

***Feedwater Heater Out of Service Analysis - Comparisons
of Results Using Design & Performance Modes in
PEPSE®***

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ABSTRACT

PEPSE is often used to analyze the power-system impact of taking a feedwater heater out of service. The easiest way to do such an analysis is to use the performance mode for the feedwater heater(s). How reliable are the results of such an analysis? The question is motivated by the fact that removal of one heater impacts the feedwater conditions received by the next-higher-pressure heater. Due to these changed conditions, the receiving heater probably will not provide the fixed performance parameters (TTD and DCA) as it did when all heaters were in service.

The design mode of analysis in PEPSE provides a tool that accounts for the local conditions. This paper presents a comparison between the results from the performance and design modes of analysis in these circumstances.

ACKNOWLEDGEMENT

Acknowledgement is made of Don Fleming's work to provide the finished turbine cycle model with all feedwater heaters described in design mode. This is the model that was used to run the cases for this study.

INTRODUCTION

PEPSE is frequently used to calculate the sensitivity of system performance to variations within the system. It is often the case that there is more than one possible approach to such analyses. One method may be simple, while another is complex. It is to be expected that the more complex, mechanistic analysis will be more rigorous and thus more nearly technically "correct". It is reasonable to ask, "How good are the answers that I get from the easier analysis?" If we can get "pretty good" answers from an easy analysis, then we'd prefer to do it this way.

Full turbine cycles are often modeled in order to determine the effect of taking feedwater heaters out of service. It is easy to do this analysis with PEPSE. One needs only to "close" the steam inlet stream that is connected to the feedwater heater that is to be taken out of service.

Such analyses are most frequently done with the feedwater heaters in the "performance mode". This is an easy modeling approach. Are the answers "any good"?

If one heater is out of service, the condition of the feedwater reaching the next-higher-pressure heater is altered from "normal". In this case the higher pressure heater's performance parameters, TTD and DCA, will therefore probably not be "normal". So, how "bad" is the result of analyzing the system in performance mode, assuming that the TTD and DCA are normal?

PEPSE provides the tools to answer this question. We can run analyses of the heater out of service scenario using two different approaches and compare the results of the two. The easy approach is the performance mode. The rigorous approach is the design mode. The design mode will automatically include the impact of the off-normal feedwater conditions on the TTD and DCA.

This paper applies this method to a "typical" fossil turbine cycle model for heaters out of service located at different positions in the train.

DESCRIPTION OF SYSTEM ANALYZED

Figure 1 shows a vendor diagram of a single-reheat fossil turbine cycle. The PEPSE schematic for this system is shown in Figure 2. This study uses this example system for the analyses, and the simulations evaluate the effects of taking selected heaters out of service. In each case of a selected heater, two analyses have been run. The first represents all of the heaters in the performance mode with fixed TTD and DCA, and the second keeps all of the active heaters in the design mode.

The PEPSE input deck for this system is presented in the appendix as Table A-1. The model deck has the heaters characterized in design mode.

Analyses using the performance mode will include the latter description by replacement cards at the end of the deck. When a run was done in design mode, all of the active heaters in the model were represented in design mode. Similarly, when performance mode was run, all heaters were analyzed in performance mode. The values of TTD and DCA in these performance mode runs were those that emerged from the base case design mode run, i.e. with all heaters in service.

As is common practice in heat balance work, these analyses have used a fixed fractional pressure drop in the extraction lines. This implies an assumption that changes in flow rate have a negligible effect on this pressure drop parameter. In addition it is assumed that the extraction line is capable of carrying the increased steam flow to the next higher pressure heater when a heater is taken out of service. These assumptions have little impact on the conclusions of the present comparative study because the extraction line flow rates are nearly the same when using the design or performance mode of analysis.

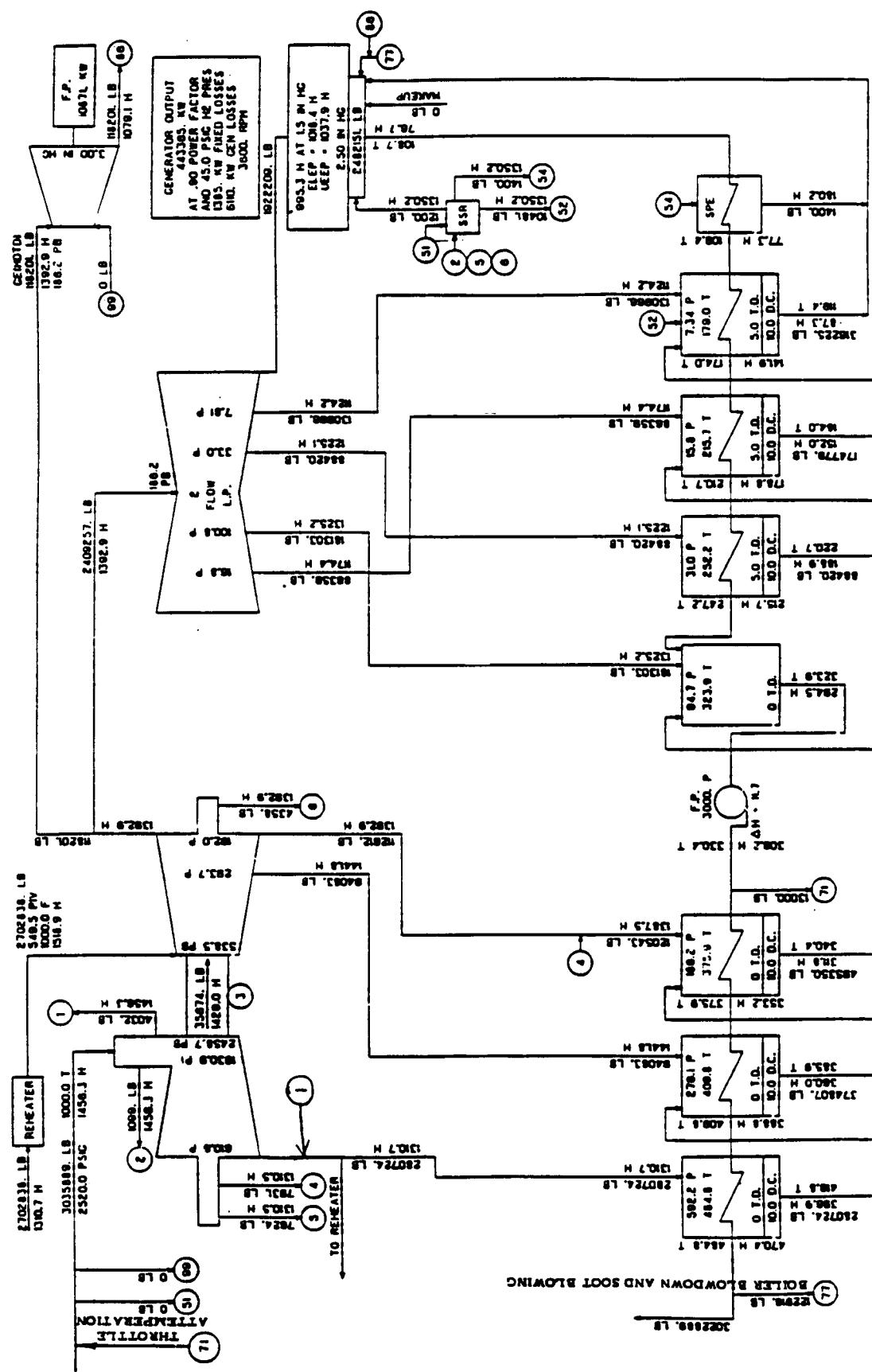
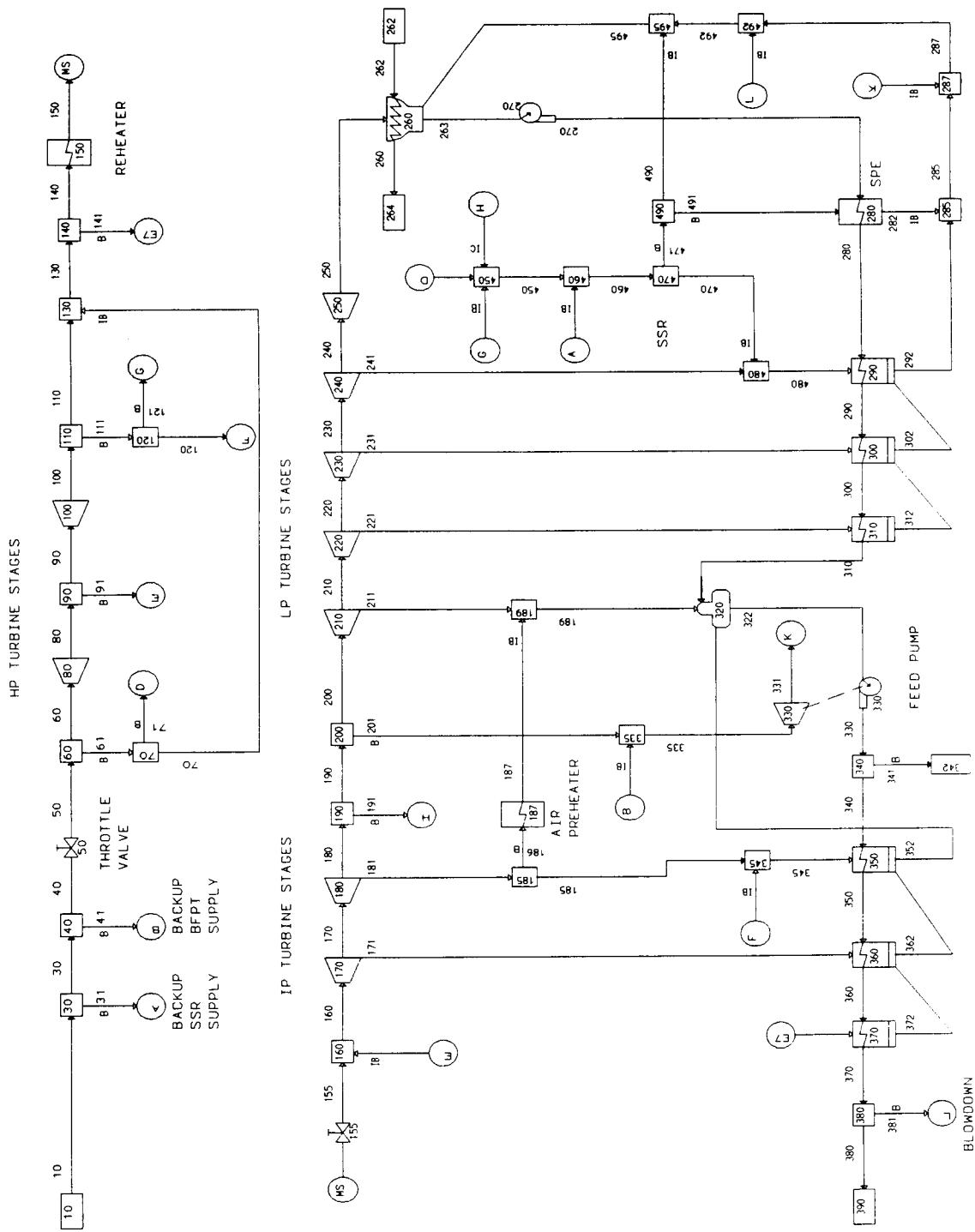


FIGURE 1 - Vendor Schematic of Fossil Turbine Cycle Used for Studies

FIGURE 2 - PEPSE Schematic of Fossil Turbine Cycle Model Used for Studies



The heaters taken out of service for this study are: the number 2 heater in the LP train (component 300) and the number 6 heater in the HP train (component 360). These were selected because the next-higher pressure heater in each case can be represented in the design mode. The results from these two cases should be representative of other potential applications.

RESULTS

Four analysis runs were made for each of the HP and LP heater studies. These runs were:

- Run 1, a base case (which is identical between the HP and LP heater studies) at full load, with heaters described in design mode.
- Run 2, design mode heater case with the selected heater out of service. This was accomplished by changing the out-of-service heater to performance mode, and the extraction line flow was shut off by a stream closure.
- Run 3, conversion of all heaters to performance mode, with all in service. This run was performed as a verification of the completeness of the conversion to performance mode. Its results in each heater study duplicated the results of the design mode, base case analysis.
- Run 4, performance mode analysis with the selected heater out of service.

The results of interest for this study are comparisons between Run 2 and Run 4 for the two different heaters out of service. These comparisons show the difference of results that derive from design versus performance mode analysis.

Table 1 shows several key results for the case of HP heater out of service, and Table 2 shows a similar set of results for the LP heater out of service study.

Table 1

Selected Results From Benchmark and Heater Out of Service Analyses Using Design and Performance Mode Feedwater Heater Descriptions -- HP Heater Out of Service

	Benchmark	Design	Performance
Next Heater TTD, °F (component 370)	2.37	4.22	2.37
Next Heater DCA, °F (component 370)	9.3	20.6	9.3
Steam flow to next heater, lbm/hr	275,202	366,605	369,704
Calculated Net Generation, mW	443.196	442.854	442.349
Calculated Net Heat Rate Btu/kW-hr	8050	8075	8070
Calculated Final Feedwater Temperature, °F	482.6	477.2	479.0

Table 2

Selected Results From Benchmark and Heater Out of Service Analyses Using Design and Performance Mode Feedwater Heater Descriptions -- LP Heater Out of Service

	Benchmark	Design	Performance
Next Heater TTD, °F (component 310)	2.37	16.17	2.37
Next Heater DCA, °F (component 310)	9.3	32.4	9.3
Steam flow to next heater, lbm/hr	88,331	148,332	163,997
Calculated Net Generation, mW	443.196	441.643	442.123
Calculated Net Heat Rate Btu/kW-hr	8050	8079	8070
Calculated Final Feedwater Temperature, °F	482.6	482.6	482.6

As seen in Tables 1 and 2, at the detailed level, there is an appreciable effect on performance parameters for the next heater in line. For the HP heater-out case, the TTD and DCA go from 2.37 and 9.3 to 4.22 and 20.6 respectively. For the LP heater-out case these parameters go to 16.17 and 32.4.

At the system performance level, the predicted generation by the design and performance mode analyses differed by about 0.5 mW for both the LP and the HP heater out of service cases. This amounts to about 0.1 percent of the calculated power. In addition the predicted heat rates are modestly different for the design and performance mode analyses, being 8079 and 8070 respectively.

In the HP heater analysis the final feedwater temperature is different by about 1.8 F in the two cases. For the LP heater analysis the final feedwater heater temperatures are identical between the design and performance mode analyses. As might be expected, when the LP heater is taken out of service, the HP heaters are able to recover the same final feedwater temperature, whereas the temperature is not recovered when the nearby HP heater is out of service.

Additional detailed results are presented in the Appendix for use by the interested reader.

The amounts of computer time required for these analyses were approximately 6 minutes for each design mode case and less than one-half minute for each performance mode case on a 486 machine with 33mHz speed.

CONCLUSIONS

Using PEPSE to analyze heaters out of service is possible with the design mode or the performance mode of description. The design mode requires more work by the user, and it runs slower. However, being more mechanistic, it should be expected to provide more reliable results than the easier to use performance mode.

This study has found that, for both HP and LP heaters out of service, the predicted power generation is about 0.5 mW different for the design mode and the performance mode. The heat rate results differ by about 5 to 9 Btu/kw-hr for the two methods of analysis.

SUMMARY

This work has examined two different methods for analyzing feedwater heater out of service in a steam turbine power cycle. The purpose has been to evaluate the reliability of using the performance mode (with specified performance parameters) description of heaters in this analysis. The benchmark for reliability has been the design mode description (which automatically and mechanistically accounts for environmentally driven variations of the performance parameters). Comparison of the results from these two methods shows that there is about a 0.5 mW difference, out of 450 mW total generation, between the two methods of analysis. It remains to the user to decide whether this difference is large enough to justify the extra work that is required to set up the model for analysis by design mode.

REFERENCES

1. Minner, Gene L, et al, PEPSE Manual Volume 1, User Input Description, 1995.

APPENDIX A

This appendix presents figures showing the detailed component-level results, including flows, and thermodynamic-state variables for the base case and the cases with the two different analysis approaches. These results are shown on the PEPSE schematic for the system. Figure A-1 presents the base case. Figures A-2 and A-4 present the (Run 2) results for the design mode analyses for HP heater out and LP heater out, respectively. Figures A-3 and A-5 present the (Run 4) results for the performance mode analyses for the HP and LP heater out, respectively.

Also presented here as Table A-1 is the PEPSE input deck for the turbine cycle model with the feedwater heaters modeled in design mode. This deck also includes stacked cases for the HP heater out-of-service study.

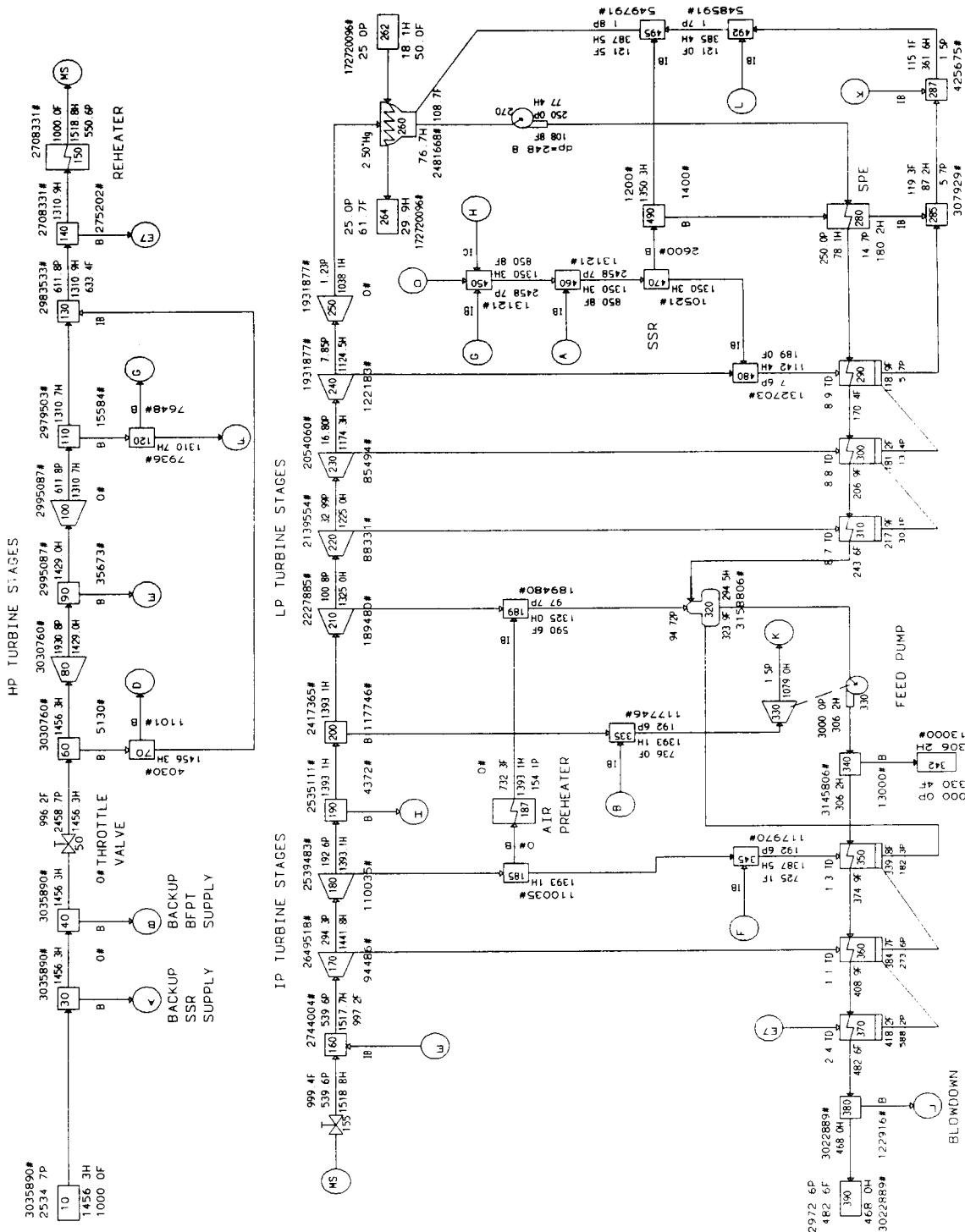


FIGURE A-1 - Detailed Results for Base Case Run, Shown on the PEPSE Schematic

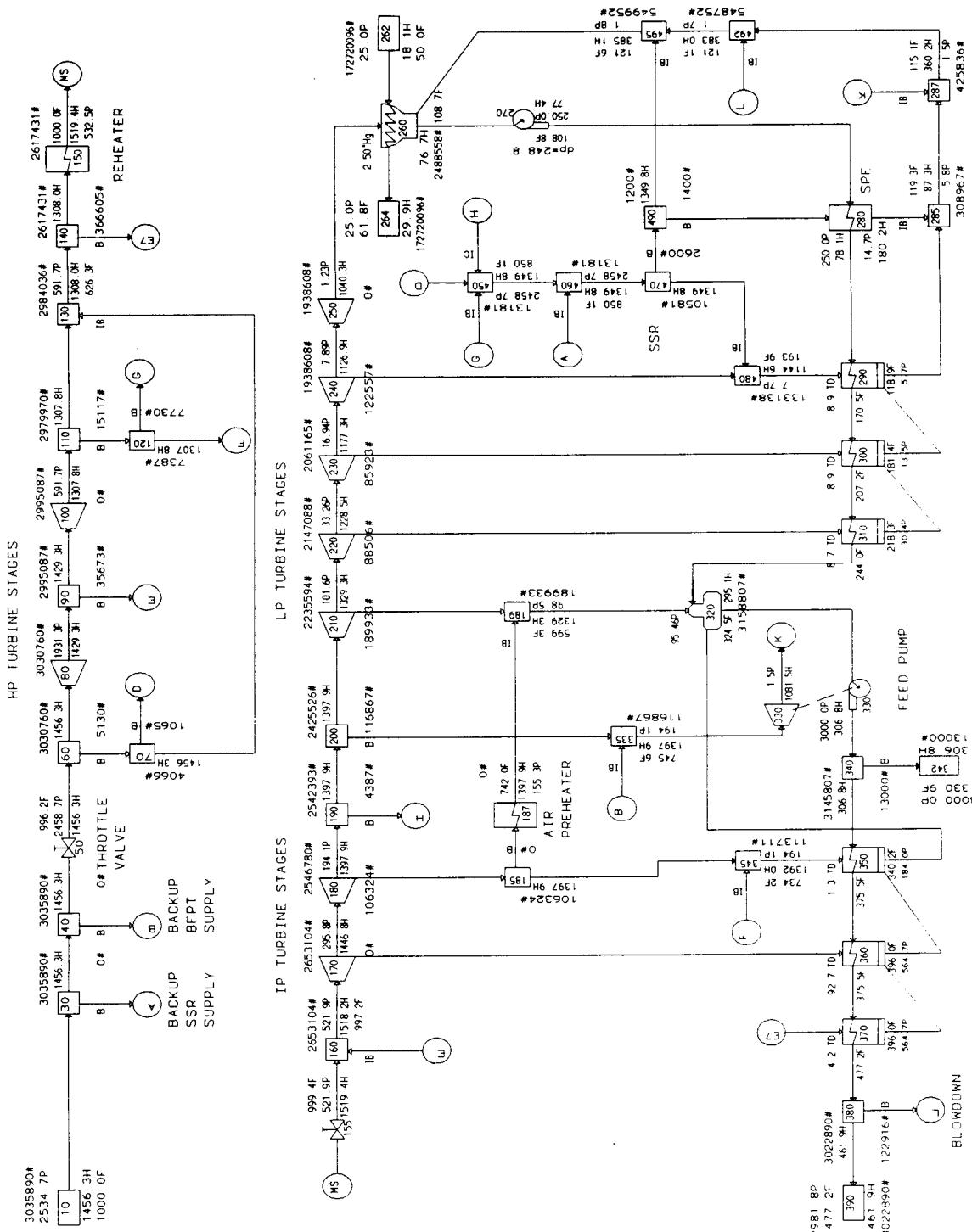


FIGURE A-2 - Detailed Results for the HP Heater-Out-Of-Service Case, Analyzed Using Design Mode (Run 2)

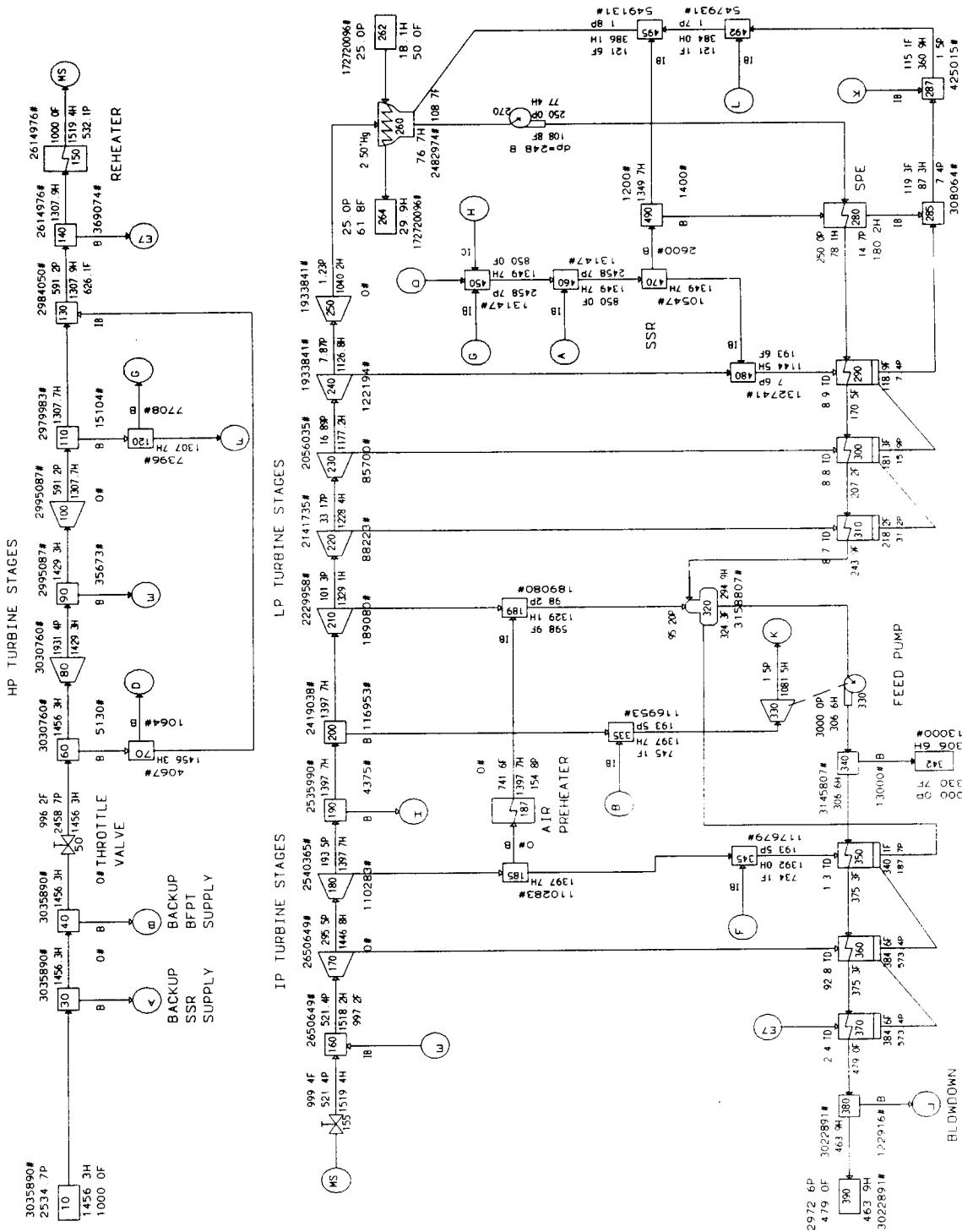


FIGURE A-3 - Detailed Results for the HP Heater-Out-Of-Service Case, Analyzed Using Performance Mode (Run 4)

FIGURE A-4 - Detailed Results for the LP Heater-Out-Of-Service Case, Analyzed Using Design Mode (Run 2)

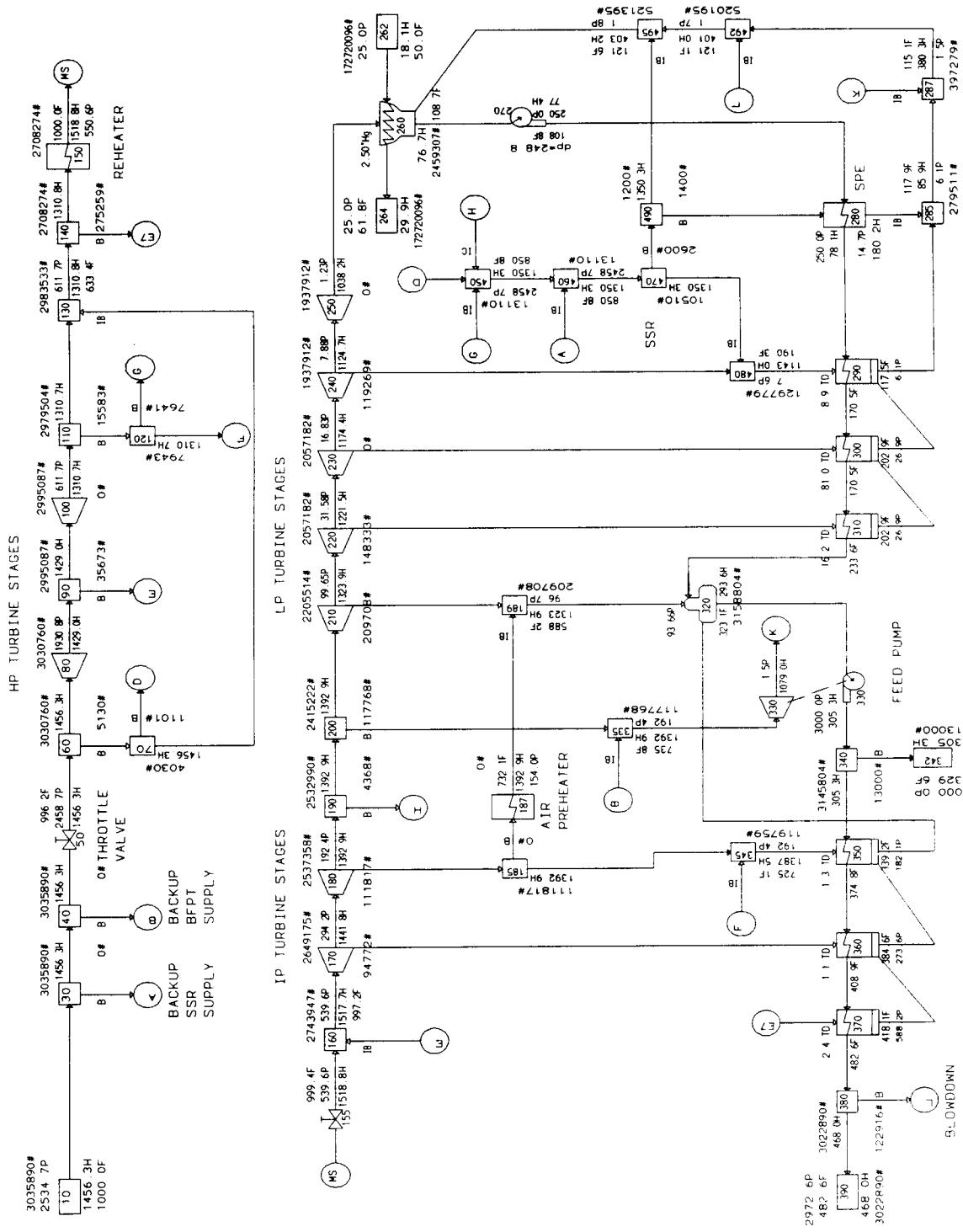


FIGURE A-5 - Detailed Results for the LP Heater-Out-Of-Service Case, Analyzed Using Performance Mode (Run 4)

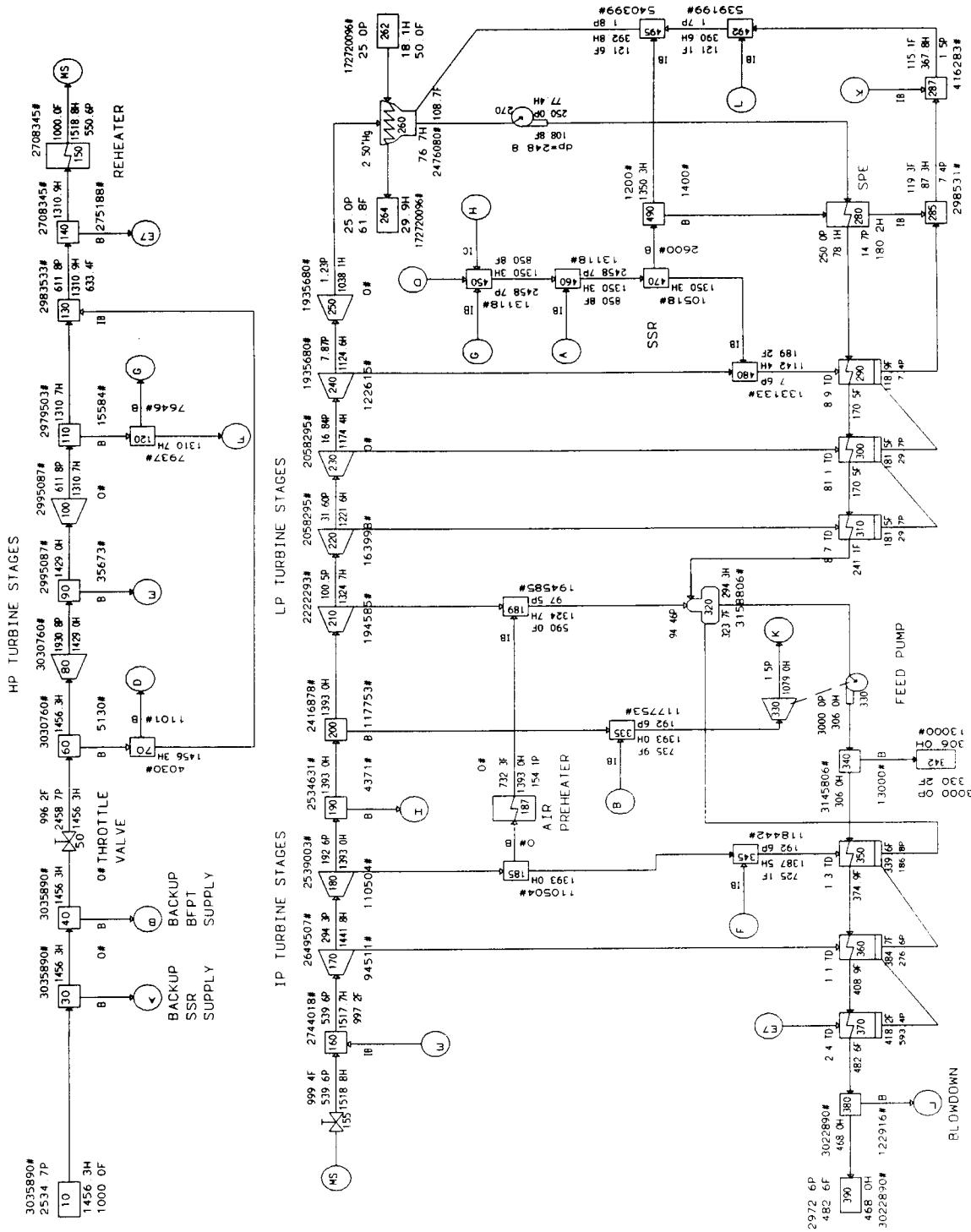


Table A-1
PEPSE Input Data Set for the HP Heater out of Service Analysis

```

010001      80      PRINT
*
*          PEPSE USER : DRF
*          DATE : 04/16/96
*          TIME : 09:48
*          MODEL FILE ID : XYZGB
*          JOB FILE ID : \EASEPLUS\DEMO\XYZGB.JOB
*          RESULTS FILE ID : \EASEPLUS\DEMO\XYZGB.OUT
*
*= XYZGB - SINGLE REHEAT FOSSIL TURBINE CYCLE - VWO LOAD
*
*
*
*****
*      GENERIC INPUT DATA
*****
*
*      UNITS FLAGS
*
*      CYCLE FLAGS
010200      2       3       1       1       1       0       0.       0.
010201      3
*
*      GENERATOR #1 FLAGS AND DATA
011010      1       2       1       0       3600     493300.     0.9      59.7      59.7     0.
011011      1385.   0.       0.
*
*      CYCLE CONVERGENCE DATA
012000      25      5.       5.       0.       0.       0.       0.
*
*      PEPSE OUTPUT SUPPRESSION CARDS
*
020000      PRINT
020002      NOPRNT
020004      NOPRNT
020005      NOPRNT
020021      NOPRNT
020022      NOPRNT
020023      NOPRNT

```

TABLE A-1 (Continued)

020024	NOPRNT
020025	NOPRNT
020032	NOPRNT
020033	NOPRNT
020040	NOPRNT
020041	NOPRNT

*

*

* GEOMETRY CARDS

*

500100	10	U	30	I
500300	30	U	40	I
500310	30	B	460	IB
500400	40	U	50	I
500410	40	B	335	IB
500500	50	U	60	I
500600	60	U	80	I
500610	60	B	70	I
500700	70	U	130	IB
500710	70	B	450	IA
500800	80	U	90	I
500900	90	U	100	I
500910	90	B	160	IB
501000	100	U	110	I
501100	110	U	130	IA
501110	110	B	120	I
501200	120	U	345	IB
501210	120	B	450	IB
501300	130	U	140	I
501400	140	U	150	T
501410	140	B	370	S
501500	150	T	155	I
501550	155	U	160	IA
501600	160	U	170	I
501700	170	U	180	I
501710	170	E	360	S
501800	180	U	190	I
501810	180	E	185	I
501850	185	U	345	IA
501860	185	B	187	T

TABLE A-1 (Continued)

501870	187	T	189	IB
501890	189	U	320	S
501900	190	U	200	I
501910	190	B	450	IC
502000	200	U	210	I
502010	200	B	335	IA
502100	210	U	220	I
502110	210	E	189	IA
502200	220	U	230	I
502210	220	E	310	S
502300	230	U	240	I
502310	230	E	300	S
502400	240	U	250	I
502410	240	E	480	IA
502500	250	U	260	S
502600	260	T	264	I
502630	260	D	270	I
502620	262	U	260	T
502700	270	U	280	T
502800	280	T	290	T
502820	280	D	285	IB
502850	285	U	287	IA
502870	287	U	492	IA
502900	290	T	300	T
502920	290	D	285	IA
503000	300	T	310	T
503020	300	D	290	D
503100	310	T	320	FW
503120	310	D	300	D
503220	320	D	330	IP
503300	330	UP	340	I
503310	330	UT	287	IB
503350	335	U	330	IT
503400	340	U	350	T
503410	340	B	342	I
503450	345	U	350	S
503500	350	T	360	T
503520	350	D	320	D
503600	360	T	370	T
503620	360	D	350	D
503700	370	T	380	I
503720	370	D	360	D

TABLE A-1 (Continued)

503800	380	U	390	I
503810	380	B	492	IB
504500	450	U	460	IA
504600	460	U	470	I
504700	470	U	480	IB
504710	470	B	490	I
504800	480	U	290	S
504900	490	U	495	IB
504910	490	B	280	S
504920	492	U	495	IA
504950	495	U	260	D

*

*

*** SPECIAL STREAM SPECIFICATIONS**

*

***** **STREAM TYPES 1 - 7**

*

*** HEATER 7 EXTRACTION PRESSURE DROP**

601410	2	0.03	0.	0.	0.	0.	0.
--------	---	------	----	----	----	----	----

*** HEATER 6 EXTRACTION PRESSURE DROP**

601710	2	0.031	0.	0.	0.	0.	0.
--------	---	-------	----	----	----	----	----

*** AIR PREHEATER EXTRACTION PRESSURE DROP**

601860	2	0.2	0.	0.	0.	0.	0.
--------	---	-----	----	----	----	----	----

*** HEATER 4 EXTRACTION PRESSURE DROP**

601890	2	0.031	0.	0.	0.	0.	0.
--------	---	-------	----	----	----	----	----

*** CROSSOVER PRESSURE DROP**

602000	2	0.03	0.	0.	0.	0.	0.
--------	---	------	----	----	----	----	----

*** HEATER 3 EXTRACTION PRESSURE DROP**

602210	2	0.03	0.	0.	0.	0.	0.
--------	---	------	----	----	----	----	----

*** HEATER 2 EXTRACTION PRESSURE DROP**

602310	2	0.03	0.	0.	0.	0.	0.
--------	---	------	----	----	----	----	----

*** BFPT EXTRACTION PRESSURE DROP**

603350	2	0.03	0.	0.	0.	0.	0.
--------	---	------	----	----	----	----	----

*** HEATER 5 EXTRACTION PRESSURE DROP**

603450	2	0.03	0.	0.	0.	0.	0.
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*** HEATER 1 EXTRACTION PRESSURE DROP**

604800	2	0.03	0.	0.	0.	0.	0.
--------	---	------	----	----	----	----	----

*

*

TABLE A-1 (Continued)

* COMPONENT DATA

*

***** TURBINES

*

* GOVERNING STAGE

700800	4	1	1	1	1	0
700801	4	0	41.15			
700802	0.	0.	0.	0.	0.00731	0

* HP TURBINE STAGE GROUP

701000	5	1	1	0	1	0.
701001	1930.9	1429.	2.99508E+6	610.6		0.
701002	0.	0.	0.	0.		

* IP - 1ST STAGE GROUP

701700	6	1	0	1	2	1	0.03
701701	538.5	1517.7	2.73851E+6	293.7		94083.	
701702	0.	0.	0.	0.	0.	0.	

* IP - 2ND STAGE GROUP

701800	6	1	3	1	2	1	0.
701801	293.7	1441.8	2.64443E+6	192.		112612.	
701802	0.	0.	0.	0.	0.	0.	

* LP - 1ST STAGE GROUP

702100	7	1	0	1	3	2	0.03
702101	186.2	1392.9	2.40926E+6	100.8		181303.	0.
702102	0.	0.	0.	0.	0.		
702103	0	0.	0.				

* LP - 2ND STAGE GROUP

702200	7	1	1	1	3	2	0.03
702201	100.8	1325.2	2.22795E+6	33.		88420.	0.
702202	0.	0.	0.	0.	0.		
702203	0	0.	0.				

* LP - 3RD STAGE GROUP

702300	7	1	1	1	3	2	0.03
702301	33.	1225.1	2.13953E+6	16.8		86359.	0.
702302	0.	0.	0.	0.	0.		
702303	0	0.	0.				

* LP - 4TH STAGE GROUP

702400	7	1	1	1	3	2	0.03
702401	16.8	1174.4	2.05318E+6	7.81		130966.	0.
702402	0.	0.	0.	0.	0.		
702403	0	0.	0.				

TABLE A-1 (Continued)

* LP - 5TH STAGE GROUP

702500	7	1	3	0	3	2	0.					
702501	7.81		1124.2		1.92221E+6		1.2275		0.			66.1
702502	0.	0.	0.	0.	0.							
702503	0	0.	0.									

*

***** CONDENSERS AND FEEDWATER HEATERS

*

* CONDENSER

702600	10	1	2	0.	-2.5							
702601	0.	0.	0.	0.	0.							
702602	0.	0.	0.	0.	0.							

* HEATER 1

702900	16	1	240	4	0.	2	2	0	0	1	0	0
+	2	2										
702901	0.68	0.75	906.7	793.	9.3	0.9375	14.	14.	27.78	10.		
702903	0.	0.0002	0.	-0.6628		0.9375	10.5					
702906	167.6	282.7	8.	14.08	0.9144	0.9998	0.0002	0.0003				
+	-0.7186	0.										
702907	0.	0.	0.	0.	0.	0.	0.	0.				
702909	0	0	0.	0.	0.	0.	0.	0.	5.	10.	0	
+	0	0	0.									

* HEATER 2

703000	16	1	230	4	0.	2	2	0	0	1	0	0
+	2	2										
703001	0.68	0.75	793.6	633.	9.4	0.9375	14.	14.	28.28	8.		
703003	0.	0.0002	0.	-0.6545	0.9375	7.125						
703006	65.2	196.3	6.	12.6	1.0261	0.9984	0.0002	0.0003	-0.7433			
+	0.											
703007	0.	0.	0.	0.	0.	0.	0.	0.				
703009	0	0	0.	0.	0.	0.	0.	0.	5.	10.	0	
+	0	0	0.									

* HEATER 3

703100	16	0	220	4	0.	2	2	0	0	1	0	0
+	2	2										
703101	0.68	0.75	772.6	602.	9.5	0.9375	14.	14.	24.	6.		
703103	0.	0.0002	0.	-0.6854	0.9375	8.25						
703106	36.	125.7	5.	12.3	0.9163	0.9994	0.0002	0.0003	-0.6903			
+	0.											
703107	0.	0.	0.	0.	0.	0.	0.	0.				
703109	0	0	0.	0.	0.	0.	0.	0.	5.	10.	0	
+	0	0	0.									

TABLE A-1 (Continued)

* HEATER 5													
703500	18	1	180	4	0.	2	2	0	0	1	2	2	
+	2	2											
703501	0.481	0.625	484.8	1844.	9.95	0.8125	16.5	16.5	14.	12.			
703503	0.	0.0002	0.	-0.841	0.8125	10.							
703504	65.4	817.1	1.	10.75	1.0041	0.8444	0.0002	0.0003	-0.738				
+	0.												
703505	0.	0.	0.	0.	0.								
703506	94.3	363.2	5.	21.5	1.0223	0.9947	0.0002	0.0003	-0.7906				
+	0.												
703507	0.	0.	0.	0.	0.	0.	0.	0.					
703509	0	0	0.	0.	0.	0.	0.	0.	0.	10.	0		
+	0	0	0.										
* HEATER 6													
703600	18	1	170	4	0.	2	2	0	0	1	2	2	
+	2	2											
703601	0.459	0.625	427.3	1844.	10.	0.8125	16.5	11.1875	10.				
+	8.												
703603	0.	0.0002	0.	-0.8444	0.8125	9.25							
703604	58.3	769.8	1.	10.75	0.9788	0.9652	0.0002	0.0003					
+	-0.6454	0.											
703605	0.	0.	0.	0.	0.								
703606	58.5	342.1	4.	21.5	0.8944	0.9946	0.0002	0.0003	-0.8022				
+	0.												
703607	0.	0.	0.	0.	0.	0.	0.	0.					
703609	0	0	0.	0.	0.	0.	0.	0.	0.	10.	0		
+	0	0	0.										
* HEATER 7													
703700	18	0	140	4	0.	2	2	0	0	1	2	2	
+	2	2											
703701	0.459	0.625	541.8	2179.	11.	0.8125	16.4	16.4	12.	10.			
703703	0.	0.0002	0.	-0.8005	0.8125	9.75							
703704	79.6	841.3	1.	23.3	1.1278	0.9616	0.0002	0.0003	-0.8119				
+	0.												
703705	0.	0.	0.	0.	0.								
703706	67.	373.9	6.	23.3	0.911	0.994	0.0002	0.0003	-0.7739				
+	0.												
703707	0.	0.	0.	0.	0.	0.	0.	0.					
703709	0	0	0.	0.	0.	0.	0.	0.	0.	10.	0		
+	0	0	0.										

TABLE A-1 (Continued)

* HEATER 4 - DEAERATOR

703200	15	1	210	0.	0.			
703201	0	0.	0.	0.	0.	0.		
703202	0.	0.	0.	0.	0	0.	0.	

*

***** HEAT EXCHANGERS

*

* SHAFT PACKING EXHAUSTER

702800	20	0.						
702801	0.	0.	0.	0.	0.	0.	14.696	0.

* REHEATER

701500	25	2	1000.					
701501	0.1	0.	0.	0.	0.			

* AIR PREHEATER

701870	27	0.	0.	0.	0.			
--------	----	----	----	----	----	--	--	--

*

***** SOURCES, SINKS, AND VALVES

*

* MAIN STEAM - VWO LOAD

700100	33	1000.	2534.7	3.03589E+6	0.	0.	0	
700102	0	0	0					

* CIRCULATING WATER SOURCE

702620	31	50.	25.	-345000.	0.	0.	0	
702622	0	0	0					

* CIRCULATING WATER SINK

702640	30							
--------	----	--	--	--	--	--	--	--

* ATTEMPORATION SPRAY SINK

703420	30							
--------	----	--	--	--	--	--	--	--

* OUTPUT - TO ECONOMIZER

703900	32							
--------	----	--	--	--	--	--	--	--

* THROTTLE VALVE

700500	35	-2.	-2.	-2.	0.35	2534.7	1456.3	3.03589E+6
--------	----	-----	-----	-----	------	--------	--------	------------

* INTERCEPT VALVE

701550	34	0.02	0.	0.				
701551	0.	0.	0.	0.				

*

***** PUMPS, COMPRESSORS, AND FANS

*

* BOILER FEED PUMP - VWO

703300	40	200	3000.	-3.	0.	0.794		
703301	0.	0.809	0.	0.	0.	0.	0.	
703309	0.75	2	0.					

TABLE A-1 (Continued)

* CONDENSATE PUMP

702700	41	250.	0.	0.	0.	
702701	0.	0.	0.	0.	0.	0.

*

***** MIXERS

*

*

701890	50	1	0.			
--------	----	---	----	--	--	--

*

702850	51	0	0.			
--------	----	---	----	--	--	--

*

702870	51	0	0.			
--------	----	---	----	--	--	--

*

703350	50	3	0.			
--------	----	---	----	--	--	--

*

703450	50	1	0.			
--------	----	---	----	--	--	--

* LEAKAGE MIXER

704600	50	1	0.			
--------	----	---	----	--	--	--

*

704920	51	0	0.			
--------	----	---	----	--	--	--

*

704950	51	0	0.			
--------	----	---	----	--	--	--

* LEAKAGE MIXER

701300	50	1	0.			
--------	----	---	----	--	--	--

* LEAKAGE MIXER

701600	50	1	0.			
--------	----	---	----	--	--	--

*

704800	50	1	0.			
--------	----	---	----	--	--	--

* LEAKAGE MIXER

704500	54	1	0.			
--------	----	---	----	--	--	--

*

***** SPLITTERS

*

* BACKUP SSR SUPPLY

700300	60	0.	0.	0.	0	0.
--------	----	----	----	----	---	----

* BACKUP BFPT SUPPLY

700400	60	0.	0.	0.	0	0.
--------	----	----	----	----	---	----

* VALVE LEAKAGE

700600	68	0.	0.	0.		
--------	----	----	----	----	--	--

* VALVE LEAKAGE

700700	68	0.	0.	0.		
--------	----	----	----	----	--	--

* SHAFT LEAKAGE

700900	64	500.	0.	0.		
--------	----	------	----	----	--	--

TABLE A-1 (Continued)

* SHAFT LEAKAGE SPLITTER
 701100 64 620. 0. 0.

* SHAFT LEAKAGE SPLITTER
 701200 64 970. 0. 0.

* HEATER 7 EXTRACTION
 701400 60 0. 280724. 0. 0 0.

* AIR PREHEATER SPLITTER
 701850 61 0. 0.

* IP SHAFT LEAKAGE
 701900 64 600. 0. 0.

* BFPT SUPPLY SPLITTER
 702000 60 0. 118201. 0. 40 0.

* ATTEMPORATION SPLITTER
 703400 61 0. 13000.

* BLOWDOWN SPLITTER
 703800 61 0. 122916.

* STEAM SEAL REGULATOR
 704700 67 30 0. 0. 2600.

* SPE SPLITTER
 704900 61 0. 1400.

*

*

* SPECIAL FEATURES

*

***** SCHEDULES

*

*

800100 'BOILER FEED PUMP EFFICIENCY'

* X VALUES

810100	0.	350.	600.	1000.	1350.
810101	1600.	1900.	2200.	2500.	2900.
810102	3200.	3500.	3750.	4000.	4300.
810103	4600.	4900.	5200.	5500.	5800.

* Z AND Y VALUES

810110	0.	0.000000	0.199000	0.310000	0.460000	0.567000
810111	0.630000	0.692000	0.742000	0.781000	0.819000	
810112	0.835000	0.845000	0.849000	0.845000	0.837000	
810113	0.820000	0.795000	0.760000	0.712000	0.650000	

* Y, X, AND Z MULTIPLIERS

820100	1.	16.0417	0.			
--------	----	---------	----	--	--	--

*

TABLE A-1 (Continued)

800200	'BOILER FEED PUMP HEAD'							
*	X VALUES							
810200	0.	350.	600.	1000.	1350.			
810201	1600.	1900.	2200.	2500.	2900.			
810202	3200.	3500.	3750.	4000.	4300.			
810203	4600.	4900.	5200.	5500.	5800.			
*	Z AND Y VALUES							
810210	0.	9320.000000	9300.000000	9275.000000	9190.000000			
+	9090.000000							
810211	8975.000000	8825.000000	8650.000000	8400.000000	8075.000000			
810212	7750.000000	7350.000000	7010.000000	6650.000000	6200.000000			
810213	5700.000000	5210.000000	4700.000000	4150.000000	3600.000000			
*	Y, X, AND Z MULTIPLIERS							
820200	1.	16.017	0.					
*								
***** SCHEDULE VARIABLES								
*								
*								
* BOILER FEED PUMP EFFICIENCY								
830100	1	EFFPMP	330	WV	322			
830108	DELETE							
*								
* BOILER FEED PUMP HEAD								
830200	2	PHEAD	330	WV	322			
830208	DELETE							
*								
***** OPERATIONAL VARIABLES								
*								
* MEGAWATT TO KILOWATT CONVERSION								
874000	1000.							
*								
***** OPERATIONS								
*								
* HEAT RATE								
880010	HH	10	SUB	HH	380	OPVB	1	
*								
880020	WW	10	MUL	OPVB	1	OPVB	2	
*								
880030	HH	380	SUB	HH	341	OPVB	3	
*								
880040	WW	341	MUL	OPVB	3	OPVB	4	
*								
880050	BBSTRM		150	SUB	BBSTRM	140	OPVB	5

TABLE A-1 (Continued)

*				
880060	OPVB 2	ADD	OPVB 4	OPVB 6
*				
880070	OPVB 5	ADD	OPVB 6	OPVB 7
*				
880080	OPVB 7	DIV	BKGROS	0 OPVB 8
*				
880090	OPVB 8	DIV	OPVB 400	OPVB 8
*				
***** SPECIAL INPUT/OUTPUT				
*				
890010	'HEAT RATE'			
890011	OPVB 8			
890019	F10.0			
891000	'HEATER 1 TUBE ROUGHNESS [RFNC]'			
891001	RFNC 290 0.0007953 I			
891010	'HEATER 1 TUBE ROUGHNESS [RFNDC]'			
891011	RFNDC 290 0.0007953 I			
891020	'HEATER 1 FORM LOSS COEF.'			
891021	SHKIN 290 1E-6 I			
891030	'HEATER 2 TUBE ROUGHNESS [RFNC]'			
891031	RFNC 300 0.0005596 I			
891040	'HEATER 2 TUBE ROUGHNESS [RFNDC]'			
891041	RFNDC 300 0.0005596 I			
891050	'HEATER 2 FORM LOSS COEF.'			
891051	SHKIN 300 1E-6 I			
891060	'HEATER 3 TUBE ROUGHNESS [RFNC]'			
891061	RFNC 310 0.0003929 I			
891070	'HEATER 3 TUBE ROUGHNESS [RFNDC]'			
891071	RFNDC 310 0.0003929 I			
891080	'HEATER 3 FORM LOSS COEF.'			
891081	SHKIN 310 1E-6 I			
891090	'HEATER 5 TUBE ROUGHNESS [RFNC]'			
891091	RFNC 350 0.00106 I			
891100	'HEATER 5 TUBE ROUGHNESS [RFNDC]'			
891101	RFNDC 350 0.00106 I			
891110	'HEATER 5 TUBE ROUGHNESS [RFNDS]'			
891111	RFNDS 350 0.00106 I			
891120	'HEATER 5 FORM LOSS COEF.'			
891121	SHKIN 350 0.729 I			
891130	'HEATER 6 TUBE ROUGHNESS [RFNC]'			
891131	RFNC 360 0.0001908 I			

TABLE A-1 (Continued)

891140	'HEATER 6 TUBE ROUGHNESS [RFNDC]'								
891141	RFNDC	360	0.0001908	I					
891150	'HEATER 6 TUBE ROUGHNESS [RFNDS]'								
891151	RFNDS	360	0.0001908	I					
891160	'HEATER 6 FORM LOSS COEF.'								
891161	SHKIN	360	0.4146 I						
891170	'HEATER 7 TUBE ROUGHNESS [RFNC]'								
891171	RFNC	370	0.0009586	I					
891180	'HEATER 7 TUBE ROUGHNESS [RFNDC]'								
891181	RFNDC	370	0.0009586	I					
891190	'HEATER 7 TUBE ROUGHNESS [RFNDS]'								
891191	RFNDS	370	0.0009586	I					
891200	'HEATER 7 FORM LOSS COEF.'								
891201	SHKIN	370	0.2578	I					
*									
*									
*									
*									

* END OF BASE DECK									

*									
*									
\$									
\$	GLM MODS FOR FWH-OUT-OF-SVC STUDY								
\$									
=	(COMPAQ)C:\UGM96\FWHCASEH - BASE CASE, ALL FWH IN DESIGN MODE								
*									
* SUPPRESS UNNECESSARY TABLES									
*									
021000	36	37	38	39	40	41	42	43	44
/									
=	..\FWHCASEH - HP HTR OUT OF SVC CASE, ALL FWH IN DESIGN MODE								
*									
* CLOSE SHELL-INLET STREAM FOR HEATER 360									
*									
601716	CLOSE								
*									
* CONVERT HEATER 6 TO PERFORMANCE MODE FOR REMOVAL FROM SERVICE									
*									

TABLE A-1 (Continued)

* HEATER 6							
703600	18	1	170	2	0.	1.07	9.8
703601							
703603							
703604							
703605							
703606							
703607							
703609							
/							
= ..\FWHCASEH - ALL FWH IN PERFORMANCE MODE							
*							
* REOPEN STREAM 171 TO HEATER 360 SHELL							
*							
601716		OPEN					
*							
* CHANGE DESCRIPTIONS TO PERFORMANCE MODE. PART OF THE FOLLOWING							
* CARDS ARE NEEDED TO "CANCLE OUT" THE DESIGN MODE CARDS THAT WERE							
* USED IN THE PRECEDING CASES							
*							
*	1	2	3	4	5	6	7
*	CTYPE	IDRAIN	IDXTGE	NMODFW	FRFWUT	TTD	DCA
* HEATER 1							
702900	16	1	240	2	0.	8.88	9.4
702901							
702903							
702906							
702907							
702909							
* HEATER 2							
703000	16	1	230	2	0.	8.80	10.8
703001							
703003							
703006							
703007							
703009							
* HEATER 3							
703100	16	0	220	2	0.	8.69	11.0
703101							
703103							
703106							
703107							
703109							

TABLE A-1 (Continued)*** HEATER 5**

703500 18 1 180 2 0. 1.26 9.4

703501

703503

703504

703505

703506

703507

703509

*** HEATER 6**

703600 18 1 170 2 0. 1.07 9.8

703601

703603

703604

703605

703606

703607

703609

*** HEATER 7**

703700 18 0 140 2 0. 2.37 9.3

703701

703703

703704 703705

703706 703707

703709

*** HEATER 4 - DEAERATOR**

703200 15 1 210 0. 0.

703201

703202

*

*** SPECIAL INPUTS OF FEEDWATER OUTLET PRESSURE**

*

890291 PPFO,290, 241.4,I

890301 PPFO,300, 231.4,I

890311 PPFO,310, 221.4,I

890351 PPFO,350, 2990.9,I

890361 PPFO,360, 2981.7,I

890371 PPFO,370, 2972.55,I

/=..\FWHCASEH - HP HTR OUT OF SVC CASE, ALL FWH IN PERFORMANCE MODE

*

TABLE A-1 (Continued)

* CLOSE SHELL-INLET STREAM FOR HEATER 360

*

601716 CLOSE