Condenser Performance Evaluation of Atlantic Electric's B. L. England Unit #1

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ABSTRACT

The condensers on B. L. England Units 1&2 do not presently operate at their original level of performance. This is due to both chemical treatment for corrosion, which impedes heat transfer, and a change in material from the original Aluminum-brass to 90-10 copper-nickel in the late 1960s due to corrosion problems. The current condenser cleanliness factor is less than 60 percent for each unit.

The PEPSE heat balance program was used to model the performance of B. L. England Unit 1 with the proposed titanium condenser design. It was found that the new design would yield an improvement of approximately 0.7 percent in both heat rate and generating capability over that of the current condenser. Because Units 1&2 are similar in both design and heat rate, the results would also apply to B. L. England Unit 2.

Introduction

The original condenser for B. L. England Units 1 and 2 used aluminum-brass tubes, which were installed in the early 1960s. Due to their salt water service, corrosion and erosion were problems and resulting tube failures were common. In 1971, the original aluminum - brass tubes were replaced with 90-10 copper nickel tubes; these are 7 percent less effective than the original aluminum-brass. Also, even the original design was marginal considering the consistently high circulating water inlet temperatures the plant must tolerate in the summer months. These temperatures average 79°F, 19°F higher than original condenser design from June to September. Summer inlet temperatures even higher than 90°F have also been recorded for extended time periods. With the change to 90-10 copper-nickel tubes, any existing margin was eliminated so that the condenser cannot now meet the original performance expectations.

A current operating cleanliness factor of 60 percent has been determined through testing and trend data. Currently, there is a reluctance to raise the cleanliness factor by cleaning the condenser to achieve an expected operating cleanliness factor of 85 percent. This is because stripping the tubes of any coating created by chemical water treatment is undersireable although it does maintain the extra level of corrosion protection.

This PEPSE study investigated whether tube replacement can be justified by the performance gains only. Previous studies concerning replacement due to expected tube failure rates had indicated that replacement could not be cost justified at a 1.5 million dollar expenditure per condenser. But based on this PEPSE Performance Study, the expenditure for replacement can be justified.

PEPSE Modeling

The modeling was rather simple. An HEI condenser was modeled for the base case, and this was used for the subsequent upgrade cases. In the model, maximum continuous rating (MCR) steam flow to the turbine was used to evaluate conditions when maximum load is required. The circulating water temperature (for technical data and model see Appendix II), tube material, surface areas, and cleanliness were changed to come up with the upgraded condenser.

The unit was modeled to reflect the current tested heat rate and MW hour output. This was done by reducing the benchmark turbine efficiencies by about 3.12 percent. Since good extraction test data was not available, using a constant reduction produced a heat rate and MW hour output equivalent to the most current test.

Performance Analysis

The following runs were modeled for the performance evaluation.

Run	Clean-liness	Circulating Water Temps	TUBE DIA	TUBE MAT'l	Circulating Water Pump Flow	Surface Area	BWG
1	60%	40-90°F by 5°F	7/8"	90-10	Lo-sp Hi- sp one or two pumps	Original	18
2	90-100%	80-90°F "	"	"	Two pumps, Hi-sp		18
3	60%	80-90°F "	"	"	Lo-sp Hi-sp Two pumps	Original	18
4	90%	80-90°F "	7/8"	TI	Lo-sp Hi-sp Two pumps	Original	27
5	90%	80-90°F "	"	"	Lo-sp Hi-sp Two pumps	Original	25
6	90%	80-90°F "	"	"	Lo-sp Hi-sp Two pumps	Original	20
7	90%	40-90°F "	3/4"	TI	Lo-sp Hi-sp Two pumps	Upgraded By 27%	25
8	90%	40-60°F "	"	"	Lo-sp Hi-sp One pumps	Upgraded By 27%	25

Titanium tubes were chosen for all upgrades because of inherent resistance to both erosion and corrosion.

The first run was to obtain a current 90-10 condenser benchmark for heat rates and output to compare them to any upgrades. The second gave a set of heat rates as a goal when changing the material to titanium. Since a 7 percent degradation in performance occurred from the change from aluminimum-brass to 90-10, the cleanliness rate for the 90-10 would have to be higher than 92 percent to be equivalent to the original condensers. The same or improved performance over the original aluminum-brass design was desired; therefore, the 90 percent, 95 percent and 100 percent cleanliness factors were run to give targets for initial comparisons.

The most cost effective option would be replacement of the 90-10 with the same size diameter titanium tubes. Therefore, PEPSE runs four through six, with the 7/8"OD TI tubes, were completed using different tube gauges and a 90 percent cleanliness factor (standard for TI condensers). It was found that improvement over the current 90-10 condenser at 60 percent cleanliness could be achieved, but it would still be worse than a 90-10 condenser at 90 percent cleanliness, even using the thin walled 27 BWG tubes for optimum heat transfer rates. Also, it was found that changing from 25 BWG tubes to 27 BWG tubes, resulted in only an insignificant the incremental decrease in heat rate. Therefore, the more common 25 BWG tube gauge will be used for subsquent upgrade cases.

The next option was to increase surface area by using to the next smaller tube diameter of 3/4". To maintain a constant velocity through the tubes, the cross sectional area available for water flow of the 3/4" diameter tubes was made equivalent to that same area for the 7/8" diameter tubes. Doing this should also yield similar condenser tubeside pressure drops between the current and upgraded versions. The effect is to increase the condenser surface by 27 percent and the number of tubes by 40 percent. It was found that with this upgrade, using 25 BWG tubes yielded a unit heat rate performance better than the 90-10 at the 100 percent cleanliness factor.

The 27 percent increase in surface area yielded a 0.7 percent decrease in annualized heat rate and a 0.7 percent increase in annualized maximum output for Unit 1. Similar performance results are expected for Unit 2. The estimated payback from the predicted improvements would be eight and five years, respectively (See Report, Appendix I). These condensers are in the budget for replacement within the next two years.

REFERENCES

1. PEPSE Manual: Volumes I, II and III, E. I. International Inc.
P.O. Box 50736, Idaho Falls, Idaho
Revision 15, 4/12/90

2. ASTM Standards For TItanium Specifications, 1916 Race Street
Philadelphia, PA, 19103, August 1986

3. Delta T. Study, Report #86-34 Atlantic Electric's,
September 1986, J. C. Eigenbrood

APPENDIX I

M E M O R A N D U M

February 12, 1990

TO: J.C. McCullough

FROM: L.M. Svensen

SUBJECT: Condenser Performance B.L. England Units 1&2

The condensers on B.L. England Units 1&2 are not operating at their original level of performance. This is due to both chemical treatment for corrosion, which impedes heat transfer, and a change in material from the original Al-bronze to 90-10 copper-nickel in the late 60s. The current condenser cleanliness factor is less than 60 % on both Units.

A study was completed in 1986 (the Delta T Study, report #86-39) which proposed retubing the condensers with titanium tubes and tubesheets. Because the heat transfer coefficient of titanium is less than that of 90-10 copper nickel, a 27 percent increase in condenser surface area was also recommended. Condenser cleanliness factors of 90% are predicted with this configuration.

The enclosed analysis has been completed to determine the effect of these proposed condenser modifications on unit performance.

The PEPSE heat balance program was used to model the performance of B.L. England Unit 1 with the proposed titanium condenser design. It was found that the new design would yield an improvement of approximately 0.7 percent in both heat rate and generating capability. Changes in circulating water temperature Delta T are also indicated, and may be greater or less than current depending on CW pumping mode. However, all should remain within current constraints. Because Units 1&2 are similar in design the results would also apply to B.L. England Unit 2.

The estimated cost of the condenser modifications is $1,500,000 for each unit. PROMOD III was run to determine the fuel and interchange savings that would result from the predicted performance improvements. The PROMOD study shows that the payback period would be five years for retubing Unit 2 and eight years for Unit 1. An additional savings of up to $80,000 per year is possible if credit is taken for added installed capacity. If both condensers are modified as proposed, the summer installed capacity of B.L. England Station should increase by approximately 2 MW.

The tables and memorandum that follow summarize the results of this study.

L.M. Svensen

jnk

B.L. ENGLAND UNIT #1

CIRCULATING WATER TEMPERATURES WHEN OPTIMIZING
PERFORMANCE OF 90-10 COPPER NICKEL VS. TITANIUM.

		90-10 COPPER NICKEL				TITANIUM			
PASSES	CWI	PUMPS	FLOW	CWO	DELTA-T	PUMPS	FLOW	CWO	DELTA-T
SINGLE	40	2-LO SP	88000	54.3	14.3	1-LO SP	44000	68.7	28.7
SINGLE	45	2-LO SP	88000	59.4	14.4	1-HI SP	52000	62.3	22.3
SINGLE	50	2-LO SP	88000	64.4	14.4	2-LO SP	88000	64.4	14.4
SINGLE	55	2-LO SP	88000	69.4	14.4	2-LO SP	88000	69.4	14.4
SINGLE	60	2-LO SP	88000	74.4	14.4	2-LO SP	88000	74.4	14.4
SINGLE	65	2-HI SP	104000	77.2	12.2	2-LO SP	88000	79.4	14.4
SINGLE	70	2-HI SP	104000	82.3	12.3	2-LO SP	88000	84.4	14.4
SINGLE	75	2-HI SP	104000	87.3	12.3	2-LO SP	88000	89.5	14.5
SINGLE	80	2-HI SP	104000	92.4	12.4	2-HI SP	104000	92.3	12.3
SINGLE	85	2-HI SP	104000	97.5	12.5	2-HI SP	104000	97.3	12.3
SINGLE	90	2-HI SP	104000	102.5	12.5	2-HI SP	104000	102.4	12.4

NOTE: THIS TABLE SHOWS THAT THE NEW DELTA T'S WITH THE TITANIUM CONDENSER WILL
BE WITHIN THE ALLOWABLE ENVIRONMENTAL LIMITS (IE. 16 SUMMER 35 WINTER),
DURRING BOTH SUMMER AND WINTER OPERATION.

B.L. ENGLAND UNIT #1

PERFORMANCE COMPARISION BETWEEN
90-10 COPPER NICKEL AND TITANIUM CONDENSER TUBES
WHEN VARYING CICULATING WATER FLOW TO OPTIMIZE
PERFORAMNCE.

NSHR: NET STATION HEAT RATE
CWO: CIRCULATING WATER OUTLET TEMPERATURE
CWI: CIRCULATING WATER INLET TEMPERATURE
ABS: CONDENSER ABSOLUTE IN INCHES OF HG.

		90-10 COPPER NICKEL					TITANIUM					DIFFERANCE		
PASSES	CWI	PUMPS	FLOW	ABS.	NMW	NSHR	PUMPS	FLOW	ABS.	NMW	NSHR	ABS.	NMW	NSHR
SINGLE	40	2-LO SP	88000	1.33	132.33	9776	1-LO SP	44000	1.49	132.41	9771	0.2	0.085	-5.047
SINGLE	45	2-LO SP	88000	1.40	132.36	9780	1-HI SP	52000	1.26	132.35	9775	-0.1	-0.006	-4.648
SINGLE	50	2-LO SP	88000	1.50	132.20	9787	2-LO SP	88000	1.00	132.30	9779	-0.5	0.104	-7.831
SINGLE	55	2-LO SP	88000	1.65	132.01	9801	2-LO SP	88000	1.13	132.32	9777	-0.5	0.320	-23.53
SINGLE	60	2-LO SP	88000	1.82	131.70	9823	2-LO SP	88000	1.28	132.33	9776	-0.5	0.643	-47.08
SINGLE	65	2-HI SP	104000	1.83	131.30	9854	2-LO SP	88000	1.47	132.23	9784	-0.4	0.936	-69.70
SINGLE	70	2-HI SP	104000	2.07	130.79	9892	2-LO SP	88000	1.68	131.95	9805	-0.4	1.168	-86.97
SINGLE	75	2-HI SP	104000	2.36	129.98	9954	2-LO SP	88000	1.93	131.47	9840	-0.4	1.488	-113.4
SINGLE	80	2-HI SP	104000	2.71	129.24	10038	2-HI SP	104000	2.06	130.80	9890	-0.7	1.565	-147.1
SINGLE	85	2-HI SP	104000	3.11	127.48	10149	2-HI SP	104000	2.38	129.92	9958	-0.7	2.443	-191.1
SINGLE	90	2-HI SP	104000	3.57	125.87	10278	2-HI SP	104000	2.75	128.75	10048	-0.8	2.878	-229.6

NOTE: THIS TABLE SHOWS A COMPARISON BETWEEN BEST CASE OPERATIONS FOR A GIVEN CIRCULATING WATER INLET TEMPERATURE. IN OUR FINANCIAL ANALYSIS WE HAVE TAKEN CREDIT FOR BOTH AN IMPROVEMENT IN EFFICIENCY AND AN INCREASE IN NET GENERATION.

B.L. ENGLAND UNIT #1

CALCULATION OF PERCENT IMPROVEMENT IN HEAT RATE WITH TITANIUM CONDENSER TUBES

MONTH	FIVE YEAR AVG CWI	CIRCULATING FLOW IN GPM	DELTA H.R. IN %	FIVE YEAR AVG. MONTHLY GENERATION	MONTHLY GEN. % OF ANNUAL GENERATION	IMPROVEMENT %
1	43	44000	-0.04	74752	10.29	0.00
2	47	52000	-0.03	68529	9.44	0.00
3	49	88000	-0.07	58676	8.08	0.01
4	58	88000	-0.38	45593	6.28	0.02
5	65	88000	-0.70	49423	6.81	0.05
6	76	88000	-1.20	56955	7.84	0.09
7	81	104000	-1.58	73595	10.14	0.16
8	82	104000	-1.66	74644	10.28	0.17
9	77	88000	-1.26	54366	7.49	0.09
10	63	88000	-0.61	55401	7.63	0.05
11	56	88000	-0.29	53749	7.40	0.02
12	48	88000	-0.06	60433	8.32	0.00
			SUM	726117	100.00	0.7

NOTE: THE IMPROVEMENT IN PERFORMANCE WITH TITANIUM CONDENSER TUBES WILL VARY DEPENDING ON THE COOLING WATER TEMPRATURE. THIS TABLE PREDICTS THE MONTHLY PERFORMANCE IMPROVEMENT BASED ON THE EXPECTED GENERATION AND AVERAGE CIRCULATING WATER INLET TEMPERATURE FOR EACH MONTH.

B.L. ENGLAND UNIT #1

PERFORMANCE COMPARISION BETWEEN
90-10 COPPER NICKEL AND TITANIUM CONDENSER TUBES
WITH CONSTANT CIRCULATING WATER FLOW.

NSHR:NET STATION HEAT RATE
CWI: CIRCULATING WATER INLET TEMPERATURE
ABS:CONDENSER ABSOLUTE IN INCHES OF HG.

		90-10 COPPER NICKEL					TITANIUM					DELTA		
PASSES	CWI	PUMPS	FLOW	ABS.	NMW	NSHR	PUMPS	FLOW	ABS.	NMW	NSHR	ABS.	NMW	NSHR
SINGLE	40	1-LO SP	44000	2.92	128.78	10046	1-LO SP	44000	1.49	132.41	9771	-1.423	3.63	-275
SINGLE	45	1-LO SP	44000	2.94	128.72	10052	1-LO SP	44000	1.60	132.28	9780	-1.335	3.56	-271
SINGLE	50	1-LO SP	44000	3.03	128.38	10078	1-LO SP	44000	1.74	132.05	9797	-1.288	3.67	-281
SINGLE	55	1-LO SP	44000	3.23	127.67	10133	1-LO SP	44000	1.93	131.69	9824	-1.298	4.01	-308
SINGLE	60						1-LO SP	44000	2.16	131.15	9864			
SINGLE	40	1-HI SP	52000	2.35	130.50	9914	1-HI SP	52000	1.26	132.35	9775	-1.090	1.85	-139
SINGLE	45	1-HI SP	52000	2.37	130.37	9924	1-HI SP	52000	1.36	132.33	9776	-1.011	1.96	-148
SINGLE	50	1-HI SP	52000	2.47	130.04	9948	1-HI SP	52000	1.48	132.23	9784	-0.987	2.18	-164
SINGLE	55	1-HI SP	52000	2.65	129.46	9993	1-HI SP	52000	1.65	132.01	9800	-0.999	2.55	-194
SINGLE	60						1-HI SP	52000	1.85	131.65	9827			
SINGLE	65						1-HI SP	52000	2.09	131.12	9867			
SINGLE	40	2-LO SP	88000	1.33	132.32	9776	2-LO SP	88000	0.81	132.29	9780	-0.517	-0.04	4
SINGLE	45	2-LO SP	88000	1.40	132.36	9780	2-LO SP	88000	0.90	132.33	9777	-0.504	-0.03	-2
SINGLE	50	2-LO SP	88000	1.50	132.19	9787	2-LO SP	88000	1.00	132.30	9779	-0.502	0.10	-8
SINGLE	55	2-LO SP	88000	1.65	132.00	9801	2-LO SP	88000	1.13	132.32	9777	-0.515	0.32	-24
SINGLE	60	2-LO SP	88000	1.82	131.69	9823	2-LO SP	88000	1.28	132.33	9776	-0.539	0.64	-47
SINGLE	65	2-LO SP	88000	2.04	131.23	9858	2-LO SP	88000	1.47	132.23	9784	-0.574	1.00	-75
SINGLE	70	2-LO SP	88000	2.30	130.56	9909	2-LO SP	88000	1.68	131.95	9805	-0.621	1.39	-105
SINGLE	75	2-LO SP	88000	2.62	129.54	9987	2-LO SP	88000	1.93	131.47	9840	-0.688	1.93	-147
SINGLE	80	2-LO SP	88000	3.00	128.27	10085	2-LO SP	88000	2.23	130.75	9895	-0.768	2.48	-190
SINGLE	85	2-LO SP	88000	3.45	126.69	10211	2-LO SP	88000	2.58	129.68	9976	-0.871	3.00	-235
SINGLE	90	2-LO SP	88000	3.95	125.01	10349	2-LO SP	88000	2.97	128.38	10077	-0.979	3.37	-272
SINGLE	40	2-HI SP	104000	1.15	131.93	9805	2-HI SP	104000	0.73	131.93	9805	-0.427	0.00	0
SINGLE	45	2-HI SP	104000	1.23	131.94	9805	2-HI SP	104000	0.81	131.90	9809	-0.419	-0.05	4
SINGLE	50	2-HI SP	104000	1.33	131.94	9805	2-HI SP	104000	0.91	131.94	9805	-0.419	0.00	-0
SINGLE	55	2-HI SP	104000	1.46	131.84	9813	2-HI SP	104000	1.03	131.91	9808	-0.429	0.06	-5
SINGLE	60	2-HI SP	104000	1.63	131.64	9827	2-HI SP	104000	1.17	131.94	9805	-0.454	0.30	-22
SINGLE	65	2-HI SP	104000	1.83	131.29	9854	2-HI SP	104000	1.34	131.93	9806	-0.484	0.64	-47
SINGLE	70	2-HI SP	104000	2.07	130.78	9892	2-HI SP	104000	1.54	131.75	9819	-0.523	0.97	-72
SINGLE	75	2-HI SP	104000	2.36	129.98	9954	2-HI SP	104000	1.78	131.38	9847	-0.580	1.40	-107
SINGLE	80	2-HI SP	104000	2.71	129.23	10038	2-HI SP	104000	2.06	130.80	9890	-0.651	1.56	-147
SINGLE	85	2-HI SP	104000	3.11	127.48	10149	2-HI SP	104000	2.38	129.92	9958	-0.734	2.44	-191
SINGLE	90	2-HI SP	104000	3.57	125.87	10278	2-HI SP	104000	2.75	128.75	10048	-0.828	2.88	-230

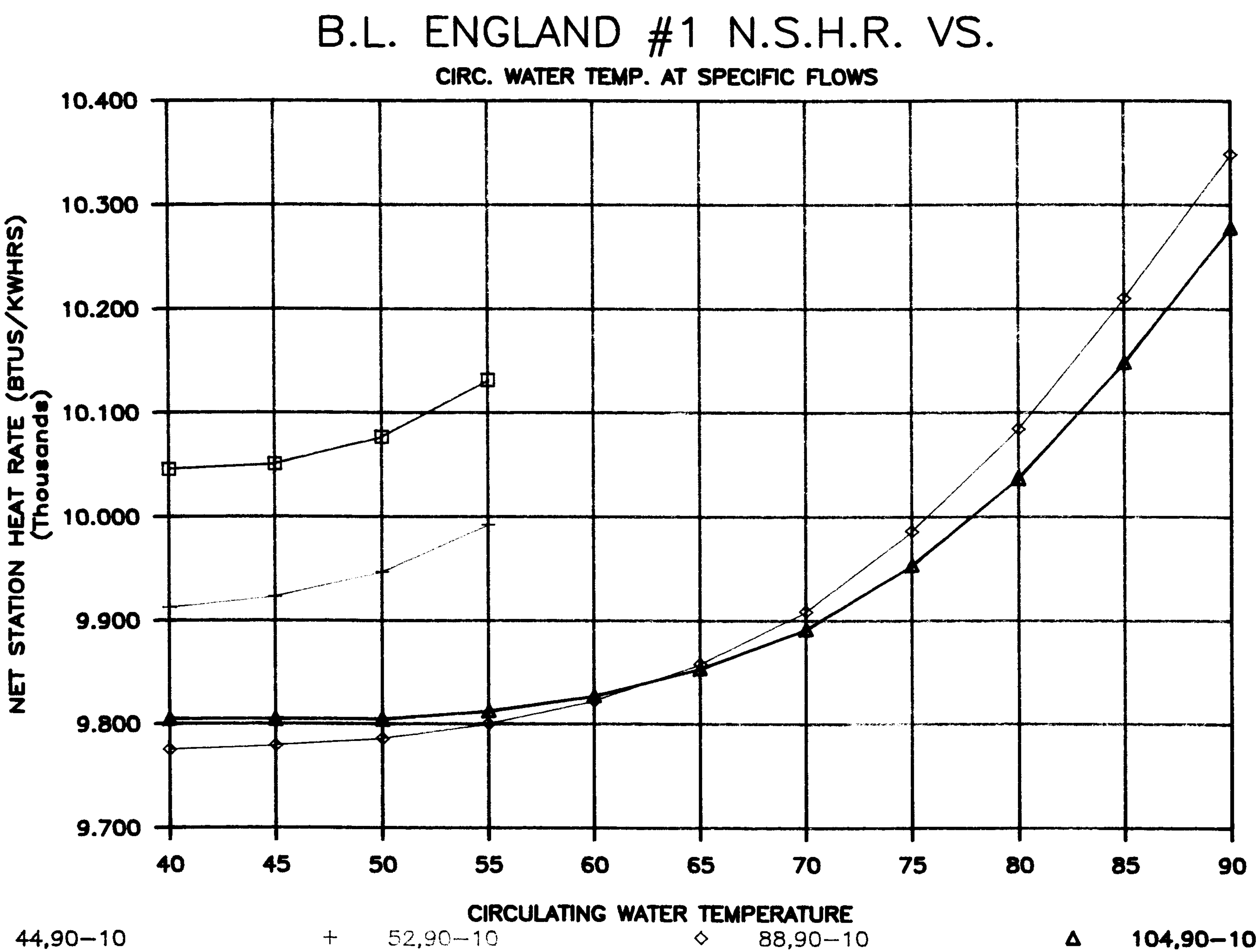
. . ENGLAND UNIT #1

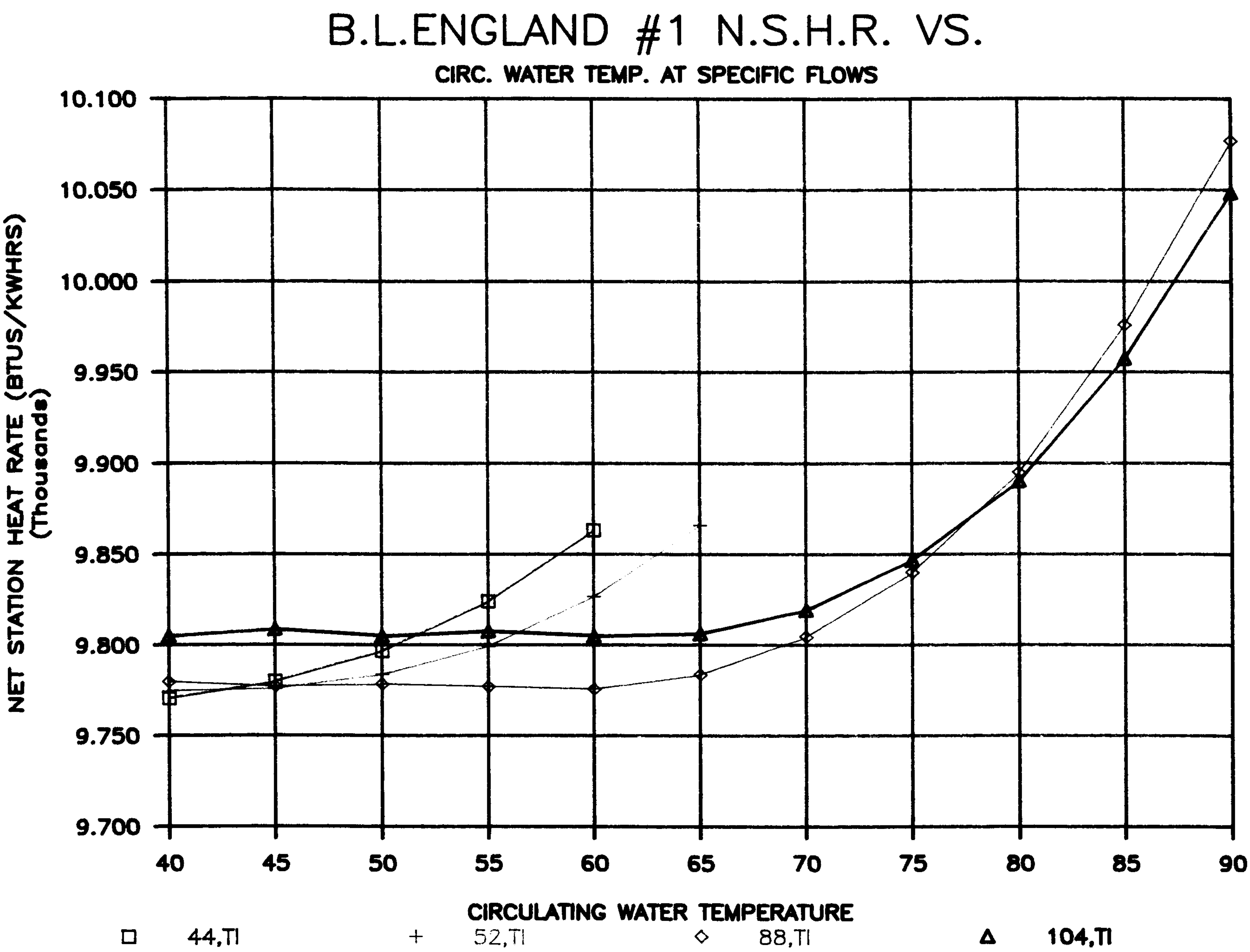
GTHR:GROSS TURBINE HEAT RATE
NSHR:NET STATION HEAT RATE
CL%:CLEANLINESS FACTOR IN PERCENT

CWI: CIRCULATING WATER INLET TEMPERATURE
CWO: CIRCULATING WATER OUTLET TEMPERATURE
COND ABS:CONDENSER ABSOLUTE IN INCHES OF HG.

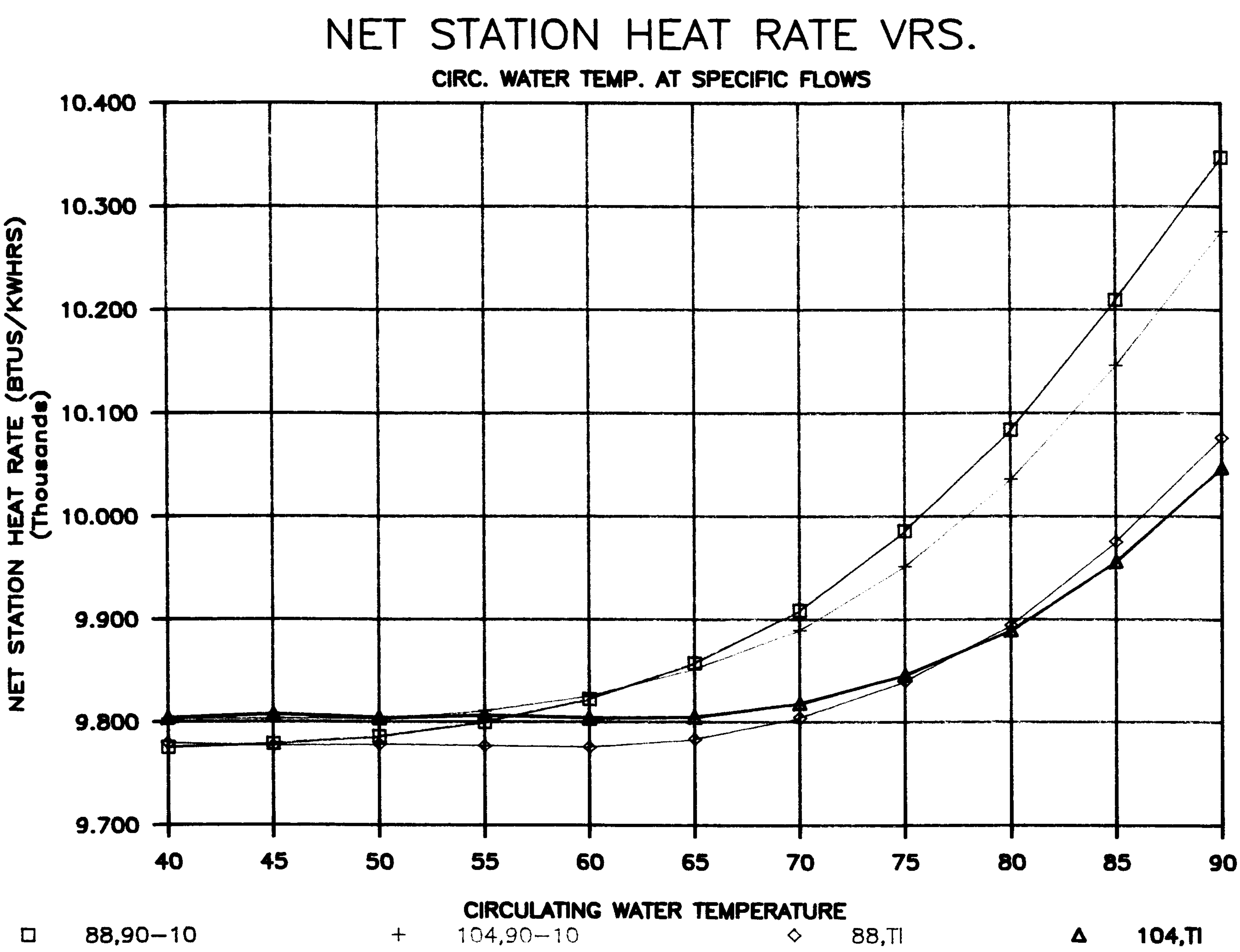
COMPARING CURRENT PERFORMANCE WITH TI CONDENSER. OPERATING
THE UNIT AT THE SAME GMW AS CURRENT PERFORMANCE INDICATES.

STEAM FLOW % MCR	NUMBER OF TUBES	BWG	MAT'L	FLOW	CL%	CWI	COND ABS.	GMW	GTHR CURRENT CONDITIONS	AUX MW	NMW	NSHR	PREDICTED CWO	DELTA TEMP.	REDUCTION IN DELTA + OR - F	HEAT RATE IMPROVEMENT %
100.0	9152	18	90-10	88000	0.6	70	2.30	138.17	8240	7.610	130.56	9909	85	14.5		
100.0	9152	18	90-10	88000	0.6	75	2.62	137.15	8301	7.610	129.54	9987	90	14.6		
100.0	9152	18	90-10	88000	0.6	80	3.00	135.88	8378	7.610	128.27	10085	95	14.7		
100.0	9152	18	90-10	88000	0.6	85	3.45	134.30	8476	7.610	126.69	10211	100	15.0		
100.0	9152	18	90-10	88000	0.6	90	3.95	132.63	8584	7.610	125.02	10349	105	15.0		
100.0	9152	18	90-10	104000	0.6	70	2.07	138.79	8203	8.000	130.79	9892	82	12.3		
100.0	9152	18	90-10	104000	0.6	75	2.36	137.98	8251	8.000	129.98	9954	87	12.3		
100.0	9152	18	90-10	104000	0.6	80	2.71	137.24	8318	8.000	129.24	10038	92	12.4		
100.0	9152	18	90-10	104000	0.6	85	3.11	135.48	8403	8.000	127.48	10149	97	12.5		
100.0	9152	18	90-10	104000	0.6	90	3.57	133.87	8504	8.000	125.87	10278	103	12.5		
98.8	13558	25	TI	88000	0.9	70	1.66	138.18	8156	7.610	130.57	9808	84	14.3	0.3	1.03
98.3	13558	25	TI	88000	0.9	75	1.91	137.15	8183	7.610	129.54	9846	89	14.3	0.4	1.43
97.8	13558	25	TI	88000	0.9	80	2.20	135.89	8227	7.610	128.28	9903	94	14.3	0.5	1.84
97.3	13558	25	TI	88000	0.9	85	2.54	134.31	8290	7.610	126.70	9987	99	14.3	0.7	2.24
97.0	13558	25	TI	88000	0.9	90	2.92	132.63	8372	7.610	125.02	10092	104	14.3	0.6	2.54
99.1	13558	25	TI	104000	0.9	70	1.54	138.79	8144	8.000	130.79	9821	82	12.1	0.2	0.72
98.7	13558	25	TI	104000	0.9	75	1.77	137.98	8166	8.000	129.98	9851	87	12.1	0.2	1.05
98.6	13558	25	TI	104000	0.9	80	2.04	137.23	8201	8.000	129.23	9896	92	12.1	0.3	1.43
97.8	13558	25	TI	104000	0.9	85	2.35	135.49	8253	8.000	127.49	9967	97	12.1	0.4	1.82
97.4	13558	25	TI	104000	0.9	90	2.71	133.87	8325	8.000	125.87	10062	102	12.1	0.4	2.15

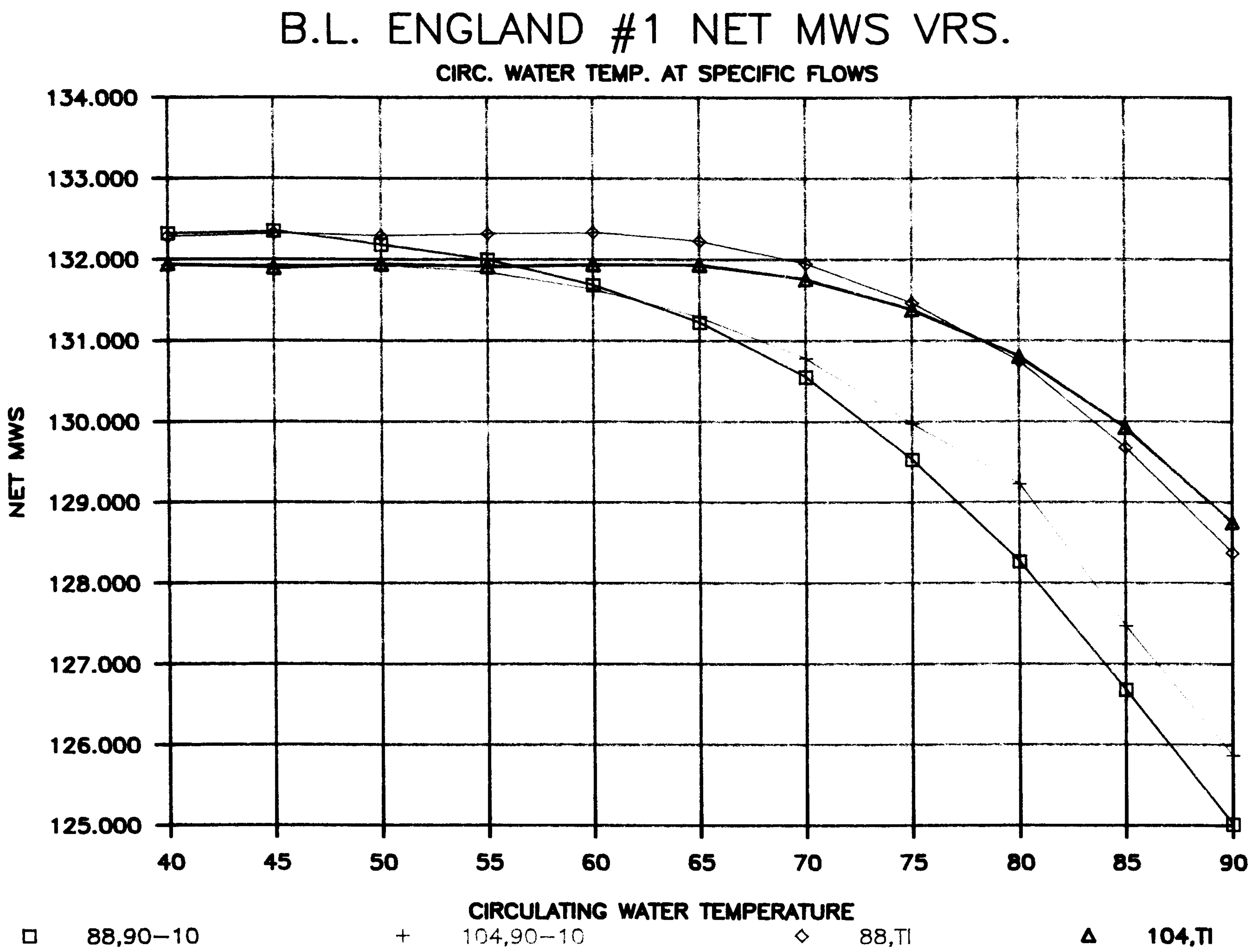

B.L. ENGLAND #1 N.S.H.R. VS.
CIRC. WATER TEMP. AT SPECIFIC FLOWS
NET STATION HEAT RATE (BTUS/KWHRS)
(Thousands)
10.400
10.300
10.200
10.100
10.000
9.900
9.800
9.700
40
45
50
55
60
65
70
75
80
85
90
CIRCULATING WATER TEMPERATURE
44,90−10
+ 52,90−10
◇ 88,90−10
Δ 104,90−10



B.L.ENGLAND #1 N.S.H.R. VS.
CIRC. WATER TEMP. AT SPECIFIC FLOWS
NET STATION HEAT RATE (BTUS/KWHRS)
(Thousands)
10.100
10.050
10.000
9.950
9.900
9.850
9.800
9.750
9.700
40
45
50
55
60
65
70
75
80
85
90
CIRCULATING WATER TEMPERATURE
□ 44,TI
+ 52,TI
◇ 88,TI
Δ 104,TI



NET STATION HEAT RATE VRS.
CIRC. WATER TEMP. AT SPECIFIC FLOWS
NET STATION HEAT RATE (BTUS/KWHRS)
(Thousands)
10.400
10.300
10.200
10.100
10.000
9.900
9.800
9.700
40
45
50
55
60
65
70
75
80
85
90
CIRCULATING WATER TEMPERATURE
□ 88,90-10
+ 104,90-10
◇ 88,TI
Δ 104,TI


B.L. ENGLAND #1 NET MWS VRS.
CIRC. WATER TEMP. AT SPECIFIC FLOWS
NET MWS
134.000
133.000
132.000
131.000
130.000
129.000
128.000
127.000
126.000
125.000
40
45
50
55
60
65
70
75
80
85
90
CIRCULATING WATER TEMPERATURE
88,90−10
104,90−10
88,TI
104,TI

MEMORANDUM

December 22, 1989

To: L. M. Svensen

From: R. E. Herrmann

Subject: Estimated Energy Cost Savings Due to Improving BLE 1&2 Heat Rate and Capacity

Our analysis of the energy cost savings of a 1% improvement in the heat rate and capability of BLE 1&2 is attached. The analyses were performed for each unit separately and for both units together. There is virtually no difference in the separate and combined results.

The analysis shows the following annualized savings (in 1990 dollars) over the period 1990-1999:

	Unit 1	Unit 2	Combined
1% Heat Rate improvement	$107,000	$222,000	$327,000
1% Capability improvement*	150,000	180,000	328,000

* 1 MW on Unit 1, 2 MW on unit 2

The analysis was performed using the PROMOD III production costing model, and is based on the 1990-1992 Budget database. The savings were de-escalated to 1990 levels using the compound escalation rate of #6 oil, which drives the value of replacement (or displaced) energy.

The additional 3 MW of capability <u>may</u> offset future installed capacity requirements. The estimated 1990 PJM capacity deficiency rate of $179/MW-day, factored up by AE's reserve reqirement of 17%, is a proxy of its value, assuming it is required 6 months per year:

(3 MW * $179/MW-day * 1.17 * 365 days/year * 0.5) = $115,000/year

If you have any questions or need additional analysis, please let me know.

Bob

xc: E. A. Zimmerman

Analysis of Energy Cost Savings Associated with
BLE 1&2 1% Capacity Improvements

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Total Savings	Annual Savings
BLE 1 Capacity												
"Base" Fuel $	155036	177701	213232	268516	289145	297001	326080	341473	358969	401305		
Fuel $ w/Capacity Improvement	154908	177597	213125	268386	289026	296860	325859	341237	358719	401036		
Value of Capacity Improvement	128	104	107	130	119	141	221	236	250	269		
Value in 1990 $	128	95	89	99	82	89	128	124	120	118	1072	107
BLE 2 Capacity												
"Base" Fuel $	155036	177701	213232	268516	289145	297001	326080	341473	358969	401305		
Fuel $ w/Capacity Improvement	154809	177472	212980	268250	288892	296716	325664	340997	358410	400712		
Value of Capacity Improvement	227	229	252	266	253	285	416	476	559	593		
Value in 1990 $	227	209	210	202	175	180	240	251	268	260	2222	222
BLE 1&2 Capacity												
"Base" Fuel $	155036	177701	213232	268516	289145	297001	326080	341473	358969	401305		
Fuel $ w/Capacity Improvement	154716	177370	212859	268133	288768	296560	325449	340748	358163	400451		
Value of Capacity Improvement	320	331	373	383	377	441	631	725	806	854		
Value in 1990 $	320	302	311	291	261	279	364	382	387	374	3271	327

Prepared by Power Economics
12/22/89

Analysis of Energy Cost Savings Associated with BLE 1&2 1% Heat Rate Improvements

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Total Savings	Annual Savings
BLE 1 Heat Rate												
"Base" Fuel $	155036	177701	213232	268516	289145	297001	326080	341473	358969	401305		
Fuel $ w/Heat Rate Improvement	154823	177508	213044	268318	288962	296796	325814	341216	358697	401020		
Value of Heat Rate Improvement	213	193	188	198	183	205	266	257	272	285		
Value in 1990 $	213	176	157	150	127	130	153	135	131	125	1497	150
BLE 2 Heat Rate												
"Base" Fuel $	155036	177701	213232	268516	289145	297001	326080	341473	358969	401305		
Fuel $ w/Heat Rate Improvement	154819	177469	212985	268266	288896	296793	325772	341142	358655	400923		
Value of Heat Rate Improvement	217	232	247	250	249	208	308	331	314	382		
Value in 1990 $	217	212	206	190	173	132	178	174	151	167	1798	180
BLE 1&2 Heat Rate												
"Base" Fuel $	155036	177701	213232	268516	289145	297001	326080	341473	358969	401305		
Fuel $ w/Heat Rate Improvement	154629	177277	212792	268066	288720	296574	325533	340879	358363	400638		
Value of Heat Rate Improvement	407	424	440	450	425	427	547	594	606	667		
Value in 1990 $	407	387	366	342	295	270	316	313	291	292	3278	328

Prepared by Power Economics
12/22/89

M E M O R A N D U M

March 27, 1990

TO:	H. C. Schwemm J. C. McCullough J. A. Isabella	G. E. Walters V. N. Bhamidipati E. Essington
FROM:	L. M. Svensen	
SUBJECT:	B. L. England 1&2 Condenser Study (dated 2/12/90 attached)	

During the March 6, 1990 B. L. England production engineering meeting concern was expressed that the increased MW output of the units with new upgraded condensers might increase the heat rejection to the bay.

The condenser performance study was completed using constant inlet steam conditions, including throttle steam flow. An upgraded condenser would allow the turbine steam to exhaust to that condenser at a lower pressure than is permitted by the existing condenser. As the exhaust pressure is decreased, the turbine realizes a greater pressure drop to extract additional energy from steam; therefore, an increase in MW output for the same throttle steam flow results. Because of the greater amounts of energy extracted from each pound of steam with the upgrade condenser, for the same throttle flow the energy in BTU/hr rejected to the bay would be less with the upgraded condenser than with the existing condenser.

Another way of looking at this would be to use the temperature Entropy (T-S) diagram (see attached figure) and a simple rankine cycle. With the existing condenser, the cycle would be A,B,C,D, E and have a heat rejection equal the area A,E,F,G. The rankine cycle with the upgraded condenser would be A',B,C,D,E', and have a heat rejection area of E', F, G', A' which is less than the area of A,E,F,G.

The attached table summarizes the study results. At temperatures below 60°F there is barely a difference between the performance of the existing condenser and the performance of the upgraded condenser.

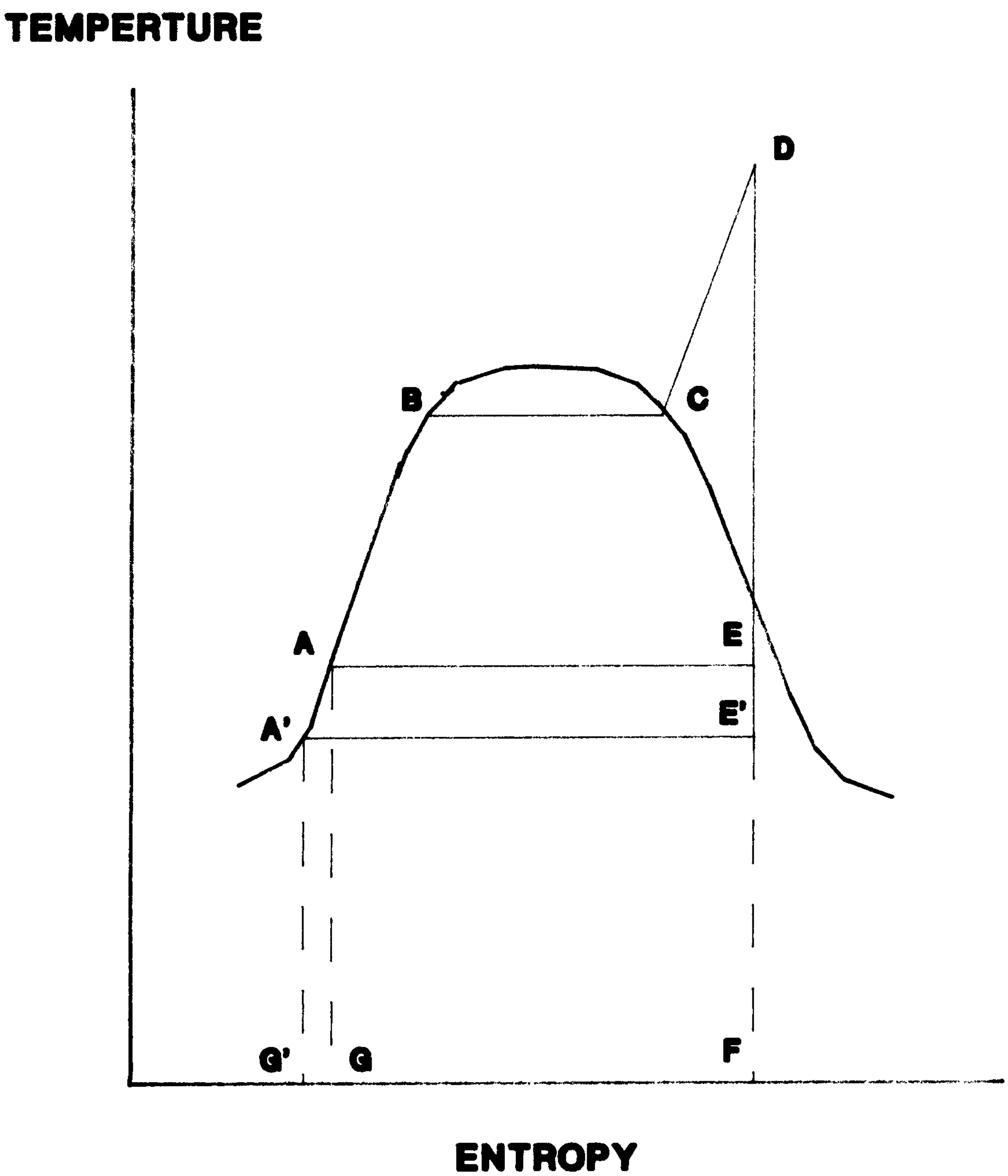
Please feel free to contact me at 625-6964 if you have any questions..

L. M. Svensen

LMS/jnk

xc: E. N. Belski
M. L. Puri
E. N. Adolfsen

T-S DIAGRAM



B.L. ENGLAND UNIT #1

PERFORMANCE COMPARISION BETWEEN
90-10 COPPER NICKEL AND TITANIUM CONDENSER TUBES
FOR HEAT REJECTION TO THE CIRCULATING WATER.

NSHR:NET STATION HEAT RATE
NMW: NET MEGA WATTS
CWI: CIRCULATING WATER INLET TEMPERATURE
ABS:CONDENSER ABSOLUTE IN INCHES OF HG.
Q:HEAT REJECTION TO THE CIRCULATING WATER

				90-10 COPPER NICKEL				TITANIUM				DIFFERANCE	
PASSES	CWI	PUMPS	FLOW	ABS.	NMW	NSHR	Q (BTU/HR)	ABS.	NMW	NSHR	Q (BTU/HR)	Q %	Q (BTU/HR)
SINGLE	40	2-LO SP	88000	1.33	132.33	9776	6.491E+08	0.81	132.29	9780	6.495E+08	0.07	4.750E+05
SINGLE	45	2-LO SP	88000	1.40	132.36	9780	6.492E+08	0.90	132.33	9777	6.494E+08	0.03	1.800E+05
SINGLE	50	2-LO SP	88000	1.50	132.20	9787	6.491E+08	1.00	132.30	9779	6.492E+08	0.01	8.500E+04
SINGLE	55	2-LO SP	88000	1.65	132.01	9801	6.491E+08	1.13	132.32	9777	6.491E+08	0.01	7.200E+04
SINGLE	60	2-LO SP	88000	1.82	131.70	9823	6.492E+08	1.28	132.33	9776	6.491E+08	-0.01	-8.300E+04
SINGLE	65	2-LO SP	88000	2.04	131.24	9858	6.499E+08	1.47	132.23	9784	6.490E+08	-0.13	-8.520E+05
SINGLE	70	2-LO SP	88000	2.30	130.56	9909	6.512E+08	1.68	131.95	9805	6.494E+08	-0.28	-1.804E+06
SINGLE	75	2-LO SP	88000	2.62	129.54	9987	6.532E+08	1.93	131.47	9840	6.505E+08	-0.42	-2.773E+06
SINGLE	80	2-LO SP	88000	3.00	128.27	10085	6.563E+08	2.23	130.75	9895	6.523E+08	-0.61	-4.003E+06
SINGLE	85	2-LO SP	88000	3.45	126.69	10211	6.604E+08	2.58	129.68	9976	6.549E+08	-0.83	-5.466E+06
SINGLE	90	2-LO SP	88000	3.95	125.02	10349	6.655E+08	2.97	128.38	10077	6.588E+08	-1.00	-6.666E+06
SINGLE	40	2-HI SP	104000	1.15	131.94	9805	6.492E+08	0.73	131.93	9805	6.496E+08	0.07	4.340E+05
SINGLE	45	2-HI SP	104000	1.23	131.95	9805	6.491E+08	0.81	131.90	9809	6.495E+08	0.06	3.980E+05
SINGLE	50	2-HI SP	104000	1.33	131.94	9805	6.492E+08	0.91	131.94	9805	6.493E+08	0.02	1.220E+05
SINGLE	55	2-HI SP	104000	1.46	131.85	9813	6.491E+08	1.03	131.91	9808	6.491E+08	0.00	2.000E+04
SINGLE	60	2-HI SP	104000	1.63	131.64	9827	6.491E+08	1.17	131.94	9805	6.492E+08	0.02	1.380E+05
SINGLE	65	2-HI SP	104000	1.83	131.30	9854	6.493E+08	1.34	131.93	9806	6.491E+08	-0.04	-2.730E+05
SINGLE	70	2-HI SP	104000	2.07	130.79	9892	6.502E+08	1.54	131.75	9819	6.491E+08	-0.18	-1.141E+06
SINGLE	75	2-HI SP	104000	2.36	129.98	9954	6.519E+08	1.78	131.38	9847	6.498E+08	-0.31	-2.038E+06
SINGLE	80	2-HI SP	104000	2.71	129.24	10038	6.543E+08	2.06	130.80	9890	6.513E+08	-0.46	-3.001E+06
SINGLE	85	2-HI SP	104000	3.11	127.48	10149	6.578E+08	2.38	129.92	9958	6.535E+08	-0.66	-4.356E+06
SINGLE	90	2-HI SP	104000	3.57	125.87	10278	6.623E+08	2.75	128.75	10048	6.568E+08	-0.83	-5.525E+06

APPENDIX II

3051
M2-216-1

309 HB 225

CALCULATED DATA - NOT GUARANTEED
FOR ENGINEERING PURPOSES ONLY *

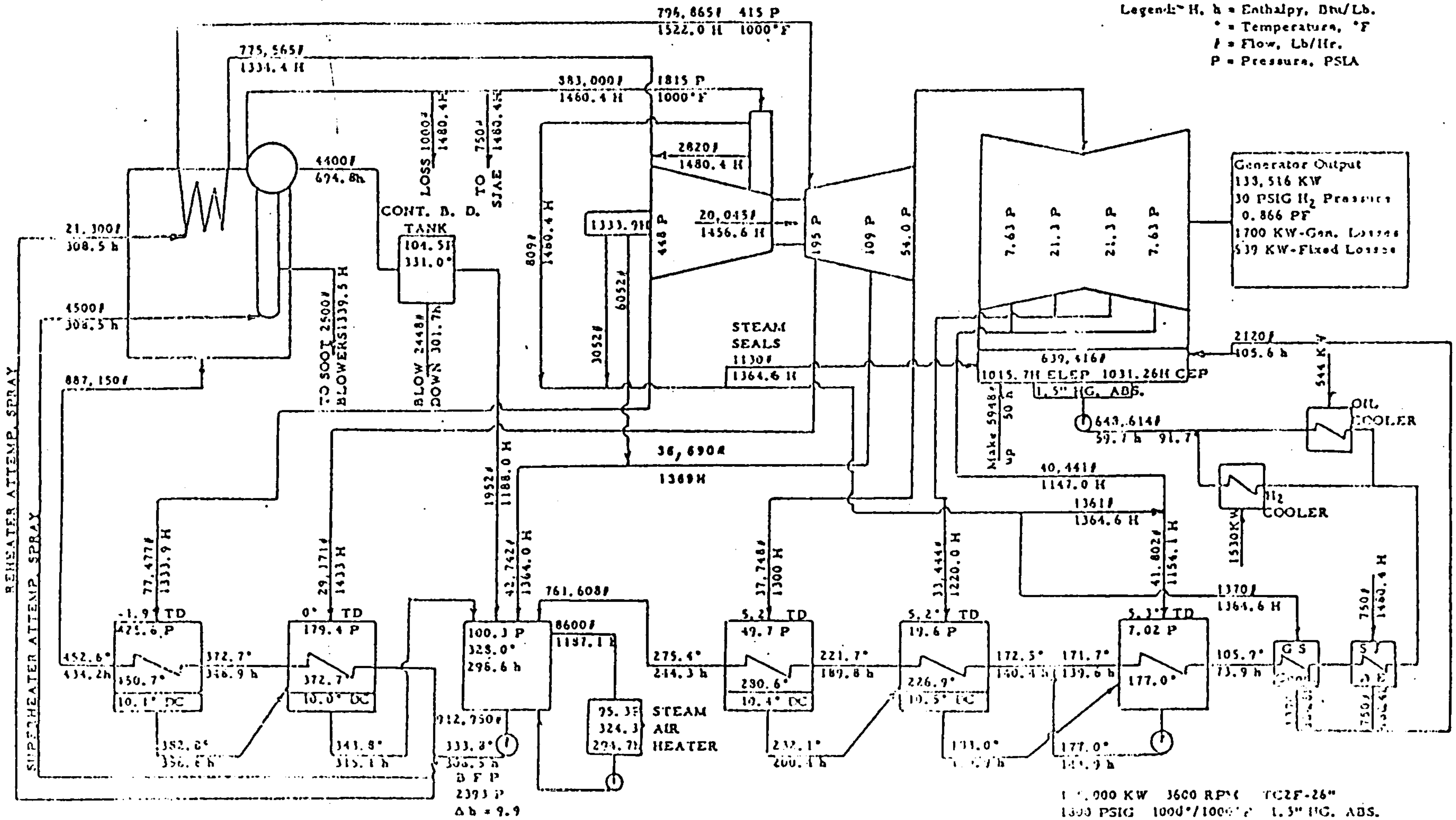


FIGURE NO. 2.1

*GROSS HEAT RATE = $\frac{(851,000 + 1000 + 750)(1480.4) + 2500(1339.5) + 4400(694.8) - 881,150(434.2) - 4500(308.5) + 796,865(1522.0) - 775,565(1334.4) - 21,300(308.5)}{138,516}$ = 7948 BTU/KW-HR.

*INCLUDES ALL HEAT ADDED TO THE CYCLE BY BOILER AND REHEATER

1..,000 KW 3600 RPM TC2F-26"
1300 PSIG 1000°/1000°F 1.5" HG. ABS.
GEN: 160 MVA @ 30 PSIG H_2 PRESS. & 0.85 PF
(CONV.)

R.P. [illegible] 7/3/61

ATLANTIC CITY ELECTRIC COMPANY
BEESLEY'S POINT GENERATING STATION, UNIT NO. 1
HEAT BALANCE DIAGRAM - DESIGN LOAD
BECHTEL CORPORATION JOB 3051

GENERAL ELECTRIC COMPANY, SCHENECTADY, NEW YORK

309 HB 225

CONDENSER

Manufacturer	Ingersoll-Rand
Type	Single Pass, Divided Waterbox
Cooling Surface	62,500 sq. ft.
Hotwell Capacity	5600 GPM
Shell and Tube Support Plates	A285 Gr. C (Copper bearing)
Tube Sheets	Silicon Bronze
Water Boxes	Steel, fibre-glass lined
Tubes	Arsenical Aluminum Brass ← 1971 CHANGED TO 90-10
Number	9152
Dia. & Gauge	7/8" O.D. 18 BWG
Effective Length	29'-9-3/4"
Total Length	30'-0'1/4"
No. of Inlet Nozzles	2-54" dia.
No. of Discharge Nozzles	4-48" dia.
Water Box Design Pressure	25 psig
Design Steam Load, #/hr.	630,000
Btu Rejected, per lb. of Steam	975
Abs. Pressure, in Hg.	1.30
Circulating Water	88,000 GPM at 60°F
Cleanliness Factor	85
Oxygen Content of Condensate	0.03 cc/liter

Condenser Weights

Dry	465,000 lbs.
Operating	630,000 lbs.
Flooded	1,080,000 lbs.

```
*BLE1 VWO DESIGN DATA HEAT BALANCE
*
* B. L. ENGLAND UNIT 1
*
* MODIFICATIONS BY EI 5/88
*
010000 ENGLISH
010200 2 3 1 1 1 0 0.0  -1.50                             ***EI REMOVE DEBUG
011010 1 1 1 1 3600  160000. 0.866 30. 30. 138516.   ***EI H2 P ABS?
011011 639.0 0.0                                       ***EI REMOVE 1760.0
012000 30 50. 50.
*
010201 2 *FWITER - OPTIONAL CARD TO DECREASE RUNTIME       ***EI
*
020002 NOPRNT
020004 NOPRNT
020005 NOPRNT
020015 NOPRNT
020016 NOPRNT
020021 NOPRNT
020022 NOPRNT
020023 NOPRNT
*
*GEOMETRY
*
501010      01,   U,    02,    I
501020      02,   U,    03,    I
501030      03,   U,    04,    I
501040      04,   U,    05,    I
501050      05,   U,    06,    I
501060      06,   U,    07,    I
501070      07,   U,    08,    I
501080      08,   U,    09,    IA
501090      09,   U,    10,    I
501100      10,   U,    11,    IA
501110      11,   U,    12,    T
501120      12,   T,    13,    IA
501130      13,   U,    20,    I
501140      20,   U,    21,    I
501150      21,   U,    22,    I
501160      22,   U,    23,    I
501170      23,   U,    24,    I
501180      24,   U,    25,    I
501190      35,   U,    26,    IA
501200      25,   U,    29,    S
501210      06,   B,    13,    IB
502000      29,   D,    30,    I
502010      30,   U,    31,    I
502020      31,   B,    32,    T
502030      31,   U,    33,    T
502040      34,   U,    36,    T
502050      36,   T,    38,    T
502060      38,   D,    37,    IA
502070      37,   U,    35,    IB
502080      38,   T,    39,    T
502090      39,   T,    41,    IA
502100      39,   D,    40,    I
502110      40,   U,    41,    IB
502120      41,   U,    42,    T
502130      42,   T,    43,    T
```

```
502140     43,   T,    53,    IA
504000     10,   B,    52,    S
502160     52,   D,    54,    D
502170     51,   D,    44,    S
502180     53,   U,    44,    FW
502190     44,   D,    48,    I
502200     48,   U,    49,    I
502210     49,   B,    50,    I
502220     50,   B,    58,    I
502230     50,   U,    11,    IB
502240     49,   U,    51,    T
502250     51,   T,    52,    T
502260     43,   D,    42,    D
502270     42,   D,    39,    D
502280     57,   U,    35,    IA
502290     26,   U,    29,    D
502300     52,   T,    60,    I
502310     32,   T,    34     IA
502320     33,   T,    34,    IB
502330     44,   B,    46,    T
502340     36,   D,    37,    IB
504010     20,   E,    51,    S
504020     21,   E,    27,    IA
504030     27,   U,    54,    IA
504040     54,   U,    44,    S
504050     22,   E,    43,    I
504060     23,   E,    42,    S
504070     24,   E,    28,    IA
504080     28,   U,    39,    S
*504090     45,   U,    44,    S
505010     04,   B,    14,    I
505020     14,   B,    15,    IB
505030     08,   B,    19,    I
505040     19,   U,    27,    IB
505050     19,   B,    15,    IA
505060     46,   T,    47,    I
505080     15,   U,    16,    I
505090     16,   U,    17     I
505100     16,   B,    26,    IB
505110     17,   B,    38,    S
505120     17,   U,    28,    IB
505130     14,   U,    09,    IB
505140     02,   B,    18,    I
505150     18,   U,    36,    S
505160     18,   B,    61,    I
505170     47,   U,    53,    IB
505180     59,   U,    54,    IB
506010     55,   U,    29,    T
506020     29,   T,    56,    I
*
* MODIFY GEOMETRY FOR HP EXHAUST                          ***EI
501080      08,   U,    10,    I
501090      10,   U,    09,    IA
501100      09,   U,    11,    IA
*
* MODIFY GEOMETRY FOR SSR COMPONENT                       ***EI
505090      16,   B,    17,    I
505100      16,   U,    28,    IB
505120      17,   U,    26,    IB
*
```

```
*   SPECIAL STREAM CONDITIONS

604000     2     .020619
604010     2     .051546
604030     2     .051357
604050     2     .079629                             ***EI
604060     2     .051307
604070     2     .051492
601080     2     .03
601120     2     .02
601160     2     .02                                 ***EI NOT RECOMMENDED IPLP
*
*   T G   CYCLE COMPONENT  SPECIFICATIONS
*  TURBINES
*  GOVERNING STAGE
700050 08 1 2 0 1 0 1 5 .0                             ***EI
700055 1357.000 1456.6
700059 1760.0 1480.4 879571.0
* H.P.
700070 08 1 2 0 2 0 1 5 .00                            ***EI W5
700075 448.00 1333.9
700079 1357.000 1456.6000 859326.0
* I.P
700200 08 1 0 1 3 0 1 5 .03 -29171.
700205 195.00 1433.0
700209 406.70 1520.395 816710.0                        ***EI
700210 08 1 1 1 3 0 1 5 .03 -36690.
700215 109.00 1369.0
700220 08 1 3 1 3 0 1 5 .0 -37748.                     ***EI W5
700225 54.00 1300.0
* L.P.
700230 08 1 0 1 4 0 2 5 .03 -33444.
700235 21.30 1220.0
700239 52.92 1300.0 713301.0
700240 08 1 1 1 4 0 2 5 .03 -40441.
700245 7.6300 1147.0
700250 08 1 3 0 4 0 2 5 .0 0.0 41.1                    ***EI
700255 -1.500 1015.7
*
* BENCHMARK SOLUTION TURBINES                           ***EI NEW EFFICIENCIES
* GOVERNING STAGE
700050 08 1 2 0 1 0 1 1 .0
700051 .63818 -1.297
* H.P.
700070 08 1 2 0 2 0 1 1 .00
700071 .67761 -3.029
* I P
700200 08 1 0 1 3 0 1 3 .03 -29171.
700203 .81816 1.10441E5
700210 08 1 1 1 3 0 1 3 .03 -36690.
700213 .84826 1.78434E5
700220 08 1 3 1 3 0 1 1 .0 -37748.
700221 .85733 -2.618
* L.P.
700230 08 1 0 1 4 0 2 3 .03 -33444.
700233 .90077 7.92307E5
700240 08 1 1 1 4 0 2 3 .03 -40441.
700243 .89593 1.65031E6
700250 08 1 3 0 4 0 2 1 .0 0.0 41.1
700251 .90855 .757                       *EI
```

```
* CURRENT DEGRADED TURBINE SOLUTIONS             ***EI NEW EFFICIENCIES
* GOVERNING STAGE
700030 08 1 2 0 1 0 1 1 .0
700031 .60968 -1.297
* H.P.
700070 08 1 2 0 2 0 1 1 .00
700071 .84641 -3.029
* I P
700200 08 1 0 1 3 0 1 3 .03 -29171.
700203 .76696 1.10441E5
700210 08 1 1 1 3 0 1 3 .03 -36690.
700213 .81706 1.7843E5
700220 08 1 3 1 3 0 1 1 .0 -37748.
700221 .82613 -2.018
* L.P.
700230 08 1 0 1 4 0 2 3 .03 -33444.
700233 .86957 7.02307E5
700240 08 1 1 1 4 0 2 3 .03 -40441.
700243 .86473 1.55031E6
700250 08 1 3 0 4 0 2 1 .0 0.0 41.1
700251 .87235 .737                      *EI
*
*
    * CONDENSER
700290 10 1 2 0.0 -1.5
    * FEEDWATER HEATERS
700390  17 1 24 3 0.0 5.300

700420  16 1 23 3 0.0 5.20000 10.5

700430  16 0 22 3 0.0 5.200 10.4

700440  15 1 21 0.0 0.0 00.00 0.0 0.0 0.0 0.0 0.0 0.0
        + 0.0 0.0 0.0 1 8600.0 .99973
700510  18 1 20 3 0.0 0.0 10.0

700520  18 0 -10 3 0.0 -1.9 10.1

    * HEAT EXCHANGERS
700120   25  2  998.57 .045011
700320   26  2 .9900                       ***EI COULD FIND CLOSER VALUE
700330   26  1 .9900
700460   27 -7674640.
700380   20  390.
    * STEAM JET AIR EJECTOR
700360 20 0. 0. 0. 0. 0. 0. 0. 638.75
    * THROTTLE VALVE
700030 35 -2.00 -2.00 -2.00  0.3 1815. 1480.4 883000.
700031 1815. 1480.4 883000.
    * PUMPS
700300 41 150.
700470 41 125.
700480 41 2393. 0.9 1.0 0.8 0.05 9.9        ***EI COULD INPUT EFF&REMOVE H RISE
700400 41 125.
    * MIXERS
700150 50 0
700139 50 1
700260 50 0
700270 50 1
```

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700540 50 1
700280 50 1
700340 50 1
700350 50 0
700370 50 0
700410 50 0
700530 50 0
700090 50 1
700110 50 1
  * SPLITTERS
700490 60 0.0 25800.
700029 61 0.0 1750.
700180 61 0.0  1000.
700040 68 3629. 58.16 1760.5
700140 68 809. 12.966 1760.5
700060 64 409.524
700050 64 507.015
700170 64 761.720
700150 67 0 0.0 18. 2500.                            ***EI SSR ADDED
700170 61 0.00 1370.
700100 60 0.00 77477.
700500 60 0.00 4500.
700510 63 0.00 0.5
*700450 60 1187.1 8600.
  *  INPUT COMPONENT
700010 33 1000.48 1815. 884759.
700570 31 82. 20. 5948.

700590 31 330.00 100.0 1952.
  *  OUTPUT COMPONENT
700690 32
700610 30
700580 30
  *  INFINITE SOURCE
700550 31 60. 21.7 45173450.97
  *  INFINITE SINK
700560 30
*
* CONTROLS
*
*840100 PACLEK,6,2.0045E4,0.0,1.,WW,121
*840200 PACLEK,8,9.104E3,0.0,1.,WW.503
*840300 PACLEK,19,3.052E3,0.0,1.,WW,505
*
*840400 TTVSC,1,1480.4,1.0E-4,1.0,HH,102
*840500 TTTORH,12,1522.0,1.0E-4,1.0,HH,112
*
* OPERATIONS
*
890000 1                                    ***EI890009 F10.4
870230 1000.
880010 HH, -101, MUL, WW, -101, OPVB,1
880020 HH,  230, MUL, WW, 230,  OPVB,2
880030 HH, -110, MUL, WW, -110. OPVB,3
880040 HH, -112, MUL, WW, -112, OPVB,4
880050 OPVB, 4, SUB, OPVB, 3, OPVB, 6
880060 HH,  223, MUL, WW, 223,  OPVB,7
880070 HH, -518, MUL, WW, -518, OPVB,8
880080 HH, -228, MUL, WW, -228, OPVB,9
880090 HH, -222, MUL, WW, -222, OPVB,10
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880100 OPVB, 1, SUB, OPVB, 2, OPVB, 11
880110 OPVB, 11, ADD, OPVB, 6, OPVB, 12
880120 OPVB, 12, SUB, OPVB, 7, OPVB, 13
880130 OPVB, 13, ADD, OPVB, 8, OPVB, 14
880140 OPVB, 14, ADD, OPVB, 9, OPVB, 15
880150 OPVB, 15, SUB, OPVB, 10, OPVB, 16
880160 HH, -233, MUL, WW, -233, OPVB, 17
880170 HH,  506, MUL, WW,  506, OPVB, 18
880180 OPVB, 17, SUB, OPVB, 18, OPVB, 19
880190 OPVB, 16, SUB, OPVB, 19, OPVB. 20
880200 OPVB, 16, DIV, BKGROS, 0, OPVB, 21
880210 OPVB, 20, DIV, BKGROS, 0, OPVB, 22
880220 OPVB, 21, DIV, OPVB,  23, OPVB, 24
880230 OPVB, 22, DIV, OPVB,  23, OPVB, 25
*
* SPECIAL OUTPUT TABLE
*
890010 'GROSS TURBINE HEAT RATE'
890011 OPVB, 21
890020 'MAIN STEAM HEAT IN'
890021 OPVB, 1
890030 'FEEDWATER HEAT OUT'
890031 OPVB, 2
890040 'REHEAT STM HEAT OUT'
890041 OPVB, 3
890050 'REHEAT STM HEAT IN'
890051 OPVB, 4
890060 'NET REHEAT STM HEAT IN'
890061 OPVB, 6
890070 'REHEAT ATTEMP HEAT OUT'
890071 OPVB, 7
890080 'BLOWDOWN STM HEAT IN'
890081 OPVB, 8
890090 'MAKEUP WATER HEAT IN'
890091 OPVB, 9
890100 'MAIN STM ATTEMP HEAT OUT'
890101 OPVB, 10
890110 'MAIN STM HT - FW HT'
890111 OPVB, 11
890120 'MAIN STM HT - FW HT + NT RH ST HT IN'
890121 OPVB, 12
890130 'MN ST - FW + NT RH ST - RH ATT HT'
890131 OPVB, 13
890140 'MN ST -FW  +NT RH ST  - RH ATT +BD HT'
890141 OPVB, 14
890150 'MN ST-FW+NT RH-RH ATT+BD+MU'
890151 OPVB, 15
890160 'MN ST-FW+NT RH-RH ATT+BD+MU-MS ATT'
890161 OPVB, 16
890170 'STM TO SCA/H'
890171 OPVB, 17
890180 'CONDENSATE FROM SCA/H'
890181 OPVB, 18
890190 'NET HT TO SCA/H'
890191 OPVB, 19
890200 'TOT HT TO TUR CYC - HT TO SCA/H'
890201 OPVB, 20
890210 'GR TUR H.R. INCLUDING HT TO SCA/H'
890211 OPVB, 24
890220 'GR TUR H.R. EXCLUDING HT TO SCA/H'
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590221 DFVB, 25
890530 'MAX CONT. STM FLOW'
890531 WWVSC,1.928750.,I

=     CONDENSER HEI 85% CL 60F  90-10
700550 31 60. 21.7 53386805.00
700290 10 1 5 0.0 -1.5
700295 3 .826 .875 357.756 9152. 1 -.85
890530 'CIRC WATER INLET TEMP'
890531 TTVSC ,   55,  60.0, I
/
=     CONDENSER HEI 60% CL 40F  90-10
700550 31 60. 21.7 45173450.97
700290 10 1 5 0.0 -1.5
700295 3 .826 .875 357.756 9152. 1 -.6
890530 'CIRC WATER INLET TEMP'
890531 TTVSC ,   55,  40.0, I

=     CONDENSER HEI 60% CL 45F  90-10
700550 31 60. 21.7 45173450.97
700290 10 1 5 0.0 -1.5
700295 3 .826 .875 357.756 9152. 1 -.6
890530 'CIRC WATER INLET TEMP'
890531 TTVSC ,   55,  45.0, I

=     CONDENSER HEI 60% CL 50F  90-10
700550 31 60. 21.7 45173450.97
700290 10 1 5 0.0 -1.5
700295 3 .826 .875 357.756 9152. 1 -.6
890530 'CIRC WATER INLET TEMP'
890531 TTVSC ,   55,  50.0, I
/
=     CONDENSER HEI 60% CL 55F  90-10
700550 31 60. 21.7 45173450.97
700290 10 1 5 0.0 -1.5
700295 3 .826 .875 357.756 9152. 1 -.6
890530 'CIRC WATER INLET TEMP'
890531 TTVSC ,   55,  55.0, I
/
=     CONDENSER HEI 60% CL 60F  90-10
700550 31 60. 21.7 45173450.97
700290 10 1 5 0.0 -1.5
700295 3 .826 .875 357.756 9152. 1 -.6
890530 'CIRC WATER INLET TEMP'
890531 TTVSC ,   55,  60.0, I
/
=     CONDENSER HEI 60% CL 65F  90-10
700550 31 60. 21.7 45173450.97
700290 10 1 5 0.0 -1.5
700295 3 .826 .875 357.756 9152. 1 -.6
890530 'CIRC WATER INLET TEMP'
890531 TTVSC ,   55,  65.0, I
/
=     CONDENSER HEI 60% CL 70F  90-10
700550 31 60. 21.7 45173450.97
700290 10 1 5 0.0 -1.5
700295 3 .826 .875 357.756 9152. 1 -.6
890530 'CIRC WATER INLET TEMP'
890531 TTVSC ,   55,  70.0, I
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=    CONDENSER HEI 60% CL 75F  90-10
700550 31 60. 21.7 45173450.97
700290 10 1 5 0.0 -1.5
700295 3 .826 .875 357.756 9152. 1 -.6
890530 'CIRC WATER INLET TEMP'
890531 TTVSC ,   55,  75.0, I
/
=    CONDENSER HEI 60% CL 80F  90-10
700550 31 60. 21.7 45173450.97
700290 10 1 5 0.0 -1.5
700295 3 .826 .875 357.756 9152. 1 -.6
890530 'CIRC WATER INLET TEMP'
890531 TTVSC ,   55,  80.0, I
/
=    CONDENSER HEI 60% CL 85F  90-10
700550 31 60. 21.7 45173450.97
700290 10 1 5 0.0 -1.5
700295 3 .826 .875 357.756 9152. 1 -.6
890530 'CIRC WATER INLET TEMP'
890531 TTVSC ,   55,  85.0, I
/
=    CONDENSER HEI 60% CL 90F  90-10
700550 31 60. 21.7 45173450.97
700290 10 1 5 0.0 -1.5
700295 3 .826 .875 357.756 9152. 1 -.6
890530 'CIRC WATER INLET TEMP'
890531 TTVSC ,   55,  90.0, I
/
=    CONDENSER HEI 60% CL 40F  90-10 HIGHER FLOW
700550 31 60. 21.7 53386805.00
700290 10 1 5 0.0 -1.5
700295 3 .826 .875 357.756 9152. 1 -.60
890530 'CIRC WATER INLET TEMP'
890531 TTVSC ,   55,  40.0, I
/
=    CONDENSER HEI 60% CL 45F  90-10 HIGHER FLOW
700550 31 60. 21.7 53386805.00
700290 10 1 5 0.0 -1.5
700295 3 .826 .875 357.756 9152. 1 -.60
890530 'CIRC WATER INLET TEMP'
890531 TTVSC ,   55,  45.0, I
/
=    CONDENSER HEI 60% CL 50F  90-10 HIGHER FLOW
700550 31 60. 21.7 53386805.00
700290 10 1 5 0.0 -1.5
700295 3 .826 .875 357.756 9152. 1 -.60
890530 'CIRC WATER INLET TEMP'
890531 TTVSC ,   55,  50.0, I
/
=    CONDENSER HEI 60% CL 55F  90-10 HIGHER FLOW
700550 31 60. 21.7 53386805.00
700290 10 1 5 0.0 -1.5
700295 3 .826 .875 357.756 9152. 1 -.60
890530 'CIRC WATER INLET TEMP'
890531 TTVSC ,   55,  55.0, I
/
=    CONDENSER HEI 60% CL 60F  90-10 HIGHER FLOW
700550 31 60. 21.7 53386805.00
700290 10 1 5 0.0 -1.5
700295 3 .826 .875 357.756 9152. 1 -.60
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890530 'CIRC WATER INLET TEMP'
890531 TTVSC ,   55,  60.0, I
/
=    CONDENSER HEI 60% CL 65F  90-10 HIGHER FLOW
700550 31 60. 21.7 53386805.00
700290 10 1 5 0.0 -1.5
700295 3 .826 .875 357.756 9152. 1 -.60
890530 'CIRC WATER INLET TEMP'
890531 TTVSC ,   55,  65.0, I
/
=    CONDENSER HEI 60% CL 70F  90-10 HIGHER FLOW
700550 31 60. 21.7 53386805.00
700290 10 1 5 0.0 -1.5
700295 3 .826 .875 357.756 9152. 1 -.60
890530 'CIRC WATER INLET TEMP'
890531 TTVSC ,   55,  70.0, I
/
=    CONDENSER HEI 60% CL 75F  90-10 HIGHER FLOW
700550 31 60. 21.7 53386805.00
700290 10 1 5 0.0 -1.5
700295 3 .826 .875 357.756 9152. 1 -.60
890530 'CIRC WATER INLET TEMP'
890531 TTVSC ,   55,  75.0, I
/
=    CONDENSER HEI 60% CL 80F  90-10 HIGHER FLOW
700550 31 60. 21.7 53386805.00
700290 10 1 5 0.0 -1.5
700295 3 .826 .875 357.756 9152. 1 -.60
890530 'CIRC WATER INLET TEMP'
890531 TTVSC ,   55,  80.0, I
/
=    CONDENSER HEI 60% CL 85F  90-10 HIGHER FLOW
700550 31 60. 21.7 53386805.00
700290 10 1 5 0.0 -1.5
700295 3 .826 .875 357.756 9152. 1 -.60
890530 'CIRC WATER INLET TEMP'
890531 TTVSC ,   55,  85.0, I
/
=    CONDENSER HEI 60% CL 90F  90-10 HIGHER FLOW
700550 31 60. 21.7 53386805.00
700290 10 1 5 0.0 -1.5
700295 3 .826 .875 357.756 9152. 1 -.60
890530 'CIRC WATER INLET TEMP'
890531 TTVSC ,   55,  90.0, I
/
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