Variable Speed Boiler Feedpump Analysis

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Abstract

A review of the Rochester Gas and Electric coal fired units was mandated by the New York State Public Service Commission in 1986. The consultant who performed the review identified variable speed feed pump operation as area of potential energy savings, and RG&E agreed to further study. The existing feedwater control system utilizes constant speed, electric motor driven pumps, with control valves to throttle the pump discharge in response to boiler water requirements. With variable speed feedwater control, the control valve is eliminated and the feedpump is operated at a speed where the discharge pressure matches the system requirement. PEPSE was used to determine system operating characteristics when using both constant speed and variable speed feedpumps.

Introduction

Rochester Gas and Electric serves the Upstate New York area, with corporate headquarters in Rochester, New York. Electric generation consists of a 500 MW nuclear plant, five (5) coal units with a total output of 350 MW, hydro-electric stations along the Genesee River with a total output of 50 MW, and two (2) 15 MW gas turbines. RG&E is also a partner with neighbor utilities for 200 MW of oil fired generation and 150 MW of nuclear. RG&E is a member of the New York Power Pool and will supply the pool or draw from the pool, depending upon the generating units available. Currently the nuclear plants are base loaded, the hydro plants will produce based upon the river flow, and the coal units will load swing on economic reserve.

The New York State Public Service Commission conducted an audit of the RG&E coal fired units in 1986. The purpose of the audit was to assure the customers that RG&E was operating the coal units efficiently and, therefore, providing electricity at the lowest possible cost. One finding from this audit was the potential energy savings associated with variable speed boiler feedpump operation. RG&E agreed to study this to determine the cost of conversion to variable speed and to better quantify the energy savings.

Description of Existing System

RG&E Units 4 and 12 were selected for this study. Each unit is 80 MW, single reheat with CE boiler and GE turbine. Unit 4 has 3-50% capacity boiler feed pumps, each driven with a 1,000 HP electric motor. One of the pumps has a hydraulic coupling. Unit 12 has a 2-50% capacity pumps, each driven by a 1,250 HP electric motor. One of these feed pumps has a hydraulic coupling. Unit 4 has one boiler feedwater control valve located between the last feedwater heater and the economizer inlet. Unit 12 has two control valves, one at each feed pump discharge. Flow schematics for the 2 units are shown in Attachment 1 and 2.

The calculated operating conditions for the two units are shown on Attachments 3 and 4. Note that the pressure drop across the feedwater control valve ranges from 400 to 700 psi, depending upon load, and this represents a considerable energy loss.

Description of Variable Speed Boiler Feedpump Operation

With variable speed operation, the feedpump speed is reduced such that the pump discharge pressure is just sufficient to match the system pressure requirement. The control valve can be eliminated, and the level control signal from the boiler fed to control pump speed rather than control valve opening. The feedpumps consume less power because the discharge pressure is reduced from that at constant speed pump operation.

PEPSE Modeling

A PEPSE model was created for the existing plant configuration. It is a typical turbine cycle model and includes the boiler feedwater control valve. A schedule for condensate pump head versus flow and boiler feed pump head versus flow was included, along with boiler feed pump efficiency versus flow. The feedwater heaters were modeled in simplified design mode. A special input card was used to specify tube relative surface roughness (RFNC) so that the heater tube side pressure drop matched the original vendor data.

A second PEPSE model was then created with variable speed feed pumps. A bivariate schedule was used for the feedpump, with head versus flow and pump speed. The feedwater control valve pressure drop was set to zero. A schedule for feedpump speed versus throttle flow was added. The pump speed, therefore, varies with unit load to provide the required pump discharge pressure.

The PEPSE schematics for Units 4 and 12 are shown in Attachments 5 and 6. The input files for Unit 4 constant speed pumps and variable speed pumps are shown in Attachments 7 and 8.

The input files for Unit 12 constant speed pumps and variable speed pumps are shown in Attachments 9 and 10.

Discussion

A summary of the PEPSE output for variable speed is shown in Attachments 11 and 12. There is a considerable savings in the feedpump brake horsepower required, both because of the reduced hydraulic requirement and because the pump is more efficient at reduced speeds. These values assume that the feedwater control valve is removed from the piping system, though in practice, some pressure drop across the valve may be desirable for flow control. The variable speed drives for the pump (either variable frequency AC motor drive or adjustable speed mechanical coupling) are not 100% efficient, so that the actual power savings will not be as large or indicated here.

Conclusion

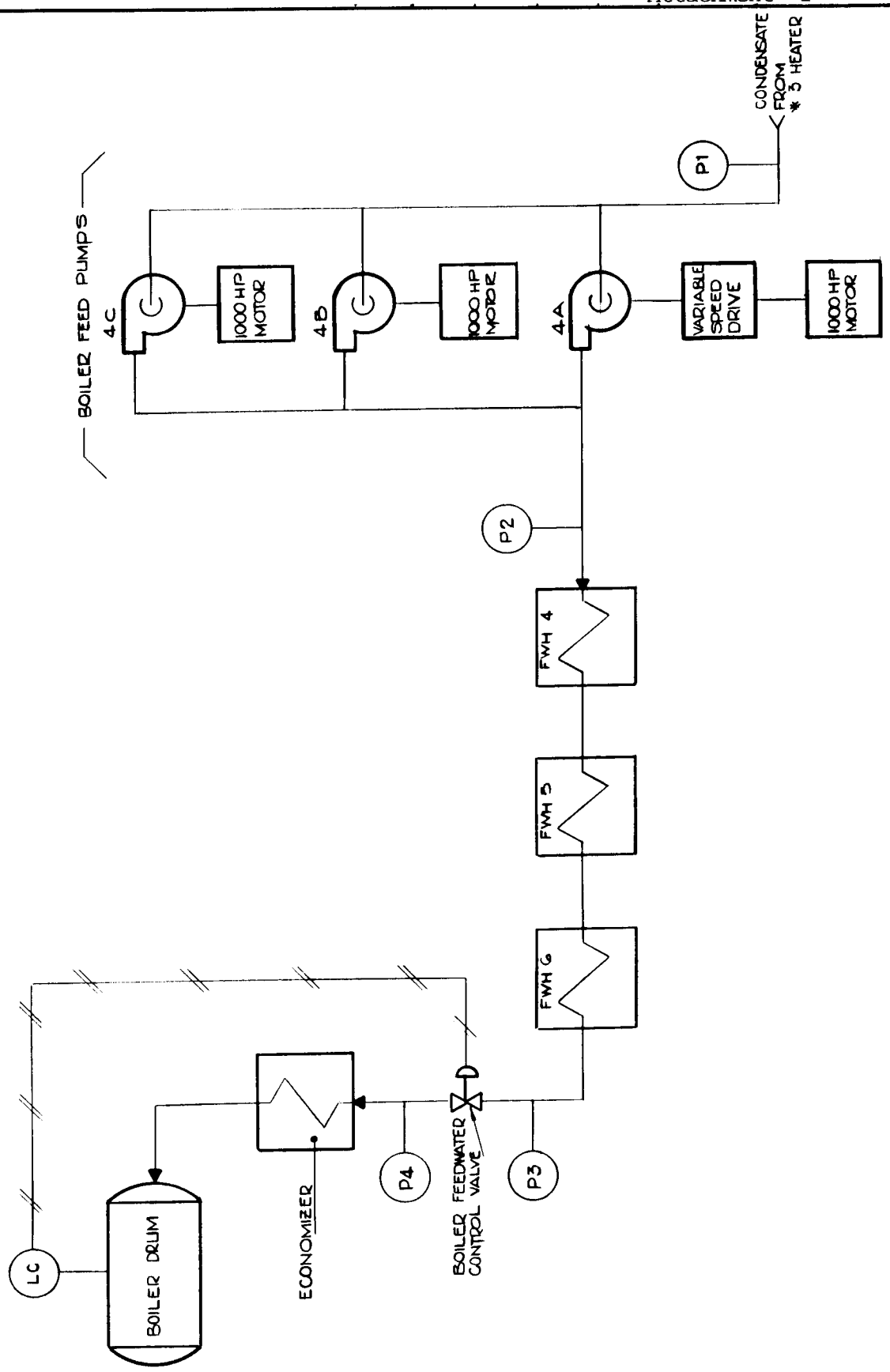
We decided not to proceed with conversion to variable speed boiler feed pumps, as the payback of the project was too long to justify the cost. Variable speed feedpump operation can probably be justified if it is incorporated into the original plant design and construction. The use of the PEPSE modeling was helpful in quantifying the pump performance at various load levels and made the analysis easier.

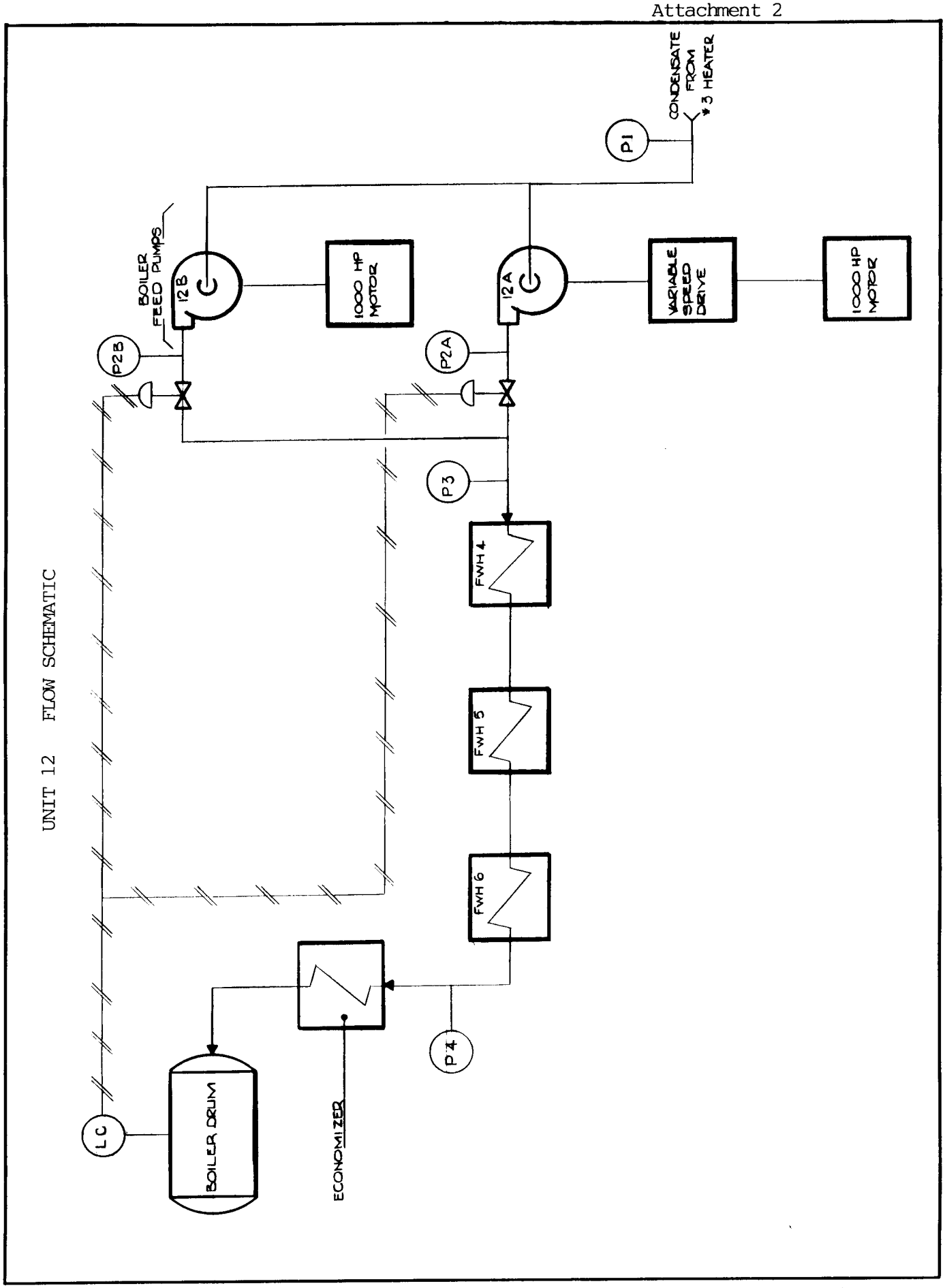
Acknowledgements

I want to recognize the help provided by Don Buehlman and Craig Litt of RG&E in preparing the PEPSE models.

TWM\A009

UNIT 4 FLOW SCHEMATIC




UNIT 12 FLOW SCHEMATIC
CONDENSATE FROM #3 HEATER
P1
BOILER FEED PUMPS
12B
1000 HP MOTOR
12A
VARIABLE SPEED DRIVE
1000 HP MOTOR
P2B
P2A
P3
FWH 4
FWH 5
FWH 6
P4
LC
BOILER DRUM
ECONOMIZER
CONTACT SUPPLY

Unit 4 Calculated Operating Conditions
Constant Speed Pump Operation

Calculated Operating Data

Unit Load, MW(G)	84	75	65	55	45	35
Throttle Flow, K Lb/Hr	565	492	416	346	280	218
Condensate Flow, K Lb/Hr	426	376	323	273	225	179
BFP Flow, K Lb/Hr	582	509	432	362	296	233
Cond. Pump Disch., PSIA	263	268	273	276	260	270
BFP Suction, PSIA	234	246	256	264	252	265
BFP Discharge, PSIA	2396	2480	2552	2599	2445	2580
No. 6 Htr Out, PSIA	2367	2458	2536	2588	2437	2575
BFW Valve Out, PSIA	1991	1954	1925	1905	1883	1870
Boiler Drum, PSIA	1935	1915	1900	1885	1868	1861
Main Steam, PSIA	1815	1815	1815	1815	1815	1815

Calculated Feedpump Performance

BFP Hydraulic HP	1573	1416	1231	1043	797	660
BFP Efficiency, %	70.7	67.8	63.6	58.4	70.8	66.0
BFP Brake HP	2225	2088	1935	1786	1125	1000
BFP Head, Feet	5352	5510	5639	5706	5334	5598
BFP Speed, RPM	3580	3580	3580	3580	3580	3580

Notes:

1) One boiler feedpump and one condensate pump operate at unit loads below 50 MW; two feedpumps and two condensate pumps operate at unit loads 50 MW and above.

2) Boiler feedpump performance from GAI Data Book curve H-2966

3) Condensate pump performance from GAI Data Book curve H-2961

4) Pressure drop for LP feedwater heaters from Marley data sheets, and pressure drop for HP heaters from GAI Data Book.

5) Boiler drum pressure from GAI Heat Balances B-43265

Attachment 4

Unit 12 Calculated Operating Conditions
Constant Speed Pump Operation

Calculated Operating Data

Unit Load, MW(G)	84	75	65	55	45	35
Throttle Flow, K Lb/Hr	565	492	416	346	280	218
Condensate Flow, K Lb/Hr	426	376	323	273	225	179
BFP Flow, K Lb/Hr	568	495	418	348	281	219
Cond. Pump Disch., PSIA	265	271	278	284	262	274
BFP Suction, PSIA	232	245	259	269	252	268
BFP Discharge, PSIA	2406	2492	2561	2608	2470	2596
BFW Valve Out, PSIA	2024	1991	1944	1915	1892	1875
No. 6 Htr Out, PSIA	1988	1964	1925	1905	1883	1870
Boiler Drum, PSIA	1935	1915	1900	1885	1868	1861
Main Steam, PSIA	1815	1815	1815	1815	1815	1815

Calculated Feedpump Performance

BFP Hydraulic HP	1544	1384	1194	1004	767	623
BFP Efficiency, %	70.3	67.2	62.6	58.1	70.1	62.3
BFP Brake HP	2197	2060	1906	1727	1094	973
BFP Head, Feet	5383	5541	5652	5714	5394	5630
BFP Speed, RPM	3580	3580	3580	3580	3580	3580

Notes:

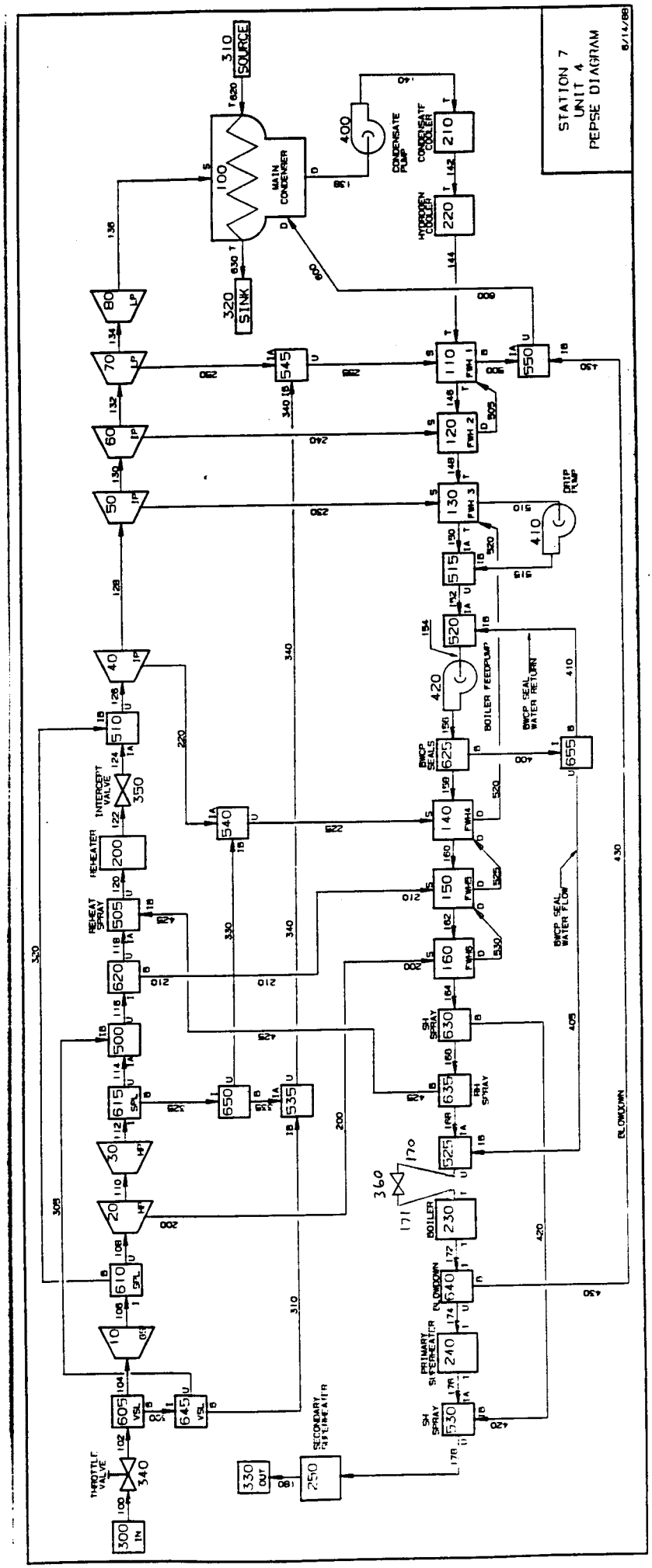
1) One boiler feedpump and one condensate pump operate at unit loads below 50 MW; two feedpumps and two condensate pumps operate at unit loads 50 MW and above.

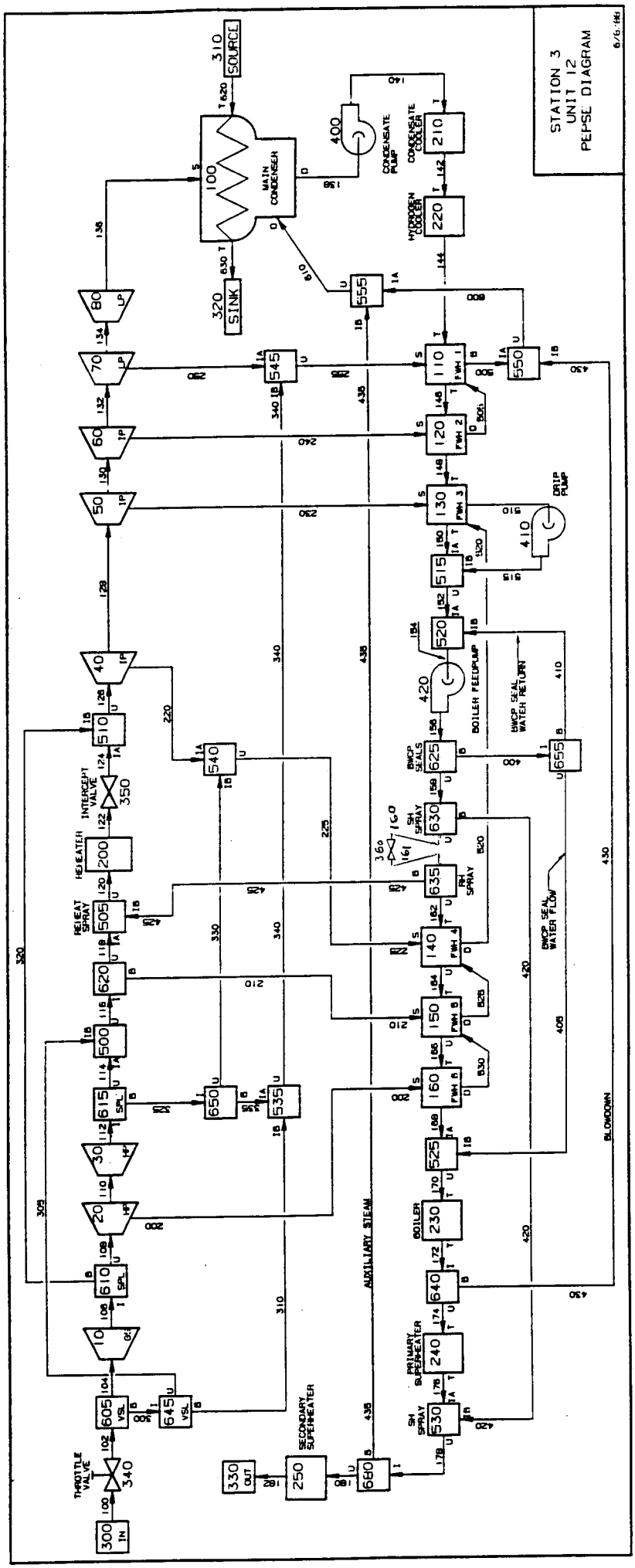
2) Boiler feedpump performance from GAI Data Book curve H-3326

3) Condensate pump performance from GAI Data Book curve H-3321

4) Pressure drop for feedwater heaters from GAI Data Book.

5) Boiler drum pressure from GAI Heat Balances B-43265 (Unit 4)


STATION 7
UNIT 4
PEPSE DIAGRAM
8/14/88
310 SOURCE
320 SINK
100 MAIN CONDENSER
400 CONDENSATE PUMP
210 CONDENSATE COOLER
220 HYDROGEN COOLER
80 LP
70 LP
60 IP
50 IP
40 IP
30 HP
20 HP
10
110 FWH 1
120 FWH 2
130 FWH 3
140 FWH 4
150 FWH 5
160 FWH 6
410 DRIP PUMP
420 BOILER FEEDPUMP
BWCP SEAL WATER RETURN
BWCP SEAL WATER FLOW
BLOWDOWN
230 BOILER
240 PRIMARY SUPERHEATER
250 SECONDARY SUPERHEATER
200 REHEATER
350 INTERCEPT VALVE
340 THROTTLE VALVE
360
170
300 IN
330 OUT


STATION 3
UNIT 12
PEPSE DIAGRAM
SOURCE
SINK
MAIN CONDENSER
CONDENSATE PUMP
CONDENSATE COOLER
HYDROGEN COOLER
BOILER FEEDPUMP
DRIP PUMP
BMCP SEALS
BMCP SEAL WATER RETURN
BMCP SEAL WATER FLOW
SH SPRAY
RH SPRAY
REHEAT SPRAY
INTERCEPT VALVE
THROTTLE VALVE
HEATER
PRIMARY SUPERHEATER
SECONDARY SUPERHEATER
BOILER
AUXILIARY STEAM
BLOWDOWN
IN
OUT

LISTING OF INPUT DATA FOR CASE 1

```
  1      UNIT 4 CONSTANT SPEED BOILER FEED PUMP
  2    * MODEL FILENAME IS R4CSBFP
  3    * MODEL INCLUDES THE FOLLOWING:
  4    * FEEDWATER HEATERS IN SIMPLIFIED DESIGN MODE
  5    * SCHEDULE FOR H2 COOLER HEAT INPUT
  6    * SCHEDULE FOR BWCP INJECTION LEAKOFF ENTHALPY
  7    * SCHEDULE FOR GENERATOR VARIABLE LOSS
  8    * SCHEDULE FOR TURBINE EXHAUST LOSS USING ANNULUS VELOCITY
  9    * SCHEDULE FOR FEED VALVE PRESSURE DROP
 10    * SCHEDULE FOR DRUM PRESSURE DROP
 11    * SCHEDULE FOR PRIMARY SUPERHEATER PRESSURE DROP
 12    * SCHEDULE FOR CONDENSATE PUMP HEAD VS CONDENSATE FLOW
 13    * SCHEDULE FOR BOILER FEED PUMP HEAD VS BFP FLOW
 14    * SCHEDULE FOR BOILER FEED PUMP EFFICIENCY VS BFP FLOW
 15    * TEMPERATURE CONTROL FOR SUPERHEAT SPRAY FLOW RATE
 16    * Generic Input Data
 17    010200 2 3 1 1 1
 18    010201 3
 19    011010 1 2 1 0 3600 96000. .85 45. 45.
 20    011011 446. 1175.
 21    012000 25 50. 50. 0. 0. 0. 0 1.E5
 22    * Table Suppression
 23    020001 NOPRNT
 24    020002 NOPRNT
 25    020004 NOPRNT
 26    020005 NOPRNT
 27    020006 NOPRNT
 28    020007 NOPRNT
 29    020010 NOPRNT
 30    020011 NOPRNT
 31    020012 NOPRNT
 32    020013 NOPRNT
 33    020014 NOPRNT
 34    020015 NOPRNT
 35    020016 NOPRNT
 36    020017 NOPRNT
 37    020018 NOPRNT
 38    020020 NOPRNT
 39    020021 NOPRNT
 40    020022 NOPRNT
 41    020023 NOPRNT
 42    020024 NOPRNT
 43    020025 NOPRNT
 44    020026 NOPRNT
 45    020031 NOPRNT
 46    020032 NOPRNT
 47    020033 NOPRNT
 48    020034 NOPRNT
 49    020035 NOPRNT
 50    020037 NOPRNT
 51    020038 NOPRNT
 52    020040 NOPRNT
 53    020042 NOPRNT
 54    * GEOMETRY
 55    * MAIN STEAM AND FEEDWATER STREAMS
 56    501000 300, U, 340, I
 57    501020 340, U, 605, I
 58    501040 605, U,  10, I
 59    501060  10, U, 610, I
 60    501080 610, U,  20, I
 61    501100  20, U,  30, I
 62    501120  30, U, 615, I
 63    501140 615, U, 500, IA
 64    501160 500, U, 620, I
 65    501180 620, U, 505, IA
 66    501200 505, U, 200, T
 67    501220 200, T, 350, I
 68    501240 350, U, 510, IA
 69    501260 510, U,  40, I
 70    501280  40, U,  50, I
 71    501300  50, U,  60, I
 72    501320  60, U,  70, I
 73    501340  70, U,  80, I
 74    501360  80, U, 100, S
 75    501380 100, D, 400, I
 76    501400 400, U, 210, T
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501420 210, T, 220, T
501440 220, T, 110, T
501460 110, T, 120, T
501480 120, T, 130, T
501500 130, T, 515, IA
501520 515, U, 520, IA
501540 520, U, 420, I
501560 420, U, 625, I
501580 625, U, 140, T
501600 140, T, 150, T
501620 150, T, 160, T
501640 160, T, 630, I
501660 630, U, 635, I
501680 635, U, 525, IA
501700 525, U, 360, I
501710 360, U, 230, T
501720 230, T, 640, I
501740 640, U, 240, T
501760 240, T, 530, IA
501780 530, U, 250, T
501800 250, T, 330, I
* EXTRACTION STREAMS
502000  20, E, 160, S
502100 620, B, 150, S
502200  40, E, 540, IA
502250 540, U, 140, S
502300  50, E, 130, S
502400  60, E, 120, S
502500  70, E, 545, IA
502550 545, U, 110, S
* VALVE STEM AND SHAFT PACKING LEAKOFFS
503000 605, B, 645, I
503050 645, U, 500, IB
503100 645, B, 535, IB
503200 610, B, 510, IB
503250 615, B, 650, I
503300 650, U, 540, IB
503350 650, B, 535, IA
503400 535, U, 545, IB
* OTHER SPLITTER FLOWS
504000 625, B, 655, I
504050 655, U, 525, IB
504100 655, B, 520, IB
504200 630, B, 530, IB
504250 635, B, 505, IB
504300 640, B, 550, IB
* DRAIN LINES
505000 110, D, 550, IA
505050 120, D, 110, D
505100 130, D, 410, I
505150 410, U, 515, IB
505200 140, D, 130, D
505250 150, D, 140, D
505300 160, D, 150, D
* MISCELLANEOUS LINES
506000 550, U, 100, D
506200 310, U, 100, T
506300 100, T, 320, I
* TURBINE DATA
700100 4 1 1 1 1 0 0 0 36.04 0.
700108 .978186
700200 5 1 0 1 1 0. 1815. 1510.9 536440. 707. 40140.
700300 5 1 1 0 1 0. 707. 1410. 496300. 366. 0.
700400 6 1 0 1 2 1 0. 323.4 1523.2 458030. 124. 21970.
700408 .999473
700500 6 1 1 1 2 1 0. 124. 1406. 436060. 53. 21980.
700600 6 1 3 1 2 1 0. 53. 1319. 414080. 19. 21300.
700700 7 1 0 1 3 2 0. 19. 1228. 392780. 6. 22660.
700800 7 1 3 0 3 2 0. 6. 1147. 370120. .491 0. 26.2 0. 0. 0. 0. 0. 3 25.
* FEEDWATER HEATER DATA
701000 10 1 2 0. .491
701100 16 1 70 4 0. 2 2 0 0 1 0 0 2 2
701101 .652 .75 866. 125. 70. .9375 7.625 7.625 24.4 7.625
701103 16. .0002 .0001 0. .9375 0.
701106 210. 5.6 3. 6. .95 .97 .0002 .0003 0. .652
701107 .75 125. 70. .9375 .9375 0. 30. .5
701109 0 0 0. 0. 0. 0. 5. 1. 5.
701200 16 0 60 4 0. 2 2 0 0 1 0 0 2 2
701201 .527 .625 492. 206. 70. .8125 7.625 7.625 14.2 5.761
701203 14. .0002 0. 0. .8125 0.
701206 45. 1.4 2. 7. .98 .96 .0002 .0003 0. .527
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158  701207 .625 206. 70. .8125 .8125 0. 30. .5
159  701209 0 0 0. 0. 0. 0. 5. 1. 5.
160  701300 17 1 50 4 0. 2 2 1 1 1
161  701301 .527 .625 492. 196. 70. .8125 7.625 7.625 10.02 9.75
162  701303 14. .0002 0. 0. .8125 0.
163  701309 0 0 0. 0. 0. 0. 5. 1. 5. * This Card Helps Convergence of FWH3
164  701400 18 1 40 4 0. 2 2 0 0 1 2 2 2 2
165  701401 .481 .625 541. 316. 20. .8125 8.5 8.5 7.981 5.761
166  701403 18. .0002 .0001 0. .8125 0.
167  701404 89. 363. 3. 9. .95 .96 .0002 0. 0. .481
168  701405 .625 316. 20. .8125 .8125
169  701406 165. 9. 3. 9. .96 .98 .0002  .0003 0. .481
170  701407 .625 316. 20. .8125 .8125 0. 30. .5
171  701409 0 0 0. 0. 0. 0. 5. 1. 5.
172  701500 18 1 620 4 0. 2 2 0 0 1 2 2 2 2
173  701501 .481 .625 556. 448. 20. .8125 8.5 8.5 7.981 5.761
174  701503 21. .0002 .0001 0. .8125 0.
175  701504 107. 62. 3. 11. .95 .96 .0002 .0003 0. .481
176  701505 .625 448. 20. .8125 .8125
177  701506 135. 8. 4. 11. .93 .95 .0002 .0003 0. .481
178  701507 .625 448. 20. .8125 .8125 0. 30. .5
179  701509 0 0 0. 0. 0. 0. 5. 1. 5.
180  701600 18 0 20 4 0. 2 2 0 0 1 2 2 2 2
181  701601 .527 .625 604. 255. 16. .8125 6.813 6.813 10. 6.
182  701603 16. .0002 0. 0. .8125 0.
183  701604 95. 34. 3. 8. .95 .95 .0002 .0003 0. .527
184  701605 .625 255. 16. .8125 .8125
185  701606 78. 3. 3. 8. .93 .92 .0002 .0003 0. .527
186  701607 .625 255. 16. .8125 .8125 0. 30. .5
187  701609 0 0 0. 0. 0. 0. 5. 1. 5.
188  * HEAT EXCHANGER DATA
189  702000 25 2 1000. .098361
190  702100 27 0.
191  702200 27 4.33E6
192  702300 25 2 .995 .0786
193  702400 25 2 850. 0.
194  702500 25 2 1050. 0. 0. 0. 1815.
195  * PUMP DATA
196  704000 41 245. 1. 1. 1. 0. 1.
197  704100 41 250. 1. 1. 1. 0. 1.1
198  704200 41 2100. 1. 1. 1. 0. 9.
199  * SOURCE, SINK AND VALVE DATA
200  703000 33 1050. 1815. 565000.
201  703100 31 47. 26. 1.5E7
202  703200 30
203  703300 32
204  703400 35 -2. -2. -2. .3 1815. 1510.9 557000.
205  703500 34 .02
206  703600 34 .25
207  * MIXER DATA
208  705000 50 1
209  705050 51 1
210  705100 50 1
211  705150 50 1
212  705200 50 1
213  705250 50 1
214  705300 50 1
215  705350 50 1
216  705400 50 1
217  705450 50 1
218  705500 51 1
219  * SPLITTER DATA
220  706050 68 0. 60.924
221  706100 64 320.303
222  706150 64 445.632
223  706200 60 0. 51610.
224  706250 61 0. 20000.
225  706300 61 0. 2000.
226  706350 61 0. 1000.
227  706400 62 1.
228  706450 68 0. 53.2777
229  706500 64 651.476
230  706550 61 249. 13300.
231  * STREAM DATA
232  602000 2 .034
233  602100 2 .008
234  602250 2 .044
235  602300 2 .043
236  602400 2 .03
237  602550 2 .03
238  604300 5 25. 75.
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605100 1 7.981 50. 0. 0. 0. 0. 25.
* LP TURBINE EXHAUST LOSS CALCULATION
870310 0.
870320 188640.
870330 .87
870340 1.
870350 .65
880100 OPVB 31 PHG PP 136 OPVB 10
880110 PP 136 PHV OPVB 10 OPVB 11
880120 PP 136 PHX HHACP 80 OPVB 12
880130 WW 136 MUL OPVB 11 OPVB 13
880140 OPVB 13 MUL OPVB 12 OPVB 14
880150 OPVB 14 DIV OPVB 32 OPVB 15
800100 'EXHAUST LOSS VS. ANNULUS VEL'
810101    128.  150.  175.  200.  250.  300.  350.  400.  450.  500.
810111 0. 25.6  20.6  16.1  12.8  8.33  5.53  4.09  3.73  3.95  4.90
810102    550.  600.  650.  700.  800.  900.  1000. 1100. 1200. 1300.
810112    6.57  8.65  10.9  13.6  19.4  25.6  32.0  38.4  44.4  49.9
830100 1 OPVB 16 OPVB 15
880160 OPVB 34 SUB OPVB 12 OPVB 17
880170 OPVB 17 MUL OPVB 35 OPVB 18
880180 OPVB 34 SUB OPVB 18 OPVB 19
880190 OPVB 16 MUL OPVB 33 OPVB 20
880200 OPVB 20 MUL OPVB 12 OPVB 21
880210 OPVB 21 MUL OPVB 19 EXUSLS 80
* DEFINE GENERATOR LOSSES
800200 'GENERATOR LOSSES'
810201    15.   20.   30.   40.   50.   60.   70.   80.   81.5  90.
810210 0. 600.  625.  675.  740.  825.  920.  1025. 1150. 1175. 1175.
830200 2 BKELEI 1 BKTURB 1
* DEFINE HYDROGEN COOLER HEAT INPUT
800300 'HYROGEN COOLER HEAT'
810301    33.7   53.0   71.1   75.1   83.4
810310 0. 2.12E6 2.64E6 3.57E6 3.74E6 4.29E6
830300 3 BBHXGR 220 BKGRO 1
* DEFINE BWCP SEAL LEAKOFF ENTHALPY
800400 'SEAL LEAKOFF ENTHALPY'
810401    33.0 53.0 71.1 75.1 83.4
810410 0. 204. 225. 242. 245. 249.
830400 4 HHFIXB 655 BKGRO 1
* DEFINE FEEDWATER VALVE PRESSURE DROP
800500 'FEEDWATER VALVE PRESSURE DROP'
810501    2.33E5 2.96E5 3.279E5 3.28E5 3.62E5 4.32E5 5.09E5 5.82E5
810510 0.  .274   .227   .199    .273   .264   .241   .205   .159
831500 5 PDVS 360 WW 156
* DEFINE BOILER DRUM PRESSURE DROP
800600 'DRUM PRESSURE DROP'
810601    2.34E5 2.96E5 3.28E5 3.62E5 4.32E5 5.09E5 5.82E5
810610 0.  .005   .008   .009   .010   .013   .020   .028
830600 6 PDHXTU 230 WW 156
* DEFINE PRIMARY SUPERHEATER PRESSURE DROP
800700 'PRI SUPERHEAT PRESSURE'
810701    2.34E5 2.96E5 3.28E5 3.62E5 4.32E5 5.09E5 5.82E5
810710 0.  .012   .015   .018   .016   .022   .026   .031
830700 7 PDHXTU 240 WW 156
* TEMPERATURE CONTROL ON SUPERHEAT SPRAY
840100 WWFIXB 630 840. 5.E-4 1. TT 178
840109 500. 6000.
* DEFINE CONDENSATE PUMP CURVE
800800 'CONDENSATE PUMP CURVE'
810801    5.E4 1.E5 1.5E5 2.E5 2.499E5 2.5E5 3.E5 3.5E5 4.E5 4.5E5 5.E5
810811 0. 655. 650. 635.  615. 585.    640. 635. 625.  615. 600.  585.
830800 8 PHEAD 400 WW 140
* DEFINE FEED PUMP CURVE
800900 'BOILER FEED PUMP CURVE'
810901   1.40E5 1.87E5 2.33E5 2.80E5 3.279E5 3.28E5 3.73E5 4.67E5 5.60E5 6.06E5
810911 0. 5750.  5700.  5600.  5400.  5200.   5725.  5700.  5600.  5400.  5300.
830900 9 PHEAD 420 WW 156
* DEFINE FEED PUMP EFFICIENCY
801000 'BOILER FEED PUMP EFFICIENCY'
811001   1.40E5 1.87E5 2.33E5 2.80E5 3.279E5 3.28E5 3.73E5 4.67E5 5.60E5 6.06E5
811011 0. .495   .595   .660   .700   .725    .550   .595   .660   .700   .715
831000 10 EFFPMP 420 WW 156
* CALCULATE FEED PUMP HYDRAULIC HP
870600 1.98E6
880060 WW 156 MUL PHEAD 420 OPVB 61
880610 OPVB 61 DIV OPVB 60 OPVB 62
* CALCULATE FEED PUMP BHP
880620 OPVB 62 DIV EFFPMP 420 OPVB 63
* ROUGHNESS FACTORS FOR FWH DELTA P
890011 RFNC 110 .0034 I
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890021 RFNC 120 .0017 I
890031 RFNC 130 .00085 I
890041 RFNC 140 .0019 I
890051 RFNC 150 .0041 I
890061 RFNC 160 .00032 I
* USE SPECIAL OPTION 3
*850000 3
* PRINT OUTPUT
890070 'BFP SUCTION PRESSURE, PSIA'
890071 PP 154
890080 'BFP DISCHARGE PRESSURE, PSIA'
890081 PP 156
890090 'NO. 6 HEATER OUTLET PRESSURE, PSIA'
890091 PP 164
890100 'FEEDWATER VALVE OUTLET PRESSURE, PSIA'
890101 PP 171
890110 'DRUM PRESSURE, PSIA'
890111 PP 172
890120 'LTSH OUTLET PRESSURE, PSIA'
890121 PP 176
890130 'MAIN STEAM PRESSURE, PSIA'
890131 PP 180
890140 'BFP FLOW, LB/HR'
890141 WW 156
890150 'BFP HEAD, FEET'
890151 PHEAD 420
890160 'BFP HYDRAULIC HORSEPOWER'
890161 OPVB 62
890170 'BFP EFFICIENCY'
890171 EFFPMP 420
890180 'BFP BRAKE HORSEPOWER'
890181 OPVB 63
*
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LISTING OF INPUT DATA FOR CASE 1

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  1      UNIT 4 VARIABLE SPEED BOILER FEED PUMP
  2    * MODEL FILENAME IS R4VSBFP
  3    * MODEL INCLUDES THE FOLLOWING:
  4    * FEEDWATER HEATERS IN SIMPLIFIED DESIGN MODE
  5    * SCHEDULE FOR H2 COOLER HEAT INPUT
  6    * SCHEDULE FOR BWCP INJECTION LEAKOFF ENTHALPY
  7    * SCHEDULE FOR GENERATOR VARIABLE LOSS
  8    * SCHEDULE FOR TURBINE EXHAUST LOSS USING ANNULUS VELOCITY
  9    * SCHEDULE FOR DRUM PRESSURE DROP
 10    * SCHEDULE FOR PRIMARY SUPERHEATER PRESSURE DROP
 11    * TEMPERATURE CONTROL FOR SUPERHEAT SPRAY FLOW RATE
 12    * SCHEDULE FOR CONDENSATE PUMP HEAD VS FLOW
 13    * SCHEDULE FOR FEED PUMP HEAD VS FLOW
 14    * SCHEDULE FOR FEED PUMP EFFICIENCY VS FLOW
 15    * SCHEDULE FOR FEED PUMP SPEED VS FLOW
 16    * CALCULATION FOR FEED PUMP BHP
 17    * Generic Input Data
 18    010200 2 3 1 1 1
 19    010201 3
 20    011010 1 2 1 0 3600 96000. .85 45. 45.
 21    011011 446. 1175.
 22    012000 25 50. 50. 0. 0. 0. 0 1.E5
 23    * Table Suppression
 24    020001 NOPRNT
 25    020002 NOPRNT
 26    020004 NOPRNT
 27    020005 NOPRNT
 28    020006 NOPRNT
 29    020007 NOPRNT
 30    020010 NOPRNT
 31    020011 NOPRNT
 32    020012 NOPRNT
 33    020013 NOPRNT
 34    020014 NOPRNT
 35    020015 NOPRNT
 36    020016 NOPRNT
 37    020017 NOPRNT
 38    020018 NOPRNT
 39    020020 NOPRNT
 40    020021 NOPRNT
 41    020022 NOPRNT
 42    020023 NOPRNT
 43    020024 NOPRNT
 44    020025 NOPRNT
 45    020026 NOPRNT
 46    020031 NOPRNT
 47    020032 NOPRNT
 48    020033 NOPRNT
 49    020034 NOPRNT
 50    020035 NOPRNT
 51    020037 NOPRNT
 52    020038 NOPRNT
 53    020040 NOPRNT
 54    020042 NOPRNT
 55    * GEOMETRY
 56    * MAIN STEAM AND FEEDWATER STREAMS
 57    501000 300, U, 340, I
 58    501020 340, U, 605, I
 59    501040 605, U,  10, I
 60    501060  10, U, 610, I
 61    501080 610, U,  20, I
 62    501100  20, U,  30, I
 63    501120  30, U, 615, I
 64    501140 615, U, 500, IA
 65    501160 500, U, 620, I
 66    501180 620, U, 505, IA
 67    501200 505, U, 200, T
 68    501220 200, T, 350, I
 69    501240 350, U, 510, IA
 70    501260 510, U,  40, I
 71    501280  40, U,  50, I
 72    501300  50, U,  60, I
 73    501320  60, U,  70, I
 74    501340  70, U,  80, I
 75    501360  80, U, 100, S
 76    501380 100, D, 400, I
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501400 400, U, 210, T
501420 210, T, 220, T
501440 220, T, 110, T
501460 110, T, 120, T
501480 120, T, 130, T
501500 130, T, 515, IA
501520 515, U, 520, IA
501540 520, U, 420, I
501560 420, U, 625, I
501580 625, U, 140, T
501600 140, T, 150, T
501620 150, T, 160, T
501640 160, T, 630, I
501660 630, U, 635, I
501680 635, U, 525, IA
501700 525, U, 360, I
501710 360, U, 230, T
501720 230, T, 640, I
501740 640, U, 240, T
501760 240, T, 530, IA
501780 530, U, 250, T
501800 250, T, 330, I
* EXTRACTION STREAMS
502000  20, E, 160, S
502100 620, B, 150, S
502200  40, E, 540, IA
502250 540, U, 140, S
502300  50, E, 130, S
502400  60, E, 120, S
502500  70, E, 545, IA
502550 545, U, 110, S
* VALVE STEM AND SHAFT PACKING LEAKOFFS
503000 605, B, 645, I
503050 645, U, 500, IB
503100 645, B, 535, IB
503200 610, B, 510, IB
503250 615, B, 650, I
503300 650, U, 540, IB
503350 650, B, 535, IA
503400 535, U, 545, IB
* OTHER SPLITTER FLOWS
504000 625, B, 655, I
504050 655, U, 525, IB
504100 655, B, 520, IB
504200 630, B, 530, IB
504250 635, B, 505, IB
504300 640, B, 550, IB
* DRAIN LINES
505000 110, D, 550, IA
505050 120, D, 110, D
505100 130, D, 410, I
505150 410, U, 515, IB
505200 140, D, 130, D
505250 150, D, 140, D
505300 160, D, 150, D
* MISCELLANEOUS LINES
506000 550, U, 100, D
506200 310, U, 100, T
506300 100, T, 320, I
* TURBINE DATA
700100 4 1 1 1 1 0 0 0 36.04 0.
700108 .978186
700200 5 1 0 1 1 0. 1815. 1510.9 536440. 707. 40140.
700300 5 1 1 0 1 0. 707. 1410. 496300. 366. 0.
700400 6 1 0 1 2 1 0. 323.4 1523.2 458030. 124. 21970.
700408 .999473
700500 6 1 1 1 2 1 0. 124. 1406. 436060. 53. 21980.
700600 6 1 3 1 2 1 0. 53. 1319. 414080. 19. 21300.
700700 7 1 0 1 3 2 0. 19. 1228. 392780. 6. 22660.
700800 7 1 3 0 3 2 0. 6. 1147. 370120. .491 0. 26.2 0. 0. 0. 0. 0. 3 25.
* FEEDWATER HEATER DATA
701000 10 1 2 0. .491
701100 16 1 70 4 0. 2 2 0 0 1 0 0 2 2
701101 .652 .75 864. 125. 70. .9375 7.625 7.625 24.4 7.625
701103 10. .0002 0. 0. .9375 0.
701106 204. 0. 4. 7. 1. .95 .0002 .0003 0. .627
701107 .75 125. 70. .9375 .9375 0. 30. .5
701200 16 0 60 4 0. 2 2 0 0 1 0 0 2 2
701201 .527 .625 492. 206. 70. .8125 7.625 7.625 14.2 5.761
701203 10. .0002 0. 0. .8125 0.
701206 45. 0. 2. 7. 1. .96 .0002 .0003 0. .527
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701207 .625 206. 70. .8125 .8125 0. 30. .5
701300 17 1 50 4 0. 2 2 1 1 1
701301 .527 .625 492. 196. 70. .8125 7.625 7.625 10.02 9.75
701303 10. .0002 0. 0. .8125 0.
701309 0 0 0. 0. 0. 0. 5. 1. 5. * This Card Helps Convergence of FWH3
701400 18 1 40 4 0. 2 2 0 0 1 2 2 2 2
701401 .481 .625 541. 316. 20. .8125 8.5 8.5 7.981 5.761
701403 10. .0002 0. 0. .8125 0.
701404 89. 0. 4. 7. 1. .95 .0002 0. 0. .481
701405 .625 316. 20. .8125 .8125
701406 165. 0. 3. 7. 1. .98 .0002  .0003 0. .481
701407 .625 316. 20. .8125 .8125 0. 30. .5
701409 0 0 0. 0. 0. 0. 5. 1. 0.
701500 18 1 620 4 0. 2 2 0 0 1 2 2 2 2
701501 .481 .625 556. 448. 20. .8125 8.5 8.5 7.981 5.761
701503 10. .0002 0. 0. .8125 0.
701504 107. 0. 7. 7. 1. .96 .0002 .0003 0. .481
701505 .625 448. 20. .8125 .8125
701506 135. 0. 2. 7. 1. .98 .0002 .0003 0. .481
701507 .625 448. 20. .8125 .8125 0. 30. .5
701600 18 0 20 4 0. 2 2 0 0 1 2 2 2 2
701601 .527 .625 604. 255. 16. .8125 6.813 6.813 10. 6.
701603 10. .0002 0. 0. .8125 0.
701604 95. 0. 9. 7. 1. .96 .0002 .0003 0. .527
701605 .625 255. 16. .8125 .8125
701606 78. 0. 2. 7. 1. .95 .0002 .0003 0. .527
701607 .625 255. 16. .8125 .8125 0. 30. .5
* HEAT EXCHANGER DATA
702000 25 2 1000. .098361
702100 27 0.
702200 27 4.33E6
702300 25 2 .995 .0786
702400 25 2 850. 0.
702500 25 2 1050. 0. 0. 0. 1815.
* PUMP DATA
704000 41 245. 1. 1. 1. 0. 1.
704100 41 250. 1. 1. 1. 0. 1.1
704200 41 2100. 1. 1. 1. 0. 9.
* SOURCE, SINK AND VALVE DATA
703000 33 1050. 1815. 565000.
703100 31 47. 26. 1.5E7
703200 30
703300 32
703400 35 -2. -2. -2. .3 1815. 1510.9 557000.
703500 34 .02
703600 34 0.
* MIXER DATA
705000 50 1
705050 51 1
705100 50 1
705150 50 1
705200 50 1
705250 50 1
705300 50 1
705350 50 1
705400 50 1
705450 50 1
705500 51 1
* SPLITTER DATA
706050 68 0. 60.924
706100 64 320.303
706150 64 445.632
706200 60 0. 51610.
706250 61 0. 20000.
706300 61 0. 2000.
706350 61 0. 1000.
706400 62 1.
706450 68 0. 53.2777
706500 64 651.476
706550 61 249. 13300.
* STREAM DATA
602000 2 .034
602100 2 .008
602250 2 .044
602300 2 .043
602400 2 .03
602550 2 .03
604300 5 25. 75.
605100 1 7.981 50. 0. 0. 0. 0. 25.
*  LP TURBINE EXHAUST LOSS CALCULATION
870310 0.
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870320 188640.
870330 .87
870340 1.
870350 .65
880100 OPVB 31 PHG PP 136 OPVB 10
880110 PP 136 PHV OPVB 10 OPVB 11
880120 PP 136 PHX HHACP 80 OPVB 12
880130 WW 136 MUL OPVB 11 OPVB 13
880140 OPVB 13 MUL OPVB 12 OPVB 14
880150 OPVB 14 DIV OPVB 32 OPVB 15
800100 'EXHAUST LOSS VS. ANNULUS VEL'
810101    128.  150.  175.  200.  250.  300.  350.  400.  450.  500.
810111 0. 25.6  20.6  16.1  12.8  8.33  5.53  4.09  3.73  3.95  4.90
810102    550.  600.  650.  700.  800.  900.  1000. 1100. 1200. 1300.
810112    6.57  8.65  10.9  13.6  19.4  25.6  32.0  38.4  44.4  49.9
830100 1 OPVB 16 OPVB 15
880160 OPVB 34 SUB OPVB 12 OPVB 17
880170 OPVB 17 MUL OPVB 35 OPVB 18
880180 OPVB 34 SUB OPVB 18 OPVB 19
880190 OPVB 16 MUL OPVB 33 OPVB 20
880200 OPVB 20 MUL OPVB 12 OPVB 21
880210 OPVB 21 MUL OPVB 19 EXUSLS 80
* DEFINE GENERATOR LOSSES
800200 'GENERATOR LOSSES'
810201    15.   20.   30.   40.   50.   60.   70.   80.   81.5  90.
810210 0. 600.  625.  675.  740.  825.  920.  1025. 1150. 1175. 1175.
830200 2 BKELEI 1 BKTURB 1
* DEFINE HYDROGEN COOLER HEAT INPUT
800300 'HYROGEN COOLER HEAT'
810301    33.7   53.0   71.1   75.1   83.4
810310 0. 2.12E6 2.64E6 3.57E6 3.74E6 4.29E6
830300 3 BBHXGR 220 BKGRO 1
* DEFINE BWCP SEAL LEAKOFF ENTHALPY
800400 'SEAL LEAKOFF ENTHALPY'
810401    33.0 53.0 71.1 75.1 83.4
810410 0. 204. 225. 242. 245. 249.
830400 4 HHFIXB 655 BKGRO 1
* DEFINE BOILER DRUM PRESSURE DROP
800600 'DRUM PRESSURE DROP'
810601    2.34E5 2.96E5 3.28E5 3.62E5 4.32E5 5.09E5 5.82E5
810610 0.  .005   .008   .009   .010   .013   .020   .028
830600 6 PDHXTU 230 WW 156
* DEFINE PRIMARY SUPERHEATER PRESSURE DROP
800700 'PRI SUPERHEAT PRESSURE'
810701    2.34E5 2.96E5 3.28E5 3.62E5 4.32E5 5.09E5 5.82E5
810710 0.  .012   .015   .018   .016   .022   .026   .031
830700 7 PDHXTU 240 WW 156
* TEMPERATURE CONTROL ON SUPERHEAT SPRAY
840100 WWFIXB 630 840. 5.E-4 1. TT 178
840109 500. 6000.
* DEFINE CONDENSATE PUMP CURVE
800800 'CONDENSATE PUMP CURVE'
810801    5.E4 1.E5 1.5E5 2.E5 2.49E5 2.5E5 3.E5 3.5E5 4.E5 4.5E5 5.E5
810810 0. 655. 650. 635.  615. 585.   640.  635. 625.  615. 600.  585.
830800 8 PHEAD 400 WW 140
* DEFINE FEED PUMP CURVE
800900 'BOILER FEED PUMP CURVE'
810901       1.87E5 2.34E5  2.80E5 3.279E5 3.28E5 3.73E5 4.67E5 5.60E5 6.06E5
810910 2900. 3800.  3750.   3450.  3200.   3875.  3800.  3750.  3450.  3350.
810920 3100. 4400.  4250.   4050.  3800.   4450.  4400.  4250.  4050.  3925.
810930 3300. 5000.  4850.   4650.  4450.   5050.  5000.  4850.  4650.  4550.
810940 3500. 5700.  5550.   5350.  5100.   5750.  5700.  5550.  5350.  5225.
830900 9 PHEAD 420 WW 156 OPVB 50
* ADJUST PUMP SPEED
*840200 OPVB 50 2020. 0. 1. PP 156
*840209 3250. 3300.
* DEFINE FEED PUMP EFFICIENCY
801000 'BOILER FEED PUMP EFFICIENCY'
811001       1.87E5 2.33E5 2.80E5 3.279E5 3.28E5 3.73E5 4.67E5 5.60E5 6.06E5
811010 2900. .63    .69    .72    .73     .57    .63    .69    .72    .73
811020 3100. .60    .68    .72    .73     .55    .60    .68    .72    .73
811030 3300. .58    .65    .71    .73     .52    .58    .65    .71    .72
811040 3500. .54    .64    .69    .72     .50    .54    .64    .69    .71
831000 10 EFFPMP 420 WW 156 OPVB 50
* DEFINE BOILER FEED PUMP SPEED
801100 'BOILER FEED PUMP SPEED'
811101    2.33E5 2.96E5 3.279E5 3.28E5 3.62E5 4.32E5 5.09E5 5.82E5
811111 0. 2960.  3108.  3179.   2945.  2975.  3039.  3137.  3242.
831100 11 OPVB 50 WW 156
*870500 2945.
* CALCULATE FEED PUMP HYDRAULIC HP
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320     870600 1.98E6
321     880600 WW 156 MUL PHEAD 420 OPVB 61
322     880610 OPVB 61 DIV OPVB 60 OPVB 62
323     * CALCULATE FEEDPUMP BHP
324     880620 OPVB 62 DIV EFFPMP 420 OPVB 63
325     * ROUGHNESS FACTORS FOR FWH DELTA P
326     890011 RFNC 110 .0029 I
327     890021 RFNC 120 .0014 I
328     890031 RFNC 130 .0011 I
329     890041 RFNC 140 .0019 I
330     890051 RFNC 150 .0042 I
331     890061 RFNC 160 .00028 I
332     * PRINT OUTPUT VARIABLES
333     890070 'BFP SUCTION PRESSURE, PSIA'
334     890071 PP 154
335     890080 'BFP DISCHARGE PRESSURE, PSIA'
336     890081 PP 156
337     890090 'NO. 6 HEATER DISCHARGE PRESSURE, PSIA'
338     890091 PP 164
339     890100 'DRUM PRESSURE, PSIA'
340     890101 PP 172
341     890110 'LTSH OUTLET PRESSURE, PSIA'
342     890111 PP 176
343     890120 'MAIN STEAM PRESSURE, PSIA'
344     890121 PP 180
345     890130 'BFP FLOW, LB/HR'
346     890131 WW 156
347     890140 'BFP HEAD, FEET'
348     890141 PHEAD 420
349     890150 'BFP HYDRAULIC HORSEPOWER'
350     890151 OPVB 62
351     890160 'BFP EFFICIENCY'
352     890161 EFFPMP 420
353     890170 'BFP BRAKE HORSEPOWER'
354     890171 OPVB 63
355     890180 'BFP SPEED, RPM'
356     890181 OPVB 50
357     *
358     .
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LISTING OF INPUT DATA FOR CASE 1

```
  1      RG&E BEEBEE STATION UNIT 12 CONSTANT SPEED FEEDPUMP
  2    * MODEL FILENAME IS B12CSBFP
  3    * MODEL INCLUDES THE FOLLOWING:
  4    * FEEDWATER HEATERS IN SIMPLIFIED DESIGN MODE
  5    * SCHEDULE FOR H2 COOLER HEAT INPUT
  6    * SCHEDULE FOR GENERATOR VARIABLE LOSSES
  7    * SCHEDULE FOR TURBINE EXHAUST LOSSES USING ANNULUS VELOCITY
  8    * SCHEDULE FOR DRUM PRESSURE DROP
  9    * SCHEDULE FOR PRIMARY SUPERHEATER PRESSURE DROP
 10    * SCHEDULE FOR CONDENSATE PUMP HEAD VS CAPACITY
 11    * SCHEDULE FOR BOILER FEED PUMP HEAD VS CAPACITY
 12    * SCHEDULE FOR BFW PUMP EFFICIENCY
 13    * COEFFICIENT 'A' FOR EXTRACTION LINE PRESSURE DROP
 14    * SPECIFIED LEAKAGE CONSTANTS FOR SPLITTERS
 15    * SPECIFIED TURBINE EFFICIENCY FACTORS
 16    * SPECIFIED FLOW FOR REHEAT SPRAY
 17    * TEMPERATURE CONTROL ON SUPERHEAT SPRAY FLOW
 18    * SPECIFIED AUXILIARY STEAM LOAD
 19    * CALCULATION FOR BFW PUMP HYDRAULIC AND BRAKE HP
 20    * Generic Input Data
 21    010200 2 3 1 1 1
 22    010201 3
 23    011010 1 2 1 0 3600 96000. .87 45. 45.
 24    011011 360. 1190.
 25    012000 25 50. 50. 0. 0. 0. 0 1.E5
 26    * Table Suppression
 27    020001 NOPRNT
 28    020002 NOPRNT
 29    020004 NOPRNT
 30    020005 NOPRNT
 31    020006 NOPRNT
 32    020007 NOPRNT
 33    020010 NOPRNT
 34    020011 NOPRNT
 35    020012 NOPRNT
 36    020013 NOPRNT
 37    020014 NOPRNT
 38    020015 NOPRNT
 39    020016 NOPRNT
 40    020017 NOPRNT
 41    020018 NOPRNT
 42    020020 NOPRNT
 43    020021 NOPRNT
 44    020022 NOPRNT
 45    020023 NOPRNT
 46    020024 NOPRNT
 47    020025 NOPRNT
 48    020026 NOPRNT
 49    020031 NOPRNT
 50    020032 NOPRNT
 51    020033 NOPRNT
 52    020034 NOPRNT
 53    020035 NOPRNT
 54    020037 NOPRNT
 55    020038 NOPRNT
 56    020040 NOPRNT
 57    020042 NOPRNT
 58    * GEOMETRY
 59    * MAIN STEAM AND FEEDWATER STREAMS
 60    501000 300, U, 340, I
 61    501020 340, U, 605, I
 62    501040 605, U,  10, I
 63    501060  10, U, 610, I
 64    501080 610, U,  20, I
 65    501100  20, U,  30, I
 66    501120  30, U, 615, I
 67    501140 615, U, 500, IA
 68    501160 500, U, 620, I
 69    501180 620, U, 505, IA
 70    501200 505, U, 200, T
 71    501220 200, T, 350, I
 72    501240 350, U, 510, IA
 73    501260 510, U,  40, I
 74    501280  40, U,  50, I
 75    501300  50, U,  60, I
 76    501320  60, U,  70, I
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501340  70, U,  80, I
501360  80, U, 100, S
501380 100, D, 400, I
501400 400, U, 210, T
501420 210, T, 220, T
501440 220, T, 110, T
501460 110, T, 120, T
501480 120, T, 130, T
501500 130, T, 515, IA
501520 515, U, 520, IA
501540 520, U, 420, I
501560 420, U, 625, I
501580 625, U, 630, I
501600 630, U, 360, I
501610 360, U, 635, I
501620 635, U, 140, T
501640 140, T, 150, T
501660 150, T, 160, T
501680 160, T, 525, IA
501700 525, U, 230, T
501720 230, T, 640, I
501740 640, U, 240, T
501760 240, T, 530, IA
501780 530, U, 680, I
501800 680, U, 250, T
501820 250, T, 330, I
* EXTRACTION STREAMS
502000  20, E, 160, S
502100 620, B, 150, S
502200  40, E, 540, IA
502250 540, U, 140, S
502300  50, E, 130, S
502400  60, E, 120, S
502500  70, E, 545, IA
502550 545, U, 110, S
* PACKING LEAKOFFS
503000 605, B, 645, I
503050 645, U, 500, IB
503100 645, B, 535, IB
503200 610, B, 510, IB
503250 615, B, 650, I
503300 650, U, 540, IB
503350 650, B, 535, IA
503400 535, U, 545, IB
* OTHER SPLITTER LEAKOFFS
504000 625, B, 655, I
504050 655, U, 525, IB
504100 655, B, 520, IB
504200 630, B, 530, IB
504250 635, B, 505, IB
504300 640, B, 550, IB
504350 680, B, 555, IB
* DRAIN LINES
505000 110, D, 550, IA
505050 120, D, 110, D
505100 130, D, 410, I
505150 410, U, 515, IB
505200 140, D, 130, D
505250 150, D, 140, D
505300 160, D, 150, D
* MISCELLANEOUS LINES
506000 550, U, 555, IA
506100 555, U, 100, D
506200 310, U, 100, T
506300 100, T, 320, I
* TURBINE DATA
700100 4 1 1 1 1 1 8 0 36.04 0.
700108 .996198
700200 5 1 0 1 1 0. 1815. 1510.9 533177. 700.2 41401.
700300 5 1 1 0 1 0. 700.2 1406.3 491776. 357.3 0.
700400 6 1 0 1 2 1 0. 315.17 1523. 457187. 122.5 19740.
700408 .997539
700500 6 1 1 1 2 1 0. 122.5 1406.6 437447. 55.88 23991.
700600 6 1 3 1 2 1 0. 55.88 1324.6 413456. 18.42 20827.
700700 7 1 0 1 3 2 0. 18.42 1227. 392629. 5.868 17360.
700800 7 1 3 0 3 2 0. 5.868 1145.8 375269. -1.5 0. 26.17 0. 0. 0. 0. 0. 3 25.
* FW HEATER DATA
701000 10 1 2 0. -1.5
701100 16 1 70 -4 0. 2 2 0 0 1 0 0 2 2
701101 .527 .625 553. 274. 70. .8125 7.981 7.981 24.4 5.761
701103 10. .0002 .0003 0. .8125 0.
```

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158   701106 148. 3.6 1. 8. .99 .92 .0002 .0003 0. .527
159   701107 .625 274. 70. .8125 .8125 0. 30. .5
160   701109 0 0 0. 0. 0. 0. 5. 1. 5.
161   701200 16 0 60 -4 0. 2 2 0 0 1 0 0 2 2
162   701201 .527 .625 590. 156. 70. .8125 7.981 7.981 14.2 3.826
163   701203 10. .0002 0. 0. .8125 0.
164   701206 85. 1.06 1. 6. .95 .94 .0002 .0003 0. .527
165   701207 .625 156. 70. .8125 .8125 0. 30. .5
166   701209 0 0 0. 0. 0. 0. 5. 1. 5. * This Card Helps Convergence of FWH2
167   701300 17 1 50 -4 0. 2 2 1 1 1
168   701301 .527 .625 569. 156. 70. .8125 7.981 7.981 10.02 9.75
169   701303 12. .0002 0. 0. .8125 0.
170   701309 0 0 0. 0. 0. 0. 5. 1. 5. * This Card Helps Convergence of FWH3
171   701400 18 1 40 -4 0. 2 2 0 0 1 2 2 2 2
172   701401 .459 .625 552. 316. 19. .8125 8.5 8.5 7.981 5.761
173   701403 18. .0002 .0003 0. .8125 0.
174   701404 92. 98. 3. 9. .95 .98 .0002 .0003 0. .459
175   701405 .625 316. 19. .8125 .8125
176   701406 148. 11. 5. 9. .97 .94 .0002 .0003 0. .459
177   701407 .625 316. 19. .8125 .8125 0. 30. .5
178   701500 18 1 620 -4 0. 2 2 0 0 1 2 2 2 2
179   701501 .459 .625 582. 448. 20. .8125 8.5 8.5 7.981 5.761
180   701503 21. .0002 .0003 0. .8125 0.
181   701504 99. 107. 3. 11. .95 .93 .0002 .0003 0. .459
182   701505 .625 448. 21. .8125 .8125
183   701506 116. 8.6 5. 11. .94 .95 .0002 .0003 0. .459
184   701507 .625 448. 20. .8125 .8125 0. 30. .5
185   701600 18 0 20 -4 0. 2 2 0 0 1 2 2 2 2
186   701601 .527 .625 624. 255. 16. .8125 8.5 8.5 5.761 3.826
187   701603 16. .0002 .0001 0. .8125 0.
188   701604 95. 41. 3. 8. .95 .98 .0002 .0003 0. .527
189   701605 .625 255. 16. .8125 .8125
190   701606 58. 4. 5. 8. .94 .93 .0002 .0003 0. .527
191   701607 .625 255. 16. .8125 .8125 0. 30. .5
192   * HEAT EXCHANGER DATA
193   702000 25 2 1000. .09992
194   702100 27 0.
195   702200 27 3.74E6
196   702300 25 2 .994865 0.
197   702400 25 2 850. 0.
198   702500 25 2 1050. 0. 0. 0. 1815.
199   * PUMP DATA
200   704000 41 245. 1. 1. 1. 0. 0.
201   704100 41 250. 1. 1. 1. 0. 0.
202   704200 41 2100. 1. 1. 1. 0. 8.7
203   * SOURCE SINK AND VALVE DATA
204   703000 33 1050. 1815. 565000.
205   703100 31 47. 26. 1.5E7
206   703200 30
207   703300 32
208   703400 35 -2. -2. -2. .3 1815. 1510.9 557000.
209   703500 34 .02
210   703600 34 .15
211   * MIXER DATA
212   705000 50 1
213   705050 51 1
214   705100 50 1
215   705150 50 1
216   705200 50 1
217   705250 50 1
218   705300 50 1
219   705350 50 1
220   705400 50 1
221   705450 50 1
222   705500 51 1
223   705550 51 1
224   * SPLITTER DATA
225   706050 68 0. 57.7267
226   706100 64 386.633
227   706150 64 505.423
228   706200 60 0. 50554.
229   706250 61 0. 0.
230   706300 61 0. 3000.
231   706350 61 0. 0.
232   706400 62 1.
233   706450 68 0. 52.1239
234   706500 64 721.182
235   706550 61 0. 0.
236   706800 61 0. 0.
237   * STREAM DATA
238   602000 2 .08
```

```
602100 2 .05
602250 2 .08
602300 2 .08
602400 2 .08
602550 2 .08
604300 5 25. 75.
604350 5 25. 75.
605100 1 7.981 50. 0. 0. 0. 0. 25.
* LP TURBINE EXHAUST LOSS CALCULATION
* GE 2007C USED FOR EXHAUST LOSS
870310 0.
870320 188640.
870330 .87
870340 1.
870350 .65
880100 OPVB 31 PHG PP 136 OPVB 10
880110 PP 136 PHV OPVB 10 OPVB 11
880120 PP 136 PHX HHACP 80 OPVB 12
880130 WW 136 MUL OPVB 11 OPVB 13
880140 OPVB 13 MUL OPVB 12 OPVB 14
880150 OPVB 14 DIV OPVB 32 OPVB 15
* EXHAUST LOSS FROM VELOCITY
800100 'EXHAUST LOSS VS. ANNULUS VEL'
810101     128.  150.  175.  200.  250.  300.  350.  400.  450.  500.
810111 0.  25.6  20.6  16.1  12.8  8.33  5.53  4.09  3.73  3.95  4.90
810102     550.  600.  650.  700.  800.  900.  1000. 1100. 1200. 1300.
810112     6.57  8.65  10.9  13.6  19.4  25.6  32.0  38.4  44.4  49.9
830100 1 OPVB 16 OPVB 15
880160 OPVB 34 SUB OPVB 12 OPVB 17
880170 OPVB 17 MUL OPVB 35 OPVB 18
880180 OPVB 34 SUB OPVB 18 OPVB 19
880190 OPVB 16 MUL OPVB 33 OPVB 20
880200 OPVB 20 MUL OPVB 12 OPVB 21
880210 OPVB 21 MUL OPVB 19 EXUSLS 80
* DETERMINE GENERATOR LOSSES
800200 'GENERATOR LOSSES'
810201    22.4  25.  30.  35.  40.  50.  60.  70.  80.   84.8  90.
810210 0. 478.  492. 520. 551. 586. 662. 756. 885. 1096. 1190. 1190.
830200 2 BKELEI 1 BKTURB 1
* DETERMINE HYDROGEN COOLER HEAT ADDED
800300 'HYDROGEN COOLER HEAT'
810301    21.5   31.8   42.1   51.9   60.9   68.4   76.2   83.3
810310 0. 1.32E6 1.52E6 1.77E6 2.03E6 2.34E6 2.69E6 3.27E6 3.75E6
830300 3 BBHXGR 220 BKGRO 1
* DETERMINE FEEDWATER VALVE PRESSURE DROP
800400 'FEEDVALVE PRESSURE DROP'
810401   2.19E5 2.81E5 3.279E5 3.28E5 3.48E5 4.18E5 4.95E5 5.68E5
810410 0. .278   .234   .195    .270   .266   .241   .201   .159
830400 4 PDVS 360 WW 156
* DETERMINE ECONOMIZER DROP
800500 'ECONOMIZER DELTA P'
810501   2.19E5 2.81E5 3.28E5 3.48E5 4.18E5 4.95E5 5.68E5
810510 0. .005   .008   .009   .010   .013   .025   .027
830500 5 PDHXTU 230 WW 156
* DETERMINE PRIMARY SH PRESSURE DROP
800600 'PRI SH PRESSURE DROP'
810601   2.19E5 2.81E5 3.28E5 3.48E5 4.18E5 4.95E5 5.68E5
810610 0. .012   .014   .017   .019   .022   .026   .031
830600 6 PDHXTU 240 WW 156
* CONTROL FOR SUPERHEAT SPRAY FLOW RATE
840100 WWFIXB 630 840. 5.E-4 1. TT 178
840109 500. 5000.
* CONDENSATE PUMP CURVE
800700 'CONDENSATE PUMP HEAD-CAPY CURVE'
810701    1.0E5 1.5E5 2.0E5 2.5E5 2.579E5 2.58E5 3.0E5 3.5E5 4.0E5 4.5E5 5.0E5
810711 0. 670.  650.  620.  590.  580.    655.   650.  635.  620.  605.  590.
830700 7 PHEAD 400 WW 140
* BOILER FEED PUMP CURVE
800800 'BOILER FEED PUMP HEAD-CAPY CURVE'
810801    1.4E5 1.87E5 2.33E5 2.80E5 3.279E5 3.28E5 3.73E5 4.67E5 5.60E5 6.06E5
810811 0. 5750. 5700.  5600.  5400.  5200.   5725.  5700.  5600.  5400.  5300.
830800 8 PHEAD 420 WW 156
* BOILER FEED PUMP EFFICIENCY
800900 'BOILER FEED PUMP EFFICIENCY'
810901    1.4E5 1.87E5 2.33E5 2.80E5 3.279E5 3.28E5 3.73E5 4.67E5 5.60E5 6.06E5
810911 0.  .495  .595   .66    .70    .725   .57    .595   .66    .70    .715
830900 9 EFFPMP 420 WW 156
* CALCULATE FEEDPUMP HYDRAULIC HORSEPOWER
870400 1.98E6
880010 WW 156 MUL PHEAD 420 OPVB 41
880020 OPVB 41 DIV OPVB 40 OPVB 42
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320   * CALCULATE FEEDPUMP BRAKE HORSEPOWER
321   880030 OPVB 42 DIV EFFPMP 420 OPVB 43
322   * ROUGHNESS FACTORS FOR FWH TUBESIDE DP
323   890011 RFNC 110 .0039 I
324   890021 RFNC 120 .0013 I
325   890031 RFNC 130 .00066 I
326   890041 RFNC 140 .0019 I
327   890051 RFNC 150 .0023 I
328   890061 RFNC 160 .0016 I
329   * PRINT OPERATIONAL VARIABLES
330   890070 'BFW PUMP SUCTION PRESSURE, PSIA'
331   890071 PP 154
332   890080 'BFW PUMP DISCHARGE PRESSURE, PSIA'
333   890081 PP 156
334   890090 'BFW CONTROL VALVE OUTLET PRESSURE, PSIA'
335   890091 PP 161
336   890100 'HEATER NO. 6 OUTLET PRESSURE, PSIA'
337   890101 PP 168
338   890110 'DRUM PRESSURE, PSIA'
339   890111 PP 172
340   890120 'LTSH OUTLET PRESSURE, PSIA'
341   890121 PP 176
342   890130 'MAIN STEAM PRESSURE, PSIA'
343   890131 PP 182
344   890140 'BFP FLOW, LB/HR'
345   890141 WW 156
346   890150 'BFP HEAD, FEET'
347   890151 PHEAD 420
348   890160 'BFW PUMP HYDRAULIC HP'
349   890161 OPVB 42
350   890170 'BFP EFFICIENCY'
351   890171 EFFPMP 420
352   890180 'BFW PUMP BRAKE HORSEPOWER'
353   890181 OPVB 43
354   *
355   .
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LISTING OF INPUT DATA FOR CASE 1

```
  1      RG&E BEEBEE STATION UNIT 12 VARIABLE SPEED FEEDPUMP
  2    * MODEL FILENAME IS B12V5BFP
  3    * MODEL INCLUDES THE FOLLOWING:
  4    * FEEDWATER HEATERS IN SIMPLIFIED DESIGN MODE
  5    * SCHEDULE FOR H2 COOLER HEAT INPUT
  6    * SCHEDULE FOR GENERATOR VARIABLE LOSSES
  7    * SCHEDULE FOR TURBINE EXHAUST LOSSES USING ANNULUS VELOCITY
  8    * SCHEDULE FOR DRUM PRESSURE DROP
  9    * SCHEDULE FOR PRIMARY SUPERHEATER PRESSURE DROP
 10    * SCHEDULE FOR CONDENSATE PUMP HEAD VS CAPACITY
 11    * SCHEDULE FOR BOILER FEED PUMP HEAD VS CAPACITY
 12    * SCHEDULE FOR BFW PUMP EFFICIENCY
 13    * COEFFICIENT 'A' FOR EXTRACTION LINE PRESSURE DROP
 14    * SPECIFIED LEAKAGE CONSTANTS FOR SPLITTERS
 15    * SPECIFIED TURBINE EFFICIENCY FACTORS
 16    * SPECIFIED FLOW FOR REHEAT SPRAY
 17    * TEMPERATURE CONTROL ON SUPERHEAT SPRAY FLOW
 18    * SPECIFIED AUXILIARY STEAM LOAD
 19    * CALCULATION FOR BFW PUMP HYDRAULIC AND BRAKE HP
 20    * Generic Input Data
 21    010200 2 3 1 1 1
 22    010201 3
 23    011010 1 2 1 0 3600 96000. .87 45. 45.
 24    011011 360. 1190.
 25    012000 25 50. 50. 0. 0. 0. 0 1.E5
 26    * Table Suppression
 27    020001 NOPRNT
 28    020002 NOPRNT
 29    020004 NOPRNT
 30    020005 NOPRNT
 31    020006 NOPRNT
 32    020007 NOPRNT
 33    020010 NOPRNT
 34    020011 NOPRNT
 35    020012 NOPRNT
 36    020013 NOPRNT
 37    020014 NOPRNT
 38    020015 NOPRNT
 39    020016 NOPRNT
 40    020017 NOPRNT
 41    020018 NOPRNT
 42    020020 NOPRNT
 43    020021 NOPRNT
 44    020022 NOPRNT
 45    020023 NOPRNT
 46    020024 NOPRNT
 47    020025 NOPRNT
 48    020026 NOPRNT
 49    020031 NOPRNT
 50    020032 NOPRNT
 51    020033 NOPRNT
 52    020034 NOPRNT
 53    020035 NOPRNT
 54    020037 NOPRNT
 55    020038 NOPRNT
 56    020040 NOPRNT
 57    020042 NOPRNT
 58    * GEOMETRY
 59    * MAIN STEAM AND FEEDWATER STREAMS
 60    501000 300, U, 340, I
 61    501020 340, U, 605, I
 62    501040 605, U,  10, I
 63    501060  10, U, 610, I
 64    501080 610, U,  20, I
 65    501100  20, U,  30, I
 66    501120  30, U, 615, I
 67    501140 615, U, 500, IA
 68    501160 500, U, 620, I
 69    501180 620, U, 505, IA
 70    501200 505, U, 200, T
 71    501220 200, T, 350, I
 72    501240 350, U, 510, IA
 73    501260 510, U,  40, I
 74    501280  40, U,  50, I
 75    501300  50, U,  60, I
 76    501320  60, U,  70, I
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501340  70, U,  80, I
501360  80, U, 100, S
501380 100, D, 400, I
501400 400, U, 210, T
501420 210, T, 220, T
501440 220, T, 110, T
501460 110, T, 120, T
501480 120, T, 130, T
501500 130, T, 515, IA
501520 515, U, 520, IA
501540 520, U, 420, I
501560 420, U, 625, I
501580 625, U, 630, I
501600 630, U, 360, I
501610 360, U, 635, I
501620 635, U, 140, T
501640 140, T, 150, T
501660 150, T, 160, T
501680 160, T, 525, IA
501700 525, U, 230, T
501720 230, T, 640, I
501740 640, U, 240, T
501760 240, T, 530, IA
501780 530, U, 680, I
501800 680, U, 250, T
501820 250, T, 330, I
* EXTRACTION STREAMS
502000  20, E, 160, S
502100 620, B, 150, S
502200  40, E, 540, IA
502250 540, U, 140, S
502300  50, E, 130, S
502400  60, E, 120, S
502500  70, E, 545, IA
502550 545, U, 110, S
* PACKING LEAKOFFS
503000 605, B, 645, I
503050 645, U, 500, IB
503100 645, B, 535, IB
503200 610, B, 510, IB
503250 615, B, 650, I
503300 650, U, 540, IB
503350 650, B, 535, IA
503400 535, U, 545, IB
* OTHER SPLITTER LEAKOFFS
504000 625, B, 655, I
504050 655, U, 525, IB
504100 655, B, 520, IB
504200 630, B, 530, IB
504250 635, B, 505, IB
504300 640, B, 550, IB
504350 680, B, 555, IB
* DRAIN LINES
505000 110, D, 550, IA
505050 120, D, 110, D
505100 130, D, 410, I
505150 410, U, 515, IB
505200 140, D, 130, D
505250 150, D, 140, D
505300 160, D, 150, D
* MISCELLANEOUS LINES
506000 550, U, 555, IA
506100 555, U, 100, D
506200 310, U, 100, T
506300 100, T, 320, I
* TURBINE DATA
700100 4 1 1 1 1 1 8 0 36.04 0.
700108 .996198
700200 5 1 0 1 1 0. 1815. 1510.9 533177. 700.2 41401.
700300 5 1 1 0 1 0. 700.2 1406.3 491776. 357.3 0.
700400 6 1 0 1 2 1 0. 315.17 1523. 457187. 122.5 19740.
700408 .997539
700500 6 1 1 1 2 1 0. 122.5 1406.6 437447. 55.88 23991.
700600 6 1 3 1 2 1 0. 55.88 1324.6 413456. 18.42 20827.
700700 7 1 0 1 3 2 0. 18.42 1227. 392629. 5.868 17360.
700800 7 1 3 0 3 2 0. 5.868 1145.8 375269. -1.5 0. 26.17 0. 0. 0. 0. 0. 3 25.
* FW HEATER DATA
701000 10 1 2 0. -1.5
701100 16 1 70 -4 0. 2 2 0 0 1 0 0 2 2
701101 .527 .625 553. 274. 70. .8125 7.981 7.981 24.4 5.761
701103 10. .0002 .0003 0. .8125 0.
```

```
158   701106 148. 3.6 1. 8. .99 .92 .0002 .0003 0. .527
159   701107 .625 274. 70. .8125 .8125 0. 30. .5
160   701109 0 0 0. 0. 0. 0. 5. 1. 5.
161   701200 16 0 60 -4 0. 2 2 0 0 1 0 0 2 2
162   701201 .527 .625 590. 156. 70. .8125 7.981 7.981 14.2 3.826
163   701203 10. .0002 0. 0. .8125 0.
164   701206 85. 1.06 1. 6. .95 .94 .0002 .0003 0. .527
165   701207 .625 156. 70. .8125 .8125 0. 30. .5
166   701209 0 0 0. 0. 0. 0. 5. 1. 5. * This Card Helps Convergence of FWH2
167   701300 17 1 50 -4 0. 2 2 1 1 1
168   701301 .527 .625 569. 156. 70. .8125 7.981 7.981 10.02 9.75
169   701303 12. .0002 0. 0. .8125 0.
170   701309 0 0 0. 0. 0. 0. 5. 1. 5. * This Card Helps Convergence of FWH3
171   701400 18 1 40 -4 0. 2 2 0 0 1 2 2 2 2
172   701401 .459 .625 552. 316. 19. .8125 8.5 8.5 7.981 5.761
173   701403 18. .0002 .0003 0. .8125 0.
174   701404 92. 98. 3. 9. .95 .98 .0002 .0003 0. .459
175   701405 .625 316. 19. .8125 .8125
176   701406 148. 11. 5. 9. .97 .94 .0002 .0003 0. .459
177   701407 .625 316. 19. .8125 .8125 0. 30. .5
178   701500 18 1 620 -4 0. 2 2 0 0 1 2 2 2 2
179   701501 .459 .625 582. 448. 20. .8125 8.5 8.5 7.981 5.761
180   701503 21. .0002 .0003 0. .8125 0.
181   701504 99. 107. 3. 11. .95 .93 .0002 .0003 0. .459
182   701505 .625 448. 21. .8125 .8125
183   701506 116. 8.6 5. 11. .94 .95 .0002 .0003 0. .459
184   701507 .625 448. 20. .8125 .8125 0. 30. .5
185   701600 18 0 20 -4 0. 2 2 0 0 1 2 2 2 2
186   701601 .527 .625 624. 255. 16. .8125 8.5 8.5 5.761 3.826
187   701603 16. .0002 .0001 0. .8125 0.
188   701604 95. 41. 3. 8. .95 .98 .0002 .0003 0. .527
189   701605 .625 255. 16. .8125 .8125
190   701606 58. 4. 5. 8. .94 .93 .0002 .0003 0. .527
191   701607 .625 255. 16. .8125 .8125 0. 30. .5
192   * HEAT EXCHANGER DATA
193   702000 25 2 1000. .09992
194   702100 27 0.
195   702200 27 3.74E6
196   702300 25 2 .994865 0.
197   702400 25 2 850. 0.
198   702500 25 2 1050. 0. 0. 0. 1815.
199   * PUMP DATA
200   704000 41 245. 1. 1. 1. 0. 0.
201   704100 41 250. 1. 1. 1. 0. 0.
202   704200 41 2100. 1. 1. 1. 0. 8.7
203   * SOURCE SINK AND VALVE DATA
204   703000 33 1050. 1815. 565000.
205   703100 31 47. 26. 1.5E7
206   703200 30
207   703300 32
208   703400 35 -2. -2. -2. .3 1815. 1510.9 557000.
209   703500 34 .02
210   703600 34 0.
211   * MIXER DATA
212   705000 50 1
213   705050 51 1
214   705100 50 1
215   705150 50 1
216   705200 50 1
217   705250 50 1
218   705300 50 1
219   705350 50 1
220   705400 50 1
221   705450 50 1
222   705500 51 1
223   705550 51 1
224   * SPLITTER DATA
225   706050 68 0. 57.7267
226   706100 64 386.633
227   706150 64 505.423
228   706200 60 0. 50554.
229   706250 61 0. 0.
230   706300 61 0. 3000.
231   706350 61 0. 0.
232   706400 62 1.
233   706450 68 0. 52.1239
234   706500 64 721.182
235   706550 61 0. 0.
236   706800 61 0. 0.
237   * STREAM DATA
238   602000 2 .08
```

```
602100 2 .05
602250 2 .08
602300 2 .08
602400 2 .08
602550 2 .08
604300 5 25. 75.
604350 5 25. 75.
605100 1 7.981 50. 0. 0. 0. 0. 25.
* LP TURBINE EXHAUST LOSS CALCULATION
* GE 2007C USED FOR EXHAUST LOSS
870310 0.
870320 188640.
870330 .87
870340 1.
870350 .65
880100 OPVB 31 PHG PP 136 OPVB 10
880110 PP 136 PHV OPVB 10 OPVB 11
880120 PP 136 PHX HHACP 80 OPVB 12
880130 WW 136 MUL OPVB 11 OPVB 13
880140 OPVB 13 MUL OPVB 12 OPVB 14
880150 OPVB 14 DIV OPVB 32 OPVB 15
* EXHAUST LOSS FROM VELOCITY
800100 'EXHAUST LOSS VS. ANNULUS VEL'
810101     128.  150.  175.  200.  250.  300.  350.  400.  450.  500.
810111 0.  25.6  20.6  16.1  12.8  8.33  5.53  4.09  3.73  3.95  4.90
810102     550.  600.  650.  700.  800.  900.  1000. 1100. 1200. 1300.
810112     6.57  8.65  10.9  13.6  19.4  25.6  32.0  38.4  44.4  49.9
830100 1 OPVB 16 OPVB 15
880160 OPVB 34 SUB OPVB 12 OPVB 17
880170 OPVB 17 MUL OPVB 35 OPVB 18
880180 OPVB 34 SUB OPVB 18 OPVB 19
880190 OPVB 16 MUL OPVB 33 OPVB 20
880200 OPVB 20 MUL OPVB 12 OPVB 21
880210 OPVB 21 MUL OPVB 19 EXUSLS 80
* DETERMINE GENERATOR LOSSES
800200 'GENERATOR LOSSES'
810201    22.4  25.  30.  35.  40.  50.  60.  70.  80.  84.8  90.
810210 0. 478.  492. 520. 551. 586. 662. 756. 885. 1096. 1190. 1190.
830200 2 BKELEI 1 BKTURB 1
* DETERMINE HYDROGEN COOLER HEAT ADDED
800300 'HYDROGEN COOLER HEAT'
810301    21.5   31.8   42.1   51.9   60.9   68.4   76.2   83.3
810310 0. 1.32E6 1.52E6 1.77E6 2.03E6 2.34E6 2.69E6 3.27E6 3.75E6
830300 3 BBHXGR 220 BKGRO 1
* DETERMINE FEEDWATER VALVE PRESSURE DROP
*800400 'FEEDVALVE PRESSURE DROP'
*810401   2.19E5 2.81E5 3.279E5 3.28E5 3.48E5 4.18E5 4.95E5 5.68E5
*810410 0. .278   .234   .195   .270   .266   .241   .201   .159
*830400 4 PDVS 360 WW 156
* DETERMINE ECONOMIZER DROP
800500 'ECONOMIZER DELTA P'
810501   2.19E5 2.81E5 3.28E5 3.48E5 4.18E5 4.95E5 5.68E5
810510 0. .005   .008   .009   .010   .013   .025   .027
830500 5 PDHXTU 230 WW 156
* DETERMINE PRIMARY SH PRESSURE DROP
800600 'PRI SH PRESSURE DROP'
810601   2.19E5 2.81E5 3.28E5 3.48E5 4.18E5 4.95E5 5.68E5
810610 0. .012   .014   .017   .019   .022   .026   .031
830600 6 PDHXTU 240 WW 156
* CONTROL FOR SUPERHEAT SPRAY FLOW RATE
840100 WWFIXB 630 840. 5.E-4 1. TT 178
840109 500. 5000.
* CONDENSATE PUMP CURVE
800700 'CONDENSATE PUMP HEAD-CAPY CURVE'
810701    1.0E5 1.5E5 2.0E5 2.5E5 2.579E5 2.58E5 3.0E5 3.5E5 4.0E5 4.5E5 5.0E5
810711 0. 670.  650.  620.  590.  580.    655.  650.  635.  620.  605.  590.
830700 7 PHEAD 400 WW 140
* BOILER FEED PUMP CURVE
800800 'BOILER FEED PUMP HEAD-CAPY CURVE'
810801       1.87E5 2.33E5 2.80E5 3.279E5 3.28E5 3.73E5 4.67E5 5.60E5 6.06E5
810810 2900. 3800.  3700.  3550.  3300.   3875.  3800.  3700.  3550.  3425.
810820 3100. 4400.  4250.  4100.  3900.   4425.  4400.  4250.  4100.  4000.
810830 3300. 5000.  4850.  4700.  4450.   5050.  5000.  4850.  4700.  4600.
810840 3500. 5700.  5600.  5400.  5200.   5750.  5700.  5600.  5400.  5325.
830800 8 PHEAD 420 WW 156 OPVB 50
* BOILER FEED PUMP EFFICIENCY
800900 'BOILER FEED PUMP EFFICIENCY'
810901       1.87E5 2.33E5 2.80E5 3.279E5 3.28E5 3.73E5 4.67E5 5.60E5 6.06E5
810910 2900. .63    .69    .725   .73     .58    .63    .69    .725   .73
810920 3100. .61    .675   .715   .735    .56    .61    .675   .715   .725
810930 3300. .58    .66    .71    .725    .54    .58    .66    .71    .72
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320   810940 3500.  .55   .64   .70   .72    .51   .55   .64   .70   .71
321   830900 9 EFFPMP 420 WW 156 OPVB 50
322   * DEFINE BOILER FEED PUMP SPEED
323   801000 'BOILER FEED PUMP SPEED'
324   811001    2.19E5 2.81E5 3.279E5 3.28E5 3.48E5 4.18E5 4.95E5 5.68E5
325   811011 0. 2957.  3064.  3155.  2948.  2966.  3036.  3135.  3219.
326   831000 10 OPVB 50 WW 156
327   * CALCULATE FEEDPUMP HYDRAULIC HORSEPOWER
328   870400 1.98E6
329   880010 WW 156 MUL PHEAD 420 OPVB 41
330   880020 OPVB 41 DIV OPVB 40 OPVB 42
331   * CALCULATE FEEDPUMP BRAKE HORSEPOWER
332   880030 OPVB 42 DIV EFFPMP 420 OPVB 43
333   * ROUGHNESS FACTORS FOR FWH TUBESIDE DP
334   890011 RFNC 110 .0039 I
335   890021 RFNC 120 .0013 I
336   890031 RFNC 130 .00066 I
337   890041 RFNC 140 .0019 I
338   890051 RFNC 150 .0023 I
339   890061 RFNC 160 .0016 I
340   * PRINT OPERATIONAL VARIABLES
341   890070 'BFW PUMP SUCTION PRESSURE, PSIA'
342   890071 PP 154
343   890080 'BFW PUMP DISCHARGE PRESSURE, PSIA'
344   890081 PP 156
345   890090 'BFW CONTROL VALVE OUTLET PRESSURE, PSIA'
346   890091 PP 161
347   890100 'HEATER NO. 6 OUTLET PRESSURE, PSIA'
348   890101 PP 168
349   890110 'DRUM PRESSURE, PSIA'
350   890111 PP 172
351   890120 'LTSH OUTLET PRESSURE, PSIA'
352   890121 PP 176
353   890130 'MAIN STEAM PRESSURE, PSIA'
354   890131 PP 182
355   890140 'BFP FLOW, LB/HR'
356   890141 WW 156
357   890150 'BFP HEAD, FEET'
358   890151 PHEAD 420
359   890160 'BFW PUMP HYDRAULIC HP'
360   890161 OPVB 42
361   890170 'BFP EFFICIENCY'
362   890171 EFFPMP 420
363   890180 'BFW PUMP BRAKE HORSEPOWER'
364   890181 OPVB 43
365   890190 'BFP SPEED, RPM'
366   890191 OPVB 50
367   *
368   .
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Attachment 11

Unit 4 Calculated Operating Conditions
Variable Speed Pump Operation

Calculated Operating Data

Unit Load, MW(G)	84	75	65	55	45	35
Throttle Flow, K Lb/Hr	565	492	416	346	280	218
Condensate Flow, K Lb/Hr	426	376	323	273	225	179
BFP Flow, K Lb/Hr	582	509	432	362	296	233
Cond. Pump Disch., PSIA	263	268	273	276	260	270
BFP Suction, PSIA	234	246	256	264	252	265
BFP Discharge, PSIA	2020	1976	1941	1915	1891	1875
No. 6 Htr Out, PSIA	1991	1954	1925	1905	1883	1870
Boiler Drum, PSIA	1935	1915	1900	1885	1868	1861
Main Steam, PSIA	1815	1815	1815	1815	1815	1815

Calculated Feedpump Performance

BFP Hydraulic HP	1301	1097	904	739	596	460
BFP Efficiency, %	71.8	69.4	65.6	60.5	72.3	68.7
BFP Brake HP	1812	1581	1379	1221	825	669
BFP Head, Feet	4425	4271	4142	4041	3993	3901
BFP Speed, RPM	3242	3137	3039	2975	3108	2960

Notes:

1) One boiler feedpump and one condensate pump operate at unit loads below 50 MW; two feedpumps and two condensate pumps operate at unit loads 50 MW and above.

2) Boiler feedpump performance from GAI Data Book curve H-2967

3) Condensate pump performance from GAI Data Book curve H-2961

4) Pressure drop for LP feedwater heaters from Marley data sheets, and pressure drop for HP heaters from GAI Data Book.

5) Boiler drum pressure from GAI Heat Balances B-43265

Attachment 12

Unit 12 Calculated Operating Conditions
Variable Speed Pump Operation

Calculated Operating Data

Unit Load, MW(G)	84	75	65	55	45	35
Throttle Flow, K Lb/Hr	565	492	416	346	280	218
Condensate Flow, K Lb/Hr	426	376	323	273	225	179
BFP Flow, K Lb/Hr	568	495	418	348	281	219
Cond. Pump Disch., PSIA	265	271	278	284	262	274
BFP Suction, PSIA	232	245	259	269	252	268
BFP Discharge, PSIA	2024	1991	1944	1915	1892	1875
No. 6 Htr Out, PSIA	1988	1964	1925	1905	1883	1870
Boiler Drum, PSIA	1935	1915	1900	1885	1868	1861
Main Steam, PSIA	1815	1815	1815	1815	1815	1815

Calculated Feedpump Performance

BFP Hydraulic HP	1274	1077	875	708	568	431
BFP Efficiency, %	71.4	68.5	64.7	59.5	71.7	66.7
BFP Brake HP	1784	1572	1353	1189	792	645
BFP Head, Feet	4440	4311	4144	4031	3995	3891
BFP Speed, RPM	3219	3135	3036	2966	3064	2957

Notes:

1) One boiler feedpump and one condensate pump operate at unit loads below 50 MW; two feedpumps and two condensate pumps operate at unit loads 50 MW and above.

2) Boiler feedpump performance from GAI Data Book curve H-3327

3) Condensate pump performance from GAI Data Book curve H-3321

4) Pressure drop for feedwater heaters from GAI Data Book.

5) Boiler drum pressure from GAI Heat Balances B-43265 (Unit 4)