states, their coal mining and power generating companies and the American Electric Power Service Corporation. All the operating companies/ power plants and the Service Corporation are connected through the Utility Communications Computer Systems(UCS). The Service Corporation is the management, technical and professional service organization and is responsible for the development and maintenance of the heat balance diagrams for all the existing and new power plants or Co-generation systems. American Electric Power (AEP) operates 46 fossil units with a net demonstrated capability of 21475 mwn which accounts for 85% of total system generation. The balance is generated by two nuclear units and 67 hydroelectric units.

Back in 1986, AEP started a program to revise the heat balances of each series of units on its System using the main frame compatible PEPSE heat balance software. The main purpose was to develop revised heat balances to account for changes in operating philosophy and equipment modifications since the units went into commercial operation. The revised heat balances were in turn used to develop input-output, and incremental heat rate curves for economic load dispatching of the units, thus minimizing the cost of generation for AEP's customers.

The paper work generated with these heat balances was enormous. To reduce the paperwork and to make the heat balances available to everyone in the company, a program for automated processing of the PEPSE results was initiated. The PEPSE cases are run and the results are stored in a data base. The menu driven screens guide the user to generate on screen heat balance diagrams and other graphics. The heat balances and other user requested graphics are now available on demand through the UCS.

INTRODUCTION

American Electric Power (AEP) operates 46 fossil units with a net demostrated capability of 21,475 MWN, which accounts for approximately 85% of total system generation. The balance is generated by two nuclear units and 67 hydroelectric units. Back in 1986, AEP started a program to revise the heat balances of each series of units on its System using the main frame compatible PEPSE heat balance software. The main purpose was to develop heat balances to account for changes in operating philosophy and equipment modifications since the units went into commercial operation. The revised heat balances were in turn used to develop input-output, and incremental heat rate curves for economic load dispatching thus minimizing the cost of generation for AEP's customers.

The heat balances were developed at 3 or more circulating water temperatures and 4 or more load points to cover the entire load range for each unit. This generated 16 sheets of 11x17 in. paper. To make the package complete, several graphs were also attached. The graphs were manually developed by inputting the PEPSE output results into the computer. The complete heat balance package was a voluminous piece of paper work. The heat balance packages were sent to the Plant managers/ Plant engineers and to the management/ engineers in the Service Corporation. Everytime the heat balances were revised it generated as much paper.

To reduce the paperwork and make the heat balances available to everyone in the company, the new program for automated processing of PEPSE results to develop the heat balance diagrams and other user requested graphics was started. The new program will ensure that the current version of the heat balances are available to every VM or UCS user in the company.

GRAPHICS PACKAGE DEVELOPMENT

At AEP, PEPSE program is installed on an IBM ES9000 mainframe and operates in a batch mode under MVS. Considering the fairly large PEPSE models being analyzed at AEP, the batch mode of operation is the most efficient method. However, the batch mode of operation under MVS is not very "user-friendly". To alleviate this limitation of the operating environment, a number of utility programs have been developed for pre-processing, analysis, and post-processing of PEPSE calculations. Results of the PEPSE analysis for all of AEP's Fossil units are now maintained in a central repository on the VM system of the IBM Mainframe. This allows on-line access to these results for all registered VM and UCS users at the AEP head quarters at Columbus and at all the Operating Plants.

The process for generating PEPSE results involves the following steps :

. Create PEPSE input deck for the model.

. Create Cycle diagram input file (AUTOCAD).

. Upload input files to MVS and translate drawing file to Versatec format.

. Execute the PEPSE program.

. Create OPVB number and data file listing on VM.

The last item is the only additional step required for making the heat balance diagrams and PEPSE graphics available on line to the users.

Once the Performance engineering section makes the results available on the VM PEPSE repository, any user can then access the results, view them graphically and make plots on the local printer.

Some of the steps involved and the support programs developed are discussed in more detail below:

Changes made to the PEPSE program

The PEPSE source code was modified to increase the size limitations on some of the PEPSE variables such as OPVBs, Schedules, Stream, etc. This was necessitated by the rather complicated models required for some of the AEP's Plants, especially for the modelling of the 1300 MW units. The source code was also modified to write out the

final converged results of all OPVBs and Stream properties to a data file. This data file is used for all the post processing of the PEPSE results.

Create cycle diagram drawing file

The cycle diagram corresponding to a PEPSE input deck, is generated by using AUTOCAD software. The AUTOCAD environment has been customized for PEPSE by the use of pre-drawn symbols, text blocks, line sizes, etc. PEPSE results are tied into these drawings by annotating the plots with OPVB numbers or Stream Properties. A program has been written to transfer the AUTOCAD DXF files to the main frame and convert them to the drawing format required for a VERSATEC plotter running off of the mainframe computer. Some of this drawing capabilities are now available with the PEPSE EASE available on the PC, but is not compatible with the mainframe environment.

Executing PEPSE on MVS

As mentioned earlier PEPSE is installed on the MVS operating system running in batch. The JCLs needed to run the PEPSE program are rather unwieldy and require some knowledge of the operating system. To help this situation, the PEPSE jobs at AEP are submitted through ROSCOE running on MVS. A panel driven job submission routine (JSR) has been developed using the ROSCOE Programming Facility (See Figures 1-3). This panel is easy to use and gives the user a number of options. It generates a unique job name for each PEPSE run. Among other things, the user can select the print destination, hard copy plot of the cycle diagram, save results to a tape, make microfiche, run job over night, send results to the VM repository, puts a time and date stamp on the results, etc.. This program also provides a bit of "parametric" programming in the PEPSE model. This parametric design allows the user to change a value in the PEPSE model at run time rather than having to edit the corresponding PEPSE data file. If the appropriate option is chosen, the JSR automatically sends the PEPSE results file to the PEPSE repository on VM.

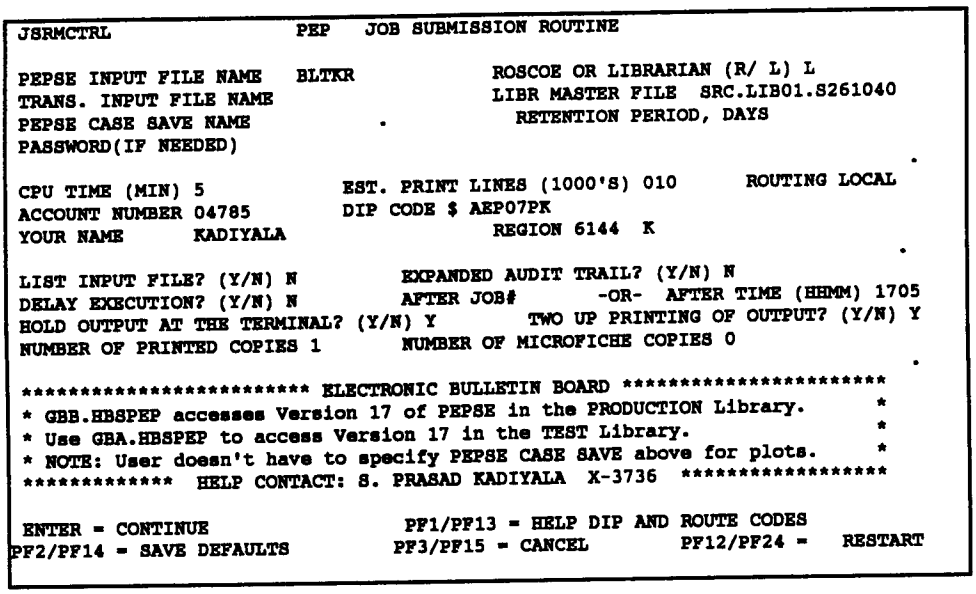
PEPSE on-line results processing on VM

PEPSE results are available AEP system wide via easy-to-use menu driven Screen Panels

on the VM system. A number of different software/languages available on the VM system have been used to make the PEPSE post-processing program very user-friendly and intuitive. The base driver program is written in REXX, a command language available in VM. The main calculation and processing programs are written in FORTRAN. The menu screens are designed using XMENU. The graphics on the screen are driven by the Graphical Data Display Manager (GDDM) from IBM. The Graphics plot screen has been designed to provide the user the capability to zoom, rotate, pan, move, scale, and print to local or remote printers.

Most of the engineering users at AEP are interconnected via a PC network running OS/2 LAN (UCS). All these users access the IBM mainframe using the 3270 emulators under OS/2. The PEPSE post-processing program utilizes the additional capabilities available with these OS/2 workstations to enhance the program functioning. For these workstations, mouse support is automatically available when running the PEPSE post processing program. The user can select plot variables off the screen with a click of the mouse button. This functionality has been provided by writing a program with CMMOUSE protocols and designing associated mouse pop-up screens.

A program written to High Level Language Application Programming Interface (HLLAPI) service of the OS/2 Communications Manager allows a user with an OS/2 workstation to make hard copies of the PEPSE plots on the local network laser printers. This program automatically transfers data from the mainframe to the local PC and routes it to the assigned printer.



```
JSRMCTRL                PEP   JOB SUBMISSION ROUTINE

PEPSE INPUT FILE NAME   BLTKR            ROSCOE OR LIBRARIAN (R/ L) L
TRANS. INPUT FILE NAME                   LIBR MASTER FILE  SRC.LIB01.S261040
PEPSE CASE SAVE NAME          .            RETENTION PERIOD, DAYS
PASSWORD(IF NEEDED)

CPU TIME (MIN) 5            EST. PRINT LINES (1000'S) 010      ROUTING LOCAL
ACCOUNT NUMBER 04785        DIP CODE $ AEP07PK
YOUR NAME      KADIYALA                  REGION 6144  K

LIST INPUT FILE? (Y/N) N          EXPANDED AUDIT TRAIL? (Y/N) N
DELAY EXECUTION? (Y/N) N          AFTER JOB#       -OR-  AFTER TIME (HHMM) 1705
HOLD OUTPUT AT THE TERMINAL? (Y/N) Y        TWO UP PRINTING OF OUTPUT? (Y/N) Y
NUMBER OF PRINTED COPIES 1        NUMBER OF MICROFICHE COPIES 0

************************* ELECTRONIC BULLETIN BOARD ************************
* GBB.HBSPEP accesses Version 17 of PEPSE in the PRODUCTION Library.       *
* Use GBA.HBSPEP to access Version 17 in the TEST Library.                 *
* NOTE: User doesn't have to specify PEPSE CASE SAVE above for plots.      *
*************  HELP CONTACT: S. PRASAD KADIYALA  X-3736  ******************

 ENTER = CONTINUE                PF1/PF13 = HELP DIP AND ROUTE CODES
PF2/PF14 = SAVE DEFAULTS         PF3/PF15 = CANCEL        PF12/PF24 =   RESTART
```

Figure 1

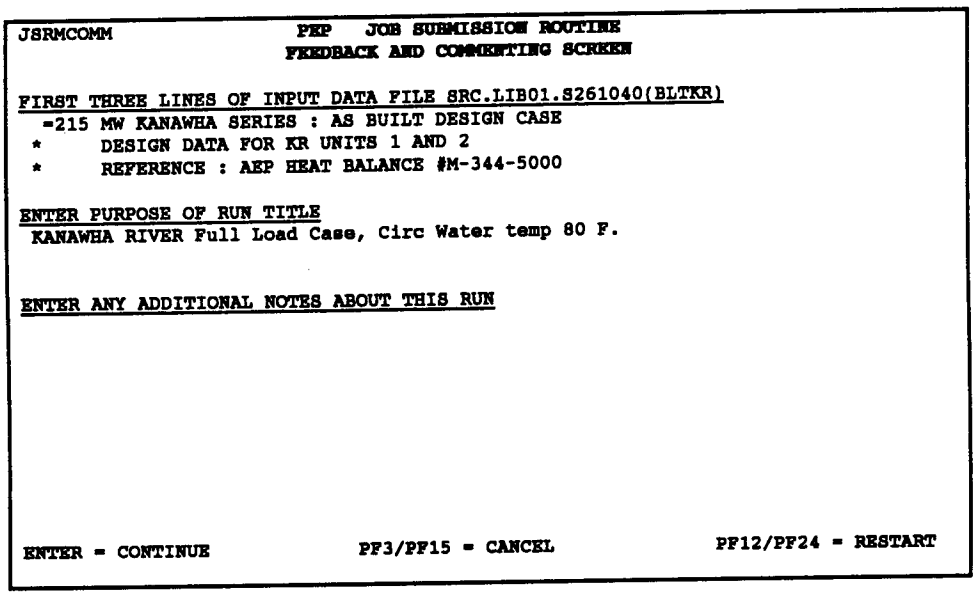

JSRMCOMM
PEP JOB SUBMISSION ROUTINE
FEEDBACK AND COMMENTING SCREEN
FIRST THREE LINES OF INPUT DATA FILE SRC.LIB01.S261040(BLTKR)
=215 MW KANAWHA SERIES : AS BUILT DESIGN CASE
* DESIGN DATA FOR KR UNITS 1 AND 2
* REFERENCE : AEP HEAT BALANCE #M-344-5000
ENTER PURPOSE OF RUN TITLE
KANAWHA RIVER Full Load Case, Circ Water temp 80 F.
ENTER ANY ADDITIONAL NOTES ABOUT THIS RUN
ENTER = CONTINUE
PF3/PF15 = CANCEL
PF12/PF24 = RESTART

Figure 2

```
JSRMEDIT                PEP   JOB SUBMISSION ROUTINE                PAGE 1 OF 1

                              VARIABLE EDIT SCREEN


:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
  USER DEFINED     |      DEFAULT      |          VARIABLE                    C
 VARIABLE NAMES    |      VALUES       |          DESCRIPTION                 G
:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::


!CWT              / 65.0/              : CIRC WATER TEMP
!MSPRES           / 2015.00/           : MAIN STM PRESS
!MSTMFLOW         / 1335000.0/         : MAIN STM FLOW
!CIRCFLOW         / 136500.00/         : CIRC WATER FLOW
!BFPSTAT          / OPEN    /          : ENTER CLOSE IF MS FLOW < 820,000
*!A               / ***/               : REMOVE *** FOR BOILER MODEL
*!B               / ***/               : REMOVE *** FOR HB DRAWING
*!C               / ***/               : REMOVE *** IF MS FLOW < 340,000
*!D               / ***/               : REMOVE *** FOR SLIDING PRESSURE
!VPPRES           /       /            : ENTER VWO PRESS IF SP ACTIVE
!VPENTH           /       /            : ENTER VWO ENTH IF SP ACTIVE
!VPSTMFLO         /         /          : ENTER VWO FLOW IF SP ACTIVE


ENTER = CONTINUE            PF3/PF15 = CANCEL            PF12/PF24 = RESTART
```

Figure 3

When the PEPSE Plotting program is started a series of menus are used to assist in creating graphics. Figure 4 shows the main menu used to select the plant, unit and to indicate whether a XY plot or heat balance diagram is needed. All the menus can be operated in one of three ways:

.The data can be directly entered into the data entry areas.

.The cursor can be moved to the desired item and PF9 is pressed to select the item.

.The mouse can be used to point at and select the desired item.

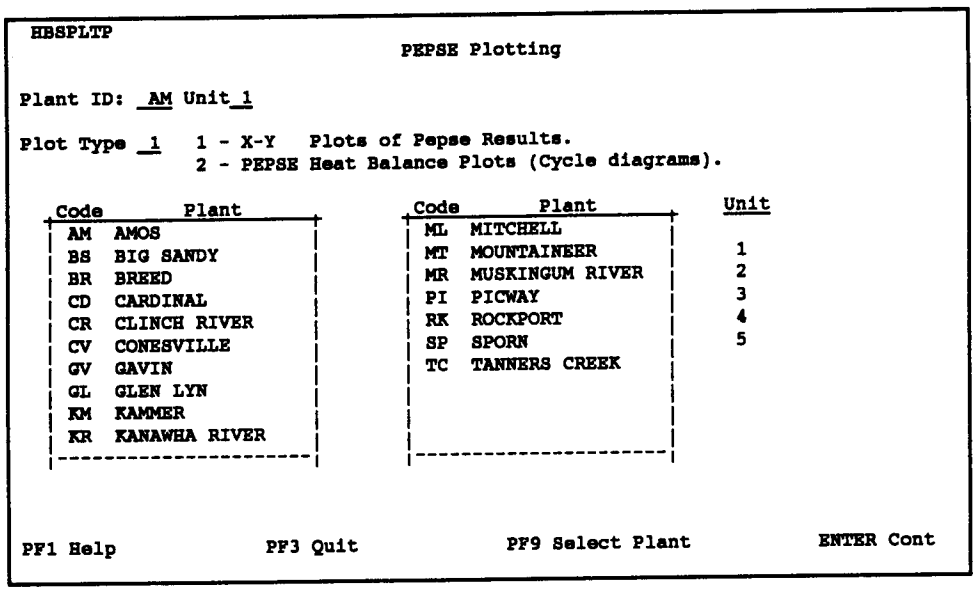


Figure 4

To generate an XY plot the screen shown in Figure 5 is used to assign X, Y, Z variables, and graph options. The scrollable OPVB list contains all the assigned OPVB model variables that can be used on the X and Y axis. For items that change as a function of circulating water (CW) temperature or load, a specific temperature or load (Z value) can be selected to generate one curve. A Z value selection menu can be accessed by using PF11. To create a family of curves "ALL" can be entered to plot a curve for each load or CW temperature series of model runs. By entering C or L for CURVE FIT a smooth curve or a straight line curve will be drawn through the data points. The user can also select whether or not to display symbols at each data point.

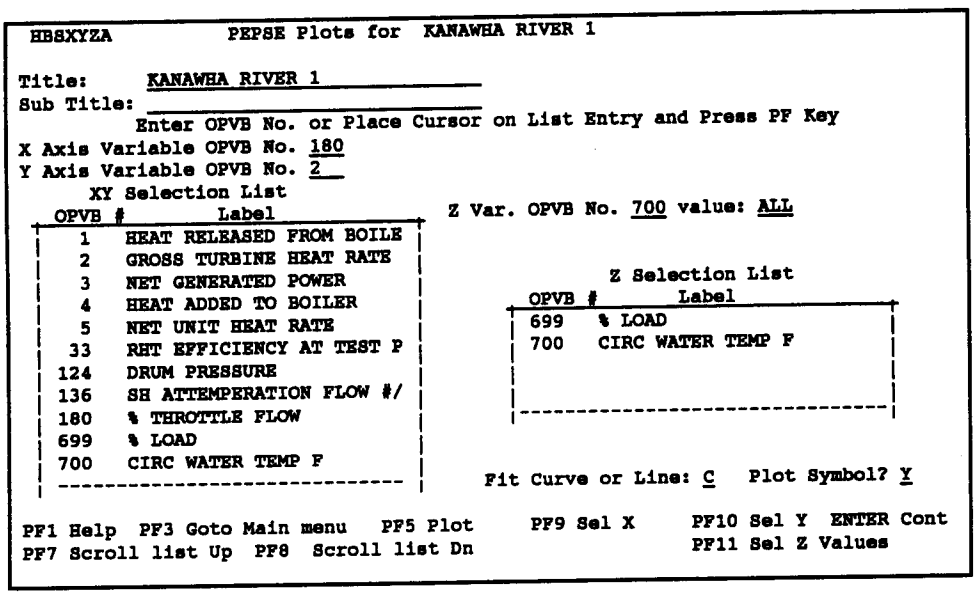


Figure 5

An example graph screen display is shown in Figure 6. A hard copy of the same graph is included in the appendix.

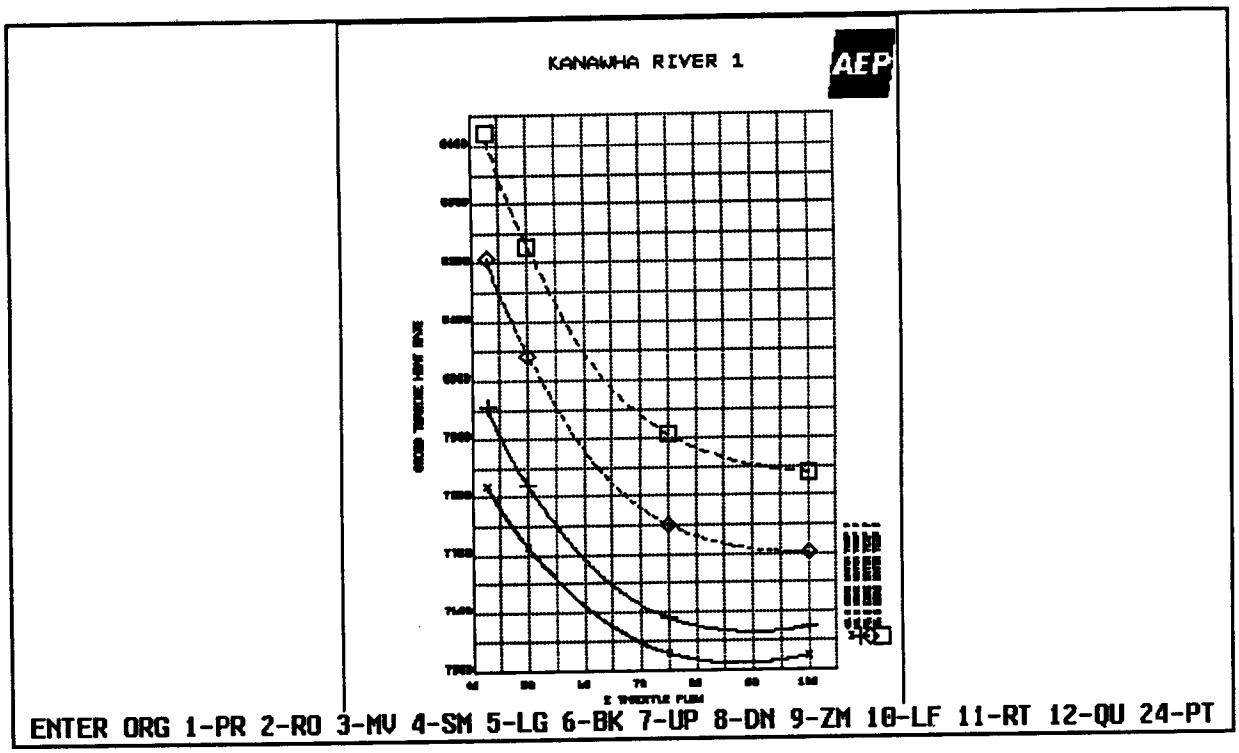


Figure 6

The size of the graph displayed can be changed by using the PF2-11 keys to move, zoom, and rotate the graph using the GDDM interface. Pressing PF24 generates a hard copy of the graph on the local UCS printer. PF1 creates a hard copy of the graph on the VM 3800 laser printer.

To display a heat balance diagram the screen shown in Figure 7 is used to select the desired drawing. The Plot Selection List can be scrolled to show all the available drawings for the indicated plant.

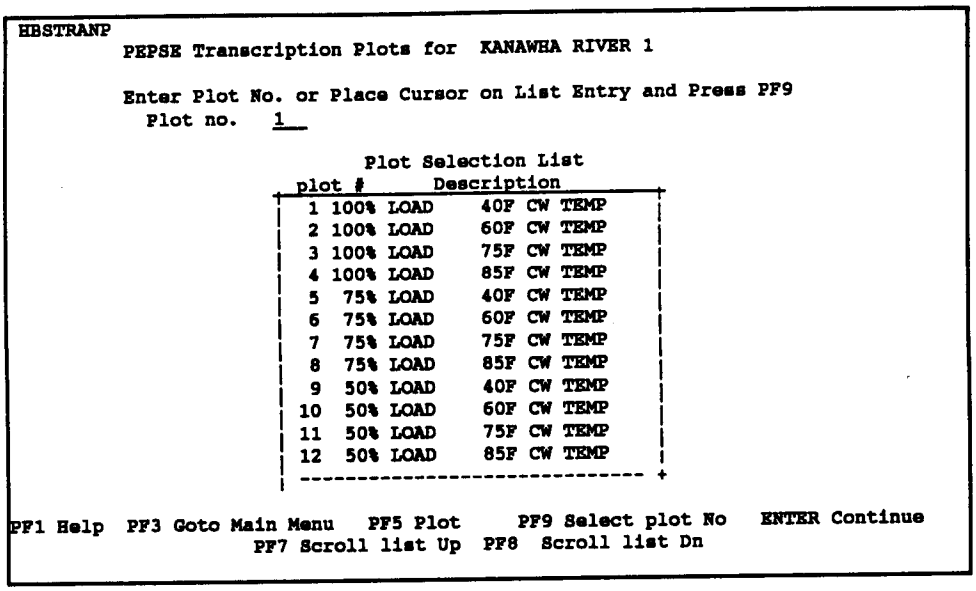


Figure 7

Once the plot number is entered by the user, the PF5 key is pressed to display the plot. An example heat balance diagram is shown in Figure 8. Function keys can be used to zoom, move, and print this diagram as well. Figure 9 shows an enlarged view of the same diagram shown in Figure 8. A hard copy of the diagram is included in the Appendix.

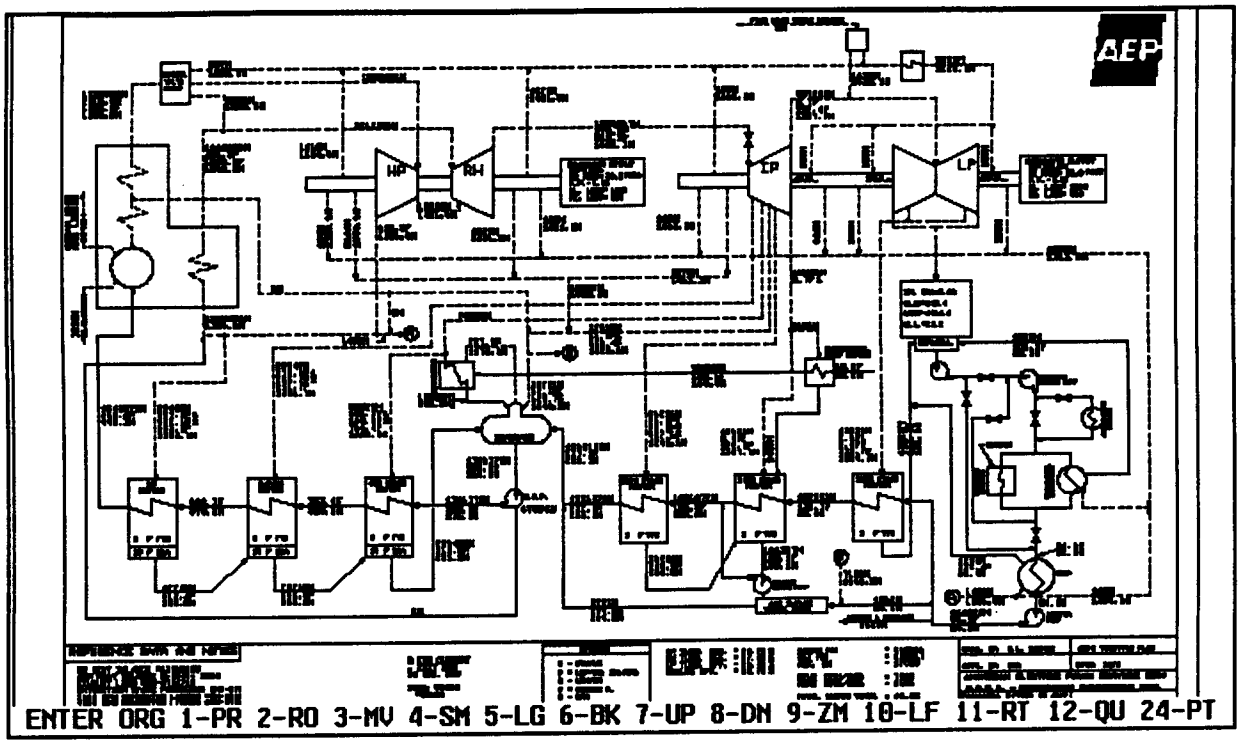


Figure 8

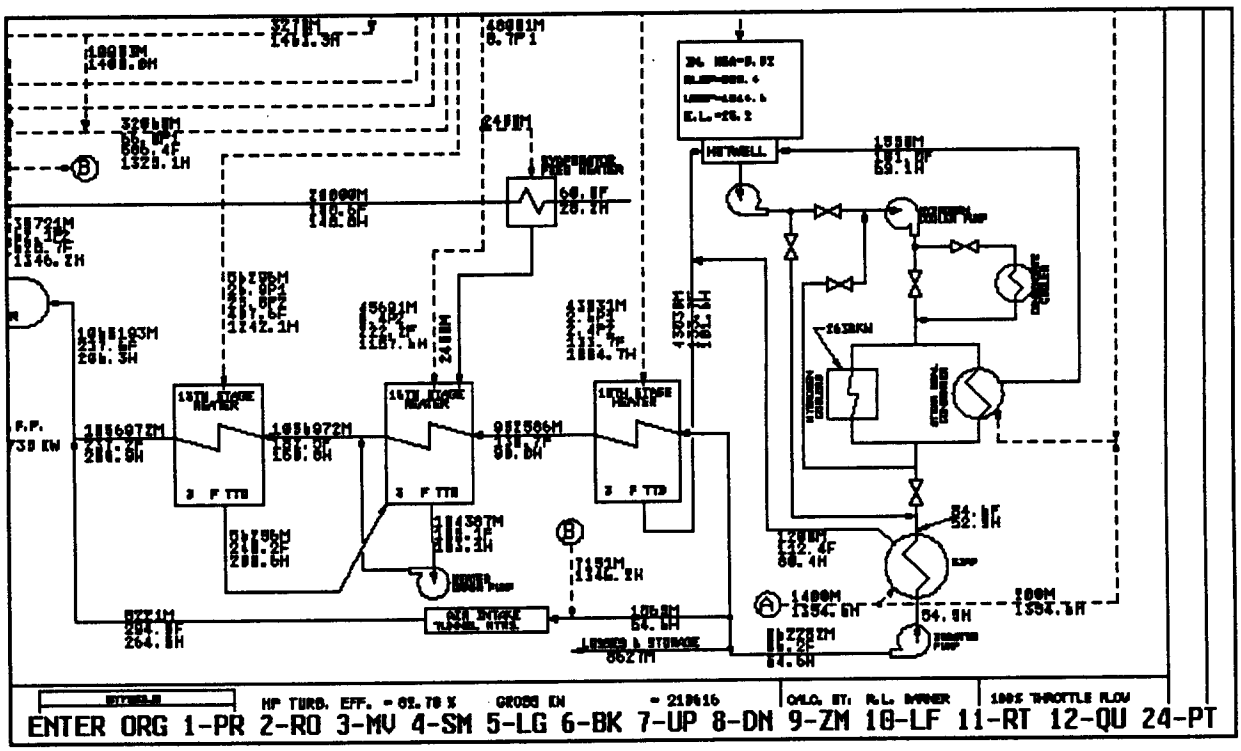


Figure 9

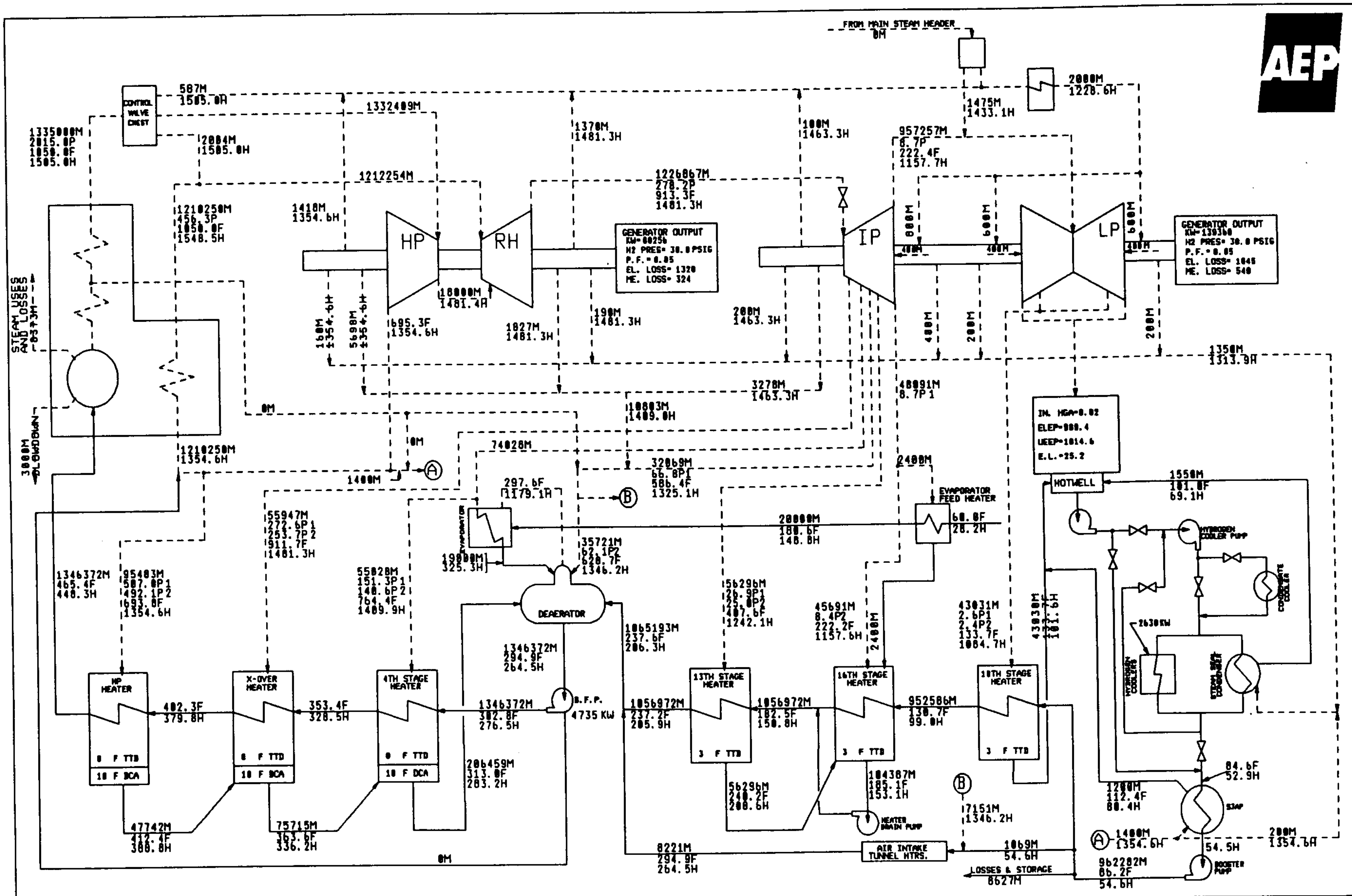
SUMMARY

With the implementation of the Main frame graphics program, the heat balance diagrams and other user requested graphics are now available on demand through the Utility Communication System (UCS), OS2 LAN network or directly from the VM system. Prior to the implementation of this program, the heat balance diagrams could only be printed on the Versatec plotter located in the AEP building and delivered to the different floors by mail. Sometimes the plotter had problems and it would take entire day to get the plots. The new program has eliminated this problem and made it possible to not only be able to see the diagrams on the screen but to print them on any UCS printer. This capability will come very handy when the heat balance demand for Co-generation projects in the AEP system increases. The paper volume generated with the previous method has also been eliminated. The new program has provided the convenience of being able to generate graphs to compare units in one series for their auxilliary power use, efficiencies of various equipments etc. and take steps to investigate excessive auxilliary power use on some units or improve deteriorated equipment efficiencies, or check the input-output and the incremental heat rate curves. This is an example of expanding the scope of PEPSE to develop and display at user discretion the input-output and incremental heat rate curves used for dispatching of the units on least cost basis thus allowing to take necessary steps to improve the heat rates and making AEP better equipped to achieve its goal of becoming the least cost power producer and least cost provider of electricity to its consumers.

APPENDIX

Figure A Heat Balannce Diagram.

Figure B Throttle flow vs. Heat rate graph.


FROM MAIN STEAM HEADER
0M
CONTROL VALVE CHEST
HP
RH
IP
LP
GENERATOR OUTPUT
KW=80256
H2 PRES= 30.0 PSIG
P.F.=0.85
EL. LOSS= 1320
ME. LOSS= 324
GENERATOR OUTPUT
KW=139360
H2 PRES= 30.0 PSIG
P.F.=0.85
EL. LOSS= 1045
ME. LOSS= 540
STEAM USES AND LOSSES
BLOWDOWN
DEAERATOR
B.F.P.
4735 KW
EVAPORATOR
EVAPORATOR FEED HEATER
HP HEATER
X-OVER HEATER
4TH STAGE HEATER
13TH STAGE HEATER
16TH STAGE HEATER
18TH STAGE HEATER
HOTWELL
HEATER DRAIN PUMP
AIR INTAKE TUNNEL HTRS.
LOSSES & STORAGE
SJAE
BOOSTER PUMP
HYDROGEN COOLER PUMP
HYDROGEN COOLERS
CONDENSATE COOLER
IN. HGA=0.02
ELEP=988.4
UEEP=1014.6
E.L.=25.2

REFERENCE DATA AND NOTES

GE HEAT BALANCE #139HB130
AEP HEAT BALANCE M-3344- 5000
EXHAUST LOSS #MN-9764718
EXTRACTION STAGE PRESSURES #MH-9768854
3600 RPM GENERATOR LOSSES #KN-9768856
1800 RPM GENERATOR LOSSES #KN-9768857

B&W SPECIFICATION SHEETS;
BOILER EFFICIENCY ADJUSTED FOR CURRENT FUEL ANALYSIS AND 335 DEG. EXIT GAS TEMPERATURE TO MAINTAIN 310 DEG. ESP INLET TEMPERATURE.
CONDENSER EXPECTED PERFORMANCE; #3222
BLR. FEED PUMP PERFORMANCE; #20687

SYMBOLS	
H	BTU/LB
P	LBF/SQ. IN. ABS.
M	LBM/HR
F	DEGREE F.
N	RPM
- -	STEAM
—	WATER

HP TURB. EFF.	82.70 %
RH TURB. EFF.	87.65 %
LP TURB. EFF.	86.89 %
BOILER EFF.	88.79 %

GROSS KW	219616
NET KW	202617
AUX. KW	17000
GTHR (BTU/KWH)	7525
NUHR (BTU/KWH)	8186
CIRC. WATER TEMP.	40.0F

CALC. BY: R.L. GARNER
100% THROTTLE FLOW
APPR. BY: MGR
DATE: DATE
AMERICAN ELECTRIC POWER SERVICE CORP
F.P.E.D. - PERFORMANCE ENGINEERING SECT.
KANAWHA RIVER PLANT
UNITS 1 & 2
APPALACHIAN POWER CO.
DWGNO

FIGURE A

KANAWHA RIVER 1

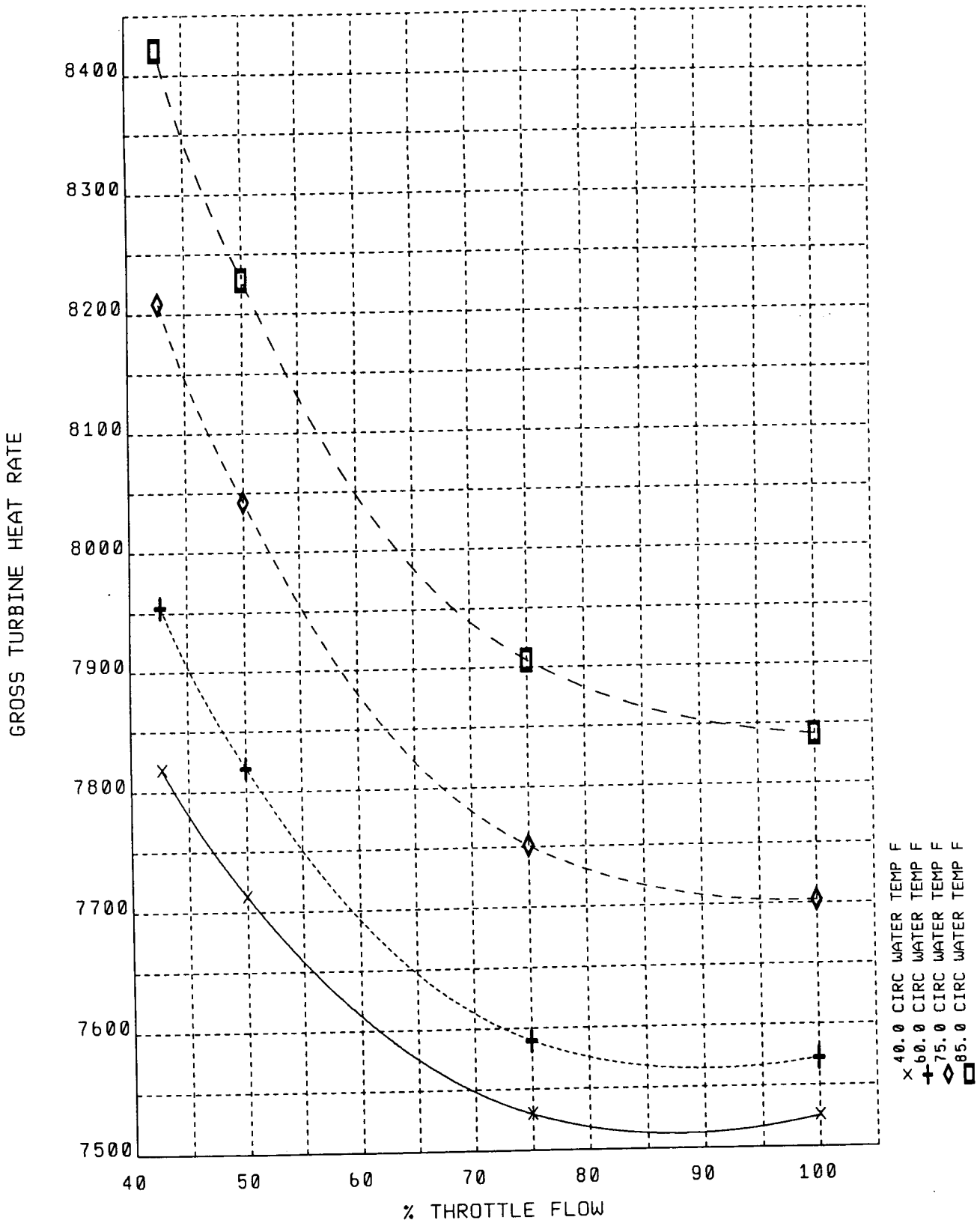


FIGURE B