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CAROLINA POWER
H.B. ROBINSO
NUCLEAR GEN

SUPPLEMENTAL INFORMATION FOR DEGRADED GRID VOLTAGE ANALYSIS

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REPORT

CAROLINA POWER & LIGHT COMPANY

H. B. ROBINSON NUCLEAR GENERATING STATION UNIT 2

SUPPLEMENTAL INFORMATION
FOR DEGRADED GRID VOLTAGE ANALYSIS

			Date
Prepared By:	I. V. Narayani	Indra Narayani	9/20/82
Checked By:	W. W. Fields	W. W. Fields	9/27/82
Verified By:	B. J. Casey	B J Casey	9/27/82
QA By:	Ron Moreland	Ron Moreland.	9/27/82.

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1.0 INTRODUCTION

This report addresses specific items identified in NRC Docket Number 50-261 dated January 13, 1981 from Steven A. Varga to J. A. Jones of Carolina Power and Light regarding the adequacy of the H. B. Robinson Unit No. 2 station electrical distribution system when subjected to degraded system grid voltage.

A similar report dated October 3, 1976 was prepared by Ebasco for Carolina Power and Light in response to an NRC request following the Millstone Event. The 1976 report provided an analysis of voltage conditions on the station electric distribution system at the 4160 and 480 volt bus levels. The study contained in this report analyzes, in addition to these, bus voltage conditions on the 208 and 120 volt buses as requested by the NRC.

In accordance with the latest FSAR Section 8.2.2, the switchyard operating limits are documented as follows:

> "The nominal switchyard voltages for the Robinson Plant are 115 kV and 230 kV. A voltage schedule supplied by the Systems Control Center calls for voltages to be maintained between 97 percent and 101 percent of the nominal voltage on the 115 kV bus. A review of the recording voltmeter traced during 1976 shows that at no time had the voltage on the 115 kV bus fallen below 97 percent, even during an unscheduled outage of the HBR Unit 2."

At the request of the NRC the subject analyses are conducted using the postulated grid voltages of 0.95, 1.0 and 1.06 pu, recognizing that the extreme hypothetical limits of 0.95, and 1.06 pu will never be reached in the actual operation of the plant.

Furthermore, to approximate as closely as possible maximum operating conditions, the "design point" brake horsepower for all large and medium size equipment listed in the FSAR is assumed as the load on the driven equipment. These data were obtained from speed-torque characteristic curves and where not available, the nameplate horsepower of the motor is used. It has been observed and recorded during September 1976, February 1982, and August 1982 that the running load of the large and medium size equipment was on an average of approximately 10 percent below the design point brake horsepower thus assuring that this approach provides inherent margin of safety in the calculated values.

For additional information concerning the design point brake horsepower values of the equipment, refer to Paragraph 5.8.

This report also includes two in-plant test procedures used to obtain data for verification of calculated results. These data, obtained from field measurements, are compared with calculated values using Ebasco's computerized auxiliary system program (Program 2027). This comparison is summarized in Paragraph 5.6, Table No. 1 of this report.

2.0 PURPOSE AND SCOPE

The analyses contained in this report analyzes auxiliary bus voltage conditions for various modes of plant operation and the effect of degraded system grid voltage condition specifically for the following safety related buses: 480 Volt Switchgear Bus No.'s E1 and E2, 480 Volt Motor Control Center Bus No's 5, 5A, 6 and 6A and 120/208 Volt Motor Control Center Bus No's 9 and 10. An analysis was performed for each of the following plant operating conditions:

2.1 Normal Operation

The electrical distribution system for H. B. Robinson Unit No. 2 is designed such that during a power loading of 5 percent or greater, 4160 Volt Bus No. 3, 480 Volt Bus No. 3, 480 Volt Emergency Bus No. E2, 480 Volt MCC No. 6 and 120/208 Volt MCC No. 9, are powered from the Start-Up Transformer "Y" winding with all other major buses being supplied by the Unit Auxiliary Transformer. Normal operation is therefore analyzed for the following system configurations with input voltage conditions ranging from 0.95 pu to 1.06 pu.

2.1.1 The plant auxiliary system is connected to the Main Generator by a means of the Unit Auxiliary Transformer. Loads which are required for the normal operation of the plant are assumed connected to the auxiliary system and operating.

2.1.2 The auxiliary system is connected to the 115kV Switchyard by means of the Start-Up Transformer due to the unavailability of the Unit Auxiliary Transformer. Loads which are required for normal operation of the plant are assumed connected to the auxiliary system and operating.

2.2 Emergency Operation

The plant auxiliary system is connected to the 115kV Switchyard by means of the Start-Up Transformer. Loads which are required for the normal operation and ESF with safety injection actuated are assumed connected to the auxiliary system and operating with switchyard voltage conditions ranging from 0.95 pu to 1.06 pu.

2.3 Cold Shutdown Operation

The plant auxiliary system is connected to the 115kV Switchyard by means of the Start-Up Transformer. All plant buses are loaded in their most lightly loaded condition with the system grid at 1.06 per unit voltage.

3.0 SYSTEM PARAMETERS

System parameters established in the 10/13/76 report are used where applicable. Parameters for equipment added since that time were obtained from equipment nameplates, control wiring diagrams, vendor equipment drawings and in instances where data were not available maximum operating design conditions were assumed. Using these system parameters, a computer analysis using Ebasco's auxiliary system computer program (Program 2027) was performed for each of the operating conditions listed in Section I, Paragraph 2, "Purpose and Scope".

System impedance values used in the computer program are summarized on the applicable system one-line diagram for the computer simulation included in Section II, Paragraph D, Sketch E-1, Sheet 7 and 8.

4.0 BASIS AND ASSUMPTIONS

4.1 In the absence of actual motor data, the following parameters were utilized:

a. HP - Nameplate Rating

b. pf_{run} - 0.88

c. pf_{start} - 0.20

d. EFF - 0.92

e. LRA/FLA - 6.5

4.2 The motor's source of power and cable feeder size and length are as indicated on CP&L Breaker Coordination Study (Reference No. 1; 1976 Report)

4.3 Loads required for start-up and normal operation are per CP&L indications on the one lines. (Reference No. 2; 1976 Report)

4.4 System criteria as noted in Study JFM-3, Criteria and Results, Dated October 5, 1976. (Appendix C; 1976 Report)

4.5 The following transformer data was obtained from equipment nameplates for the transformer noted.

a. Start-Up Transformer No. 2.

1. Voltage Ratio: 120.8/117.9/115.0/112.1/109.3-4.368/4.368 kV

2. MVA: 44: 22/22

3. Impedance: H-X = 10.2%, H-Y = 10.3%
X-Y = 20.5% (incorrectly listed on nameplate as 2%)
X/R = 50 (assumed)

b. Unit Auxiliary Transformer No. 2

1. Voltage Ratio: 21.95/21.42/20.9/20.38/19.85-4.16/4.16 kV

2. MVA: 44: 22/22

3. Impedance: H-X = 10.8%, H-Y = 10.6%
X-Y = 20.5%
X/R = 50 (assumed)

c. Station Service Transformers No. 2A and No. 2C

1. Voltage Ratio: 4.365/4.260/4.16/4.053/3.95-.480 kV

2. MVA 2.0/2.66

3. Impedence: 5.8%
X/R = 5 (assumed)

d. Station Service Transformer No. 2B

1. Voltage Ratio: Same as 2A

2. MVA: 1.5/2.0

3. Impedance: 5.5%
X/R = 5 (assumed)

4.6 Generator parameters are in accordance with Westinghouse's letter of October 5, 1966.

4.7 Starter parameters are in accordance with Westinghouse A/200 Contactor Data dated September 20, 1966.

4.8 The minimum and maximum grid voltages are assumed to be 0.95 and 1.06 respectively.

4.9 Safety injection electrical loads on Emergency Buses E1 and E2 are based on the FSAR.

4.10 The procedure for tripping Steam Generator Feed Pumps A & B during safety injection is based on the telephone conversation between R. L. Forester of Ebasco and S. Allen of CP&L on August 6, 1981 (Reference 6.8).

4.11 The transient computer analysis of this report is based on starting the largest motor on each bus; i.e., a 6000 hp reactor coolant pump on a 4160 volt bus, a 350 hp motor on 480 Volt Emergency Bus E1 and E2 respectively, a 125 hp motor on 480 Volt MCC 5 & 6, and a 3.9 hp motor on 208/120 Volt MCC 9 & 10.

4.12 The design point brake horsepower of the large and medium size pumps is taken from the FSAR and from manufacturer's certified speed-torque curves. (Section I, Paragraph 5.8, Table 2)

4.13 In those cases where the design point brake horsepower of the driven equipment can not be determined, nameplate horsepower rating of the motor is assumed.

4.14 The power factor values used for the large and medium size motors at the brake horsepower loads were extrapolated from a typical induction motor characteristic curve (Ref. 6.10).

5.0 <u>NRC QUESTIONS AND PROPOSED RESPONSES</u>

The following questions and proposed responses referenced to here, correspond to those appearing in the NRC request for additional information.

Ref. 1: NRC letter (A. Schwencer) to CP&L (E. E. Utley), dated August 8, 1979.

Ref. 2: CP&L letter (E. E. Utley) to NRC (A. Schwencer), dated October 5, 1979.

Ref. 3: CP&L letter (E. E. Utley) to NRC (A. Schwencer), dated October 3, 1979.

Ref. 4: CP&L letter (E. E. Utley) to NRC (S. A. Varga), dated July 23, 1980.

5.1 Question No. 1

5.1.1 Reference No. 2 bases the worst case voltage analysis on operation at 100% power and indicates that operation following a LOCA is less limiting because of the decreased load on the electrical distribution system. Are the Class 1E buses assumed to be very heavily loaded during the analysis at 100% power? If not, the resultant heavier loading of the 480V Class 1E buses following an accident could result in worst case voltage to these buses even though total loading on the electrical distribution system is less. Therefore an analysis of the Class 1E buses and load terminal voltages (steady state and transient) should be provided to evaluate this condition in accordance with NRC Guidelines 1, 3, 7, 9, 10 and 12 of Ref. 1. Starting of large non-Class 1E motors, including the reactor main coolant pump, should be part of the transient conditions considered during this event.

5.2 Response to Question 1:

Based on NRC question #1 and the subsequent clarification obtained by CP&L in a telephone conversation between Joe Curley and NRC on March 17, 1981, the following analyses are made:

5.2.1 Normal Plant Operation

The following conditions were assumed to exist during the conduct of this study:

a. The plant is assumed to be operating at 100 percent power.

b. All electrical loads required to support the unit are being supplied from the Generator via the Auxiliary Transformer, "X" winding.

c. Start-Up Transformer "Y" winding loads are always fed from the Start-Up Transformer and are not transferred to the Auxiliary Transformer under normal operating conditions.

d. All electrical loads required to support the unit are operating with the exception of the motor being started.

e. All electrical loads which are required to support operations are operating for steady state analysis.

f. The largest non-safety load (6000 hp Reactor Coolant Pump) is assumed to be starting for the transient analysis.

g. The Generator is assumed to be operating at 0.95 per unit voltage.

The calculated voltages for each of the major buses are as follows:

Plant Safety Buses	Minimum Voltages Steady State	Transient
4160V Bus 1 & 2	3916	3325
480V Bus E1	423	348
480V MCC 5	420	344
208V MCC 10	180	147
6000 hp Motor Terminals	3910	3281

From the results tabulated above, the worst case contactor drop-out voltage, approximately 290 volts for 480 volt and 111 volts for 208 volt buses, is not reached under any postulated condition analyzed (Refer to Calculation JFM-4, P. 23 of the 1976 report and Calculation No. 5 of this report).

The worst case contactor pick-up voltage of 403 volts for 480 volt equipment and 166 volts for 208 volt equipment is only reached during transient conditions and will exist for only a few seconds during acceleration of a 6000 hp RCP. The steady state voltages on all buses are above contactor pick-up voltages and within the $\pm$ 10 percent voltage variation necessary for satisfactory equipment operation.

The undervoltage relay trip setting of 328 volts on Bus E1 is not reached under any analyzed condition and, therefore, the safety related buses will not experience spurious separation from their power sources.

The above results show that all 4160, 480, and 208 volt buses are maintained above the minimum manufacturer's recommended voltage for continuous motor opertion which is 3600, 414, and 180 volts respectively.

The instrument buses considered in this analysis are supplied from 480V MCC 5 through step down harmonic neutralized regulating transformers capable of maintaining an output voltage of 120V $\pm$ 1/2 percent over an input voltage range of 380 to 520 volts. Under a steady state condition at 0.95 pu generator voltage, these transformers operate within a $\pm$ 1/2 percent regulated output range. Under the transient condtions postulated, input voltage is calculated to dip to a low of 344 volts. Although this is 24 percent below the midpoint input voltage (450V), published data from the manufacturer indicates that the output voltage will be maintained to within 3-4 percent of nominal with the transformer fully loaded. At half load, these transformers will regulate to within 3-4 percent of nominal with a 50 percent dip in input voltage. Consequently, the instrument buses experience no deleterious excursions in voltage.

The 120 volt vital ac loads are powered from the inverter sets and are not affected by degraded grid voltage.

5.2.2 Plant Operation Following Unit Trip Signal

The following conditions were assumed to exist during the conduct of this study:

a. The plant is assumed to be operating at 100 percent power.

b. All electrical loads which are required to support power operations are operating.

c. All electrical loads which are required to support the unit are being powered from the 115 kV Switchyard via the Start-Up Transformer.

d. Switchyard voltage is assumed to be at 0.95 per unit.

e. The largest non-safety load (6000 hp Reactor Coolant Pump) is assumed to be starting for the transient analysis.

The calculated voltages for each of the major buses are as follows:

Plant Safety Buses	Minimum Voltages Steady State	Transient
4160V Bus 1 & 2	3903	3304
4160V Bus 3 & 4	3917	3310
480V Bus E1	421	346
480V Bus E2	419	341
480V MCC 5	418	342
480V MCC 6	416	337
208V MCC 10	179	146
208V MCC 9	178	144
6000 hp Motor Terminals (B-1)	3896	3260

From the results tabulated above, all the following conditions are satisfied:

- Worst case contactor drop-out voltage for 480 and 208 volt buses is not reached under any condition.
- Worst case contactor pick-up voltage for 480 and 208 volt buses under steady state condition is not reached.
- The undervoltage relay trip setting of 328 volt on bus E1 is not reached under any condition and therefore the safety related buses will not experience spurious separation from their power sources.

The above results indicate that all 4160 and 480 volt buses are maintained above the minimum manufacturer's recommended voltage for continuous motor operation.

- Under the steady state conditions postulated, the instrument buses supplied from 480 Volt MCC's 5 and 6 will operate a ± 1/2 percent of nominal output voltage.

- Under transient conditions, the maximum momentary dip in voltage on the instrument buses will be approximately 3-4 percent of nominal which is not deleterious to the connected loads.

5.2.3 Loss of Coolant Accident

The following conditions were assumed to exist during the conduct of this study:

a. The plant is assumed to be operating at 100 percent power.

b. All electrical loads which are required to support the unit are being supplied from the 115 kV Switchyard via the Start-Up Transformer.

c. All electrical loads which are required to support the unit for normal and LOCA modes are operating with the exception of the RHR pump being started.

d. The 115 kV Switchyard voltage is assumed to be at 0.95 pu.

The system is analyzed at the time buses are 100 percent loaded and a loss of coolant accident occurs. The containment spray, safety injection and RHR pumps start before any load shedding occurs.

Buses Connected to Start-up Transformer

Plant Safety Buses	Minimum Voltages		
	Steady State		Transient
	Before Starting	After Starting	
4160V Bus 1 & 2	3914	3907	3876
4160V Bus 3 & 4	3923	3916	3884
480V Bus E1	403	398	373
480V Bus E2	399	394	364
480V Shutdown Bus	404	399	376
480V MCC 5	393	388	362
480V MCC 6	388	383	358
208V MCC 9	166	164	153
208V MCC 10	168	166	155
RHR Motor Terminals (D-5)	403	398	373

From the results tabulated above, the worst case contactor drop out voltage, (approximately 290 volts for 480 volt equipment and 111 volts for 208 volt equipment buses) is not reached under any of the postulated conditions.

The undervoltage trip setting of 328 volts on 480 Volt Buses E1 and E2 is not reached under any postulated conditions. Therefore, the safety related buses will not experience spurious separation from their power sources.

The plant safety bus voltage levels are improved under:

a. Operating conditions establish a minimum system grid operating voltage of 0.97 pu.

b. No credit is taken for load shedding which will occur after the initiation of a LOCA.

c. Design point brake horsepowers (or nameplate horsepowers where data were not available) were assumed where actual loading on the auxiliary buses has been found to average approximately 10 percent below these assumed values.

d. The computer calculated voltages, when assuming low bus voltage and starting large motors, will be lower than that actually experienced because of the constant MVA base modeled for all running motors.

e. The tap setting on the 4160 volt winding of the station service transformers A, B, C & D should be lowered by 2-1/2 percent.

The input voltages to the step-down regulating transformers supplied from 480 Volt MCC's 5 and 6 under steady state condition are within the ± 1/2 percent regulating range of the transformers (380 - 520 volts). Under the worst case calcuated transient condition of 358 volts (480 Volt MCC 6), these transformers will maintain their output voltage to within 3-4 percent of nominal which is not deleterious to the connected loads.

5.3 Question No. 2:

Per NRC Guideline 11 (Ref. 1), submit Class 1E load terminal voltages for maximum expected grid voltage (1.06 pu) and minimum plant load conditions.

5.4 Response to Question No. 2:

Using minimum plant load connected to the start-up transformer for maximum grid voltage (1.06 pu) as requested by the NRC, the following maximum expected voltages at the safety buses are calculated.

Class 1E Load	Maximum Steady State Bus Voltage
480 Volt Bus E2	521
480 Volt MCC 6	515
208 Volt MCC 9	220

Since "X" winding of the Start-up Transformer has more connected and assumed more running load under cold shutdown conditions, the "Y" winding was analyzed only (Calculation No. 8).

The maximum operating voltage for 460 and 200 volt rated motors is 506 and 220 volts respectively or ± 10 percent of nameplate. This condition is exceeded by 15 volts or 2.9 percent on 480 Volt Bus E2. However, this is not considered significant. These maximum operating voltages are also not excessive for the operation for all non-rotating equipment not requiring a regulated input including the input side of regulating transformers on this unit. It should also be noted that the grid voltage of 1.06 per unit is in excess of the 1.01 pu operating range at the H. B. Robinson plant, and consequently, under normal cold shutdown conditions, the load terminal voltages of all safety loads and their starting circuits will be safely within acceptable limits.

5.5 Question No. 3

The ESF event described in Ref. 2 and Ref. 3 does not meet the analysis verification requirement of the NRC. With all the buses at least 40% loaded, measure and record the loads and impedances during steady state, starting of a large 4160V motor and starting of a large Class 1E motor. Use these measured values in the computer load flow programs and compare the calculated voltages to develop a deviation value. With an acceptable deviation value, the analysis verification requirement will be met. Submit the test verification data and deviation values.

5.6 Response to Question No. 3:

The actual test procedures used for conducting "In-Plant" tests and summary of test results are included in Section II, Paragraphs A, B and C. The bases of computer input data is included in Section I, Paragraph 9.0 Calculation #6.

The Analysis Verification Table (Table No. 1) exhibited on page 8 is based on the following tests:

Test No. 1

Starting of 350 hp Auxiliary Feedwater Pump 2A on 480 Volt Bus No. E-1.

Test No. 2

Starting of 125 hp Service Water Booster Pump 2A on 480 Volt MCC No. 5.

Test No. 3

Starting of 6000 hp Steam Generator Feed Pump 2A on 4160 Volt Bus No. 1.

In accordance with Test Procedure TP-1 included in Section II, Paragraph A, the "In-Plant" test for measuring bus voltages was conducted on February 13, 1982.

The plant was operated at 50 percent reactor power and the test procedure was followed for the entire test. During this test, the 6000 hp Steam Generator Feed Pump 2A (4160 V Bus No. 1), and 350 hp Auxiliary Feedwater Pump 2A (480V MCC No. 5) were started sequentially and the resultant voltage at each bus monitored was recorded.

An assumed power factor of 0.88 and an efficiency of 0.92 representing typical full load motor conditions were used for the computer model.

The recording voltmeters used during the "In-Plant" test have a ± 2 percent accuracy and the chart scale was 6 volts per millimeter for the 480 volt buses. Considering the instrument accuracy and the chart reading accuracy (about 1/2 of the chart scale per division) the maximum deviation of about 2.6 percent between the calculated and measured values is acceptable.

The computer analyses were run using the actual load flow as measured on the 4160 volt buses and observed based on operating load on 480 volt buses. The calculated bus voltages were compared with the actual voltages measured and it was found that the maximum deviation was about 4.88 percent. It was also found that the voltage deviation on the 4160 volt buses were within 0.25 percent where actual measured power factor was coincident with the 0.88 power factor used in the computer model.

Further investigation to explain the 4.88 percent deviation suggested that the power factor on those buses having high deviations was lower than that assumed and since there was no easy way to determine the actual operating power factor of each motor at the time of test, it was concluded that a second "In-Plant" test to measure power factor at the various buses in question was necessary.

This second test to measure the power factor was conducted on August 26, 1982, at 50 percent reactor power and the buses were loaded to approximately the same level as observed during the first test.

The test was run for three hours to record any variation in power factor. It was found that the power factor values on the 4160 volt bus remained constant at 0.88 as measured during the first test.

The power factor values for 480 Volt Bus No. E1 fluctuated between 0.75 to 0.78 and it was also observed that as the load on the bus increased, the power factor value also improved which was to be expected based on normal induction motor influence on power factor.

The power factor values for 480 Volt MCC No. 5 remained very close to 0.85. One air compressor was found cycling approximately every thirty seconds and corresponding blips were found on the ampere and power factor recorder charts.

Using the computer model of Test TP-1, additional computer analyses were made using the average power factor values observed during Test TP-2.

As seen from the Analysis Verification Table (Table No. 1), the steady state deviations between calculated and actual recorded bus voltages fall within the accuracy of the instruments used to conduct the test and reading accuracy in interpolating between divisions on recorder strip charts.

The higher deviation values for the transient condition during starting of the motors are due to the nature of the computer program. This program assumes a constant MVA base for all running motors. Consequently, when considering the starting of a large motor assuming low bus voltage and starting power factor, the starting current and corresponding voltage drop calculated is slightly higher than actual. This produces conservative results (calculated values are lower than the actual recorded) and assures that bus voltages will not exceed calculated values when considering large voltage drops.

5.7 <u>Question No. 4:</u>

The calculated bus voltages in Ref. 2 of concern for steady state and motor conditions are as follows:

a. Steady State

Using the nameplate rating of the 6000 hp RCP results in a bus voltage of 402 volts on E2 and by using brake horsepower (BHP) of 4700 hp results in a bus voltage of 426 volts.

b. Motor Starting

Using the nameplate rating of the 6000 hp RCP results in a bus voltage dip to 310 volts on Bus E2 and by using BHP a voltage dip to 336 volts during motor starting.

ANALYSIS VERIFICATION TABLE

TABLE 1

Carolina Power & Light Company
H. B. Robinson Nuclear Plant
In-Plant Test Analysis

OFS No. 2762.024 Dept. No. 504
September 3, 1982

	4160V Bus #2			480 Volt Bus #1			E1			MCC5			MCC10			
In-Plant Test No.	Actual Volts	Calculated Volts	Delta Volts	Actual Volts	Calculated Volts	Delta Volts	Actual Volts	Calculated Volts	Delta Volts	Actual Volts	Calculated Volts	Delta Volts	Actual Volts	Calculated Volts	Delta Volts	
1	4140	4142	+ 2	463.5	455	- 8.5	453	452	- 1	438	436	- 2	192	189	- 1	Before starting
	4110	4107	- 3	435	429	- 6	420	424	+ 3	402	407	+ 5	177	176	- 1	During starting
	4140	4139	- 1	462	452	-10	450	449	- 1	433.5	433	- 0.5	191	187	- 4	After starting
2	4140	4139	- 1	459	452	- 7	444	449	+ 5	432	433	+ 1	190	187	- 3	Before starting
	4110	4123	+13	453	441	-12	441	436	- 5	406.5	396	-10.5	178	172	- 6	During starting
	4140	4137	- 3	457.5	451	- 6.5	444	447	+ 3	426	429	+ 3	187	185	- 2	After starting
3	4140	4137	- 3	457.5	451	- 6.5	444	447	+ 3	426	429	+ 3	187	185	- 2	Before starting
	3510	3469	-41	385.5	367	-18.5	372	362	- 10	354	338	-16	156	146	-10	During starting
	4080	4089	+ 9	453	445	- 8	441	441	0	421.5	422	- 0.5	186	183	- 3	After starting

	4160V Bus #2	480 Volt Bus #1	E1	MCC5	MCC10
Power Factor	(.88)	(.76)	(.76)	(.85)	(Lightly loaded bus)
Scale:	60V/mm	6V/mm	6V/mm	6V/mm	2.6V/mm
Steady State Deviation in Percentage	0.22	2.16	1.1	0.70	2.09
Transient Deviation in Percentage	1.16	4.79	2.69	4.52	6.41

Notes: 1. Recording voltmeters used for the test - Esterline Angus Model #S22907
Accuracy - ±2% FS

Ref. 4 defines the loss-of-voltage setpoints of 328 volts ± 1 volt with a time delay of .75 seconds ± .25 seconds. Ref. 3 defines the second-level protection setpoint of 413 (changed to 412 volts by Amendment 52) volts + 1 volt with a time delay of 10 seconds ± .5 seconds. The manufacturer's recommended minimum continuous operating voltage is 414 volts (Ref. 2).

The use of nameplate ratings is indicative of design conditions and to determine the full capacity and capability of the onsite distribution system to supply adequate voltage, should be based on design conditions.

Based on conservative engineering judgment, reasonable assurance has not been provided in Ref. 2 that the brake horsepower rated loads will not change in time and that a considerable voltage margin on the Class 1E buses and load terminals with respect to the undervoltage relay setpoints and equipment voltage ratings is present using BHP values. Per NRC Guidelines 9, 10 and 12, submit how CP&L plans to meet the requirements of equipment voltage ratings for normal operation, adequacies in relay setpoints of voltages and time, and avoiding spurious Class 1E bus separation when using design conditions.

5.8 <u>Response to Question No. 4</u>

Based on the design parameters established for the plant systems such as maximum flow, static head, etc., the operating or design points used to establish horsepower requirements represent maximum or "worst case" design conditions. During normal operation, the load will vary from this design point downward. Motor nameplate horsepower was conservatively selected on the basis of these design points to provide a reasonable margin in motor horsepower above that required by the driven equipment. Thus the brake horsepower required to drive equipment at design point conditions represents maximum horsepower required by the driven equipment and is consequently used to calculate voltage drop which is a function of running load. Nameplate horsepower on the other hand represents the capability of the motor, not the driven equipment.

As observed and recorded during September 1976, February 1982, and August 1982, the actual running load of the large pumps has been historically lower than the design point brake horsepower. Therefore, using design point brake horsepower rating of the equipment for calculating bus voltages provides inherent margin of safety, thus ensuring that the actual bus voltages will always be higher than the calculated voltages.

For the above reasons this analysis is made using design point brake horsepower of the large and medium size pumps.

Table No. 2 gives a comparison of nameplate horsepower for selected motors 300 hp and above with the brake horsepower required by the driven equipment. These design points were obtained from the FSAR and manufacturers' drawings contained in Carolina Power and Light record files. However, where the design point brake horsepower is not available, the nameplate horsepower of the motor is used.

TABLE No. 2
Brake Horsepower Data for
Large Pumps

	Service	Brake HP (Design)	Motor HP (Nameplate)	Volts	Bus No.
1.	Reactor Coolant Pump	5067	6000	4160	1, 2 & 4
2.	Circulating Water Pump	1685	1750	4160	1 & 4
3.	Condensate Pump	2702	3000	4160	1 & 4
4.	Heater Drain Pump	625	700	4160	1 & 4
5.	Steam Generator Feed Pump	5428	6000	4160	1 & 4
6.	Component Cooling Pump	309	350	480	E1 & E2
7.	Auxiliary Feed Water Pump	325	350	480	E1 & E2
8.	Reactor Containment Fan Cooler	117/244	350	480	E1 & E2
9.	Service Water Pumps	275	300	480	E1 & E2
10.	Residual Heat Removal Pump	285	300	480	E1& E2

For pump performance curves, refer to Section II, Paragraph F, Page II-102.

A copy of each of the pump characteristic curve indicating design point brake horsepower is included in Section II, Paragraph F.

As long as plant designs are not changed and the replacement equipment is sized within design points, the brake horsepower required by the pump should not exceed the design point brake horsepower. If, for any reason, the plant designs are changed by changing the equipment size, CP&L will notify the NRC and the electrical distribution system will be reanalyzed to evaluate the impact.

The steady state and transient analyses requested in this question are made in response to Question No. 1 included in Section I, Paragraph 5.2.

As demonstrated in Paragraph 5.2 above, the voltage levels at the safety related buses under all plant operating conditions are satisfactory.

5.9 Question No. 5:

Per NRC Guideline 7 (Ref. 1), submit Class 1E load terminal voltages for the cases in Table No. 1 and Table No. 2 (Ref. 2) including any low voltage ac (less than 480V) Class 1E equipment. Is all the equipment capable of sustaining the analyzed voltages without blowing fuses, overheating, stalling, etc., without affecting the equipment's ability to perform its required function (especially instrumentation and control circuits)?

5.10 Response to Question No. 5:

The analysis of degraded bus voltages as presented with the Ref. 2 document are expanded to include 120/208 volt buses. The calculations are conducted using identical bases as summarized below for quick reference.

a. Steady State Conditions

The steady state voltage studies for H. B. Robinson Unit No. 2 were conducted to determine the minimum voltages which could be expected on the major on-site electrical buses during steady state power operations as the grid voltage was varied from 0.95 pu to 1.06 pu of 115 kV. The following conditions were assumed to exist during the conduct of this study:

1. The plant is assumed to be operating at 100 percent power.

2. All electrical loads which are required to the unit are supplied from the 115 kV grid via the Start-Up Transformer.

3. All running electrical loads are assumed to be in continuous operation (i.e., no equipment starts or stops).

The calculated bus voltages during steady state operation of the plant are as tabulated below:

PU	4160 Volt Bus		480 Volt Bus					208V Bus	
	1/2	3/4	E1	E2	SHDN	MCC5	MCC6	MCC9	MCC10
0.95	3903	3917	421	419	421	418	416	178	179
1.00	4138	4151	450	448	450	447	445	191	192
1.06	4417	4429	484	483	484	481	480	206	206

From the results calculated above, it is demonstrated that during steady state condition all 4160 and 480 volt buses are maintained above the manufacturers' recommended minimum voltage for continuous motor operation, i.e., 3600 volts and 414 volts respectively. The manufacturer's recommended minimum continuous operating voltage for 208 volt motors is 180 volts. The 208 Volt MCC 9 and MCC 10 shows minimum bus voltages of 178 and 179 volts respectively. Considering the conservatism of the computer model which assumes all running motors as constant MVA loads, these voltages, which are within 1 percent of the normal allowable operating range of the motors, is considered acceptable.

The undervoltage trip setting of 328 volts on Emergency Buses E1 and E2 is not exceeded. Consequently, these buses will not experience spurious separation from their power sources.

The maximum recommended voltage for continuous operation of the 4000, 460 and 200 volt motors (4400 volts, 506 volts and 220 volts respectively) is satisfied for all grid voltages except at 1.06 pu where the 4160 volt buses are calculated to exceed the maximum recommended voltage by 0.38 percent. This is not considered deleterious to the equipment.

Minimum contactor pick-up voltages of 403 and 166 volts and minimum contactor drop-out voltages 290 and 111 volts for 480 and 208 volt equipment respectively are not exceeded under any postulated condition.

The voltage regulating transformers feeding 120 Volt Instrument Bus No.'s 1 and 6 are supplied from 480 Volt MCC 5. The voltage regulating transformers feeding 120 Volt Instrument Buses 4 and 9 are supplied from 480 Volt MCC 6. These constant voltage transformers maintain an output within ± 1/2 percent of nominal with a variable input voltage from 380 to 520 volts. Since the degraded voltage under steady state conditions is always within these limits, the output voltage will not be affected. The remaining 120 volt instrument buses are fed from inverters and are not affected with the degraded voltage of the ac buses.

b. Transient Conditions

The transient voltage studies for H. B. Robinson Unit No. 2 were conducted to determine the minimum voltage which could be expected on the major on-site electrical buses during the starting of large motors as grid voltage is varied from 0.95 pu to 1.06 pu of 115kV. The following conditions were assumed to exist during the conduct of this study:

1. The plant is assumed to be operating at 100 percent load.
2. All electrical loads which are required to support power operations are operating with the exception of the motor being started.
3. All electrical loads are being powered from the 115kV transmission grid via the Start-up Transformer.

Minimum Calculated Bus Voltage During Starting of Large Motors,

Start-up of 6000 HP Motor on 4160V Bus

PU	4160 Volt Bus		480 Volt Bus					208V Bus	
	1/2	3/4	E1	E2	SHDN	MCC5	MCC6	MCC9	MCC10
0.95	3304	3310	346	341	344	342	337	144	146
1.00	3503	3507	371	367	369	367	363	155	157
1.06	3739	3742	401	397	399	397	393	168	170

Start-up of 350 HP Motor on 480V Bus E1 & E2

PU	4160 Volt Bus		480 Volt Bus					208V Bus	
	1/2	3/4	E1	E2	SHDN	MCC5	MCC6	MCC9	MCC10
0.95	3874	3887	399	397	400	395	394	169	169
1.00	4106	4119	426	425	427	423	421	180	181
1.06	4383	4395	458	457	460	455	454	194	195

Start-Up of 125 HP Motor on 480V Bus E1 and E2

PU	4160 Volt Bus		480 Volt Bus					208V Bus	
	1/2	3/4	E1	E2	SHDN	MCC5	MCC6	MCC9	MCC10
0.95	3889	3917	412	410	412	390	384	164	167
1.00	4125	4137	440	438	440	417	411	176	179
1.06	4403	4414	473	472	474	448	442	189	192

Although it is unrealistic to be starting a reactor coolant pump at 100 percent power, this condition was assumed in the computer program to study the effect of starting the largest motor in the plant while the electrical distribution system is fully loaded.

From the results tabulated above, the undervoltage trip setting of 328 volts on the 480 volt buses E1 and E2 is not reached during transient condition of starting the largest motor in the plant.

The worst case contactor drop-out voltage approximately 290 volts for 480 volt and 111 volt for 208 volt buses is not reached under the analyzed conditions.

During transient conditions which last less than 10 seconds, the input voltage to the instrument regulating transformer falls to a low of 337 volts (480 volt MCC 6 @ 0.95 pu). Although this is 25 percent below the midpoint range (450V) for these transformers, published data from the manufacturer indicates the output voltage will be maintained to within approximately 8 percent of nominal. Assuming the output is set at 120 volts, this would result in the instrument bus voltage falling momentarily to 110 volts. This is not considered deleterious to the connected load.

5.11 Question No. 6:

Ref. 4, Item 3 states that an analysis is not required when backfeeding through the unit auxiliary transformer since its capacity rating is the same as the start-up transformer. When backfeeding, the main transformer bank is in series with the unit auxiliary transformer which results in a higher equivalent impedance. The higher impedance will cause more of a potential drop to the Class 1E buses. Therefore, an analysis is required per NRC Guideline 1. Submit an analysis when backfeeding through the unit auxiliary transformer.

5.12 Response to Question No. 6

Ref. 4, Item 3 addressed possibility of backfeeding the plant distribution system through the Unit Auxiliary Transformer in the event of a failure of the Start-Up Transformer. However, there is no credit taken in the FSAR for this option as a back up off-site supply and therefore the analysis is not required.

6.0 REFERENCES

Additional reference documents used for the study above those listed in the 1976 Report are as follows:

.1 CP&L Letter No. CO-03689 dated April 14, 1981, from A. B. Cutler to F. C. Wimberly.

.2 Telephone conversation notes between Joe Curley and NRC on March 17, 1981.

.3 NRC Letter Docket No. 50-261 dated January 13, 1981.

.4 CP&L Letter No. CO-04012 dated July 2, 1981 from A. B. Cutter to I. Narayani.

.5 Observed information obtained from site trip dated May 28, 1981.

.6 H. B. Robinson Unit 2 4160 volt One-Line Diagram 5379-5373, R5 - dated June 27, 1977.

.7 H. B. Robinson Unit 2 480 volt One-Line Diagram 5379-5374, R4 - dated June 27, 1977.

.8 Telecon with CP&L (S. Allen) August 6, 1981.

.9 CP&L Letter No. CO_02451 dated August 19, 1981, from A. B. Cutter to I. Narayani.

.10 Robert W. Smeaton, Editor in Chief, "Motor Application and Maintenance Handbook," McGraw-Hill, 1969, Fig. 16, p. 2-39.

SECTION II

SUPPORTING DOCUMENTS

A. IN-PLANT TEST PROCEDURE TP-1

H. B. ROBINSON NO. 2

CAROLINA POWER AND LIGHT COMPANY

DEGRADED VOLTAGE STUDY

IN-PLANT TEST PROCEDURE

Table of Contents

1.0 Purpose

To determine the validity of Ebasco's computerized auxiliary system analysis program for use in analyzing the adequacy of the on-site distribution of power. This validity will be determined by obtaining field measurements under controlled conditions and comparing these measurements with results calculated by Ebasco's computerized auxiliary system analysis program.

2.0 Basic Requirements

The basic requirements are summarized from a January 13, 1981 letter from the NRC to Carolina Power and Light Company:

> "With all the buses at least 40% loaded, measure and record the loads and impedances during steady state, starting of a large 4160V motor and starting of a large Class IE motor. Use the measured values in the computer load flow programs and compare the calculated voltages to the actual voltages to develop a deviation value."

3.0 Implementation

The testing requirements as stated in Section 2.0 will be implemented by an operational test of the following buses (see Figure 1 for bus alignment):

a - 4160 Volt Bus No. 1

b - 4160 Volt Bus No. 2

c - 480 Volt Bus No. 2

d - 480 Volt Bus No. E-1*

e - 480 Volt MCC No. 1

f - 480 Volt MCC No. 5*

g - 120/208 Volt MCC No. 10*

h - Instrument Bus No. 1*

* Denotes power supplies for Engineered Safety Features (ESF) equipment.

Since the main concern for this test is the adequacy of the on-site distribution of power from the off-site circuit, the preferred source of power for the above listed buses is Start-up Transformer No. 2-X-winding.

This bus system is used because it represents a normally heavier loaded set of buses than the bus system powered from the Y-winding of Start-up Transformer No. 2.

4.0 Assumptions

The 40 percent bus loading requirement of Section 2.0 is assumed to pertain to the H. B. Robinson No. 2 auxiliary electrical system as follows:

a - The X and Y-windings of Start-up Transformer No. 2 are loaded with a minimum of 40 percent of each windings 65°C capacity. Since each winding is rated 24.6 MVA at 4368 volts (3252 amperes), 40 percent of the 65°C capacity is 1301 amperes. Therefore this condition is satisfied as long as the ammeters on both X and Y-winding incoming breakers (52-12 and 52-17 respectively) indicate a value of 1301 amperes or higher during the testing.

b - 4160 Volt Bus No. 1 and No. 2 will be considered as one bus for the Degraded Voltage Study since the two buses are always operated with the bus tie breaker closed. Thus the 40 percent bus loading requirement will apply to the total load of both buses.

c - The 120 volt, 208 volt and 480 volt systems powered by Station Service Transformer 2A will also be considered as one bus. The 40 percent bus loading requirements will apply to: 1) The total forced cooled capacity (FA) of Station Service Transformer 2A. Since the transformer is rated 2000/2666 kVA AA/FA at 4160 volts (370 amperes), 40 percent of the forced cooled (FA) capacity is 148 amperes. Therefore this condition is satisfied as long as the ammeter on 4160 Volt Breaker 52-13 indicates a value of 148 amperes or higher during the testing. 2) The normal operating nameplate loads of ESF buses 480 Volt Bus No. E-1 and 480 Volt MCC No. 5; and 3) All remaining buses shown on Figure 1 will not have minimum load requirements since 480 Volt Bus No. 1 and 480 Volt MCC No. 1 are non-saftey related, 120/208 Volt MCC No. 10 consists mainly of motor operated valves and 120 Volt Instrument Bus No. 1 consists primarily of small instrument power supply loads.

5.0 Pre-Test Requirements

5.1 Temporarily Installed Equipment Calibration

Portable instrumentation (recording voltmeters, etc.) shall be checked for proper calibration prior to the operational test. For the rented test equipment, any certification is valid only if the calibration is completed within the past six months. The calibration date shall be indicated in the proper space on Form 9.4 attached.

5.2 Test Equipment

All portable instrumentation shall be installed prior to the operational test and receive a functional test to assure proper operation.

Verified by and date	Michael J. Hein	2/13/82
	I&C Name	Date

6.0 Operating Requirements

6.1 Start-up Transformer No. 2

During the operational testing, station auxiliary power shall be from the 115kV Switchyard through Start-up Transformer No. 2.

Verified by and date	R. Garner	2/13/82
	Operations	Date

6.2 4160 Volt Buses No. 1 and No. 2

4160 Volt Buses No. 1 and No. 2 shall be conected together by Tie Breaker 52-10. 4160 Volt Bus No. 2 shall be connected to the X-winding of Start-up Transformer No. 2 by Breaker 52-12. Load current through Breaker 52-12 shall not be less than 1301 amperes at any time during the operational test. In order to meet this requirement, all of the following motors should be operating, however as a minimum three (3) of the following four (4) motors as indicated by an asterisk (*) shall be operating at all times (Steam Generator Feed Pump 2A is de-energized and will be used as the preferred starting motor):

Reactor Coolant Pump 2A * X

Reactor Coolant Pump 2C * X

Condensate Pump 2A * X

Circulating Water Pump 2A * X

Heater Drain Pump 2A X

3 of 4 must be operating.
Indicate which by (X) .

Verified by and date	R. Garner	2/13/82
	Operations	Date

The above loading is based upon motor nameplate values. No credit is taken at this point for any loading caused by: a) Steam Generator Feed Pump 2A, which is the starting motor and b) Station Service Transformer 2A and 2B, as these transformers will be used for margin. The total nameplate current of any three of the above four motors indicated by an asterisk (*) exceeds the 1301 ampere minimum requirement of the Start-up Transformer 2A and in addition represents 38 percent of the total connected load on 4160 Volt Bus No. 1 and No. 2.

6.3 4160 Volt Bus No. 3

4160 Volt Bus No. 3 shall be connected to the Y-winding of Start-up Transformer No. 2 by Breaker 52-17. Load current through Breaker 52-17 shall not be less than 1301 amperes at any time during the operational test.

6.4 Station Service Transformer 2A

Station Service Transformer 2A shall be energized by 4160 Volt Bus No. 2 through Breaker 52-13. Load current through this breaker shall not be less than 148 amperes at any time during the operational test.

6.5 480 Volt Bus No. 1

480 Volt Bus No. 1 shall be energized by Station Service Transformer 2A through Breaker 52-1B and 52-2B. Since this is not an ESF bus, the only load requirement is that all normally connected loads are energized.

6.6 480 Volt MCC No. 1

480 Volt MCC No. 1 shall be energized from 480 Volt Bus No. 1 through 480 Volt Breaker 52-3A. Since this is not an ESF bus, the only load requirement is that all normally connected loads are energized.

6.7 480 Volt Bus No. E-1

480 Volt Bus No. E-1 shall be energized by Station Service Transformer 2A through 480 Volt Breakers 52-1B and 52-18B. In order to meet the 40 percent bus loading requirement, all of the following motors should be operating, however as a minimum any four motors operating will satisfy the requirements (Auxiliary Feedwater Pump 2A is de-energized and will be used as the preferred starting motor):

Indicate what is operating by a (X)

Containment Fan Cooler HVH-1 X

Containment Fan Cooler HVH-2 X

Service Water Pump 2A X

Service Water Pump 2B X

Component Cooling Pump 2B X

Charging Pump 2B ____

Verified by and date R. Garner (Name) 2/13/82 (Date)

Any four of the above motors (using nameplate data) equals or is greater than the 40 percent minimum loading of Station Services Transformer 2A alone and represents 36.6 percent of the total connected motor load. No credit is taken at this time for any loading caused by 480 Volt MCC No. 5, as this will be used for margin.

6.8 480 Volt MCC No. 5

480 Volt MCC No. 5 shall be energized from 480 Volt Bus No. E-1 through 480 Volt Breaker 52-21A. In order to meet the 40 percent bus loading requirement, four of the following five devices shall be operating (Service Water Booster Pump 2A in de-energized and will be used as the preferred starting motor):

Indicate what is operating by a (X)

Battery Charger 2A X

Exhaust Fan HVE-2A X

CRD Fans HVH-5A X

Auxiliary Building Supply Fans HVS-1 X

Instrument Air Compressor 2A ____

Verified by and date	R. Garner	2/13/82
	Name	Date

Any four of the above loads (using nameplate data) equals or exceeds 40 percent of the rating of the feeder cable to the MCC.

6.9 120/208 Volt MCC No. 10

120/208 Volt MCC No. 10 shall be energized from 480 Volt MCC No. 5A through 480 Volt Breaker 4FR. As discussed in Section 4.0 (c), no minimum loading is required for this bus, as it consists mainly of motor operated valves. The largest normal load is a 3.9 Hp valve. Although no minimum loading is required, all normally energized loads should be operating.

Verified by and date	R. Garner	2/13/82
	Name	Date

6.10 Instrument Bus No. 1

Instrument Bus No. 1 shall be energized from 480 Volt MCC No. 5 through 480 Volt Breaker 2BL. As discussed in Section 4.0 (c), no minimum loading is required for this bus, as it consists mainly of 120 volt instrument power supplies. Although no minimum loading is required, all normally energized loads should be operating.

7.0 Test Equipment and Location

7.1 Temporarily Installed Test Equipment

Temporarily installed test equipment such as recording voltmeters, recording power factor meters and portable multimeters will be used to indicate operating voltage and voltage drops on various buses during the operational testing, indicate Start-up Transformer No. 2 loading and indicate 4160 breaker amperes. These instruments shall be calibrated and installed prior to the operational testing according to Section 5.1. These instruments and their locations are identified on Figure 1 using the symbol RV for recording voltmeter, PF for recording power factor meter and A for portable multimeters.

7.2 <u>Recording Voltmeters and Installation Information</u>

Recording voltmeters shall be Esterline Angus Model Number S22907. Control settings for all recording voltmeters are as follows:

a) Chart speed range - CM/HR

b) Chart speed - 10

c) Operating voltage range - see Paragraphs 7.2.1 thru 7.2.8

7.2.1 <u>4160 Volt Bus No. 3 (RV1)</u>

Turn voltmeter switch on 4160 Volt Breaker Cubicle 52-18 to "Off" position. Connect the spade lugs from the ac terminal blocks on rear of recording voltmeter to the two studs on rear of voltmeter on 4160 Volt Breaker Cubicle 52-18. Operation voltage range is 0-150 Volts AC. Connect the portable recorder to a 115 volt ac supply, turn the chart drive switch to "On", and then turn the voltmeter switch on 4160 Volt Breaker Cubicle 52-18 to #1, #2 or #3 position. The recorder pen should then deflect approximately 75 to 90 units on the chart. When installation is completed, turn chart drive switch to "Off".

Verified by and date	Michael J. Hein	2/13/82
	I & C Name	Date

7.2.2 <u>4160 Volt Bus No. 2 (RV2)</u>

Same as Paragraph 7.2.1 except 4160 Volt Breaker Cubicle 52-11 is used.

Verified by and date	Michael J. Hein	2/13/82
	I & C Name	Date

7.2.3 <u>480 Volt Bus No. 1 (RV3)</u>

Same as Paragraph 7.2.1 except 480 Volt Breaker Cubicle 52-1A is used.

Verified by and date	Michael J. Hein	2/13/82
	I & C Name	Date

7.2.4 <u>480 Volt MCC No. 1 (RV4)</u>

Connect the two spade lugs from the ac terminal blocks on the rear of the recording voltmeter to two poles of the breaker in Compartment 3B. (Note: this breaker was observed previously as turned "Off" with no tag). Operating voltage range is 0-600 Volts AC. Connect the portable recorder

to a 115 volt ac supply, turn the chart drive switch to "On" and then turn the breaker in Compartment 3B to "On". The recorder pen should then deflect approximately 75 to 90 units on the chart. When installation is completed, turn chart drive switch to "Off".

CAUTION: This device is connected to a 480 volt source. Plant safety requirements shall be followed and warning signs posted.

Verified by and date — Michael J. Hein (I & C Name), 2/13/82 (Date)

7.2.5 480 Volt Bus No. E-1 (RV5)

Same as Paragraph 7.2.1 except 480 Volt Breaker Cubicle 52-17A is used.

Verified by and date — Michael J. Hein (I & C Name), 2/13/82 (Date)

7.2.6 480 Volt MCC No. 5 (RV6)

Same as Paragraph 7.2.4 except that Compartment 5D is used. This breaker is for HVH-9A. Contact shift foreman prior to turning breaker off to connect recording voltmeter.

Verified by and date — Michael J. Hein (I & C Name), 2/13/82 (Date)

CAUTION: This device is connected to a 480 volt source. Plant safety requirements shall be followed.

7.2.7 120 Volt Instrument Bus No. 1 (RV7)

Connect the two spade lugs from the ac terminal blocks on the rear of the portable recorder to a) any screw connection on the 120 volt energized bus and b) to a ground point in the panel. Caution must be taken as this bus is energized and cannot be de-energized. Operating voltage range is 0-150 Volts AC. Connect the portable recorder to a 115 volt ac supply and turn the chart drive to "On". The recorder pen should then deflect to approximately 75 to 90 units on the chart. When installation is completed, turn chart drive switch to "Off".

(will use Bus Number 6)

Verified by and date — Michael J. Hein (I & C Name), 2/13/82 (Date)

7.2.8 120/208 Volt MCC No. 10 (RV8)

Connect two spade lugs from the ac terminal block on the rear of the recording voltmeter to a) one phase of the breaker in Compartment 2J and b) to a ground point in Compartment 2J. Operating voltage range is 0-150 Volts AC. Connect the portable recorder to a 115 volt ac supply, turns the chart drive switch to "On" and then turn the breaker in Compartment 2J to "On". The recorder should then deflect to approximately 75 to 90 units on the chart. When installation is complete turn chart drive switch to "Off".

Verified by and date	Michael J. Hein	2/13/82
	I & C Name	Date

7.3 Recording Power Factor Meter and Installation Information

7.3.1 External input connections for the analog system are made to terminals located on the rear of the recorder case. Break the current loop to the in-plant ammeter by lifting either wire on the meter terminals. Connect the lifted wire to the + or A terminal on the power factor meter.

Connect the - or A terminal of the power factor meter to the bare terminals of the meter.

Current was taken from Cubicle 17. Connect the 120 volt voltage terminals of the power factor meter according to paragraph 7.2.1 i.e., 4160 volt breaker cubicle #18.

Verified by and date	Michael J. Hein	2/13/82
	I & C Name	Date

7.3.2 Same as above 7.3.1 except Cubicle 11 and 12.

Verified by and date	Michael J. Hein	2/13/82
	I & C Name	Date

NOTE: If the chart recorder gives an exceptionally low reading, i.e. 50% or below, reverse the voltage input to the meter.

7.4 Portable Multimeters and Installation Information

Portable multimeters with shunts will be used to measure current through 4160 volt breakers. The portable multimeters shall be Fluke Model Number 8040A. Control settings for all portable multimeters are as follows:

a) AC/DC - AC
b) Volts/Current/OHMS - Volts
c) Range - 200 MV

7.4.1 4160 Volt Ammeters (A)

All ammeters using portable multimeter with shunts will be installed as follows:

Shunts

Two different shunts will be used. Three shunts will be 0-62.5 MV for 5 amperes and seven will be 0-50 MV for 5 amperes. All shunts will be installed by turning the appropriate ammeter switch to "Off", removing one wire terminal from the ammeter and intalling the shunt in series between the removed wire and the bare terminal on the ammeter.

The 0-62.5 MV shunts will be installed in series with the ammeters in 4160 Breaker Cubicles 52-5, 52-6 and 52-14. The 0-50 MV shunts will be installed in series with the ammeter in 4160 Breaker Cubicles 52-1, 52-2, 52-3, 52-4, 52-12, 52-13 and 52-17.

Verified by and date Michael J. Hein 2/13/82
I & C Name Date

Portable Multimeters

The portable multimeters test leads will be connected from the portable multimeter to the connections on the shunts. Then connect the portable multimeter to a 120 volt ac source. The portable multimeter should then have an indication between 0 to 100, depending on the status of the breaker and the load it is carrying.

7.5 Miscellaneous Equipment

7.5.1 The personnel responsible for making electrical connections for the instrumentation should keep sufficient quantity of flexible #16 wire (600V) with connection probes and standard cable lugs to terminate and/or connect instrumentation components.

7.5.2 For emergency communication system four (4) radio sets should be kept ready for the test operation.

7.5.3 Six (6) flash lights.

7.5.4 Have rubber mats in front of the switchgear cabinets.

8.0 Test Procedure

8.1 Starting Test

Three (3) starting tests shall be conducted. Each test will consist of recording the necessary parameters prior to starting a motor and immediately after the motor is started. The following motors are designated as the preferred starting motors:

a - Auxiliary Feedwater Pump 2A (350 Hp @ 460 v)

b - Service Water Booster Pump 2A (150 Hp @ 460 v)

c - Steam Generator Feed Pump 2F (6000 Hp @ 4160 v)

If plant conditions do not allow the starting of any of the above motors, then another motor of the same size or the next largest motor can be started (on the same bus).

Note: If a substitute motor is started, the operating requirement of Section 6.0 shall be reviewed to insure that the 40 percent minimum load requirements are met.

8.2 Records

The test record for each motor starting is detailed in Section 9.0. All parts of all records must be completed to insure proper results for this testing.

8.3 Test Instruments

The test instruments shall be installed as detailed in Section 7.0. At least 30 minutes prior to any starting test, all test instruments shall be checked for proper settings as follows:

Verified by and date	Robert Forester	2/13/82
	I & C Name	Date

8.3.1 Voltage Recorders

Power	-	On
Chart Drive	-	On
Chart Speed Range	-	CM/HR
Chart Speed	-	10
Operating Voltage Range	-	0-150*

* Except RV4 and RV6 which will be set at 0-600

At this time the Range Switch shall be turned to "Off" with the pen returning to "zero". If not, use the zero adjustment to properly "zero" the recorder. Following this check, return the Range Switch to the proper position and adjust the hour marking on the chart to the proper time setting. The pen should be indicating approximately 80 units. Sign and date the chart when completed.

Verified by and date — Robert Forester (I&C Name) — 2/13/82 (Date)

8.3.2 Recording Power Factor Meter

Insure that Power Factor Records are inking and that zero adjustment is set.

8.3.3 Portable Multimeters

Power	-	On
AC/DC	-	AC
Volts/Current/OHMS	-	Volts
Range	-	200 MV

At this time the portable multimeters shall be checked for proper operation.

Verified by and date — Robert Forester (I&C Name) — 2/13/82 (Date)

8.4 Plant Operating Condition

The preferred plant operating conditions are as follows:

a - Bus alignment as indicated in Section 6.0

b - Bus loading as indicated in Section 6.0

c - Motor test in following order:
  i) Auxiliary Feedwater Pump 2A
  ii) Service Water Booster Pump 2A
  iii) Steam Generator Feed Pump 2A

Verified by and date — Michael J. Hein (I&C Name) — 2/13/82 (Date)

Note: The first two test motors should be started following the shutdown of Steam Generator Feed Pump 2A. Plant operating procedures required a 30 minute rest period before restarting large motors.

9.0 Testing Records

Three operating tests are required to satisfy the intent of the Degraded Voltage Study. All blanks must be completed to insure proper results.

9.1 Auxiliary Feedwater Pump 2A

Ensure that the auxiliary system is aligned and operating as detailed in Section 6.0 and all test equipment connected and operating as detailed in Sections 5.0 and 7.0 (also ensure that all recorders have their chart drive running).

9.1.1 Pretest Data

Record all data indicated in Pretest Data Test on Form 9.1.

9.1.2 Following all applicable plant operating and safety procedures, notify the shift foreman that he may start Auxiliary Feedwater Pump 2A, as plant conditions govern. Prior to starting the motor, he shall announce on the plant PA system that a test is in progress. When the pump is running at normal speed, immediately record all data indicated in Post Test Data on Test Form 9.1.

Starting Test 9.1

Auxiliary Feedwater Pump 2A
(Alternate None)

		Pretest Data			Post Test Data		
1.	Day of Test	2-13-82			2-13-82		
2.	Time of Test	5:53 PM			6:02 PM		
3.	Reactor Power (%)	49.3%			49.0%		
4.	Deleted						
		Ph.1	Ph.2	Ph.3	Ph.1	Ph.2	Ph.3
5.	Switchyard Voltage kv	116	N/A	N/A	116	N/A	N/A
6.	4160 Breaker 52-17 Amperes	30.72	31.25	30.55	30.80	31.33	30.55
7.	4160 Breaker 52-1 Amperes	28.86	29.33	28.48	28.95	29.40	28.58
8.	4160 Breaker 52-2 Amperes	44.88	45.62	44.72	44.80	45.70	44.85
9.	4160 Breaker 52-3 Amperes	0	0	0	0	0	0
10.	4160 Breaker 52-4 Amperes	13.90	14.10	14.33	14.12	14.30	14.55
11.	4160 Breaker 52-5 Amperes	40.50	40.90	39.95	40.65	41.05	40.05
12.	4160 Breaker 52-6 Amperes	36.33	36.86	35.75	36.40	37.0	35.80
13.	4160 Breaker 52-12 Amperes	30.15	30.65	29.73	30.60	31.10	30.08
14.	4160 Breaker 52-13 Amperes	23.66	23.65	22.95	26.30	26.27	25.48
15.	4160 Breaker 52-14 Amperes	45.99	46.80	45.60	46.00	46.95	45.60
16.	480 Volt Bus No. E-1 Load Energized (Yes or No)						
a.	HVH-1 (Breaker 52-19B)	Yes			Yes		
b.	HVH-2 (Breaker 52-19C)	Yes			Yes		

FORM 9.1-1

Starting Test 9.1 (Continued)

c.	AFP-2A (Breaker 52-20A)	No	Yes
d.	SWP-2A (Breaker 52-20B)	Yes	Yes
e.	SWP-2B (Breaker 52-20C)	Yes	Yes
f.	400V MCC 5 (Breaker 52-21A)	Yes	Yes
g.	CP-2B (Breaker 52-21B)	No	No
h.	CCP-2B (Breaker 52-22C)	Yes	Yes
i.	Other Loads (Identify)	None	None
		None	None
		None	None
		None	None
		None	None

17. 480 Volt MCC No. 5 Load Energized (Yes or No)

a.	HVE-2A (Breaker 2M)	Yes	Yes
b.	120 Volt Bus 1 (Breaker 2BL)	Yes	Yes
c.	HVH-5A (Breaker 3M)	Yes	Yes
d.	SWBP-2A (Breaker 4M)	No	No
e.	IAC-2A (Breaker 5M)	No	No
f.	HVS-1 (Breaker 5J)	Yes	Yes
g.	BC-2A (Breaker 9C)	Yes	Yes
h.	120/208 MCC 10 (Breaker A4FR)	Yes	Yes

FORM 9.1-2

Starting Test 9.1 (Continued)

NOTE #1: Each "data recording personnel" shall initial each data entry above and also sign and initial once below.

	Signature	Initials
#1	Indru Narayani	IN
#2	Michael J. Hein	MJH
#3	Robert L. Forester	RLF
#4	R. S. McGirt	RSM

NOTE #2: Following the recording of all of the above data, mark the data, time of day, the number 9.1 and sign each each of the eight recording voltmeter charts and two power factor charts showing the voltage changes.

FORM 9.1-3

9.2 Service Water Booster Pump 2A

Ensure that the auxiliary system is aligned and operating as detailed in Section 6.0 and all test equipment connected and operating as detailed in Sections 5.0 and 7.0 (also ensure that all recorders have their chart drive running).

9.2.1 Pretest Data

Record all data indicated in Pretest Data Test on Form 9.2.

9.2.2 Following all applicable plant operating and safety procedures, notify the shift foreman that he may start Service Water Booster Pump 2A, as plant conditions govern. Prior to starting the motor, he shall announce on the plant PA system that a test is in progress. When the pump is running at normal speed, immediately record all data indicated in Post Test Data on Test Form 9.2.

Starting Test 9.2

Service Water Booster Pump 2A
(Alternate NONE)

		Pretest Data			Post Test Data		
1.	Day of Test	2-13-82			2-13-82		
2.	Time of Test	6:11 PM			6:18 PM		
3.	Reactor Power (%)	49.2%			49.9%		
4.	Deleted						
		Ph.1	Ph.2	Ph.3	Ph.1	Ph.2	Ph.3
5.	Switchyard Voltage	116	N/A	N/A	115	N/A	N/A
6.	4160 Breaker 52-17 Amperes	30.85	31.40	30.60	30.85	31.40	30.69
7.	4160 Breaker 52-1 Amperes	29.00	29.55	28.60	29.00	29.55	28.65
8.	4160 Breaker 52-2 Amperes	44.90	45.75	44.90	44.80	45.70	44.82
9.	4160 Breaker 52-3 Amperes	0	0	0	0	0	0
10.	4160 Breaker 52-4 Amperes	14.55	13.27	13.63	14.23	14.96	15.15
11.	4160 Breaker 52-5 Amperes	40.75	41.15	40.05	40.80	41.20	40.20
12.	4160 Breaker 52-6 Amperes	36.45	37.20	35.90	36.50	37.25	36.00
13.	4160 Breaker 52-12 Amperes	30.65	31.10	30.15	30.70	31.20	30.30
14.	4160 Breaker 52-13 Amperes	26.25	26.30	25.50	27.48	27.52	26.70
15.	4160 Breaker 52-14 Amperes	46.35	46.95	45.70	46.20	47.00	45.75
16.	480 Volt Bus No. E-1 Load Energized (Yes or No)						
	a. HVH-1 (Breaker 52-19B)	Yes			Yes		
	b. HVH-2 (Breaker 52-19C)	Yes			Yes		

FORM 9.2-1

Starting Test 9.2 (Continued)

c.	AFP-2A (Breaker 52-20A)	Yes	Yes
d.	SWP-2A (Breaker 52-20B)	Yes	Yes
e.	SWP-2B (Breaker 52-20C)	Yes	Yes
f.	400V MCC 5 (Breaker 52-21A)	Yes	Yes
g.	CP-2B (Breaker 52-21B)	No	No
h.	CCP-2B (Breaker 52-22C)	Yes	Yes
i.	Other Loads (Identify)	None	None
		None	None
		None	None
		None	None
		None	None

17. 480 Volt MCC No. 5 Load Energized (Yes or No)

a.	HVE-2A (Breaker 2M)	Yes	Yes
b.	120 Volt Bus 1 (Breaker 2BL)	Yes	Yes
c.	HVH-5A (Breaker 3M)	Yes	Yes
d.	SWBP-2A (Breaker 4M)	No	Yes
e.	IAC-2A (Breaker 5M)	No	No
f.	HVS-1 (Breaker 5J)	Yes	Yes
g.	BC-2A (Breaker 9C)	Yes	Yes
h.	120/208 MCC 10 (Breaker A4FR)	Yes	Yes

Starting Test 9.2 (Continued)

NOTE #1: Each "data recording personnel" shall initial each data entry above and also sign and initial once below.

	Signature	Initials
#1	Indru Narayani	IN
#2	Michael J. Hein	MJH
#3	Robert L. Forester	RLF
#4	R. S. McGirt	RSM

NOTE #2: Following the recording of all of the above data, mark the data, time of day, the number 9.1 and sign each each of the eight recording voltmeter charts and two power factor charts showing the voltage changes.

FORM 9.2-3

9.3 Steam Generator Feed Pump 2A

Ensure that the auxiliary system is aligned and operating as detailed in Section 6.0 and all test equipment connected and operating as detailed in Sections 5.0 and 7.0 (also ensure that all recorders have their chart drive running).

9.3.1 Pretest Data

Record all data indicated in Pretest Data Test on Form 9.2.

9.3.2 Following all applicable plant operating and safety procedures, notify the shift foreman that he may start Steam Generator Feed Pump 2A, as plant conditions govern. Prior to starting the motor, he shall announce on the plant PA system that a test is in progress. When the pump is running at normal speed, immediately record all data indicated in Post Test Data on Test Form 9.3.

Starting Test 9.3

Steam Generator Feed Pump 2A
(Alternate NONE)

		Pretest Data			Post Test Data		
1.	Day of Test	2-13-82			2-13-82		
2.	Time of Test	6:24 PM			6:32 PM		
3.	Reactor Power (%)	49.6%			49.7%		
4.	Deleted						
		Ph.1	Ph.2	Ph.3	Ph.1	Ph.2	Ph.3
5.	Switchyard Voltage kV	115	N/A	N/A	115	N/A	N/A
6.	4160 Breaker 52-17 Amperes	30.80	31.40	30.80	28.75	29.30	28.60
7.	4160 Breaker 52-1 Amperes	29.00	29.51	28.70	29.30	29.80	28.90
8.	4160 Breaker 52-2 Amperes	45.25	46.12	45.20	45.35	46.15	45.40
9.	4160 Breaker 52-3 Amperes	0	0	0	19.70	20.00	19.35
10.	4160 Breaker 52-4 Amperes	14.25	14.00	14.00	13.25	13.22	13.30
11.	4160 Breaker 52-5 Amperes	40.80	41.15	40.20	41.10	41.40	40.50
12.	4160 Breaker 52-6 Amperes	36.70	37.32	36.15	37.00	37.70	36.50
13.	4160 Breaker 52-12 Amperes	30.75	31.30	30.50	36.90	37.50	36.52
14.	4160 Breaker 52-13 Amperes	27.75	27.80	26.90	27.78	27.75	26.90
15.	4160 Breaker 52-14 Amperes	46.31	47.00	45.80	46.65	47.50	46.25
16.	480 Volt Bus No. E-1 Load Energized (Yes or No)						
	a. HVH-1 (Breaker 52-19B)	Yes			Yes		
	b. HVH-2 (Breaker 52-19C)	Yes			Yes		

FORM 9.3-1

Starting Test 9.3 (Continued)

c. AFP-2A (Breaker 52-20A)	Yes	Yes
d. SWP-2A (Breaker 52-20B)	Yes	Yes
e. SWP-2B (Breaker 52-20C)	Yes	Yes
f. 400V MCC 5 (Breaker 52-21A)	Yes	Yes
g. CP-2B (Breaker 52-21B)	No	No
h. CCP-2B (Breaker 52-22C)	Yes	Yes
i. Other Loads (Identify)	None	None
	None	None
	None	None
	None	None
	None	None

17. 480 Volt MCC No. 5 Load Energized (Yes or No)

a. HVE-2A (Breaker 2M)	Yes	Yes
b. 120 Volt Bus 1 (Breaker 2BL)	Yes	Yes
c. HVH-5A (Breaker 3M)	Yes	Yes
d. SWBP-2A (Breaker 4M)	Yes	Yes
e. IAC-2A (Breaker 5M)	No	No
f. HVS-1 (Breaker 5J)	Yes	Yes
g. BC-2A (Breaker 9C)	Yes	Yes
h. 120/208 MCC 10 (Breaker A4FR)	Yes	Yes

FORM 9.3-2

Starting Test 9.3 (Continued)

NOTE #1: Each "data recording personnel" shall initial each data entry above and also sign and initial once below.

#1	Indru Narayani Signature	IN Initials
#2	Michael J. Hein Signature	MJH Initials
#3	Robert L. Forester Signature	RLF Initials
#4	R. S. McGirt Signature	RSM Initials

NOTE #2: Following the recording of all of the above data, mark the data, time of day, the number 9.1 and sign each each of the eight recording voltmeter charts and two power factor charts showing the voltage changes.

FORM 9.3-3

Test Equipment Calibration Data

Symbol	Type	Serial Number	Calibration Date
RV1	EA #MS411B	GE093689	2-08-82
RV2	EA #MS411B	GE093699	2-08-82
RV3	EA #MS411B	GE093686	2-08-82
RV4	EA #MS411B	GE093685	2-08-82
RV5	EA #MS411B	GE093691	2-08-82
RV6	EA #MS411B	GE093697	2-08-82
RV7	EA #MS411B	GE093688	2-08-82
RV8	EA #MS411B	GE093666	2-08-82
PF1	EA #A601C	GE092059	11-06-81
PF2	EA #A601C	GE092120	10-06-81
A (52-1)	Fluke 8040A	GE042067	2-09-82
A (52-2)	Fluke 8040A	GE047110	2-09-82
A (52-3)	Fluke 8040A	GE041588	2-09-82
A (52-4)	Fluke 8040A	GE042452	2-09-82
A (52-5)	Fluke 8040A	GE047013	2-08-82
A (52-6)	Fluke 8040A	GE047106	2-09-82
A (52-12)	Fluke 8040A	GE092509	2-08-82
A (52-13)	Fluke 8040A	GE047015	2-09-82
A (52-14)	Fluke 8040A	GE041587	2-10-82
A (52-17)	Fluke 8040A	GE042449	2-10-82

Signature Robert L. Forester — Data Recorder — 2-13-82 Date

FORM 9.4-1

Transformer Tap Data

1. Start-Up Transformer No. 2
   High Voltage Tap Setting No change from original installation

2. Station Service Tranformer No. 2A
   High Voltage Tap Setting 3

Signature Robert L. Forester
Data Recorder

2/13/82
Date

FORM 9.5

10.0 Disconnections

After test is complete disconnect all portable test equipment and close cubical doors. Ensure panel meters are in off position prior to disconnecting portable meters.

Verified by and date	Michael J. Hein	2/13/82
	I&C Name	Date

Shift Foreman informed test equipment removed.

Verified by and date	Dave Segal	2/13/82
	Shift Foreman	Date

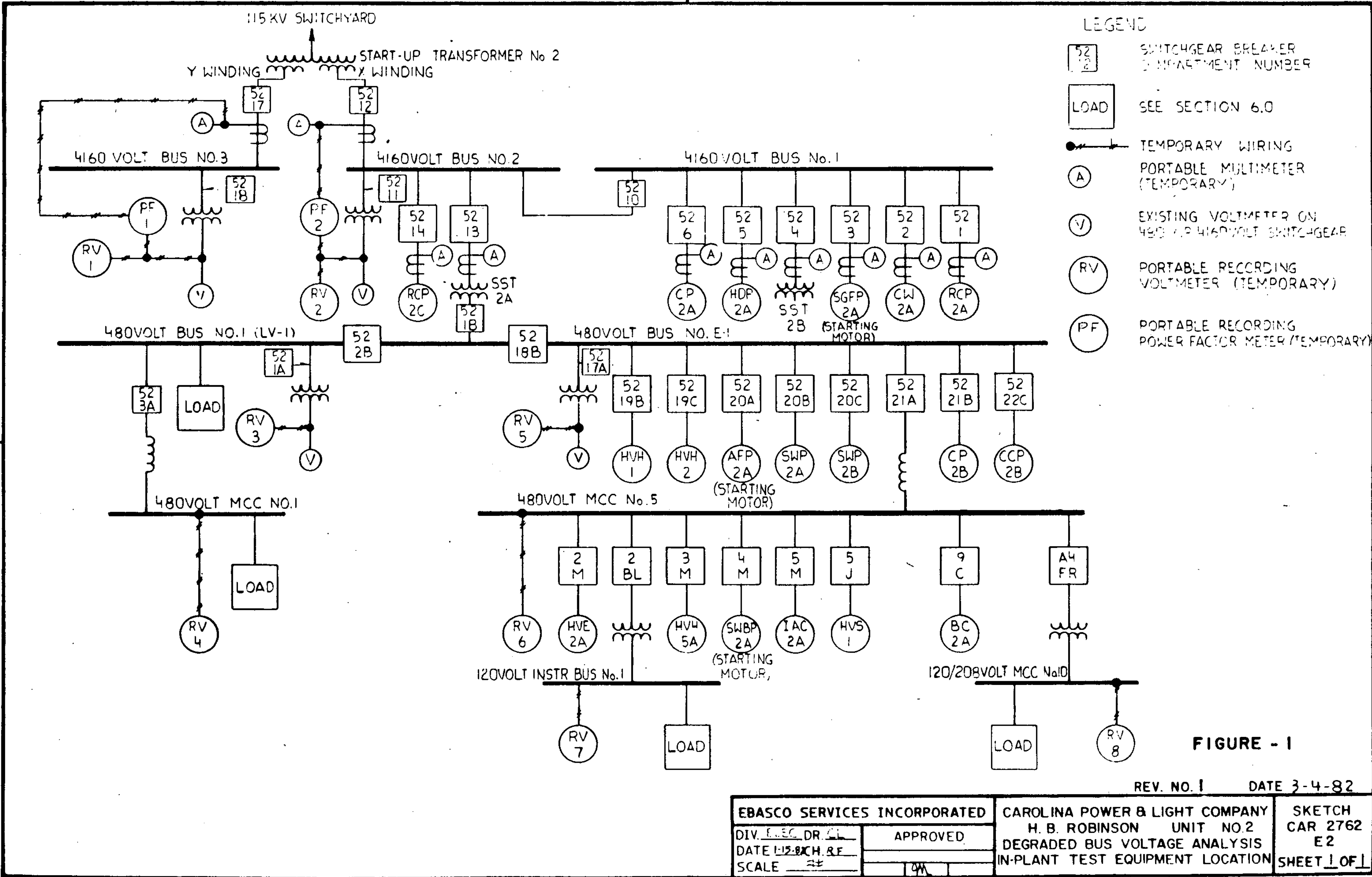

115 KV SWITCHYARD
START-UP TRANSFORMER No 2
Y WINDING
X WINDING
4160 VOLT BUS NO.3
4160VOLT BUS NO.2
4160 VOLT BUS No.1
480VOLT BUS NO.1 (LV-1)
480VOLT BUS NO. E-1
480VOLT MCC NO.1
480VOLT MCC No.5
120VOLT INSTR BUS No.1
120/208VOLT MCC No.10
SST 2A
SST 2B
(STARTING MOTOR)
LEGEND
SWITCHGEAR BREAKER COMPARTMENT NUMBER
LOAD SEE SECTION 6.0
TEMPORARY WIRING
PORTABLE MULTIMETER (TEMPORARY)
EXISTING VOLTMETER ON 480 OR 4160 VOLT SWITCHGEAR
PORTABLE RECORDING VOLTMETER (TEMPORARY)
PORTABLE RECORDING POWER FACTOR METER (TEMPORARY)
REV. NO. 1
DATE 3-4-82
EBASCO SERVICES INCORPORATED
DIV. ELEC DR. CL
DATE 1-15-82 CH. RF
SCALE
APPROVED
CAROLINA POWER & LIGHT COMPANY
H. B. ROBINSON UNIT NO. 2
DEGRADED BUS VOLTAGE ANALYSIS
IN-PLANT TEST EQUIPMENT LOCATION
SKETCH
CAR 2762
E2
SHEET 1 OF 1

FIGURE - 1

B. IN-PLANT TEST PROCEDURE TP-2

CAROLINA POWER AND LIGHT COMPANY

H. B. ROBINSON - 2

IN-PLANT POWER FACTOR
AND HARMONIC DISTORTION

TEST PROCEDURE

Table of Contents

FIGURES

1.0 PURPOSE

The purpose of the test procedure is as follows:

.1 To obtain measurements of power factor on safety related buses of the H.B. Robinson Unit No. 2 auxiliary electrical system to substantiate assumptions made for the computer simulation of test results obtained on 2/13/82.

.2 Obtain load (ampere) measurements on safety related buses to verify that power factor measurements are taken at approximately the same auxiliary load as recorded during the 2/13/82 test, that is, the same auxiliary load corresponding to 50 percent reactor power.

.3 Obtain steady-state voltage measurements in safety related buses to verify that power factor measurements are taken at approximately the same bus voltages recorded on 2/13/82.

4. Measure harmonic voltage distortion on the safety related buses to determine its magnitude and probable effects.

2.0 BASIC REQUIREMENTS

To verify assumed values of power factor, field measurements of power factors are required at the following buses:

Bus	Inst. ID
4160V Bus No. 2	PF-1
480V Bus No. E1	PF-2
480V MCC No. 1	PF-3
480V MCC No. 5	PF-4

The electrical loads on these buses must duplicate the conditions that existed during the 2/13/82 test, i.e., 50 percent reactor power.

In addition, a harmonic analysis of the voltage wave form will be made at each of the above stated buses.

3.0 IMPLEMENTATION

The data required as stated in Section 2.0 above will be obtained on the following buses:

.1 Power Factor Meters (Recorder)

Inst ID.	Bus No.	Location of Instrument close to
PF-1	4160 Volt Bus No. 2	Cubicle No. 12
PF-2	480 Volt Bus No. E1	Cubicle No. 18B
PF-3	480 Volt MCC No. 1	Reactor Cubicle
PF-4	480 Volt MCC No. 5	Reactor Cubicle

.2 Ampere Meters (Recorder)

RA-1	4160 Volt Bus No. 2	Cubicle No. 12
RA-2	4160 Volt Bus No. 2	Cubicle No. 13
RA-3	480 Volt Bus No. E1	Cubicle No. 18B
RA-4	480 Volt Mcc No. E5	Reactor Cubicle
RA-5	120/208 Volt MCC No.10	Distribution transformer at MCC 5
RA-6	120 Volt Inst. Bus No.1	Incoming Feed

.3 Voltmeters (Recorder)

RV-1	4160 Volt Bus No. 2	Cubicle No. 12
RV-2	480 Volt MCC No. 5	Reactor Cubicle

.4 Harmonic Analyzer/Detector

480 volt Bus No. 1	Cubicle No. 52-2B
480 Volt Bus No. E1	Cubicle No. 52-18B
480 Volt MCC No. 1	Reactor Cubicle
480 Volt MCC No. 5	Reactor Cubicle
120/208 Volt MCC No. 10	Incoming Feeder terminals
120 Volt Inst. Bus No. 1	Incoming Feeder terminals

Instruments listed in Sections 3.1, 3.2 and 3.3 shall be connected to the buses as listed above prior to or during start-up of the plant.

One (1) Harmonic Detector shall be used to take readings at the buses when reactor is at 50 percent power.

4.0 PRE-TEST REQUIREMENTS

4.1 Instrument Calibration

All portable instruments shall be calibrated by the rental agency specifically for H.B. Robinson Unit No. 2 "In Plant Test". The certificate of calibration shall be checked prior to installation of the instruments and shall be recorded in the proper space on attached Form 9.4.

4.2 Test Equipment

All portable instrumentation shall be placed close to the cubicles for connections as shown on Sketch CAR 2762 E3 prior to or during the start-up of the plant. The installation and functional operation of instruments shall be verified by a person other than the installer by signing in the proper space provided.

	Instrument	Installation By (I&C) Name/Date		Operation Verified By Name/Date	
4.2.1	Power Factor Meter PF-1	L. Smith	8/21/82	Michael J. Hein	8/21/82
4.2.2	Power Factor Meter PF-2	L. Smith	8/21/82	Michael J. Hein	8/21/82
4.2.3	Power Factor Meter PF-3	L. Smith	8/21/82	Michael J. Hein	8/21/82
4.2.4	Power Factor Meter PF-4	L. Smith	8/21/82	Michael J. Hein	8/21/82
4.2.5	Ampere Meter RA-1	L. Smith	8/21/82	Michael J. Hein	8/21/82
4.2.6	Ampere Meter RA-2	L. Smith	8/21/82	Michael J. Hein	8/21/82
4.2.7	Ampere Meter RA-3	L. Smith	8/21/82	Michael J. Hein	8/21/82
4.2.8	Ampere Meter RA-4	L. Smith	8/21/82	Michael J. Hein	8/21/82
4.2.9	Ampere Meter RA-5	L. Smith	8/21/82	Michael J. Hein	8/21/82
4.2.10	Ampere Meter RA-6	L. Smith	8/21/82	Michael J. Hein	8/21/82
4.2.11	Voltmeter RV-1	L. Smith	8/21/82	Michael J. Hein	8/21/82
4.2.12	Voltmeter RV-2	L. Smith	8/21/82	Michael J. Hein	8/21/82
4.2.13	Harmonic Detector HD-1	C. Price	8/26/82	Michael J. Hein	8/26/82

5.0 OPERATING REQUIREMENTS

5.1 Start-Up Transformer No. 2

During the operational testing, station auxiliary power source shall be from the 115kV switchyard through Start-Up Transformer No. 2.

Verified by and date D. McCaskill 8/26/82
(Operations) Name Date

5.2 4160 Volt Bus Nos. 1 and 2

4160 Volt Bus Nos. 1 and 2 shall be connected together by Tie Breaker No. 52-10. 4160 volt Bus No. 2 shall be connected to the X-winding of Start-Up Transformer No. 2 by Breaker No. 52-12.

Verified by and date	D. McCaskill (Operations) Name	8/26/82 Date

5.3 4160 Volt Bus No. 3

4160 Volt Bus No. 3 shall be connected to the Y-Winding of Start-Up Transformer No. 2 by Breaker No. 52-17.

Verified by and date	D. McCaskill (Operations) Name	8/26/82 Date

5.4 480 Volt Bus No. 1 and El

480 Volt Bus Nos. 1 and El shall be connected in the normal mode of operation to Station Service Transformer 2A.

Verified by and date	D. McCaskill (Operations) Name	8/26/82 Date

5.5 480 Volt MCC Nos. 1 and 5

480 Volt MCC Nos. 1 and 5 shall be connected 480 Volt Bus No. 1 and El, through breakers 52-3A and 52-21A respectively.

Verified by and date	L. Wiegand (Operations) Name	8/26/82 Date

5.6 120 Volt MCC and Instrument Bus Nos. 10 and 1

120/208 Volt MCC No. 10 and 120 Volt instrument bus No. 1 shall be connected to 480 Volt MCC No. 5 through breakers 4FR and 2BL respectively.

Verified by and date	L. Wiegand (Operations) Name	8/26/82 Date

5.7 Obtain shift Foreman's approval before starting hookup in Section 6.0.

J. Allen Shift Foreman	8/21/82 Date

6.0 TEST EQUIPMENT

.1 Recording power factor meters shall be an Esterline Angus model No. 601C. The recorders shall be connected and the set points shall be adjusted as follows:

a. 4160 Volt Bus No. 1 Cubicle No. 12 (PF-1)

Connections: External input connections for the anolog system are made to terminals located on the rear of the recorder case.

Turn the ammeter switch located on the switchgear cubicle (52-12) panel to "off" position.

Break the current loop to the ammeter of cubicle (52-12) by lifting either wire on the meter terminals.

Connect the lifted wire to the + or A' terminal on the power factor recorder (PF-1).

Connect the - or A terminal of the power factor meter to the bare terminal of the ammeter located on cubicle (52-12) panel.

Connect the voltage terminals of the power factor meter to the voltmeter terminals located on cubicle (52-11) panel. Connect chart drive power (power cord) to the external 120 volt ac power supply.

Verified by and date Boyce McLester (I & C) Name — 8/21/82 Date

b. 480 Volt Bus No. E1 Cubicle No. 18B (PF-2)

Connections: External input connections for the anolog system are made to terminals located on the rear of the recorder case.

Install clamp-on or split core type current transformer (3000-5 amp) Model No. AEMC 3035 at the transition bus E-1, located at the back side of the instrument cubicle No. 52-17A of 480 volt bus No. 1.

If clamp-on or split core C.T. cannot be installed at the transition bus, the standard bus C.T. may be installed at the breaker No. 52-18B. In such case the power factor recorder PF-2 and ampere recorder RA-3 shall be installed in series with the standard bus C.T. and therefore only one C.T. will be required.

Connect 5 amp C.T. leads to A and A' terminals of the power factor meter (PF-2). Connect voltage terminals of the power factor meter to the 480 volt bus in cubicle (52-18B). Connect chart drive power (power cord) to the external 120 volt ac power supply.

Verified by and date Jack Windham 8/26/82
(I & C) Name Date

c. <u>480 Volt MCC No. 1</u> (PF-3)

Connections: External input connections for the analog system are made to terminals located on the rear of the recorder case.

Install split core current transformer (1000-5 amp) Model No. ANNIS A-1000 around Phase "A" of the feed cable for 480 volt MCC No. 1 located in the overhead tray. The power factor meter (PF-3) should be located in the proximity of the C.T. location to minimize length of C.T. leads. Connect 5 amp C.T. leads to A and A' terminals of the power factor recorder (PF-3).

Connect voltage terminals of the power factor recorder to the 480 volt bus (phase A and B) of the reactor.

Connect chart drive power (power cord) to the external 120 volt ac power supply.

Verified by and date L. Held 8/21/82
(I & C) Name Date

d. <u>480 Volt MCC No. 5</u> (PF-4)

Connections: External input connections for the analog system are made to terminals located on the rear of the recorder case.

Locate existing junction box above current limiting reactor cubicle of MCC No. 5. Open the junction box and locate cable C21043A and G (2-1/c 500 MCM RHW insulated cables). Locate black color phase cables. Two black color cables come to a common point near the bottom of the junction box. Place split core current transformer Model No. ANNIS A-1000 around both black cables at this point. If the split core C.T. can not be installed due to the space restriction at this place, install the C.T. in the tray where cable is accessible. The power factor recorder should be located in the proximity to minimize the length of C.T. leads. Connect 5 amp C.T. leads to A and A' terminals of the power factor recorder (PF-4).

Connect voltage terminals of the power factor recorder to the 480 volt bus (phase A & B) terminals of the reactor for MCC No. 5.

Connect chart drive power (power cord) to the external 120 volt ac power supply.

Verified by and date	L. Held	8/21/82
	(I & C) Name	Date

Caution:

1. All current transformer secondary terminals shall be kept shorted if C.T. is to be left on an energized bus.

2. The clamp-on type C.T.s are equipped with secondary terminals for banana plugs. These plugs shall be secured by additional means to prevent accidental removal of the plugs while clamp-on C.T. is installed on an energized bus.

.2 Recording ampere meters RA-1, RA-2 and RA-3 shall be Esterline Angus model No. A601C. The recorders shall be connected and the set points shall be adjusted as follows:

a. 4160 Volt Bus No. 2 Cubicle No. 12 (RA-1)

Connections: External input connections for the analog system are made to terminals located on the rear of the recorder case.

Locate the recorder close to the power factor recorder (PF-1) connected in accordance with Paragraph 6.1(a).

Turn ammeter switch located on the cubicle (52-12) panel to "off" position.

Disconnect wire at terminal (- or A) of power factor meter (PF-1) and connect this wire to the terminal (- or A) of ampere recorder RA-1.

Connect jumper wire from (- or A) terminal of power factor meter (PF-1) to the (+ or A') terminal of ampere recorder (RA-1).

Connect chart drive power (power cord) to the external 120 volt ac power supply.

Verified by and date	Boyce McLester	8/21/82
	(I & C) Name	Date

b. 4160 Volt Bus No. 2 Cubicle No. 13 (RA-2)

Connections: External input connections for the analog system are made to terminals located on the rear of the recorder case.

Turn the ammeter switch located on the switchgear cubicle (52 - 13) panel to "off" position.

Break the current loop to the ammeter of cubicle (52 - 13) by lifting either wire on the meter terminals.

Connect the lifted wire to the + or A' terminal on the ampere recorder (RA-2).

Connect the - or A terminal of the ampere recorder (RA-2) to the bare terminal of the ampere meter on the cubicle (52 - 13) panel.

Connect chart drive power (power cord) to the external 120 volt ac power supply.

Verified by and date	Boyce McLester	8/21/82
	(I & C) Name	Date

c. 480 Volt Bus No. E1 Cubicle No. 52-18B (RA-3)

External input connections for the analog system are made to terminals located on the rear of the recorder case.

Install clamp-on type fully insulated current transformer (3000 - 5 amp) Model No. AEMC 3035 close to the clamp on C.T. installed for (PF-2) as described in Paragraph 6.1 (b).

Connect 5 amp C.T. leads to terminals A and A' located on the ampere recorder (RA-3)

Connect chart drive power (power cord) to the external 120 volt ac power supply.

Verified by and date	Jack Windham	8/21/82
	(I & C) Name	Date

d. <u>480 Volt MCC No. 5</u> (RA-4)

Recording ampere meters RA-4, RA-5 and RA-6 shall be Esterline Angus Model No. S22907. The recorders shall be connected and the set points shall be adjusted as follows:

Connections: External input connections for the analog system are made to terminals located on the rear of the recorder case.

Install clamp-on type fully insulated current transformer furnished with the recorder around one phase of the feed cable for 480 volt MCC No. 5 close to the C.T. installed for power factor recorder (PF-4) as described in Paragraph 6.1(d).

Connect plug-in connector of CT cable to the recorder (RA-4) C.T. input terminals.

Connect chart drive power (power cord) to the external 120 volt ac power supply.

Verified by and date	D. Meredith	8/22/82
	(I & C) Name	Date

e. <u>120/208 Volt MCC No. 10</u> (RA-5)

Connections: External input connections for the analog system are made to terminals located on the rear of the recorder case.

For installing current transformer for 120/208 volt MCC #10, go to MCC No. 5. Locate MCC No. 10 breaker cubicle (located at the far right side of the MCC No. 5. 45 KVA transformer feeding MCC No. 10 is located directly below the feeder breaker.

Open transformer cubicle and locate middle transformer (3-15 KVA single phase transformers are connected for 3-phase service).

Locate 1/0 mineral insulated cable with black tape connected to the secondary of the transformer.

Install clamp on current transformer furnished with the recorder AEMC 1035 around this cable about 3" from the splice.

Connect plug-in connector of C.T. cable to the recorder RA-5 C.T. imput terminals.

Connect chart drive power (power cord) to the external 120 volt ac power supply.

Verified by and date D. Meredith (I & C) Name — 8/22/82 Date

f. <u>120 Volt Instrument Bus No. 1</u> (RA-6)

Connections: External input connection for the analog system are made to terminals located on the rear of the recorder case.

Remove outside panel cover of the Instrument Bus No. 1 and locate breaker tagged "L-1".

Follow 1/0 black cable from breaker L-1 to exit condulet on right side of the panel.

Install clamp-on type current transformer furnished with the recorder around this cable close to the condulet.

Connect plug-in connector of C.T. cable to the recorder RA-6 C.T. input terminals.

Connect chart drive power (power cord) to the external 120 volt ac power supply.

Verified by and date Jack Windham (I & C) Name — 8/21/82 Date

.3 Recording voltmeters shall be Esterline Angus model No. S22907. The recorders shall be connected and adjusted the set points as follows:

a. <u>4160 Volt Bus No. 2 Cubicle No. 12</u> (RV-1)

Connections: Turn voltmeter switch on 4160 volt breaker cubicle (52-12) to "off" position.

Connect the spade lugs from the ac terminal blocks on rear of recording voltmeter to the two studs on near of the voltmeter on 4160 volt breaker cubicle (52-12).

Connect chart drive power (power cord) to the external 120 volt ac power supply.

Verified by and date Boyce McLester 8/21/82
(I & C) Name Date

b. <u>480 Volt MCC No. 5 Reactor Cubicle</u> (RV-2)

Connect voltage terminals of the recording voltmeter (RV-2) located on rear of the recorder to 480 volt bus phase A & B terminals at the reactor cubicle of MCC No. 5.

Connect chart drive power (power cord) to the external 120 volt ac power supply.

Verified by and date D. Meredith 8/22/82
(I & C) Name Date

.4 The spectrum analyzer will be Hewlett Packard and Model No. 3580A and will be used to detect the harmonic distortion on the following buses:

480 volt Bus No. 1, 480 volt Bus No. E1, 480 volt MCC No. 1, 480 volt MCC No. 5 and 120/208 volt MCC No. 10.

There will be one spectrum analyzer which will be used to detect the harmonic distortion on the buses as listed above and other suspected buses as determined by the testing engineer.

Use following procedure for making connections at each bus.

Connections:

1. Check the external power supply line voltage.

2. Check the voltage rating of the analyzer at the rear of the unit near fuse block.

3. If the line voltage is different than the rating visible on Pc card, then pull the fuse out and align correct side of the dc board to show correct line voltage to be applied.

4. Install correct fuse type.

   For 120 volt ac operation use 0.5A, 250V fuse HP part No. 2110-0012.

5. Connect the detachable ac power cord to the rear panel power receptacle and to the power source.

6. Connect voltage devider probe assembly to the bus at a convenient place.

7. Adjust the probe for optimum frequency response in accordance with the instruction manual.

7.0 TEST PROCEDURE

At least 60 minutes prior to reaching 50 percent reactor power, initialize all instruments, set time of day on charts and check for proper setting as follows:

.1 Power Factor Recorders

Power	-	On
Chart Drive	-	On
Chart Speed Range	-	HR
Chart Speed	-	12 inch per hr. (Preset)

If the chart recorder gives an exceptionally low reading i.e., 50 percent or below, reverse the voltage input to the meter.

Verified by, time and date	C. Price	1008	8/26/82
	(I & C) Name	Time	Date

.2 Ampere Recorders (Model #601C)

Power	-	On
Chart Drive	-	On
Chart Speed Range	-	HR
Chart Speed	-	12 inch per hr. (Preset)

Verified by, time and date	C. Price	1008	8/26/82
	(I & C) Name	Time	Date

Ampere Recorders (Model #S22907)

Power	-	On
Chart Drive	-	On
Chart Speed Range	-	HR
Chart Speed	-	12 inch per hr.
Operating Range	-	0-500 amps

.3 Voltage Recorders

Power	-	On
Chart Drive	-	On
Chart Speed Range	-	HR
Chart Speed	-	12 inch per hr.

Verified by, time and date	C. Price	1008	8/26/82
	(I & C) Name	Time	Date

.4 Spectrum Analyser

For operation on the 10 Hz, 30 Hz, 100 Hz of 300 Hz Bandwidth proceed as follows:

a. Turn the instrument on (Paragraph 3-192).

b. Set the 3580A controls in accordance with Section 3 Pages 3-1 through 3-30 of the instruction manual.

c. Using the adaptive sweep control, set the baseline threshold to -60 dB on the display.

d. Using a small screwdriver, adjust the front panel CAL 10 kHz potentiometer so that the peak of the 10 kHz response is exactly full scale.

e. Set the amplitude mode to Log 1 dB/Div. Using the adaptive sweep control, set the baseline threshold tothe bottom of the display. Repeat Step d.

.5 Record time when reactor is at 10 percent power.

Time 23 Hr 00 Min. PM

Verified by and date Michael J.Hein (I & C) Name 8/25/82 Date

.6 Record time when reactor is at 50 percent power.

Time 10 Hr 00 Min. AM

Verified by and date Michael J. Hein (I & C) Name 8/26/82 Date

.7 Connect the Spectrum Analyser to each of the following buses and record the reading in the sequence listed below:

Bus	Distortion Reading Frequency	Amplitude
a. 480 Volt Bus No. 1	60	1
	180	0
	180	0
	180	0
	180	0
	180	0
	180	0
	180	0
b. 480 Volt Bus No. E1	60	1 (Reference)
	180	.075
	300	.04
	420	0
	540	0
	540	0
	540	0
	540	0

Bus	Distortion Reading Frequency	Amplitude
c. 480 Volt MCC No. 1	60	1
	120	.05
	180	.02
	300	.03
	420	0
	540	0
	600	0
d. 480 Volt MCC No. 5	60	1
	180	.01
	300	.02
	420	.005
	540	0
	600	0
	600	0
	600	0
e. 120/208 Volt MCC No. 10	60	1
	180	0
	180	0
	180	0
	180	0
	180	0
	180	0
	180	0
f. 120 Volt Inst. Bus No. 1	60	1
	180	.02
	300	.02
	420	.01
	540	.01
	540	0
	540	0
	540	0

Verified by and date C. Price 8/26/82
(I & C) Name Date

8.0 REVIEW TEST RESULTS FOR ERRONEOUS READINGS:

Verified by and date	Michael J. Hein	8/26/82
	(I & C) Name	Date

9.0 DISCONNECTION AND REMOVAL OF TEMPORARY INSTRUMENTS

All portable instruments shall be disconnected and the plant permanent instruments shall be connected for normal operation as follows:

9.1 Recorders

PF-1

a. Turn power off for recorders PF-1, RA-1 and RV-1 and lift ink pens to avoid spreading of excess ink on the chart paper.

b. Remove chart of PF-1 and at the bottom of chart write the following:

Bus Identification	4160 V Bus No. 2
Cubicle No.	11 & 12
Recorder Serial No.	093375

c. Turn the ammeter switch located on the switchgear cubicle (52-12) panel to "OFF" position.

d. Disconnect wire at - or A terminal on the ammeter recorder (RA-1) and at the ammeter terminal located on the cubicle panel.

e. Disconnect wire at + or A' terminal on the power factor recorder (PF-1) and connect this wire to the bare ammeter terminal located on the cubicle panel.

f. Check both ammeter terminals which are now connected to the ammeter switch terminals as they were orininally connected.

g. Turn ammeter switch to phase "A" position and see the meter recording.

Caution: If there is no movement on the panet ammeter turn the switch to "OFF" position immediately and recheck the ammeter connections to the ammeter switch.

h. Turn the voltmeter switch to "OFF" position.

i. Disconnect external wires at the voltmeter terminals located on cubicle (52-11) panel.

j. Disconnect wires at the voltage terminals of the recorders (PF-1 and RV-1).

k. Check the normal operation of the voltmeter and ammeter.

l. When satisfied with the normal operation of the panel meters, close the cubicle panel and secure it for normal operation.

Verified by and date L. Smith (I & C) Name   8/26/82 Date

PF-2

a. Turn power off and lift ink pen to avoid spreading of excess ink on the chart.

b. Remove chart and at the bottom of the chart write the following:

Bus Identification	480 V Bus No. E1
Cubicle No.	18B
Recorder Serial No.	092059

c. Remove clamp-on type fully insulated C.T. installed at the 480 volt transition bus in the cubicle 52-18B.

d. Remove banana clips from current transformer.

e. Disconnect C.T. leads at the back of the recorder.

f. Disconnect external wires at the 480 volt bus located on the back side of cubicle (52-18B) panel.

g. Disconnect wires at the voltage terminals of the recorder.

h. Check the normal operation of the voltmeter.

i. When satisfied with the normal operation of the voltmeter, close the cubicle panel and secure it for normal operation.

Verified by and date L. Smith (I & C) Name   8/26/82 Date

PF-3

a. Turn power off and lift ink pen to avoid spreading of excess ink on the chart paper.

b. Remove chart and at the bottom of the chart write the following:

Bus Identification	MCC No. 1
Cubicle No.	Reactor Cubicle
Recorder Serial No.	092119

c. Remove split core C.T. from the cable in the tray.

d. Remove wires from the C.T. and the back of the recorder at terminals A and A'.

e. Disconnect voltage supply wires connected at the 480 volt bus (Phase A and B) terminals.

f. Disconnect wires at the voltage terminals of the recorder.

g. Close and secure the cubicle for normal operation.

Verified by and date L. Smith (I & C) Name — 8/26/82 Date

PF-4

a. Turn power off for PF-4 and RV-2, and lift ink pen to avoid spreading of excess ink on the chart paper.

b. Remove chart and at the bottom of the chart write the following:

Bus Identification	MCC No. 5
Cubicle No.	Reactor Cubicle
Recorder Serial No.	091744

c. Remove all clamp on C.T.'s from reactor cubicle cables.

d. Remove wires from the C.T. and the back of the recorder at terminals A and A'.

e. Disconnect all voltage supply wires for PF-4 and RV-2 at the reactor terminals of MCC #5.

f. Disconnect wires at the voltage terminals of the recorder PF-4.

g. Close and secure the cubicle for normal operation.

Verified by and date	Michael J. Hein	8/26/82
	(I & C) Name	Date

RA-1

a. Remove chart and at the bottom of the chart write the following:

Bus Identification	4160 V Bus No. 2
Cubicle No.	12
Recorder Serial No.	092925

Verified by and date	Michael J. Hein	8/26/82
	(I & C) Name	Date

RA-2

a. Turn power off and lift ink pen to avoid spreading of excess ink on the chart.

b. Remove chart and at the bottom of the chart write the following:

Bus Identification	4160 V Bus No. 2
Cubicle No.	13
Recorder Serial No.	090414

c. Turn ammeter switch located on the cubicle (52-13) panel to "OFF" position.

d. Disconnect - or A terminal of the recorder and the external wire at the ammeter terminal.

e. Disconnect + or A' terminal of the recorder and connect this lifted wire to the bare terminal of the ammeter located at the switchgear cubicle.

f. Check the ammeter terminals which are now connected as they were originally.

g. Turn the ammeter switch to phase "A" position and see the meter reading.

Caution: If there is no movement of the panel ammeter, turn the switch to "OFF" position immediately and recheck the ammeter connections to the ammeter switch.

h. Close and secure the panel for normal operation.

Verified by and date	L. Smith (I & C) Name	8/26/82 Date

RA-3

a. Turn power off and lift ink pen to avoid spreading of excess ink on the chart paper.

b. Remove chart and at the bottom of the chart write the following:

Bus Identification	Bus E1
Cubicle No.	18B
Recorder Serial No.	090415

c. Remove clamp on type C.T. from the 480 volt bus at the cubicle (52-18B).

d. Remove banana clips from the C.T. and C.T. leads from the back of the recorder terminals A and A'.

e. Close and secure the cover plate on the transition bus of Bus #E1 Cubicle #52-18B.

Verified by and date	L. Smith (I & C) Name	8/26/82 Date

RA-4

a. Turn power off and remove felt tip ink cartridge to avoid ink marks on the chart.

b. Remove chart and at the bottom of the chart write the following:

Bus Identification	480 V MCC No. 5
Cubicle No.	Reactor Cubicle
Recorder Serial No.	093684

Verified by and date L. Smith (I & C) Name 8/26/82 Date

RA-5

a. Turn power off and remove felt tip ink cartridge to avoid ink marks on the chart.

b. Remove chart and at the bottom of the chart write the following:

Bus Identification	MCC No. 10
Cubicle No.	Transformer Cubicle
Recorder Serial No.	093684

c. Remove clamp-on type C.T. from the transformer compartment.

d. Remove C.T. plug-in connections from the recorder.

e. Close and secure the cover plate on the transformer compartment of MCC #5 for normal operation.

Verified by and date L. Smith (I & C) Name 8/26/82 Date

RA-6

a. Turn power off and remove felt tip ink cartridge to avoid ink marks on the chart.

b. Remove chart and at the bottom of the chart write the following:

Bus Identification	Inst. Bus No. 1
Cubicle No.	Incoming Cable
Recorder Serial No.	093696

c. Remove clamp-on type C.T. from the instrument panel.

d. Remove C.T. plug-in connections from the recorder.

e. Close and secure the instrument panel cover for normal operation.

Verified by and date L. Smith (I & C) Name — 8/26/82 Date

RV-1

a. This recorder was disconnected while disconnecting PF-1.

b. Remove chart and at the bottom of the chart write the following:

Bus Identification 4160 V Bus No. 2
Cubicle No. 11
Recorder Serial No. 093688

Verified by and date L. Smith (I & C) Name — 8/26/82 Date

RV-2

a. This recorder was disconnected while disconnecting PF-1.

b. Remove chart and at the bottom of the chart write the following:

Bus Identification MCC No. 10
Cubicle No. Reactor Cubicle
Recorder Serial No. 093685

Verified by and date L. Smith (I & C) Name — 8/26/82 Date

Unplug power cords of all the recorders and pack the instruments in the shipping containers.

Disconnect spectrum analyzer from voltage devider probe assembly.

Record Serial No. 094132

Data Recorded by and date L. Smith (I&C) Name — 8/26/82 Date

Inform the operator of completion of test

L. Smith Name — 12:30 Time — 8/26/82 Date

9.2 SUMMARY OF TEST RESULTS:

Bus	Amps	Volts	P.F.
a. 4160 Volt Bus No. 2	2800	4140	0.88
b. 480 Volt Bus No. E1	1290	-	0.76
c. 480 Volt MCC No. 5	265	468	0.85
d. 480 Volt MCC No. 1	-	-	-
e. 120/208 Volt MCC No. 10	8.75		
f. 120 Volt Inst. Bus No. 1	30		

Data Recorded by and date Indru Naranyani (I&C) Name 8/26/82 Date

Data Verified by and date Michael J. Hein (I&C) Name 8/26/82 Date

9.3 SUMMARY OF HARMONIC DETECTION:

Bus	Frequencies				
a. 480 Volt Bus No. 1	60	-	-	-	-
b. 480 Volt MCC No. E1	60	180	300	-	-
c. 480 Volt MCC No. 1	60	120	180	300	-
d. 480 Volt MCC No. 5	60	180	300	420	-
e. 120/208 Volt MCC No. 10	60	-	-	-	-
f. 120 Volt Inst. Bus No. 1	60	180	300	420	540

Data Recorded by Indru Naranyani (I&C) Name 8/26/82 Date

Data Verified by Michael J. Hein (I&C) Name 8/26/82 Date

9.4 TEST EQUIPMENT CALIBRATIONS DATA

	Symbol	Type	Serial Number	Calibration Date
1.	PF-1	EA	093375	7-12-82
2.	PF-2	EA	092059	7-12-82
3.	PF-3	EA	092119	7-12-82
4.	PF-4	EA	091744	7-12-82
5.	RA-1	EA	092925	7-12-82
6.	RA-2	EA	090414	7-12-82
7.	RA-3	EA	090415	7-12-82
8.	RA-4	EA	093702	7-13-82
9.	RA-5	EA	093684	7-13-82
10.	RA-6	EA	093696	7-13-82
11.	RV-1	EA	093688	7-13-82
12.	RV-2	EA	093685	7/12/82
13.	HD-1	H.P.	094132	7/12/72

Data Recorded by Indru Naranyani (I&C) Name — 8/26/82 Date

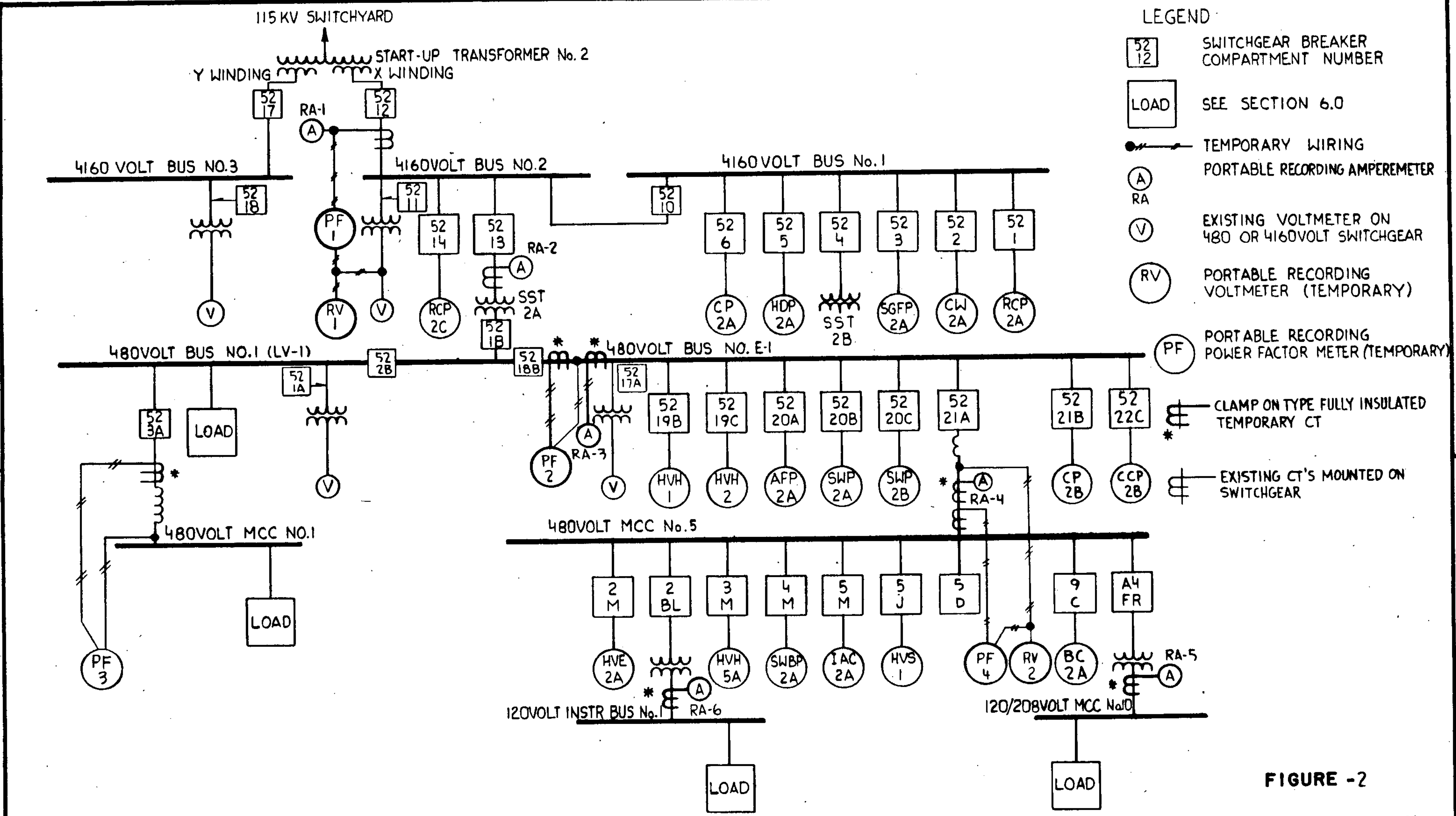


FIGURE -2

REV. NO. 2 DATE 9-15-82

EBASCO SERVICES INCORPORATED		CAROLINA POWER & LIGHT COMPANY H. B. ROBINSON UNIT NO.2 DEGRADED BUS VOLTAGE ANALYSIS IN-PLANT TEST EQUIPMENT LOCATION	SKETCH CAR 2762 E3 SHEET 1 OF 1
DIV. ELEC DR. CL DATE 7-15-82 CH. RF SCALE #	APPROVED		

SECTION II

C. Summary of Test Results

This section includes summary of test results for the "inplant" test TP-1 & TP-2.

The discussion on test results is included in Section I, paragraph 5.6.

H. B. ROBINSON UNIT #2
IN-PLANT TEST TP-1
SUMMARY OF TEST RESULTS

Device I.D.	Location	Chart Scale	Test No. 1 Before	Test No. 1 During	Test No. 1 After	Test No. 2 Before	Test No. 2 During	Test No. 2 After	Test No. 3 Before	Test No. 3 During	Test No. 3 After
PF1	4160V Bus #3	-	0.88 Lag	-	-	0.88 Lag	-	-	0.88 Lag	-	-
PF2	4160V Bus #2	-	0.88 Lag	-	-	0.88 Lag	-	-	0.88 Lag	-	-
RV1	4160V Bus #3	60V/mm	4170	4160	4150	4140	4140	4140	4140	4080	4140
RV2	4160V Bus #2	60V/mm	4140	4110	4140	4140	4110	4140	4140	3510	4080
RV3	480V Bus #1	6V/mm	463.5	435	462	459	453	457.5	457.5	385.5	453
RV4	480V MCC #1	6V/mm	456	429	454.5	453	444	453	450	378	444
RV5	480V Bus-E1	6V/mm	453	420	450	444	441	444	444	372	441
RV6	480V MCC #5	6V/mm	438	402	433.5	432	406.5	426	426	354	421.5
RV7	120V Inst. Bus #1	1.5V/mm	111.8	112.5	111.8	111.8	111.8	112.1	112.1	112.9	112.1
RV8	120V MCC #10	1.5V/mm	110.0	102	110.3	109.5	103.5	108	108	90	107.3
RV8	208V MCC #10	2.6V/mm	192.2	176.7	191	189.6	178.4	187	187	155.8	185.8
*AMP-1	BKR 52-1	-	704	-	706	709	-	709	708	-	715
AMP-2	BKR 52-2	-	274	-	274	275	-	274	277	-	277
AMP-3	BKR 52-3	-	-	-	-	-	-	-	-	-	480
AMP-4	BKR 52-4	-	113	-	114	106	-	120	112	-	106
AMP-5	BKR 52-5	-	85	-	85	85	-	85	85	-	85
AMP-6	BKR 52-6	-	291	-	291	291	-	291	291	-	291
AMP-7	BKR 52-12	-	2452	-	2488	2488	-	2496	2504	-	3000
AMP-8	BKR 52-13	-	284	-	315	316	-	330	334	-	333
AMP-9	BKR 52-14	-	707	-	707	707	-	707	707	-	707
AMP-10	BKR 52-17	-	2500	-	2506	2512	-	2512	2512	-	2344

*All Ampere Meters were installed on 4160 Volt Bus 1, 2 & 3 Breaker Cubicles.

Input By [signature] Date 9/20/82

Input Verified By [signature] Date 9/20/82

Results Checked By [signature] Date 9/20/82

H. B. ROBINSON UNIT #2
IN-PLANT TEST PROCEDURE TP-2

SUMMARY OF TEST RESULTS

Device	Location	Chart Scale	Reading Minimum	Reading Maximum
RA-1	4160 Volt Bus #2	800 amp/digit	2776A	2800A
RA-2	4160 Volt Bkr 13	120 amp/digit	210A	216A
RA-3	480 Volt Bus E1	600 amp/digit	1260A	1290A
RA-4	480 Volt MCC 5	5 amp/mm	260A	270A
RA-5	208 Volt MCC 10	0.25 amp/mm	8.5A	9A
RA-6	120 Volt Inst. Bus #1	1 amp/mm	30A	30A
PF-1	4160 Volt Bkr 12 + 11	Direct Reading	0.88 Lag	.90 Lag
PF-2	480 Volt Bus #E1	Direct Reading	0.76 Lag	.78 Lag
PF-3	480 Volt MCC #1	Direct Reading	0.76 Lag	.80 Lag
PF-4	480 Volt MCC #5	Direct Reading	0.84 Lag	.86 Lag
RV-1	4160 Volt Bkr. 11	60V/mm	4080V	4200V
RV-2	480 Volt MCC 5	6V/mm	462V	474V

Input By [signature] Date 9/20/82

Input Verified By [signature] Date 9/20/82

Results Checked By [signature] Date 9/27/82

D. One Line Diagrams for Computer Studies

1. General

The computer studies covered under this report are in specific response to NRC questions. These analyses were conducted to determine the voltage conditions under steady state and transient conditions for the major plant operating modes.

The computer analysis is also included for Voltage Analysis Verification Test using actual measured values.

2. List of One Line Diagram for Computer Studies

A. STUDY NO. 1X
Normal operation with Unit Aux. Transformer "X" Winding Loads.

B. STUDY NO. 2X
Normal operation with Start-up Transformer "X" Winding Loads.

C. STUDY NO. 2Y
Normal operation with Start-up Transformer "Y" Winding Loads.

D. STUDY NO. 3X
Emergency operation with Start-up Transformer "X" Winding Loads and Safety injection actuated.

E. STUDY NO. 3Y
Emergency operation with Start-up Transformer "Y" Winding Loads and safety injection actuated.

F. STUDY NO. 4Y
Cold Shutdown operation with Start-up Transformer "Y" Winding Loads.

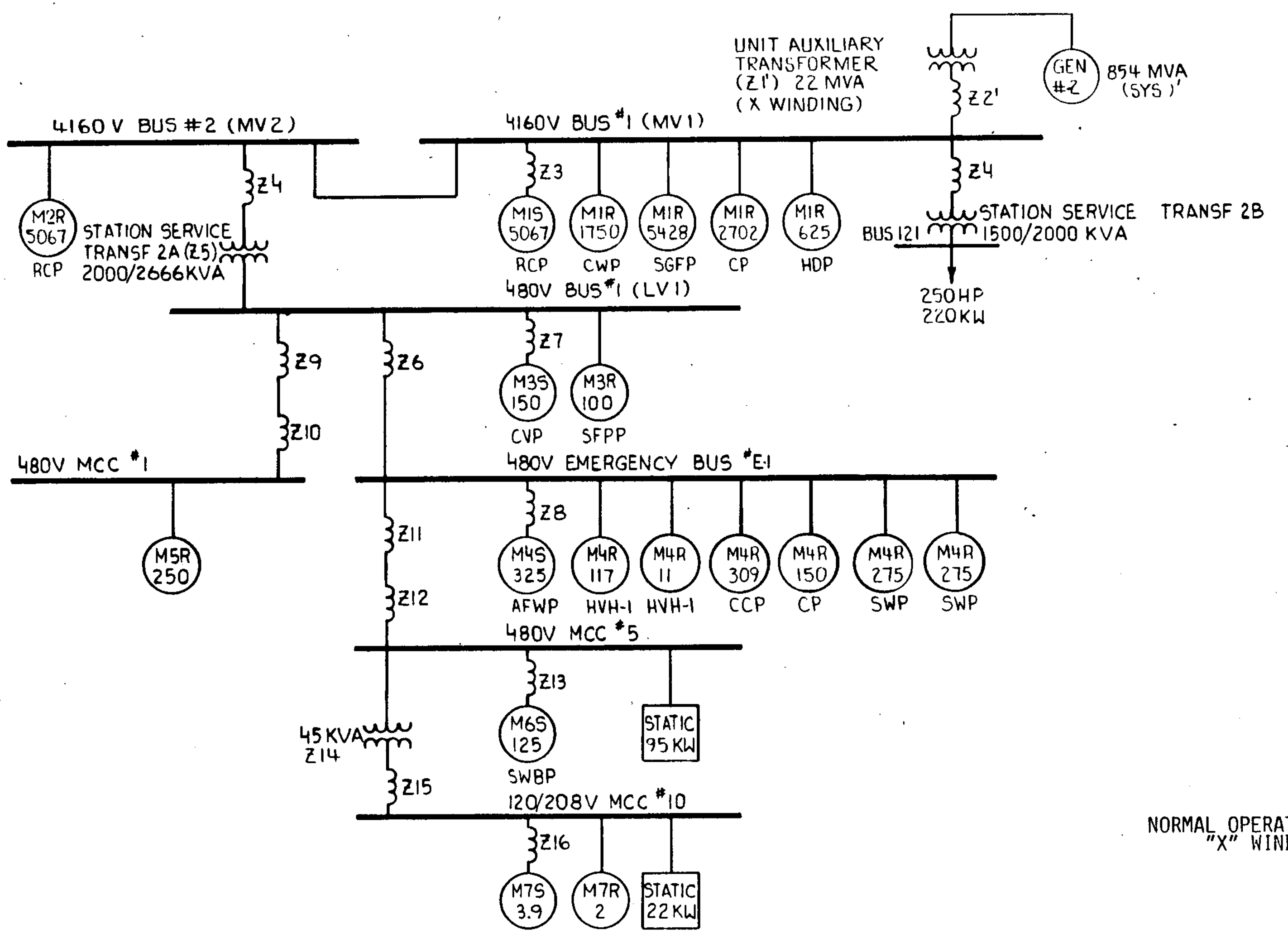
G. STUDY NO. 5X
Normal Operation with Start-up Transformer "X" Winding Loads for "In-Plant Test Procedure.

APPENDIX - A
STUDY NO.: IX
100% PLANT LOAD
NORMAL OPERATION WITH
UNIT AUXILIARY TRANSFORMER "X" WINDING

Input By Indu Narayani Date 9/15/82

Input Verified By Robert L Forester Date 9/20/82

Results Checked By W. W. Field Date 9/27/82



NOTE

SEE SHEET 7 FOR DETAILED INFORMATION

STUDY NO. 1X
NORMAL OPERATION WITH UNIT AUXILIARY TRANSFORMER "X" WINDING BREAK HORSEPOWER LOADS

REV. NO. 3 DATE 9-20-82

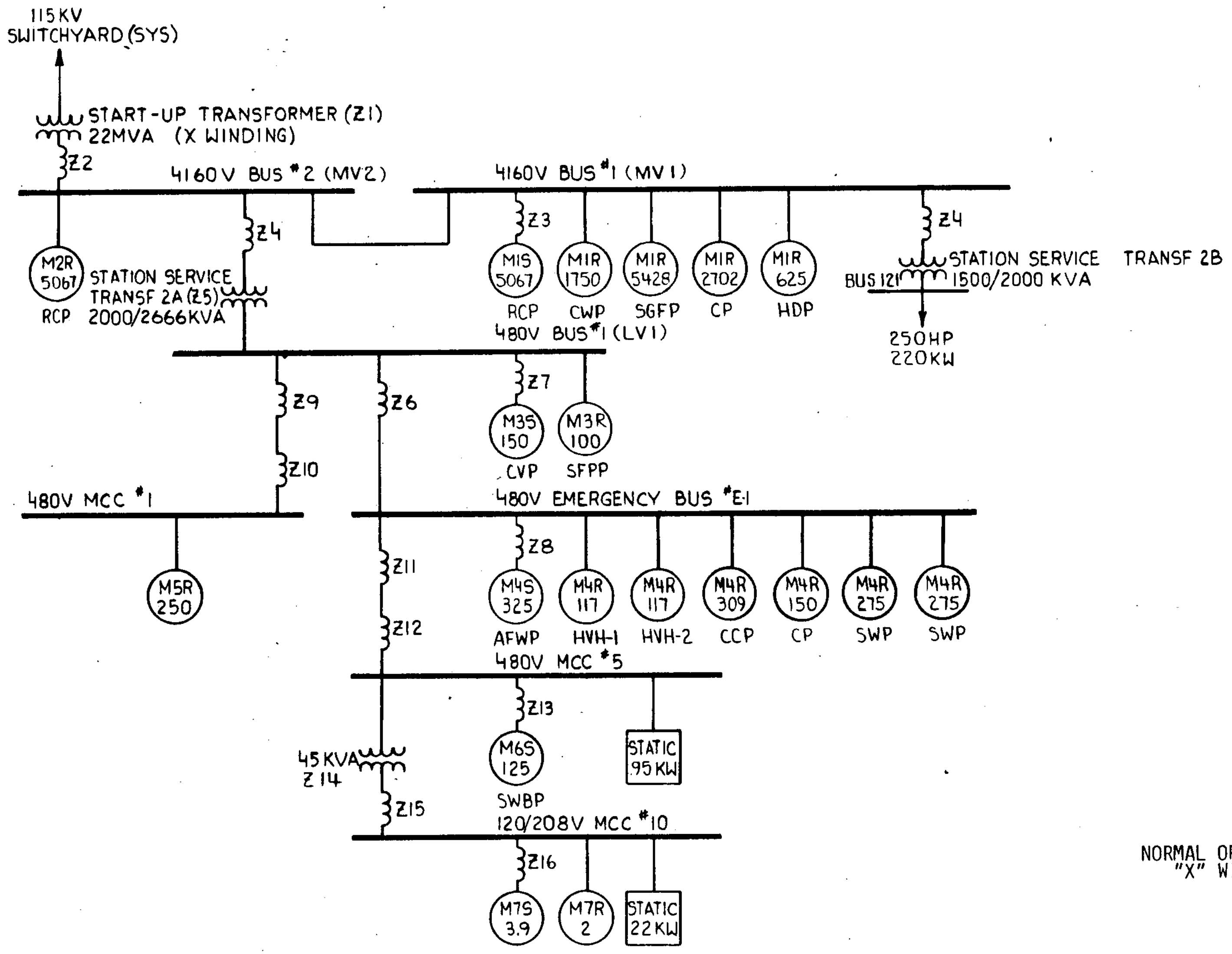
EBASCO SERVICES INCORPORATED		CAROLINA POWER & LIGHT COMPANY H.B. ROBINSON UNIT NO. 2 DEGRADED BUS VOLTAGE ANALYSIS APPENDIX-A	SKETCH CAR 2762 E1
DIV. ELEC. DR. C.L.	APPROVED		
DATE CH.			
SCALE			SHEET 1 OF 8

APPENDIX - B
STUDY NO.: 2X
100% PLANT LOAD
NORMAL OPERATION WITH
START-UP TRANSFORMER "X" WINDING

Input By Indra Narayani Date: 9/15/82

Input Verified By Robert L Forester Date: 9/20/82

Results Checked By W.W. Fitch Date: 9/27/82



NOTE

SEE SHEET 7 FOR DETAILED INFORMATION

STUDY NO. 2X
NORMAL OPERATION WITH STARTUP TRANSFORMER
"X" WINDING BREAK HORSEPOWER LOADS

REV. NO. 3 DATE 9-20-82

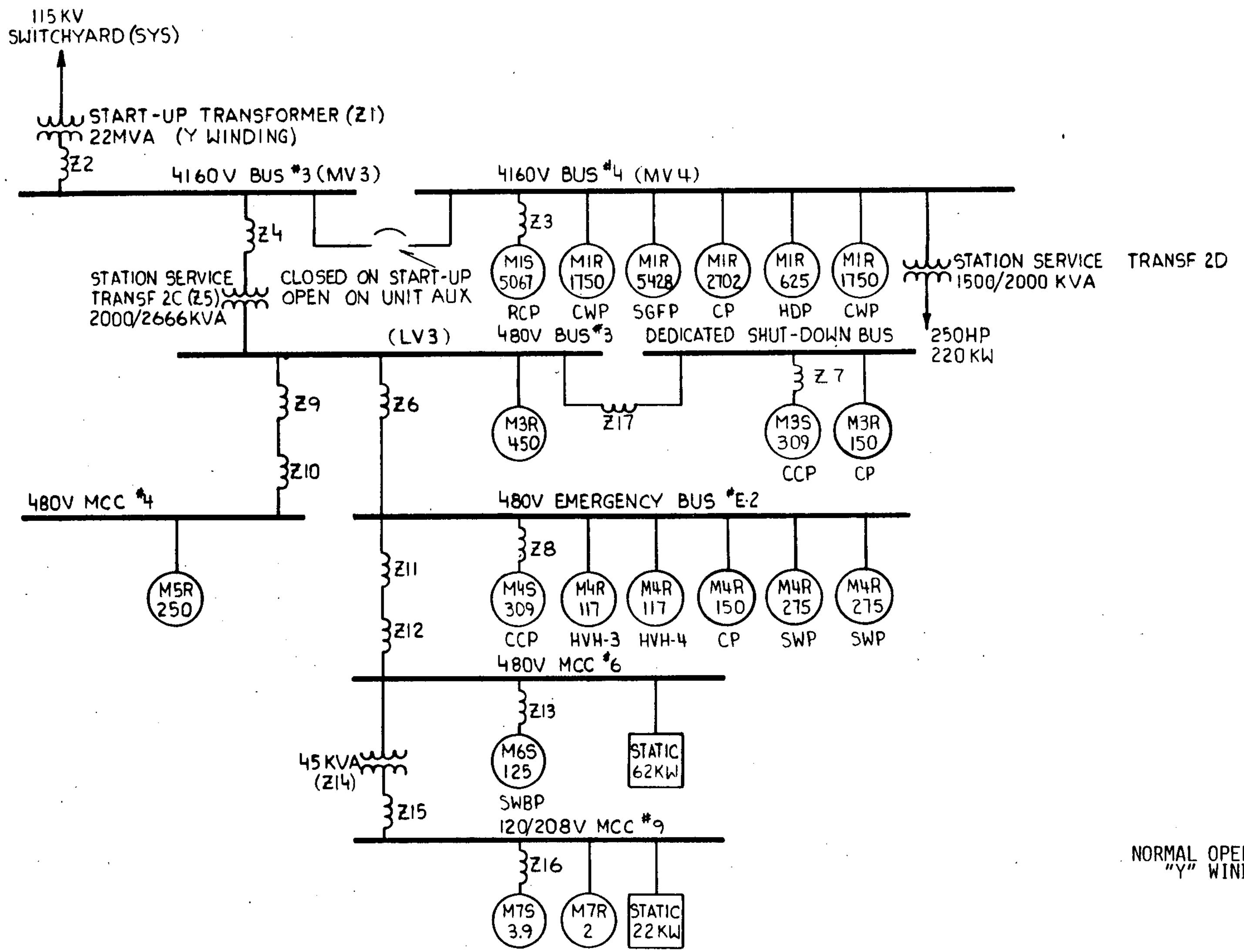
EBASCO SERVICES INCORPORATED		CAROLINA POWER & LIGHT COMPANY H.B. ROBINSON UNIT NO. 2 DEGRADED BUS VOLTAGE ANALYSIS APPENDIX-B	SKETCH CAR 2762 E1 SHEET 7 OF 8
DIV. ELEC. DR. C.L. DATE 10/20/82 CH. RF SCALE #	APPROVED		

APPENDIX - C
STUDY NO.: 2Y
100% PLANT LOAD
NORMAL OPERATION WITH
START-UP TRANSFORMER "Y" WINDING

Input By Indu Narayani Date 9/16/82

Input Verified By Robert L Forester Date 9/20/82

Results Checked By W.W. Fields Date 9/21/82



NOTE

SEE SHEET 8 FOR DETAILED INFORMATION

STUDY NO. 2Y
NORMAL OPERATION WITH STARTUP TRANSFORMER
"Y" WINDING BREAK HORSEPOWER LOADS

REV. NO. 3 DATE 9-20-82

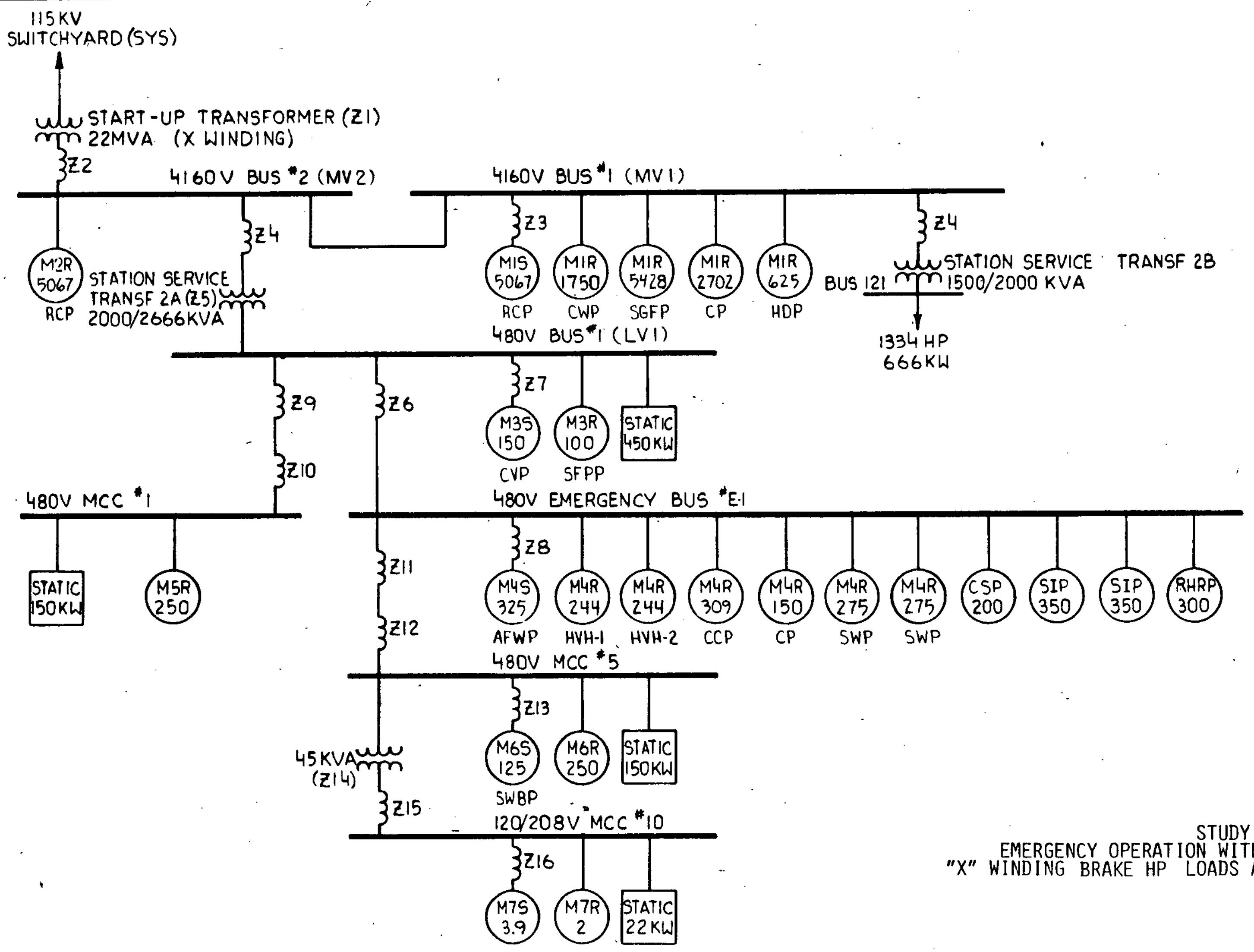
EBASCO SERVICES INCORPORATED		CAROLINA POWER & LIGHT COMPANY H.B. ROBINSON UNIT NO. 2 DEGRADED BUS VOLTAGE ANALYSIS APPENDIX-C	SKETCH CAR 2762 E1 SHEET 3 OF 8
DIV. ELEC DR. CL DATE 10/30/81 CH. RF SCALE NT	APPROVED		

APPENDIX - D
STUDY NO.: 3X
EMERGENCY OPERATION WITH START-UP
TRANSFORMER "X" WINDING BRAKE HORSEPOWER
LOADS AND SAFETY INJECTION ACTIVATED

Input By Indra Narayani Date 9/20/82

Input Verified By Robert L Forester Date 9/20/82

Results Checked By W. W. [illegible] Date 9/21/82



NOTE

SEE SHEET 7 FOR DETAILED INFORMATION

STUDY NO. 3X
EMERGENCY OPERATION WITH STARTUP TRANSFORMER
"X" WINDING BRAKE HP LOADS AND SAFETY INJECTION ACTIVATED

REV. NO. 3 DATE 9-20-82

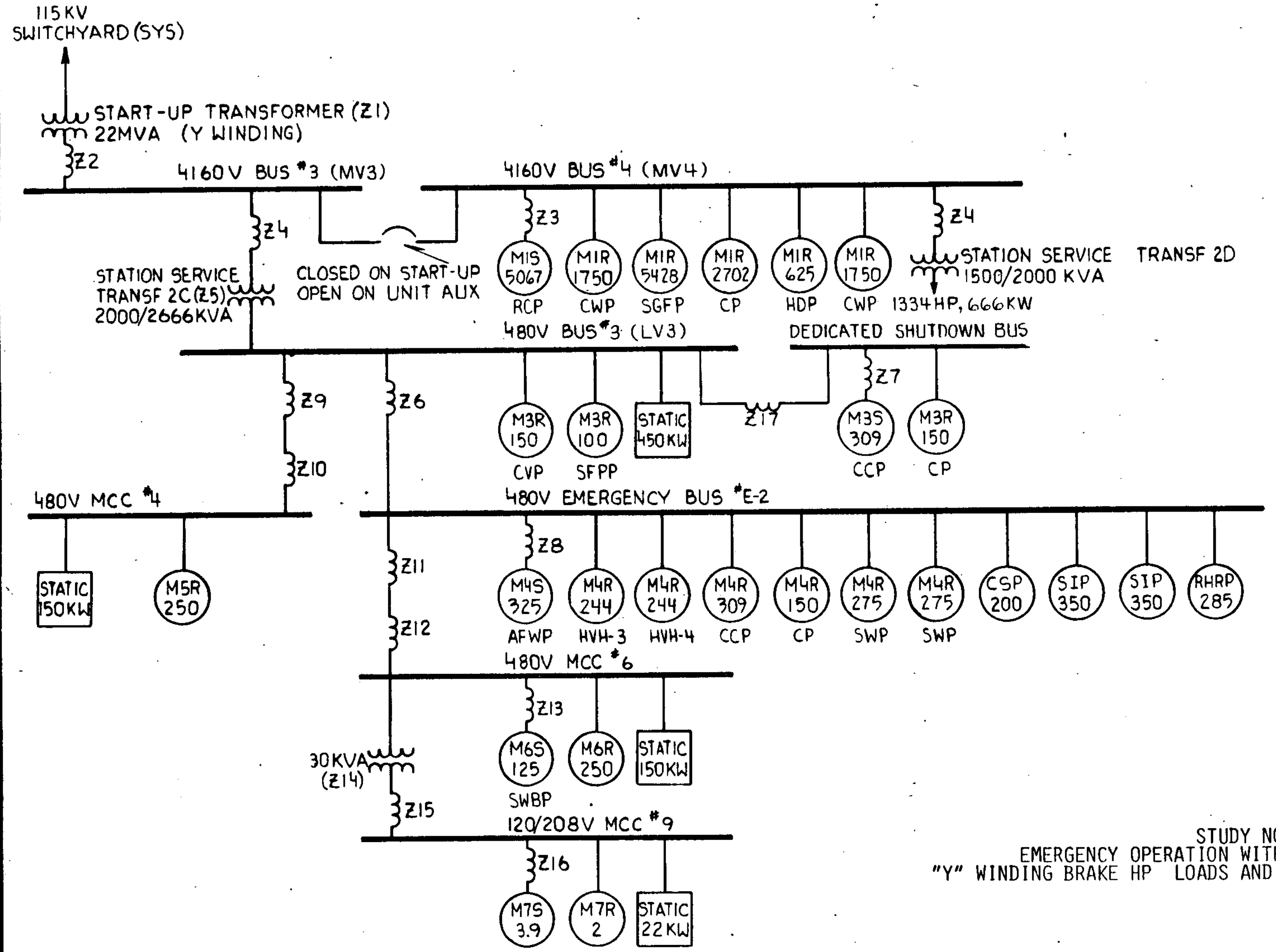
EBASCO SERVICES INCORPORATED		CAROLINA POWER & LIGHT COMPANY H.B. ROBINSON UNIT NO. 2 DEGRADED BUS VOLTAGE ANALYSIS APPENDIX-D	SKETCH CAR 2762 E1
DIV. ELEC DR. CL	APPROVED		
DATE 10/20/81 CH. RS			
SCALE #			SHEET 4 OF 8

APPENDIX - E
STUDY NO.: 3Y
EMERGENCY OPERATION WITH START-UP
TRANSFORMER "Y" WINDING BRAKE HORSEPOWER
LOADS AND SAFETY INJECTION ACTIVATED

Input By Indra Narayani Date 9/20/82

Input Verified By Robert L Forester Date 9/20/82

Results Checked By W. W. Field Date 9/27/82



NOTE

SEE SHEET 8 FOR DETAILED INFORMATION

STUDY NO. 3Y
EMERGENCY OPERATION WITH STARTUP TRANSFORMER
"Y" WINDING BRAKE HP LOADS AND SAFETY INJECTION ACTIVATED

REV. NO. 3 DATE 9-20-82

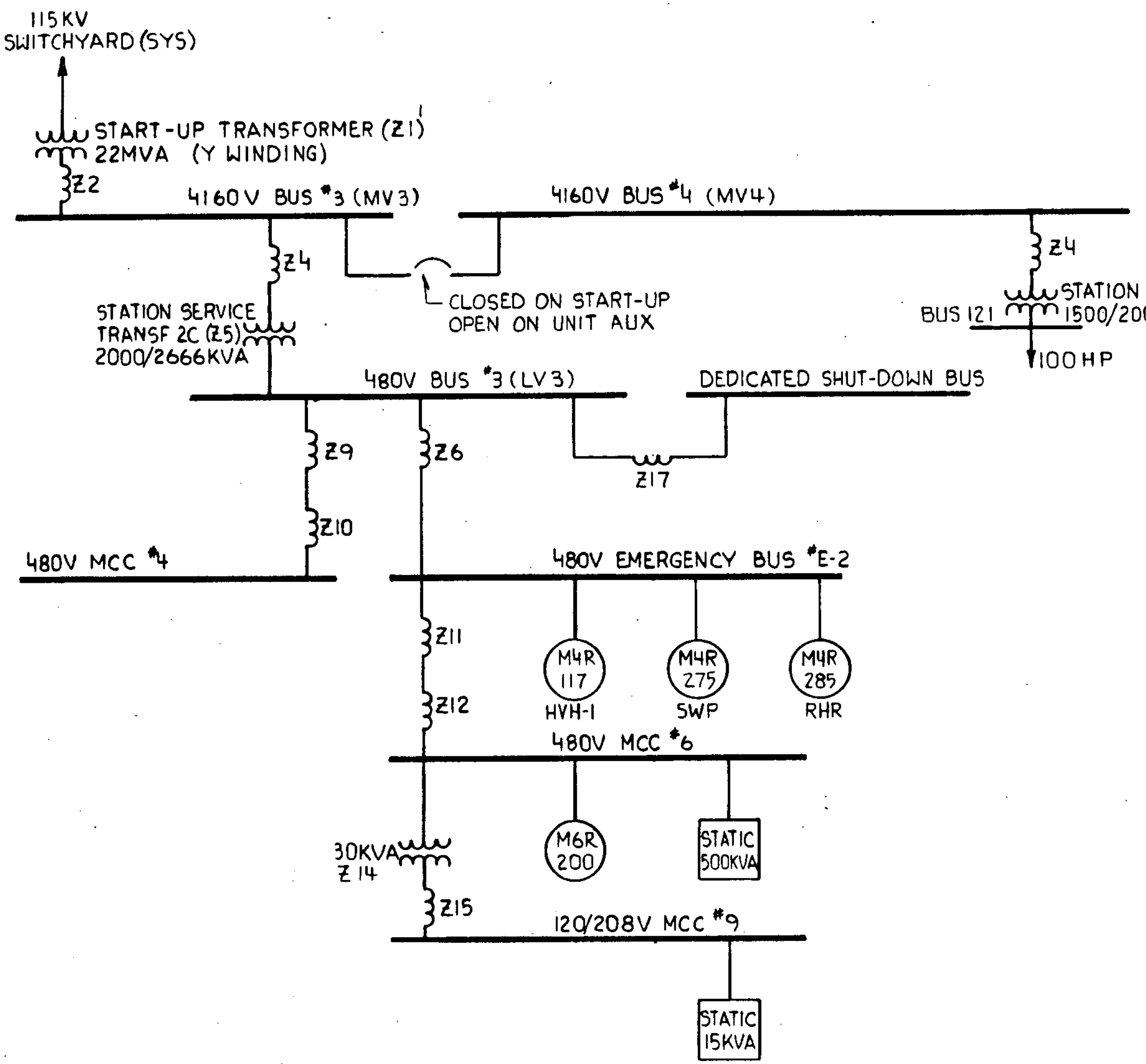
EBASCO SERVICES INCORPORATED		CAROLINA POWER & LIGHT COMPANY H.B. ROBINSON UNIT NO. 2 DEGRADED BUS VOLTAGE ANALYSIS APPENDIX-E	SKETCH CAR 2762 E1 SHEET 5 OF 8
DIV. ELEC DR. CL DATE [illegible] CH. RF SCALE —	APPROVED		

APPENDIX - F
STUDY NO.: 4Y
COLD SHUTDOWN OPERATION WITH START-UP
TRANSFORMER "Y" WINDING

Input By Mohn Narayani Date 9/20/82

Input Verified By Robert J Forester Date 9/21/82

Results Checked By W.W. Full Date 9/27/82



NOTE

SEE SHEET 8 FOR DETAILED INFORMATION

STUDY NO. 4Y
COLD SHUTDOWN OPERATION WITH STARTUP TRANSFORMER
"Y" WINDING BRAKE HORSEPOWER LOADS

REV. NO. 3 DATE 9-20-82

EBASCO SERVICES INCORPORATED		CAROLINA POWER & LIGHT COMPANY H.B. ROBINSON UNIT NO. 2 DEGRADED BUS VOLTAGE ANALYSIS APPENDIX-F	SKETCH CAR 2762 E1 SHEET 6 OF 8
DIV. ELEC DR. C.L. DATE [illegible] CH. R.F. SCALE	APPROVED		

APPENDIX - G
STUDY NO.: 5X
NORMAL OPERATIONS WITH AT LEAST
40% PLANT LOAD ON START-UP TRANSFORMER "X" WINDING

FOR "IN-PLANT" TEST

Input By Indra Narayani Date 9/20/82

Input Verified By Robert L Forester Date 9/24/82

Results Checked By W. W. Field Date 9/29/82

AF 17878B

	X	R	NOTES
Z1	10.2%	0.204%	X WINDING (22 MVA)
Z1'	11.25%	.225%	X WINDING (22 MVA)
Z2	0.0000788 Ω	0.0001814 Ω	
Z2'	0.000186 Ω	0.000427 Ω	
Z3	0.00594 Ω	0.00361 Ω	
Z4	0.00271 Ω	0.001634 Ω	
Z5	5.8%	1.16%	SST 2A (2 MVA)
Z6	0.00035 Ω	0.000806 Ω	
Z7	0.00317 Ω	0.00292 Ω	
Z8	0.00116 Ω	0.00107 Ω	
Z9	0.00244 Ω	0.00225 Ω	
Z10	0.015 Ω	0.0003 Ω	REACTOR
Z11	0.00211 Ω	0.00194 Ω	
Z12	0.015 Ω	0.0003 Ω	
Z13	0.00157 Ω	0.00861 Ω	
Z14	2.8%	X/R=5	TRANSFORMER (45 KVA)
Z15	0.00179 Ω	0.00984 Ω	
Z16	0.0195 Ω	0.433 Ω	
Z18	5.5%	X/R=5	TRANSFORMER (1.5 MVA)

MOTORS

	X"	PF RUN	EFF	PF START	LRA/FLA
ALL MOTORS	0.18	0.88	0.92	0.20	6.5
EXCEPT					
M1S (6000 HP)		0.925	0.925	0.16	6.3
M2R (6000 HP)		0.925	0.925	0.16	6.3
M4S (350 HP)		0.916	0.943	0.206	5.1
M4R (300 HP)		0.86	0.94		
M4R (300 HP)		0.86	0.94		
M6S (125 HP)					5.9
MIR (6000HP)		0.938	0.962	0.17	
MIR (3000HP)		0.919	0.95	0.21	
MIR (1750HP)		0.76	0.936	0.25	

COLD SHUTDOWN LOADS

4160 V BUS #1	100KW
480 V BUS #E1	500HP
480 V MCC #5	200HP,500KW
120/208 V MCC #10	15 KW

115KV SYSTEM SC CAPACITY = 15000 MVA

GENERATOR NO. 2 SC CAPACITY = $\frac{MVA}{X''d} = \frac{854}{0.301}$ = 2,840 MVA

TO BE USED WITH: STUDY 1X - SHEET 1
STUDY 2X - SHEET 2
STUDY 3X - SHEET 4

II-71-1

REV. NO. 3 DATE 9-20-82

EBASCO SERVICES INCORPORATED	CAROLINA POWER & LIGHT COMPANY H. B. ROBINSON UNIT NO. 2 DEGRADED BUS VOLTAGE ANALYSIS DATA SHEET FOR X WINDING	SKETCH CAR 2762 E I SHEET 7 OF 8
DIV. ELEC DR. JF DATE 10/30/81 CH. RP SCALE — APPROVED		

AF 17878B

	X	R	NOTES
Z1	10.3%	0.206%	Y WINDING (22 MVA)
Z1'	10.6%	0.212%	Y WINDING (22 MVA)
Z2	0.0001138 Ω	0.000262 Ω	
Z2'	0.000186 Ω	0.000427 Ω	
Z3	0.00392 Ω	0.00237 Ω	
Z4	0.00285 Ω	0.00172 Ω	
Z5	5.8%	1.16%	SST 2C (2 MVA)
Z6	0.000319 Ω	0.000733 Ω	
Z7	0.00211 Ω	0.00194 Ω	
Z8	0.00123 Ω	0.00113 Ω	
Z9	0.0033 Ω	0.00303 Ω	
Z10	0.015 Ω	0.0003 Ω	REACTOR
Z11	0.00066 Ω	0.00061 Ω	
Z12	0.02 Ω	0.0004 Ω	REACTOR
Z13	0.00262 Ω	0.01435 Ω	
Z14	3%	X/R=5	TRANSFORMER (30 KVA)
Z15	0.00105 Ω	0.00574 Ω	
Z16	0.0156 Ω	0.346 Ω	
Z17	0.00100 Ω	0.0001 Ω	
Z18	5.8%	X/R=5	TRANSFORMER (1.5 MVA)

MOTORS

	X"	PF_{RUN}	EFF	PF_{START}	LRA/FLA
ALL MOTORS	0.18	0.88	0.92	0.2	
EXCEPT:					
M1S (6000 HP)					5.8
M3S (400 HP)					4.62
M4S (350 HP)		0.916	0.943	0.206	5.1
M6S (125)					5.9
M1R (700)		0.926	0.955		
M4R (300)		0.86	0.94		
M4R (300)		0.86	0.94		

COLD SHUTDOWN LOADS

4160 V BUS #4	100KW
480 V BUS #E2	500HP
480 V MCC #6	200HP, 500KW
120/208 V MCC #9	15KW

115KV SYSTEM SC CAPACITY = 15000 MVA

GENERATOR NO. 2 SC CAPACITY = 2840 MVA

TO BE USED WITH: STUDY 2Y - SHEET 3
STUDY 3Y - SHEET 5
STUDY 4Y - SHEET 6

REV. NO. 2 DATE 9-20-82

EBASCO SERVICES INCORPORATED	CAROLINA POWER & LIGHT COMPANY H. B. ROBINSON UNIT NO. 2 DEGRADED BUS VOLTAGE ANALYSIS DATA SHEET FOR Y WINDING	SKETCH CAR 2762 E1
DIV. ELEC DR. JP DATE 10/3/86 CH. RF SCALE ## APPROVED		SHEET 8 OF 8

II-71-11

POLYTRACE 033

E. CALCULATIONS

All calculations and supporting documents included in the 1976 Report were used and additional calculations required to complete the analysis are included in this section.

EBASCO SERVICES INCORPORATED

NEW YORK

BY R.L.Forester DATE 1/22/81 SHEET 1 OF 1

CHKD. BY I.V.N. DATE 7/22/81 OFS NO. CAR 2762.024 DEPT. NO. 504

CLIENT CAROLINA POWER AND LIGHT COMPANY

PROJECT H. B. ROBINSON #2 - VOLTAGE DEGRADATION STUDY

SUBJECT CALCULATION INDEX

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EBASCO SERVICES INCORPORATED

NEW YORK

OFS NO. CAR 2762.024 DEPT. NO. 504

CLIENT CAROLINA POWER AND LIGHT COMPANY

PROJECT H. B. ROBINSON #2 - VOLTAGE DEGRADATION STUDY

SUBJECT CONTROL CIRCUIT LENGTHS FOR MOTOR CONTROL CENTERS 9 & 10

CALCULATION NO: 1 NUMBER OF SHEETS: 1

PROBLEM:

Tabulate the cable size and cable lengths for the control circuits for MCC 9 & 10. Calculated lengths are from Calculation #4. All other information obtained from CWD's (Dwg. 500B452) and PD&MD sheets (B-190627).

Rev. No.	Sheet Nos.	Calculation By Name	Calculation By Date	Checked By Name	Checked By Date	Approved By Name	Approved By Date
0	1	R.J. Smith	7/10/81	Indra Narayani	7/16/81	[illegible]	8/21/81

PRELIMINARY ☐ FINAL ☒ SUPERSEDES CAL. NO. ______

FORM 581 REV 7-71

EBASCO SERVICES INCORPORATED

NEW YORK

BY R.L.Forester DATE 07/12/81 SHEET 1 OF 1

CHKD. BY I.V.N. DATE -7/16/81 OFS NO. CAR 7762 DEPT. NO. 504

CLIENT CAROLINA POWER AND LIGHT COMPANY CAL #1

PROJECT H.B.ROBINSON #2 - Degraded Grid Voltage Study

SUBJECT Control Circuit Length for Motor Control Centers 9 and 10

MOTOR CONTROL CENTER # 9

CWD	Size	Compt	Control Circuit Cable Length	Cable Size	Fuse Size
648	1R	1C	1000*		1
843	1R	1J	600	#16	1
639	1R	1M	1310	#16	1
640	1R	2H	1310	#16	1
I Air Dryer	Bkr	2KL	No Controls		1
UP-29	Bkr(LP-29)	2KR	Not Applicable		1
662	1R	2ML	600	#16	1
844	1R	2MR	620	#16	1
453	1R	3C	700	#16	1
452	1R	3F	710	#16	1
664	1R	3J	520	#16	1
660	1R	3M	630	#16	3
Battery Fan B			No Controls		
Fire Prot B			NSR		

MOTOR CONTROL CENTER #10

454	1R	1F	820	#16	1
Sink	Bkr	1J	No Controls		
E-29	Bkr(LP-29)	2BL	Not Applicable		
I Air Dryer	Bkr	2BR	No Controls		
661	1R	2M	760	#16	1
647	1R	3C	1000*	#16	1
842	1R	3F	710	#16	1
451	1R	3J	830	#16	1
844	1R	3M	620	#16	1
662	1R	4C	600	#16	1
663	1R	4F	570	#16	1
638	1R	4J	1450	#16	1
649	1R	4M	1000*	#16	1
Battery Fan B			No Controls		
Fire Prot A			NSR		

* Estimated from GA's and Electrical Drawings

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EBASCO SERVICES INCORPORATED
NEW YORK

OFS NO. CAR 2762.024 DEPT. NO. 504

CLIENT CAROLINA POWER AND LIGHT COMPANY

PROJECT H. B. ROBINSON #2 - VOLTAGE DEGRADATION STUDY

SUBJECT 208V MCC STARTER FUSE ANALYSIS

CALCULATION NO: 2 NUMBER OF SHEETS: 1

PROBLEM:

1) Determine Coil Impedance

2) Based on 1) determine maximum substained current at just less than pick-up voltage.

3) Based on 2) determine blow time for fuse.

Rev. No.	Sheet Nos.	Calculation By Name	Calculation By Date	Checked By Name	Checked By Date	Approved By Name	Approved By Date
0	1	R J Forster	7/13/81	Indu Narayani	7/16/81	W. W. Field	8/21/81

PRELIMINARY ☐ FINAL ☒ SUPERSEDES CAL. NO. ______

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EBASCO SERVICES INCORPORATED

NEW YORK

BY R.L.Forester DATE 07/13/81 SHEET 1 OF 1

CHKD. BY I.V.N. DATE 07/16/81 OFS NO. CAR 2762 DEPT. NO. 504

CLIENT CAROLINA POWER AND LIGHT COMPANY CAL #2

PROJECT H. B. Robinson #2 Degraded Voltage Analysis

SUBJECT 208V MCC Starter Fuse Analysis

Information received from CP&L (07/02/81)

Starter Fuses for MCC's 9 and 10
BUSSMAN MANUFACTURING DIVISION
BUSS BAF-1 (All except MCC #9 Compartment 3M which is BAF-3)

Problem:
1) Determine Coil Impedance
2) Based on 1) determine maximum sustained current at just less than (≈) pick-up voltage
3) Based on 2), determine blow time for fuses

1) and 2) Current at depressed voltage condition ≈ 1 amp.

(From page 2 of 10/04/76 "Control Transformer Secondary Analysis")

3) Time for fuses on starters to blow at degraded voltage:

Note	Fuse	Current at Pickup	Time to Blow**
*	BAF-1	1.0	at 110% 4 Hours (min.)
*	BAF-3	1.0	Infinite
R	BAF-2	1.0	Infinite

* Present Fuse Size
R Recommended Change
** Using information from Buss Catalog SFB (2/80) Page 11

SUMMARY: Present fuses are marginal, change fuses to recommended ratings.

FORM 581 REV 7-71

EBASCO SERVICES INCORPORATED

NEW YORK

OFS NO. CAR 2762.024 DEPT. NO. 504

CLIENT CAROLINA POWER AND LIGHT COMPANY

PROJECT H. B. ROBINSON #2 - VOLTAGE DEGRADATION STUDY

SUBJECT CABLE IMPEDANCE CALCULATIONS

CALCULATION NO: 3 NUMBER OF SHEETS: 2

PROBLEM:

Calculate cable impedances for systems which did not exist or were not used for the 10/15/76 study.

a) Cable Impedance Z15: Power cable from MCC 5 to 10 and MCC 6 to 9

b) Cable Impedance Z16: Power cable from MCC 9 to V2-6B and MCC 9 to V2-6A

c) Bus Bar Impedance Z17: Non-Seg Bus from 480V Bus #3 to Ded. Shutdown Bus

Rev. No.	Sheet Nos.	Calculation By Name	Calculation By Date	Checked By Name	Checked By Date	Approved By Name	Approved By Date
0	1-3	R S Fouletti	7/7/81	Indra Narayani	7/16/81	W. W. Field	8/21/81

PRELIMINARY ☐ FINAL ☒ SUPERSEDES CAL. NO. ______

FORM 581 REV 7-71

Z_{15} The impedance of the cable which connects MCC5 to MCC10 (3 phase, 4W at 120/208V)

Cable Size: 4-1/C #2
Length: 1/4 (240)
Impedance: (.06)(0.164 + j 0.0299)
= .00984 + j .001794 ohms

The impedance of the cable which connects MCC6 to MCC9 (3 phase, 4 W at 120/208V)

Cable Size: 4-1/C #2
Length: 1/4 (140)
Impedance: (.035)(0.164 + j 0.0299)
= 0.00574 + j 0.001047 ohms

Z_{16} The impedance of the cable which connects MCC9 to V2-6B
( )

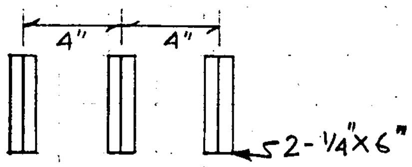
Cable Size: 2/C #19/22
Length: 400 (from CCL)
Impedance: (.4)(.866 + j .039)
= .346 + j .0156 ohms

The impedance of the cable which connects MCC10 to V2-6A
( )

Cable Size: 2/C #19/22
Length: 500' (from CCL)
Impedance: (.5)(.866 + j .039)
= 0.433 + j 0.0195 ohms

Z_{17} The impedance of Bus which connects 480V Bus #3 Dedicated Shutdown Bus

Bus Bar Size: 2-1/4" x 6"
Length of Bus: 35'
Impedance: .000096 + j .0010 ohms



Bus Length-35 Feet (Per CP&L)
Bus Rating-3000 Amps
Manufacturer -

R of 1/2" x 6" Bar = 2.75 μ Ω/foot 6 MD = 1.453
(From Table 21, page 22 of Anderson Electric - Tech. Data - 1969)

X of Bar Spacing Above

$L = 0.7411 \text{ lag } \frac{Deg}{Ds}$ mh/mils (Equation 2.73 - Element of Power System Analysis 1967)

Ds = 1.453 Above

$Deg = \sqrt{4x4x8}$ (Equation 2.72 Elements of Power System Analysis, 1962 McGraw-Hill)

$= 5.0397$

$L = 0.7411 \text{ lag } \frac{5.0397}{1.453}$

$= 0.7411 \text{ lag } 3.4685 = 0.4003$ mh/mils

$X = 2\Pi fL = 2\Pi 60 \times 0.4003 = 150.91$ mΩ/mils

$\frac{150.91}{5280} = 28.6$ μΩ/foot

35 (2.75 + j28.6) u Ω/foot = 0.000096 + j0.00100Ω

EBASCO SERVICES INCORPORATED

NEW YORK

OFS NO. CAR 2762.024 DEPT. NO. 504

CLIENT CAROLINA POWER AND LIGHT COMPANY

PROJECT H. B. ROBINSON #2 - VOLTAGE DEGRADATION STUDY

SUBJECT CALCULATION OF CONTROL CIRCUIT LENGTH

CALCULATION NO: 4 NUMBER OF SHEETS: 1

PROBLEM: Calculate length of Cable Runs using Cable and Conduit List (B-190634) and CWD's (Dwg 500B452).

CWD #	Sheet No.	Equip. Tag	Circuit Loop Length
451		V6-35A	830
452		V6-35D	710
453		V6-35B	700
454		V6-35C	820
638		V2-6A	1450
639		V2-6B	1310
647		V2-14A	1000
648		V2-14B	1000
649		V2-14C	1000
660		V2-20A	630
661		V2-20B	760
662		V2-16A	600
663		V2-16B	570
664		V2-16C	520
842		V6-16B	710
843		V6-16A	680
844		V6-16C	620

Rev. No.	Sheet Nos.	Calculation By Name	Calculation By Date	Checked By Name	Checked By Date	Approved By Name	Approved By Date
0	1	R J Forster	8/17/81	Indu Narayan	8/17/81	W. W. [illegible]	8/21/81

PRELIMINARY ☐ FINAL ☒ SUPERSEDES CAL. NO. ______

FORM 581 REV 7-71

EBASCO SERVICES INCORPORATED

NEW YORK

OFS NO. CAR 2762.024 DEPT. NO. 504

CLIENT CAROLINA POWER AND LIGHT COMPANY

[PRO]JECT H. B. ROBINSON #2 - VOLTAGE DEGRADATION STUDY

[SU]BJECT 120/208 VOLT MCC STARTER ANALYSIS

CALCULATION NO: 5 NUMBER OF SHEETS: 5

PROBLEM:

Calculate minimum MCC voltage for starter pick-up and starter drop out.

Rev. No.	Sheet Nos.	Calculation By Name	Calculation By Date	Checked By Name	Checked By Date	Approved By Name	Approved By Date
0	1-5	Rl Fausto	7/12/81	Indra Narayani	7/20/81	[signature]	8/3/81

PRELIMINARY ☐ FINAL ☒ SUPERSEDES CAL. NO. ______

FORM 581 REV 7-71

EBASCO SERVICES INCORPORATED
NEW YORK

BY R.L.Forester DATE 7/12/81 SHEET 1 OF 5
CHKD. BY I.V.N. DATE 7/20/81 OFS NO. Car. 2762 DEPT. NO. 504
CLIENT CAROLINA POWER AND LIGHT COMPANY CAL #5
PROJECT H. B. ROBINSON #2 - DEGRADED VOLTAGE ANALYSIS
SUBJECT 120/208 VOLT MCC STARTER ANALYSIS

I. EQUIPMENT PARAMETERS

1. Motor Starters

A. Manufacturer - Westinghouse
B. Voltage Rating - 120 Volt
C. Reference - A/200 Contactor Data, Daton 9/20/66
D. Parameters

	Starter Size #1
In-Rush VA (Based on 120V)	160
In-Rush PF	0.69
Volts Pick-up (In-Rush)	92
Volts Dropout (Hold-In)	64

NOTE: Above data is taken from 10/8/76 "Control Transformer Analysis" Page 3 of 23.

2. Cable

A. Voltage Rating - 480 Volt
B. Reference - Engineering Data for Copper and Aluminum Conductor Electrical Cables, The Okonite Co., Bulletin 721.1
C. Parameters

Cable Size	Impedance (Ohms per 1000')
#16	4.44 + 2.04
#19/22	.866 + 2.039

NOTE: Above data is taken from 10/8/76 "Control Transformer Analysis" Page 3 & 4 of 23.

II. Starter Resistance and Reactance For Pick-Up (In Rush) and Drop-Out (Hold-In) Considerations.

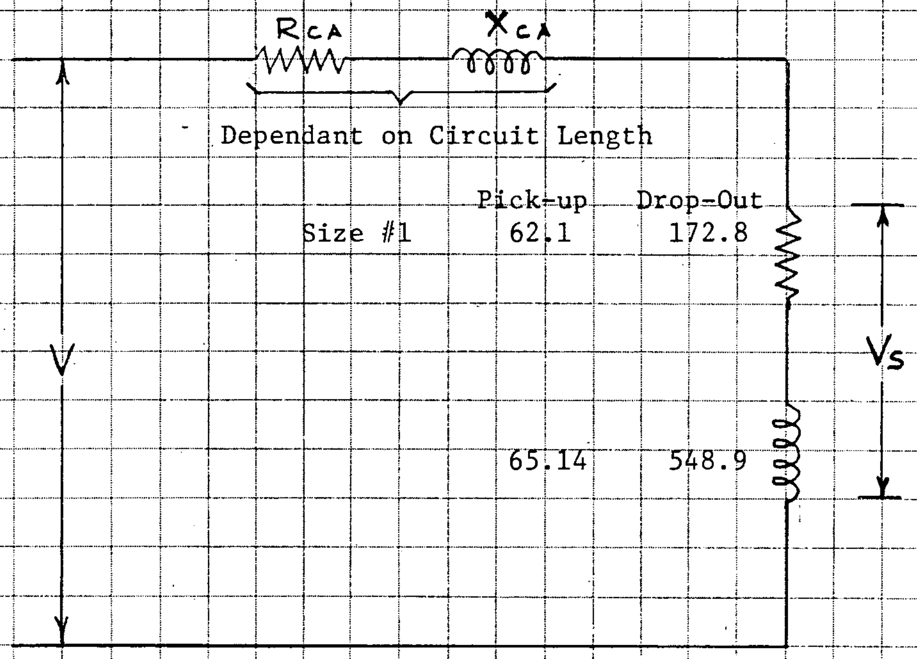
Starter Size	Iin(A)	Rin(Ω)	Xin(Ω)	Ihi(A)	Rhi(Ω)	Xhi(Ω)
#	1.33	62.1	65.14	0.21	172.8	548.9

NOTE: Above data is taken from 10/8/76 "Control Transformer Analysis" Pages 8,9 & 10 of 23.

FORM 581 REV 7-71

III. Circuit Analysis

1. Circuit Schematic



Figure

NOTES:

Rca & Xca - Cable Resistance and Reactance

Rs & Xs - Starter Resistance and Reactance

NOTE: All starters for MCC's 9 & 10 are NEMA Size 1 and are full voltage reversing. Therefore only one set of calculations will be done for each MCC using the longest control cable run.

2. Analysis based on Starter Coil Pick-up Considerations

Case I(MCC #9)
CWD 639 Feedwater Header Discharge VA V2-6B

A. Given:
1. Control Cable - 1310' of #16 Awg (From CCL)
2. Impedance of Cable - 4.44 + j0.04 per 1000'

B. Circuit: See Figure 1 - Page 3
C. Calculation:

$$Z\ Cable = \frac{1310}{1000} \times (4.44 + j0.04) = 5.82 + 0.052\Omega$$

$$I = \frac{V}{(5.82 + 62.1) + j(0.052 + 65.14)} = \frac{V}{67.9 + j65.2}$$

$$|V_s| = \frac{62.1 + j65.14}{67.9 + j65.2} = \frac{90.0}{94.1} = 0.956$$

The minimum allowable MCC voltage for starting a motor would be 166.7 Ø to Ø based upon the requirement of 92 volts as minimum operating voltage of the coil and the MCC voltage (208) being √3 time the line to neutral voltage (120).

Case II(MCC #10)
CWD 638 Feedwater Header Discharge VA V2-6A

A. Given:
1. Control Cable - 1450' of #16 Awg (From CCL)
2. Impedance of Cable - 4.44 + j0.04 per 1000'

B. Circuit: See Figure 1, page 3
C. Calculation:

$$Z\ Cable\ \frac{1450}{1000} \times (4.44 + j0.04) = 6.44 + j0.058\Omega$$

$$I = \frac{V}{(6.44 + 62.1) + j(0.052 + 65.14)} = \frac{V}{68.5 + j65.2}$$

$$|V_s| = \frac{62.1 + j65.14}{68.5 + j65.2} = \frac{90.0}{94.6} = 0.952$$

The minimum allowable MCC Voltage would be 167.4

3. Analysis Based on Starter Coil Drop-Out Consideration

Case I (MCC #9)
CWD 639 Feedwater Header Discharge Valve V2-6B

A. Given:
1. Control Cable 1310' of #16 Cable (From CCL)
2. Impedance of Cable - 4.44 + j0.04 per 1000'

B. Circuit - See Figure 1, Page 2
C. Calculation:

$$Z\ \text{Cable} = \frac{1310}{1000} \times (4.44 + j0.04) = 5.82 + 0.052\Omega$$

$$I = \frac{V}{(5.82 + 172.8) + j(0.052 + 548.9)} = \frac{V}{178.6 + j548.95}$$

$$\left|V_s\right| = \frac{172.8 + j548.9}{178.6 + j548.95} = \frac{575.46}{577.3} = 0.997$$

∴ The minimum allowable MCC voltage to prevent drop-out of running contactors would be 111.2 volts based upon the requirement of 64 volts as minimum operating voltage of the coil and the MCC voltage (208) being √3 times the line to neutral voltage (120).

Case II (MCC #10)
CWD 638 Feedwater Heater Discharge Valve V2-6A

A. Given:
1. Control Cable - 1450' of #16 Awg (From CCL)
2. Impedance of Cable - 4.44 + j0.04 per 1000'

B. Circuit - See Figure 1, Page 2
C. Calculation:

$$Z\ \text{Cable}\ \frac{1450}{1000} \times (4.44 + j0.04) = 6.44 + j0.058$$

$$I = \frac{V}{(6.44 + 172.8 + j(0.059 + 548.9)} = \frac{V}{179.2 + j548.96}$$

$$\left|V_s\right| = \frac{172.8 + j548.9}{179.2 + j548.96} = \frac{575.46}{577.5} = 0.997$$

The minimum allowable MCC voltage to prevent dropout of running contactors would be 111.2 volts.

IV. SUMMARY

1. Minimum acceptable MCC Voltage for Starter Coil Pick-Up Consideration

Case	MCC	Starter Size	Cable Length	Cable Size	Volts Pick-Up	Minimum L-N Voltage Allowable	Minimum Acceptable MCC Voltage
I	#9	1	1310	#16	92	96.2	166.7
II	#10	1	1450	#16	92	96.6	167.4

2. Minimum acceptable MCC Voltage for Starter Coil Drop-Out Consideration

Case	MCC	Starter Size	Cable Length	Cable Size	Volts Drop-Out	Minimum L-N Voltage Allowable	Minimum Acceptable MCC Voltage
I	#9	1	1310	#16	64	64.2	111.2
II	#10	1	1450	#16	64	64.2	111.2

EBASCO SERVICES INCORPORATED

BY I. Narayani DATE 09-20-82 SHEET ____ OF ____

CHKD. BY ________ DATE ________ OFS NO. CAR 2762.024 DEPT. NO. 504

T CAROLINA POWER AND LIGHT COMPANY

PROJECT H. B. ROBINSON #2 - VOLTAGE DEGRADATION STUDY

SUBJECT COMPUTER INPUT DATA CALCULATIONS

NUMBER OF SHEETS: 3

CALCULATION NO.: 6

PROBLEM:

Determine bases for the computer model to calculate verification voltage values.

Information obtained from summary of in-plant test results.

Rev. No.	Sheet Nos.	Calculation By: Name	Calculation By: Date	Checked By: Name	Checked By: Date	Approved By: Name	Approved By: Date
0		[signature]	9/20/82	[signature]	9/24/82	[signature]	9/27/82

PRELIMINARY FINAL X SUPERSEDES CAL. NO. ________

581/8-81

COMPUTER INPUT DATA CALCULATIONS
BASED ON "IN-PLANT" TEST RESULTS

1.0 Running load of starting motors

.1 Test No. 9.1 dated 2-13-82

4160 Volt bus load before starting of 350 hp Aux. Feed PP. 2A = 284 Amps.

4160 Volt bus load after starting of 350 hp Aux. Feed PP. 2A = 315 Amps.

Running load of Aux. Feed PP. 2A: (315-284) = 31 Amps.

$$H.P. = \frac{\sqrt{3} \times 31 \times 4140 \times .916 \times .943}{746}$$

$$= 257.39 \text{ hp}$$

$$\simeq 257$$

Motor Nameplate rating - 350 hp
LRA/FLA Ratio 5.1

∴ Adjusted LRA/FLA for Running load of above motor

$$= 5.1 \times \frac{350}{257} = 6.95$$

.2 Test No. 9.2 dated 2-13-82

4160 Volt bus load before starting of 125 hp Service Water Booster pump 2A = 316 Amps.

4160 Volt bus load after starting of 125 hp SWBR 2A = 330 Amps.

Running load of SWBP 2A (330-316) = 14 Amps.

$$H.P. = \frac{\sqrt{3} \times 14 \times 4140 \times .88 \times .92}{746}$$

$$= 108.95 \text{ hp}$$

$$\simeq 109 \text{ hp}$$

Motor Nameplate rating = 125 hp
LRA/FLA = 5.8

∴ Adjusted LRA/FLA $= 5.9 \times \frac{125}{109} = 6.77$

.3 Test No. 9.3 dated 2-13-82

4160 Volt bus load before starting of 6000 hp SGFP 2A = 2504A

4160 Volt bus load after starting of 6000 hp SGFP 2A = 3000A

Running load of Steam Gen. Feed Pump: (3000-2504) = 496A

$$H.P. = \frac{\sqrt{3} \times 496 \times 4140 \times .88 \times .92}{746}$$

$$= 3859.88 \text{ hp}$$

$$\simeq 3860 \text{ hp}$$

Motor Nameplate hp = 6000 hp
LRA/FLA Ratio = 5.8

∴ Adjusted LRA/FLA = $5.8 \times \frac{6000}{3860} = 9.02$

0 System load on various buses used for computer input.

.1 Running motor load on 4160 Volt Bus Nos. 1 and 2

Total load on 4160 Volt Bus Nos. 1 and 2 before test = 2452 Amps.

Total load on Station Service Transf. 2A + 2B = 284 + 113 = 397 Amps.

∴ Running motor load before test on 4160 Volt Bus Nos. 1 and 2 = 2055 Amps.

$$H.P. = \underline{\sqrt{3} \times 2055 \times 4140 \times .88 \times .92}$$

$$= 15992.06 \text{ hp}$$

$$\simeq 15992 \text{ (Equivalent hp)}$$

.2 Total running load on 480 Volt Station Service Transf. 2A

= 284 Ampa: (480 Volt Bus No. 1 + E1 + MCCs)

$$H.P. = \frac{\sqrt{3} \times 284 \times 4140 \times .76 \times .92}{746}$$

$$= 1908.72 \text{ hp}$$

$$\simeq 1909 \text{ hp (Equivalent hp)}$$

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BY I. Narayani DATE 09-03-82 SHEET 3 OF 3

CHKD. BY [signature] DATE 9/20/82 OFS NO. 2762.024 DEPT. NO. 504

T Carolina Power and Light Company

PROJECT H. B. Robinson

SUBJECT Degraded Grid Voltage Analysis CAL No. 6

2.0 (Continued)

.3 Observed running load on 480 Volt MCC No. 1 __________ 112 hp

.4 Observed running load on 480 Volt Bus No. 1 __________ 188 hp

.5 Observed running load on 480 Volt MCC No. 5 __________ 582 hp

.6 Running load on MCC No. 10-3.3 hp (MCC feeding MOVs. The load was confirmed by 8-26-82 test data).

.7 Running load on Inst. Bus No. 1-3.7 hp (load confirmed by 8-26-82 data).

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BY I. Narayani DATE 09-20-82 SHEET ____ OF ____

CHKD. BY ________ DATE ________ OFS NO. CAR 2762.024 DEPT. NO. 504

CLIENT CAROLINA POWER AND LIGHT COMPANY

PROJECT H. B. ROBINSON #2 - VOLTAGE DEGRADATION STUDY

SUBJECT POWER FACTOR VERIFICATION CALCULATIONS

CALCULATION NO: 7 NUMBER OF SHEETS: 1

PROBLEM:

To determine if the calculations based on the extrapolated power factor values scaled from the motor characteristic curve agrees with the measured power factor value during in-plant test.

Rev. No.	Sheet Nos.	Calculation By Name	Calculation By Date	Checked By Name	Checked By Date	Approved By Name	Approved By Date
0		I. Narayani	9/20/82	R L Forester	9/24/82	W. W. [illegible]	9/27/82

PRELIMINARY FINAL X SUPERSEDES CAL. NO. ________

581/8-81

EBASCO SERVICES INCORPORATED

BY I. Narayani DATE 09-13-82 SHEET 1 OF 2

CHKD. BY R D Fonato DATE 9/20/82 OFS NO. 2762.024 DEPT. NO. 504

CLIENT Carolina Power and Light Company

PROJECT H. B. Robinson

SUBJECT Degraded Grid Voltage Analysis CAL. No. 7

POWER FACTOR VERIFICATION CALCULATIONS

Basis: In-Plant Test Data Dated 8 26-82

1. Measured load on 480 Volt Bus E-1 1260-1290 A
2. Measured load on 480 Volt MCC-5 260-270 A
3. Observed operating loads on 480 Volt Bus E-1

		Nameplate hp Rating	Brake Horsepower Rating
.1	HVH-1	350	117
.2	HVH-2	350	117
.3	SWP-A	300	275
.4	SWP-B	300	275

4. Measured resultant Bus E-1 power factor 0.76 lag.
5. Measured resultant MCC-5 power factor 0.85 lag.

Calculations:

Total load in hp on MCC-5 using measured average load

$$= \frac{\sqrt{3} \times 265 \times 480 \times .85 \times .92}{746}$$

= 230 hp (Equivalent hp)

Loads	bhp	pf	kW	Kvar	Kva
HVH-1	117	.60	87.28	116.37	145.47
HVH-2	117	.60	87.28	116.37	145.47
SWP-A	275	.86	205.15	121.73	238.55
SWP-B	275	.86	205.15	121.73	238.55
MCC-5	230	.85	171.58	106.33	201 86
TOTAL			756.44	582.53	969.9

Total Amps: $\frac{969.9 \times 1000}{\sqrt{3} \times 480 \times .92} = 1268$ Amps

= 1268 Amps

Angle 37.6^{o}, PF = 0.79 Lag.
Measured PF = 0.76 - 0.78 Lag.

Error 1.2% - 3.9%

Instrument used Esterline Angus Model A601C

Instrument accuracy $\pm$ 1.5%

Based on the instrument accuracy and the extrapolated power factor values corresponding to the bhp rating, the above results are considered satisfactory.

EBASCO SERVICES INCORPORATED

BY R. L. Forester DATE 09-20-82 SHEET ____ OF ____

CHKD. BY ______ DATE ______ OFS NO. CAR 2762.024 DEPT. NO. 504

CLIENT Carolina Power and Light Company

PROJECT H. B. Robinson No. 2

SUBJECT Bare Minimum Cold Shutdown Loads

CALCULATION NO.: 8 NUMBER OF SHEETS: 1

PROBLEM: To determine worse case cold shutdown plant loads for computer analysis (Reference No. 10.8).

Rev. No.	Sheet Nos.	Calculation By: Name	Calculation By: Date	Checked By: Name	Checked By: Date	Approved By: Name	Approved By: Date
0		[signature]	9/20/82	[signature]	9/20/82	[signature]	9/27/82

PRELIMINARY FINAL X SUPERSEDES CAL. NO. ______

581/8-81

EBASCO SERVICES INCORPORATED

RL Forester

BY R. L. Forester DATE 08-06-81 SHEET 1 OF 1

CHKD. BY JM DATE 8/7/81 OFS NO. CAR 2762.024 DEPT. NO.

T Carolina Power and Light Company

PROJECT H. B. Robinson No. 2

SUBJECT Bare Minimum Cold Shutdown Loads CAL # 8

The following was obtained from an 8-6-81 telecon with S. Allen of CP&L.

BARE MINIMUM - COLD SHUTDOWN

Quantity	Name	HP
1	Circulating Water Pump	1750
1	Station Air Compressor	100
1	Spent Fuel Pump	100
2	HVH Units	350 ea.
2	Service Water Pumps	300 ea.
1	Component Cooling Water Pump	350
1	RHR Pump	300

WORST CASE BUS CONFIGURATION

	X-Bus	Y-Bus	
4160 Bus No. 1	1750 (CWP)		
480 Bus No. 1	100 (SAC)*		
480 E-1	350 (HVH)	350 (HVH)	480V E-2
480 E-1	300 (SWP)	300 (SWP)	480V E-2
480 E-1	350 (CCP)	300 (RHR)	480V E-2
480 Bus No. 2B	100 (SFP)*		

* Available only on X-Bus

Assumption: Since SAC and SFP are only on X-Bus, Y-Bus must have bare minimum load, which will consist of 950 connected horsepower. We will assume that these motors will be running at 700 hp which is more conservative. Also, we will assume a static load of 500 kVa on MCC No. 6 and is kVa on MCC No. 9.

EBASCO SERVICES INCORPORATED

BY I. Narayani DATE ________ SHEET ____ OF ____

CHKD. BY ________ DATE ________ OFS NO. ________ DEPT. NO. ________

CLIENT CAROLINA POWER & LIGHT COMPANY

PROJECT H. B. ROBINSON UNIT NO. 2 - DEGRADED GRID VOLTAGE STUDY

SUBJECT MOTOR NAMEPLATE DATA

CALCULATION NO: 9 NUMBER OF SHEETS: 4

PROMBLEM:

Motor Nameplate Data obtained from CP&L's Record file.

Rev. No.	Sheet Nos.	Calculation By Name	Calculation By Date	Checked By Name	Checked By Date	Approved By Name	Approved By Date
0		[signature]	9/20/82	[signature]	9/20/82	[signature]	9/27/82

PRELIMINARY FINAL X SUPERSEDES CAL. NO. ________

581/8-81

EBASCO SERVICES INCORPORATED

BY I. Narayani DATE 9/20/82 SHEET 1 OF 4

CHKD. BY ________ DATE ________ OFS NO. 2762.024 DEPT. NO. 504

CLIENT Carolina Power & Light Company

PROJECT H. B. Robinson Unit No. 2

SUBJECT Degraded Grid Voltage Analysis CAL #9

Motor Data (obtained from CP&L Record files)

1. Reactor Coolant Pump

6000 hp, 1200 rpm, FLA - 760, LRA - 4800

Load	100%	75%	50%
Eff. %	92.5	91	87

Full load power factor 0.925
Starting power factor 0.16

LRA/FLA = 4800/760 = 6.3

Design Point Brake horsepower = 5067

Adjusted LRA/FLA for design point brake horsepower

$$= 6.3 \times \frac{6000}{5067}$$

$$= 7.46$$

Extrapolated power factor value at bhp - 0.91

2. Steam Generator Feed Pump

6000 hp, 3600 rpm, FLA - 715, LRA - 4000

Load:	100%	75%	50%
Eff. %	96.2	96.2	95.2

Full load power factor 0.93%
Starting power factor 0.17

LRA/FLA = 4000/715 = 5.59

Design Point Brake horsepower = 5428

Adjusted LRA/FLA for design point brake horsepower

$$= 5.59 \times \frac{6000}{5428}$$

$$= 6.18$$

Extrapolated power factor value at bhp - 0.92

3. Condensate Pump

3000 hp, 1200 rpm, FLA-370, LRA - 2040

Load:	100%	75%	50%
Eff. %	95	94.9	93.8

Full load power factor 0.919
Starting power factor 0.21

LRA/FLA = 2040/370 = 5.5

Design Point Brake horsepower - 2702

Adjusted LRA/FLA for design point brake horsepower

$$= 5.5 \times \frac{3000}{2702} = 6.1$$

Extrapolated power factor value at bhp - 0.91

4. Circulating Water Pump

1750 hp, 225 rpm, FLA - 264, LRA - 1320

Load	100%	75%	50%
Eff. %	93.6	94	93.1

Full load power factor - 0.76
Starting power factor - 0.25

LRA/FLA - 1320/264 = 5

Design point Brake horsepower - 1685

Adjusted LRA/FLA for design point brake horsepower

$$= 5 \times \frac{1750}{1685} = 5.19$$

Extrapolated power factor value at bhp - 0.76

5. Heater Drain Pump

700 hp, 1800 rpm, FLA - 85.5, LRA 515

Full load Eff: 95.5%

Full load power factor - 0.926
Starting power factor - 0.217

LRA/FLA = 515/85.5 = 6.02

Design point brake horsepower - 625

Adjusted LRA/FLA for design point brake horsepower

$$= 6.02 \times \frac{700}{625} = 6.74$$

Extrapolated power factor value at bhp - 0.91

6. Auxiliary Feed Water Pump

350 hp, 3600 rpm, FLA - 379, LRA - 1931

Full load Eff: 94.3%

Full load power factor - 0.916
Starting power factor - 0.206

LRA/FLA = 1931/379 = 5.09

Design point brake horsepower - 325

Adjusted LRA/FLA for design point horsepower

$$= 5.09 \times \frac{350}{325} = 5.48$$

Extrapolated power factor value at bhp - 0.91

7. Service Water Pump

300 hp, 1200 rpm, FLA - 347, LRA - 2101

Full load Eff: 94%

Full load power factor - 0.86

Starting power factor - 0.329

LRA/FLA = 2101/347 = 6.05

Design point brake horsepower - 275

Adjusted LRA/FLA for design point brake horsepower

$$= 6.05 \times \frac{300}{275}$$

$$= 6.6$$

Extrapolated power factor value at bhp - 0.86

SECTION - II

F. Design Point Brake Horsepower Pump Curves.

Input By K. D. Kraynick Date February 9, 1982

Input Verified By Robert L Forester Date 9/20/82

Results Checked By Indm Narayani Date 9/27/82

SECTION II

F. Design Point Brake Horsepower Pump Curves

This section includes pump performance curves and mechanical design criteria for the large pumps. Test stand records for the pump and/or motor when found, is also included.

This information was obtained from the CP&L record files by Mr. K. D. Kraynick during site visit of February 1, 2, and 3, 1982.

The information has been summarized on the top cover sheet of each document package. The summary includes the manufacturer, model number, head, capacity, speed, operating/maximum horsepower, efficiency and performance curve reference.

A review with Plant Operations of their records indicated that a few of the pumps have recently been tested for head and capacity while some of the other pumps have been tested for differential pressure only. In all cases, the pumps are running below their design point thereby validating original design criteria.

The design point brake horsepower values of these pumps as obtained from the performance curves are summarized in Section I, Table 2.

TEST RESULTS

SERVICE WATER

(A)	1/28/82	–	66 PSI	Measured Differential
(B)	1/29/82	–	66 PSI	
(C)	1/29/82	–	66 PSI	
(D)	1/29/82	–	64 PSI	

AUXILIARY (MOTOR) FEEDWATER PUMP

(A)	1/20/82	–	1360 PSI
(B)	1/20/82	–	1400 PSI

COMPONENT COOLING WATER

(A)	1/21/82	–	79 PSI
(B)	1/21/82	–	84 P[SI]
(C)	1/21/82	–	84 P[SI]

RHR

(A)	12/10/81	–	137.5 P[SI]
(B)	12/10/81	–	134.5 P[SI]

SAFETY INJECTION

(A)	12/9/81	–	1939 [illegible]
(B)	12/9/81	–	1970 [illegible]

CONDENSATE ≅ 60% POWER

(A)	9/15/81	–	7168 GPM @ 1209 FT	CALC HP = 2769
(B)	9/15/81	–	7213 GPM @ 1191 FT	CALC HP = 2679

HEATER DRAIN > 93% POWER

(A)	9/15/81	–	2109 GPM @ 1017 FT	CALC HP = 716
	9/15/81	–	2514 GPM @ 1019	CALC HP = 739

FEEDWATER PUMPS 100% POWER

(A)	9/10/76	–	11,030 GPM @ 1812 FT
(B)	9/10/76	–	10,820 GPM @ 1923 FT

PUMP:	REACTOR COOLANT PUMPS
NUMBER:	THREE (3)
MANUFACTURER:	WESTINGHOUSE
MODEL NUMBER:	V11001 - B1
DESIGN FLOW:	88,500 GPM
TOTAL DYNAMIC HEAD:	266 FEET
PUMP SPEED:	1190 RPM (HOT) 1187 RPM (COLD)
PUMP EFFICIENCY:	≅ 88 %
DESIGN BRAKE HORSEPOWER:	5067 (HOT) 6943 (COLD)
MAXIMUM BRAKE HORSEPOWER:	5665 (HOT) [illegible] 7113 (COLD) [illegible]
PUMP PERFORMANCE CURVE:	FIGURE 5-1 (HOT) FIGURE 5-2 (COLD)

GENERAL DATA SUMMARY AND GENERAL DESC[illegible]N ALSO INCLUDED

Reactor Coolant Pumps

Section 1
INTRODUCTION

1.1 GENERAL DATA

(For hot and/or cold performance, see Figures 5-1 and 5-2.)

Electrical and mechanical design characteristics of the Reactor Coolant Pump V11001-B1 are listed below in Table 1-1.

TABLE 1-1 SUMMARY OF GENERAL DATA

Characteristics	
Model	V11001-B1
Type	Single-Stage, Centrifugal
Head	266 feet
Flow	88,500 gpm
Impeller	Seven-vane, single-suction type
Motor	
Brake Horsepower	
Hot (specific gravity 0.745)	5067
Cold (specific gravity 1.006)	6843
Speed	1190 (Hot) 1187 (Cold)
Insulation	Class B
Voltage	4,000 Volts
Current	
Hot (specific gravity 0.745)	638 Amps
Cold (specific gravity 1.006)	858 Amps
Frequency	60 cps
Phase	3 Phase
Power Input	
Hot (specific gravity 0.745)	4072 KW
Cold (specific gravity 1.006)	5469 KW
Cooling Water Requirements	
Upper bearing oil cooler	150 gpm at 105°F
Lower bearing oil cooler	5 gpm at 105°F
Oil Capacities	
Upper oil pot	175 gallons
Lower oil pot	25 gallons

Flywheel	
Diameter	72 in.
Weight	12,150 lb.
Pump	
Thermal Barrier	
Cooling water requirements	25 gpm at 105°F
Seal Flow	
Injection water.	8 gpm at 130°F 2250 psig (approx.)
No. 1 Seal	3 gpm
No. 2 Seal	3 gph
No. 3 Seal	100 cc/hour
Loop Temperature (Nominal).	555°F
Loop Pressure (Nominal). . .	2250 psig

1.2 GENERAL DESCRIPTION

The Model V11001-B1 Reactor Coolant Pump (see Figure 1-1) is a vertical, single-stage, centrifugal shaft seal pump designed to pump large volumes of main coolant at high temperatures and pressures. The pump is designed to produce a differential head of 266 ft. (measured from suction to discharge nozzle) while pumping 88,500 gpm of main coolant at a temperature of 555°F and a pressure of 2250 psig.

The pump consists of three general areas from bottom to top. They are the hydraulics, the shaft seals, and the motor.

1. The hydraulic section consists of an impeller, diffuser, casing, thermal barrier, heat exchanger, lower radial bearing, main flange, and pump shaft.

2. The shaft seal section consists of three devices. They are the No. 1 controlled-leakage, film-riding face seal and the Nos. 2 and 3 rubbing face seals. These seals are contained within the main flange and lower and upper seal housings.

3. The motor section consists of a vertical solid shaft, squirrel cage induction-type motor, an oil-lubricated double Kingsbury-type thrust bearing, two oil-lubricated radial bearings, and a flywheel.

Attached to the bottom of the pump shaft is the impeller. The reactor coolant is drawn up through the impeller, discharged through passages in the diffuser, and out through the discharge nozzle in the side of the casing. Above the impeller is a thermal barrier which contains a heat exchanger. The thermal barrier limits heat transfer between hot system water and injection water.

High pressure injection water is introduced through the thermal barrier wall. A portion of this water flows up the shaft to the seal area while the remainder flows down the shaft where it acts as a buffer to prevent system water from entering the radial bearing and seal section of the unit. The heat exchanger provides a means for cooling system water to an acceptable level in

the event injection flow is lost. Mounted on an inside diameter of the main flange above the thermal barrier is the pump bearing which is of the water-lubricated journal type with a spherical seat for self-aligning.

The seal system controls the upward flow of the high pressure injection water. The leakage of the No. 1 seal is channeled to the Chemical and Volume Control System. The leakage of the No. 2 and No. 3 seals is channeled to the sump.

The motor is an air-cooled, Class B Thermalastic Epoxy-insulated, squirrel cage induction motor. The rotor and stator are of standard construction and are cooled by air. Six resistance temperature detectors are located throughout the stator to sense the winding temperature. A double Kingsbury-type thrust bearing and radial guide bearing are located above the stator. These bearings are lubricated by oil which is circulated through the bearings and cooled in a vertical heat exchanger. The heat exchanger is attached to the side of the motor. Below the stator is a lower radial bearing which is also cooled by oil circulating through it. This oil is cooled by an integral heat exchanger. At the top of the motor is a flywheel and an anti-reverse rotation device.

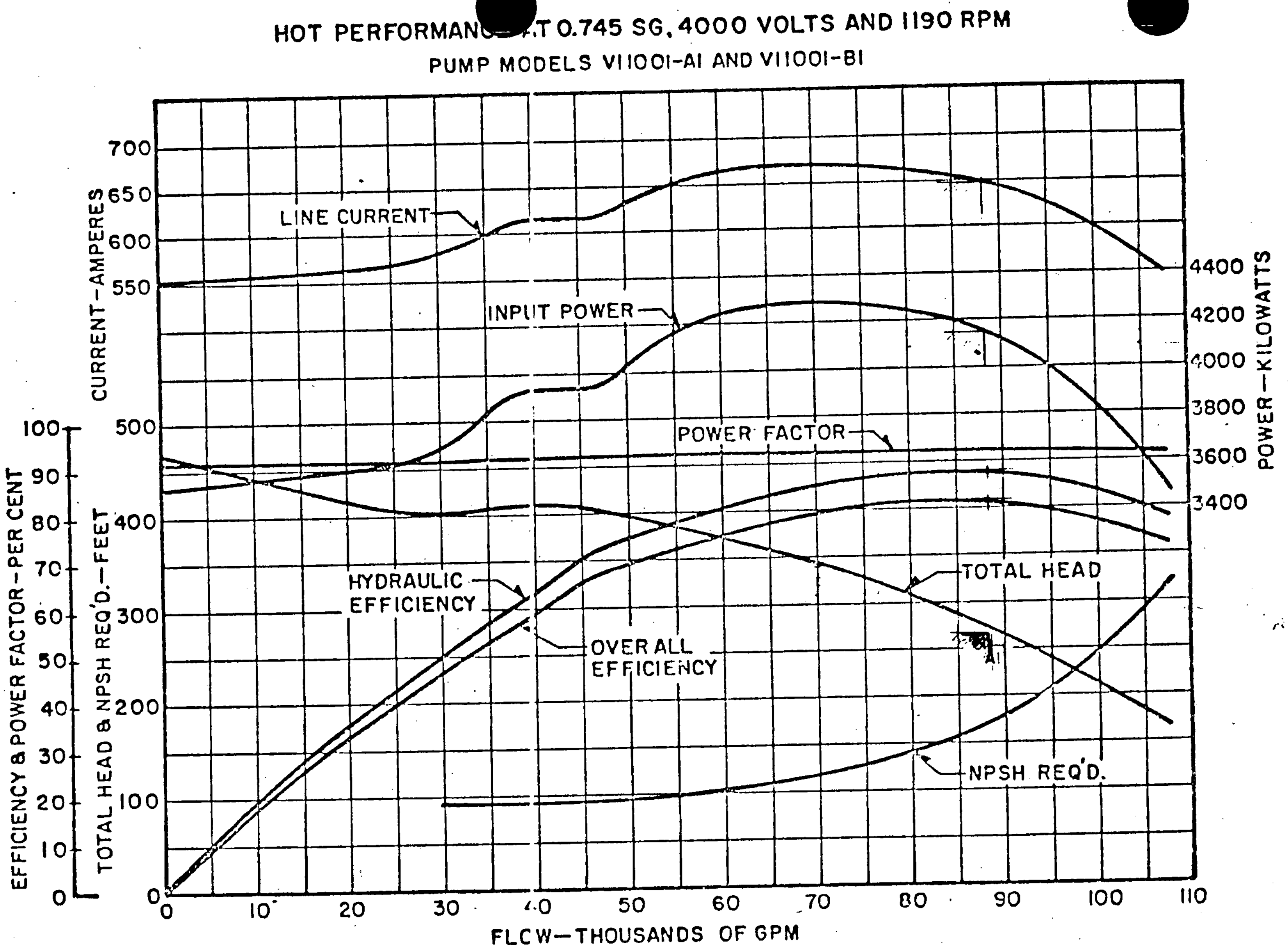


FIGURE 5-1 Hot Performance Curve

COLD PERFORMANCE AT 1.006 SG, 4000 VOLTS AND 1187 RPM
PUMP MODELS V11001-A1 AND V11001-B1

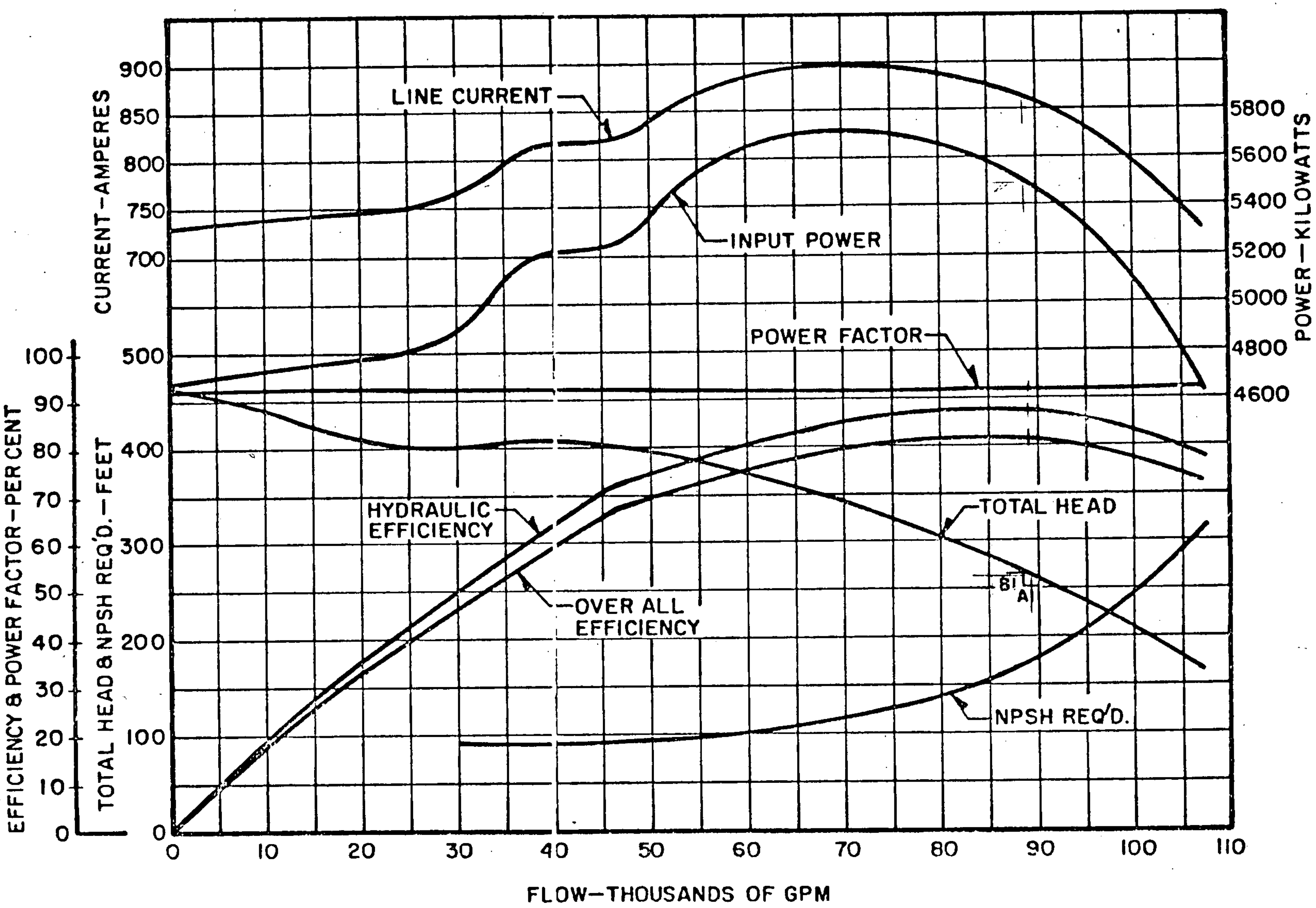


FIGURE 5-2 Cold Performance Curve

PUMP:	CIRCULATING WATER PUMP
NUMBER:	THREE (3)
MANUFACTURER:	WESTINGHOUSE
MODEL NUMBER:	90 MT
DESIGN FLOW:	160,700 GPM
TOTAL DYNAMIC HEAD:	35.3 FT
PUMP SPEED:	220 RPM
PUMP EFFICIENCY:	85 %
DESIGN BRAKE HORSEPOWER:	1685 BHP
MAXIMUM BRAKE HORSEPOWER:	1800 BHP (SHUT-OFF)
PUMP PERFORMANCE CURVE:	H.T.A 22573

SPECIAL DATA SHEET ALSO INCLUDED

HYDRAULIC GRADIENT FOR CIRCULATING WATER SYSTEM AVAILABLE.

CIRCULATING WATER
PUMP

INSTRUCTION BOOK

HEAT EXCHANGE EQUIPMENT

FOR

CAROLINA POWER & LIGHT COMPANY

UNIT NO. 2.

HARTSVILLE, SOUTH CAROLINA

Equipment	Serial No.
2 – 225,000 Sq. Ft. Surface Condensers	16-A-6210-1,-2
3 – 90 MT Circulating Pumps	16-A-6211-1,-2,-3
2 – Byron Jackson Model 28 KXHO Condensate Pumps	16-A-6212-1,-2
2 – Nash Model CL-3005 Vacuum Pumps	16-A-6214-1,-2
4 – 14,700 Sq. Ft. Moisture Separator Reheaters	16-A-6217-1,-2,-3,-4
2 – 18,069 Sq. Ft. #1 L.P. Feedwater Heaters	16-A-6218-1,-2
2 – 10,261 Sq. Ft. #2 L.P. Feedwater Heaters	16-A-6219-1,-2
2 – 11,009 Sq. Ft. #3 L.P. Feedwater Heaters	16-A-6220-1,-2
2 – 9,638 Sq. Ft. #4 L.P. Feedwater Heaters	16-A-6221-1,-2
2 – 10,080 Sq. Ft. #5 L.P. Feedwater Heaters	16-A-6222-1,-2
2 – 18,503 Sq. Ft. #6 H.P. Feedwater Heaters	16-A-6223-1,-2

General Order No. CH-25411-AR6-T3
CH-25412-AR6-T3
CH-25413-AR6-T3

Instruction Book Shop Order 16-A-6209

Instruction Book 1310-C786

October, 1968

WESTINGHOUSE ELECTRIC CORPORATION
South Philadelphia Works • Steam Divisions • Essington, Pa.

TAB 1

SPECIAL DATA

CONDENSER

Cooling Surface, Sq. Ft.	225,000
No. of Water Passes	1
Steam Condensed, lbs/hr	2,702,500
Cooling Water Supply, gpm	241,000
Cooling Water Temp. ° F.	70
Tube Cleanliness Factor	85%
Absolute Pressure - inches of Hg.	2.0

Tubes

Number	16,902	354
Size	1" O.D.	1" O.D.
Gauge	18 BWG	22 BWG
Length	50'0"	50'0"
Material	Admiralty	Stainless Steel Type 304

CIRCULATING PUMP

Capacity, gpm	160,700
Total Head in ft. of water	35.3
Submergence, feet of water	12
Speed, rpm	220
Motor Rating, hp	1,750

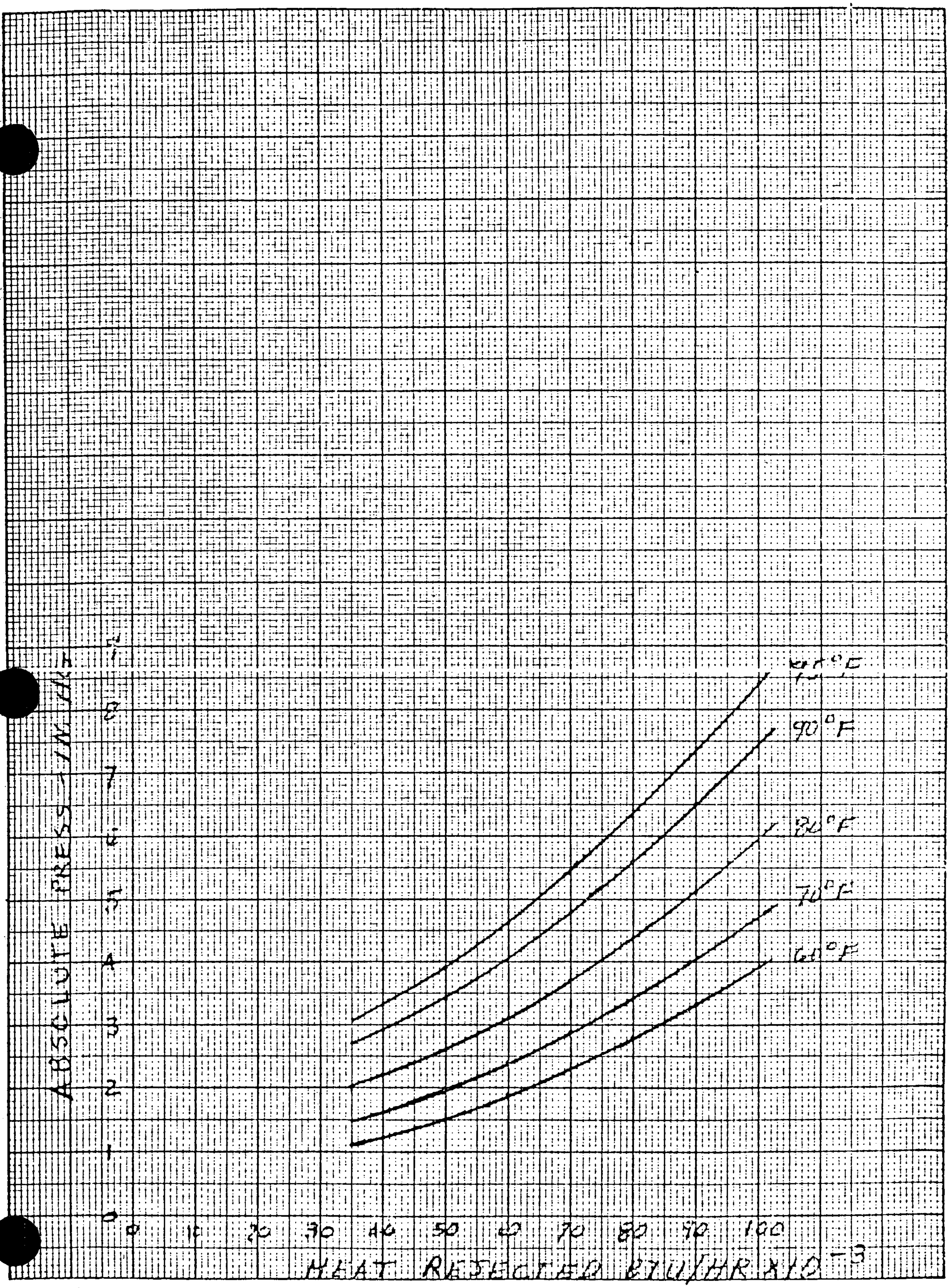
CONDENSATE PUMP

Capacity, gpm	8,000
Total Head in ft. of water	1,130
Submergence, feet of water	*
Speed	*
Motor Rating hp	*

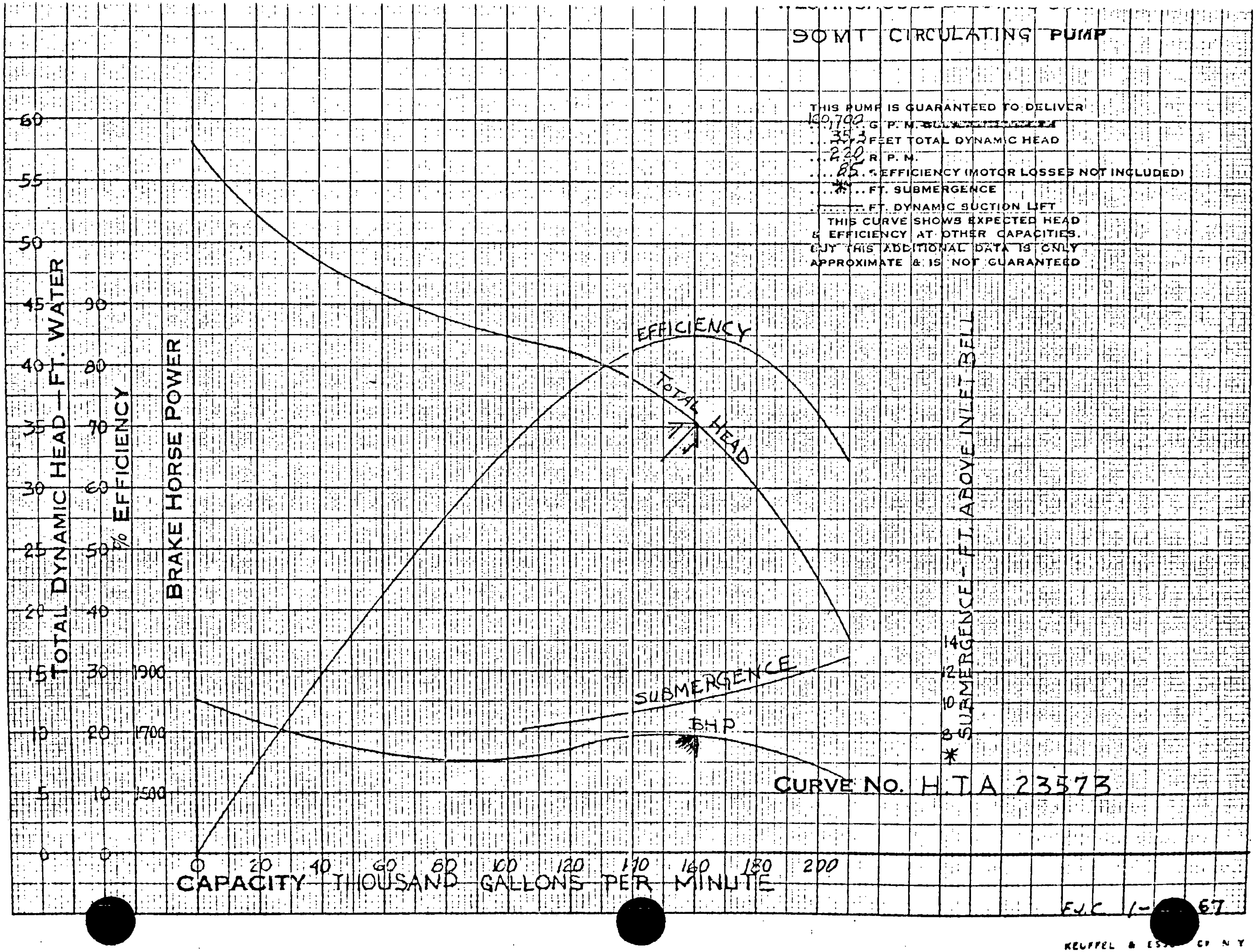
VACUUM PUMP

Nash Model CL-3005, Single Jet, Having A Holding Capacity of 24 SCFM at 1" Hg. Absolute

*See Performance Curve



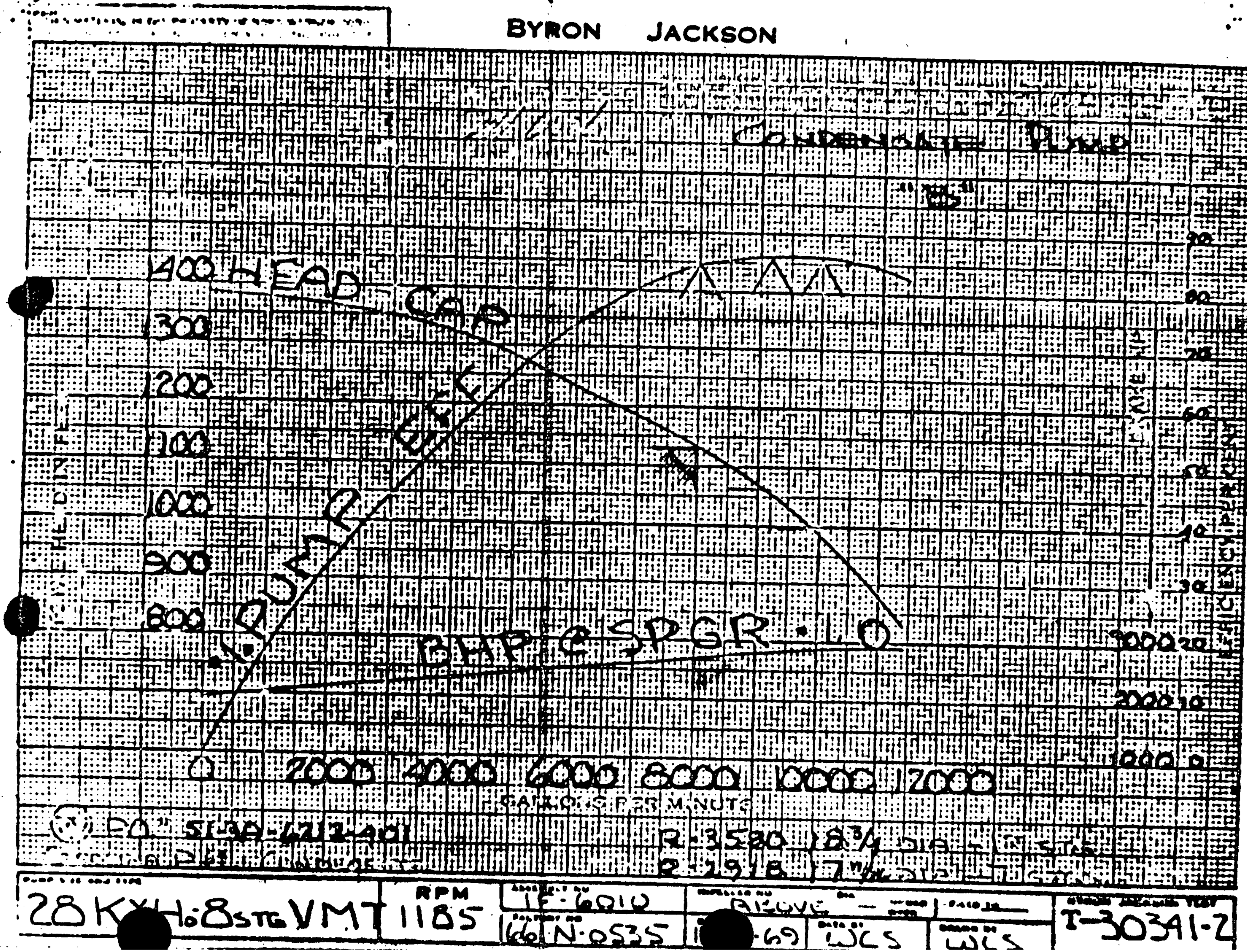
SIGNATURE ________________ DATE ________ CURVE NO. HTA 25820-A



90MT CIRCULATING PUMP
THIS PUMP IS GUARANTEED TO DELIVER
100,700 G. P. M.
35.3 FEET TOTAL DYNAMIC HEAD
220 R. P. M.
85 % EFFICIENCY (MOTOR LOSSES NOT INCLUDED)
* FT. SUBMERGENCE
FT. DYNAMIC SUCTION LIFT
THIS CURVE SHOWS EXPECTED HEAD & EFFICIENCY AT OTHER CAPACITIES. BUT THIS ADDITIONAL DATA IS ONLY APPROXIMATE & IS NOT GUARANTEED
EFFICIENCY
TOTAL HEAD
SUBMERGENCE
BHP
TOTAL DYNAMIC HEAD — FT. WATER
% EFFICIENCY
BRAKE HORSE POWER
SUBMERGENCE — FT. ABOVE INLET BELL
CAPACITY THOUSAND GALLONS PER MINUTE
CURVE No. H.T.A 23573

PUMP:	CONDENSATE PUMPS
NUMBER	THREE (3)
MANUFACTURER:	BYRON JACKSON
MODEL NUMBER:	28 KXH$_0$H$_7$ - 9 STG
DESIGN FLOW:	8,000 GPM
TOTAL DYNAMIC HEAD:	1130 FT
PUMP SPEED:	1185 RPM
PUMP EFFICIENCY:	84.5 %
DESIGN BRAKE HORSEPOWER:	2702 BHP
MAXIMUM BRAKE HORSEPOWER:	2375 BHP (RUN-OUT)
PUMP PERFORMANCE CURVE:	T-30341-2

PUMP TEST DATA SHEET ALSO INCLUDED



Condensate Pump

Byron Jackson Pump Division
BORG WARNER CORPORATION

(8) HTR ... Held - AM
Tab 7

PUMP TEST DATA

PUMP SIZE AND TYPE: 28KXH₀H₇ 8 STG

Impeller Drawing	Diameter	Vanes			
K-3580	18¾	5	—		10
R-2918	17⅝	7	—		7

GUARANTEED PUMPING CONDITIONS

	R.P.M.	G.P.M.	T.D. HEAD	PUMP EFF.	OVERALL EFF.	NPSH	SP. GR.
Field Speed / Test Speed	1186	8000	1130	—			1.0

DIFF. VEL. HD BETWEEN GAUGES AT 24 I.D. DISCH. AND — I.D. SUCT. = .79 FT AT 10,000 G.P.M.
TEST MOTOR NO. CUT 3000 # 6 POLES 4160 VOLTS
MOTOR EFF
BAROMETRIC PRESSURE IN HG

TESTED BY: WCS
FOR: W Westinghouse Elect
CUSTOMER'S ORDER NO. 51-3A-6212-401
ITEM NO.
JOB NO. N-0535
NOTES:

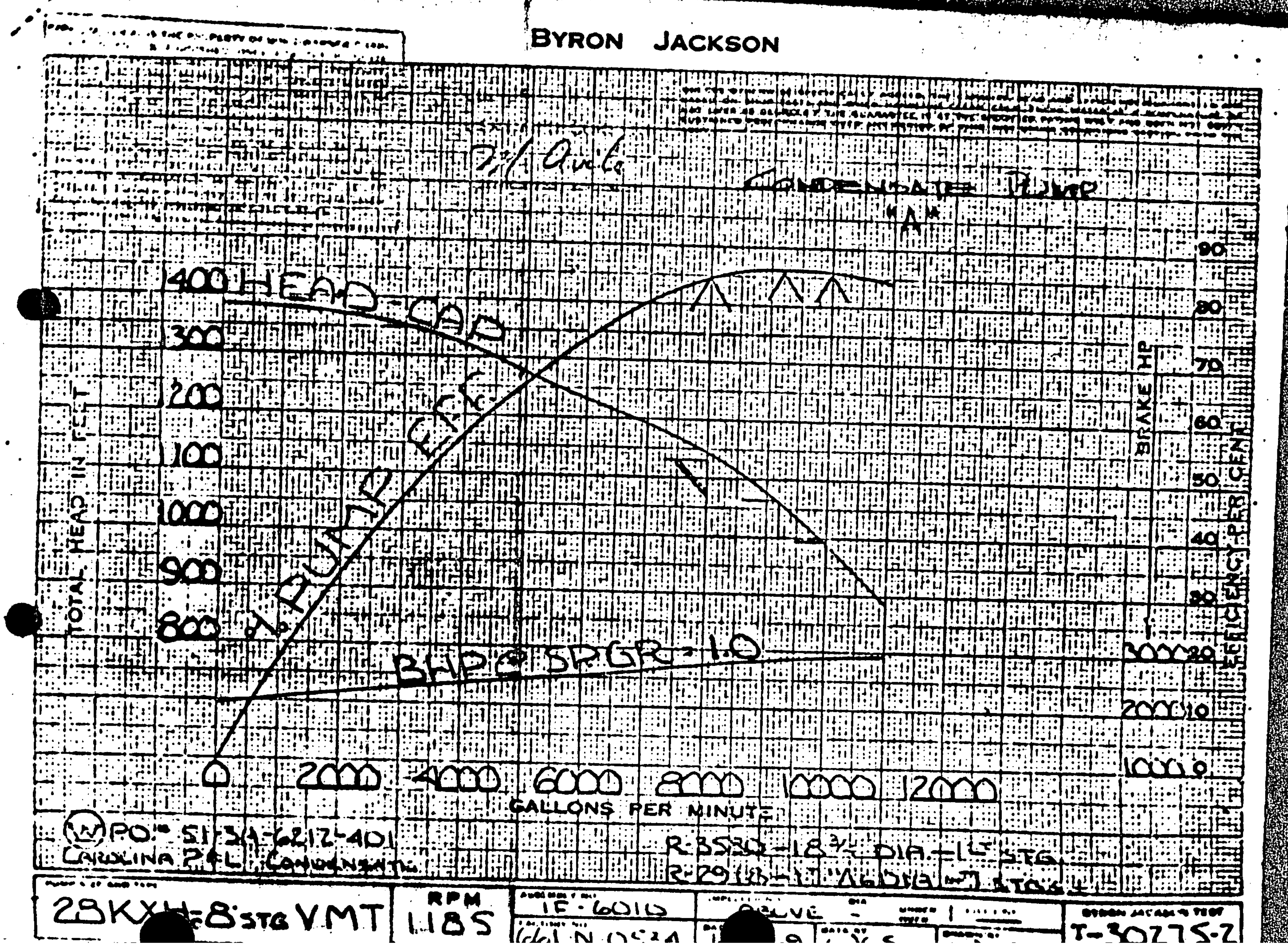
$\frac{600}{5} \times \frac{40}{1} \div .746 = 6440$ HP INPUT
KCF (W) TEST 621577

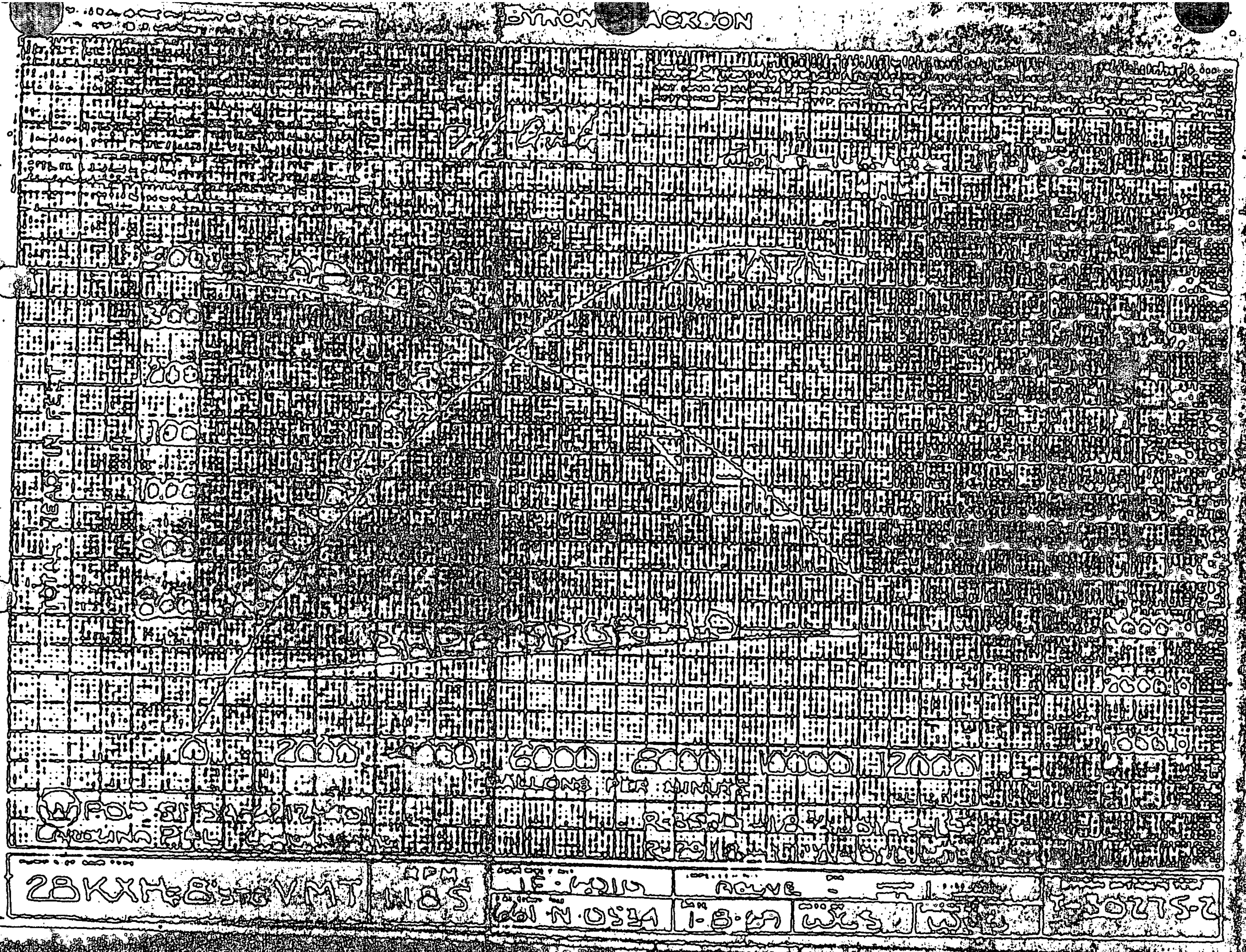
Discharge head gauge used: # 132, 1000
Capacity measured with: 24 x 12 Venturi

No.	Suct. Hd. Gauge Read	Suct. Hd. Gauge Corr.	Suct. Feet of Water	Disch. Gauge Read	Disch. Gauge Corrected	Disch. Feet of Water	Elevation Head	Differential Velocity Head	Total Dynamic Head in Feet of Water	Capacity Read	Capacity G.P.M.	Water Horse Power	Brake Horse Power	Watt Meter Reading (x 640)	Equiv. H.P. Input			Pump Efficiency			
1				354	3510	822	7.6	1.0	830.6	—	11,400	2392	2900	.473	3060			82.5			1180
2				422	4196	970		.8	978.2	—	10,000	2470	2880	.479	3030			85.9			
3				460	4582	1061		.6	1069.4	—	9,000	2435	2825	.461	2970			86.0			
4				487	4852	1124		.6	1132.1	—	8000	2290	2700	.442	2815			84.8			
5				530	5289	1223		.3	1230.9	—	5900	1835	2510	.410	2640			73.1			
6				591	5894	1364		—	1371.4	—	2000	693	2150	.352	2265			32.2			
7				596	5944	1377		0	1384.6		0	0	1925	.314	2025			0			
8																					
9																					
10																					
11																					
12																					

PUMP RH1

DATE OF TEST 1-21-69 PUMP SERIAL No. 661-N-0535 T-30341-7


BYRON JACKSON
CONDENSATE PUMP
"A"
TOTAL HEAD IN FEET
1400 HEAD-CAP
1300
1200
1100
1000
900
800
% PUMP EFF.
BHP @ SP.GR.-1.0
2000 4000 6000 8000 10000 12000
GALLONS PER MINUTE
BRAKE HP
EFFICIENCY PER CENT
90
80
70
60
50
40
30
20
10
0
PO.# 51-34-6212-401
CAROLINA P&L CONDENSATE
R-3530-18 3/4 DIA-1st STG
RPM
1185
1F-6010
T-30775-2
28KXH-8 STG VMT


BYRON JACKSON
2000
6000
8000
10000
12000
GALLONS PER MINUTE

INDUCTION MOTOR DATA SHEET

ARC-719

1 PROJECT	Carolina Power & Light Company	S O NO.	APP-CPI-360
2 FURNISHED BY			
3 MARK OR ITEM NO.	Condensate Pump	DATE	10.12.66 BY E. J. Hayford
			Revised 9/20/67

PURCHASER'S REQUIREMENTS		DATA FURNISHED BY SELLER	IRA
5 SERVICE	Pump Drive	MAKE	
6 TYPE		FRAME NO	
7 NO OF UNITS	2	HORSEPOWER	
8 MOUNTING	Vertical	SERVICE FACTOR	
9 ELEC CHARACTERISTICS	4000 V. 3 PH 60 CY	FULL LOAD RPM	
10 SYNCH. SPEED RPM	1200	FULL LOAD AMP	
11 HORSEPOWER	3000	LOCKED ROTOR AMP	
12 SERVICE FACTOR	1.15	STARTING TORQUE, % F.L.	
13 ENCLOSURE	Weather Protected - Type 2	PULL-OUT TORQUE, % F.L.	
14 INSULATION CLASS	B	EFF.-FULL LOAD, %	
15 INSULATION TREATMENT	Powerhouse	EFF.-3/4 LOAD, %	
16 AMBIENT TEMP. C	40°	EFF.-1/2 LOAD, %	
17 STATOR TEMP RISE C	60°	P.F.-FULL LOAD, %	
18 BEARING TYPE	Kingsbury, Sleeve	P.F.-3/4 LOAD, %	
19 BEARING TEMP RELAY	None	P.F.-1/2 LOAD, %	
20 BEARING THERMOCOUPLE		P.F.-LOCKED ROTOR	
21 HALF COUP. OR SHEAVE MTD. BY	1/Brg.-Cu-Cons.	SPACE HTRS. TOTAL WATTS	
22 ROTATION	Motor Mfg. (?)	RADIAL BEARING-TYPE	
23 WK² OF DRIVEN EQUIP.		THRUST BEARING-TYPE	
24 BRKWY. TORQ. DRVN. EQUIP.		BEARING SERVICE-HR.	
25 OVERSIZE COND. BOX	18"Lx14"Wx16"D Min.	NORMAL BRG. OPER. TEMP-C	
26 COND. BOX LOCATION	Standard	NET WEIGHT-LB	
27 SPACE HEATERS VOLTAGE, PHASE	120V, 1Ø, 60 cps	OIL COOL. SYS. REQ'D	
SPLIT END BELLS		BRG. OIL PRESS. RANGE, PSI	
TERMINAL LUGS TYPE	Burndy YA 1-750 MCM/Phase	BRG. OIL REQ'D EA. BRG. GPM	
STATOR HIGH TEMP DEVICE	RTD's	NAME PLATE CODE LETTER	
ADJUSTABLE SLIDE RAILS		PERMISSIBLE STARTS PER HR	
SOLE PLATES		MOTOR AT AMBIENT TEMP	
PROJECTION	225	MOTOR AT RATED TOTAL TEMP	
SHAFT SOLID		TYPE SEALED INSUL. SYS.	
COUPLING (SELF-RELEASE, SOLID, NONREVERSING, ADJUSTABLE, FLEXIBLE)		DESCRIPTION OF INSUL. SYS.	
VERT. MAX DOWNTHRUST	21,000 Lbs.		
VERT. MAX UPTHRUST			
VERT. MIN UPTHRUST			
VERT. MIN DOWNTHRUST (WITH MOTOR RUNNING)			
SIDE THRUST			
MAX REVERSE SPEED			
DRAIN PLUG AND VENT			
AIR INTAKE SCREENS			

Disposable Air Filters

REMARKS

ALL PERFORMANCE DATA BASED ON NORMAL RATED VOLTAGE AND FREQUENCY
ITEMS 4-44 APPLY TO VERTICAL MOTORS ONLY

REMARKS

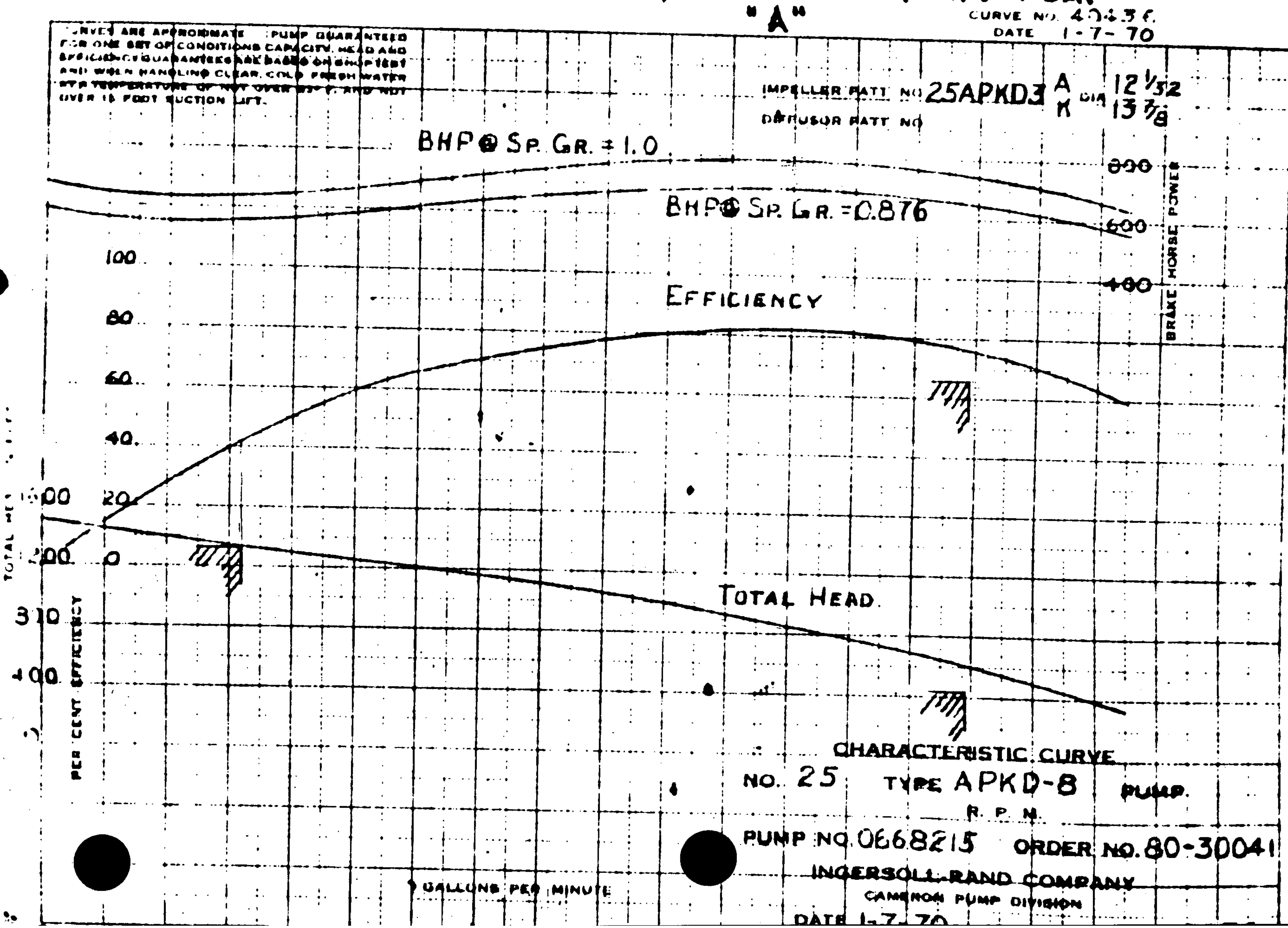
ALL PERFORMANCE DATA BASED ON NORMAL RATED VOLTAGE AND FREQUENCY
INDICATE IF DATA IS ESTIMATED

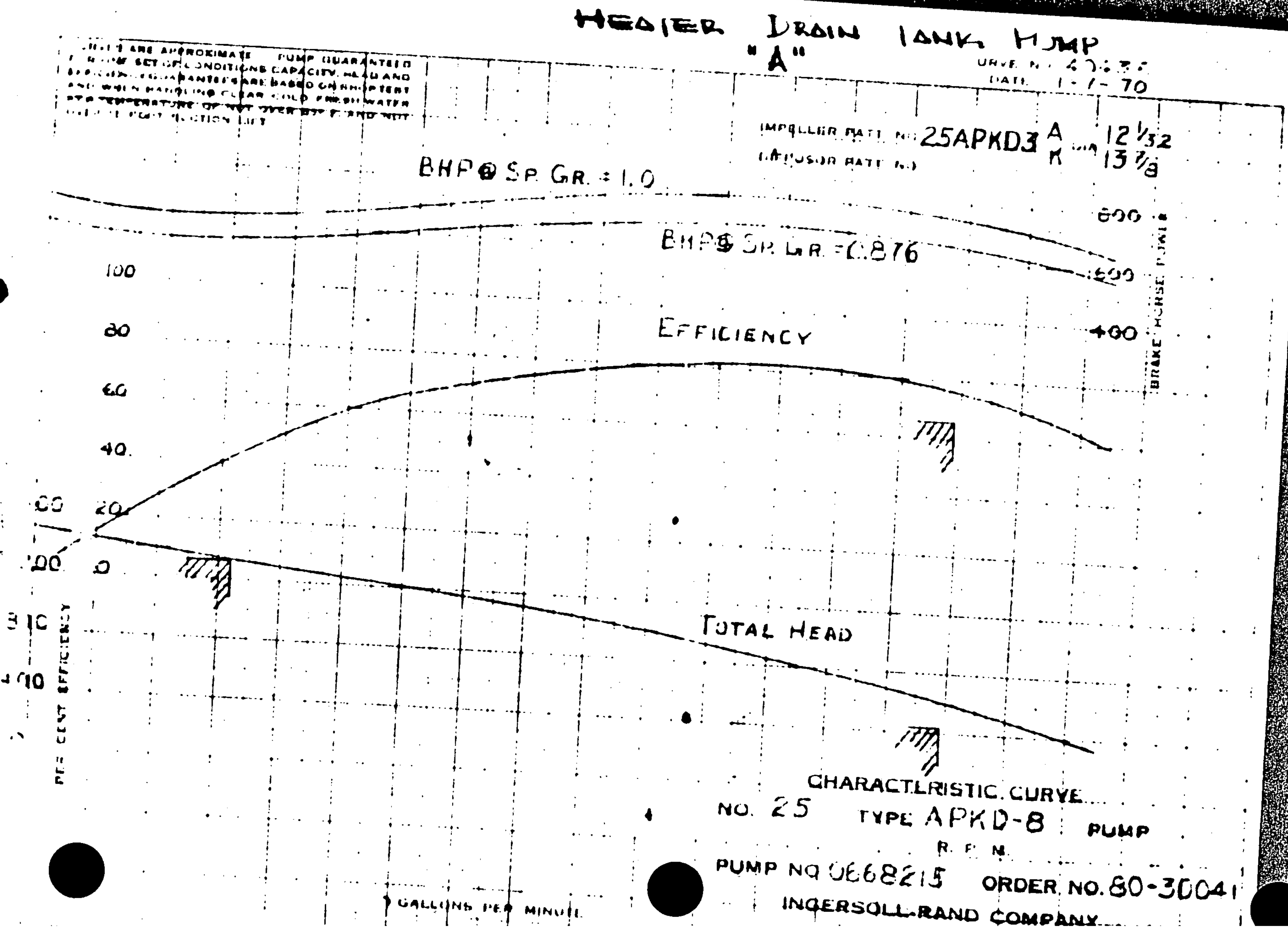
VIEWED FROM END OPPOSITE COUPLING END

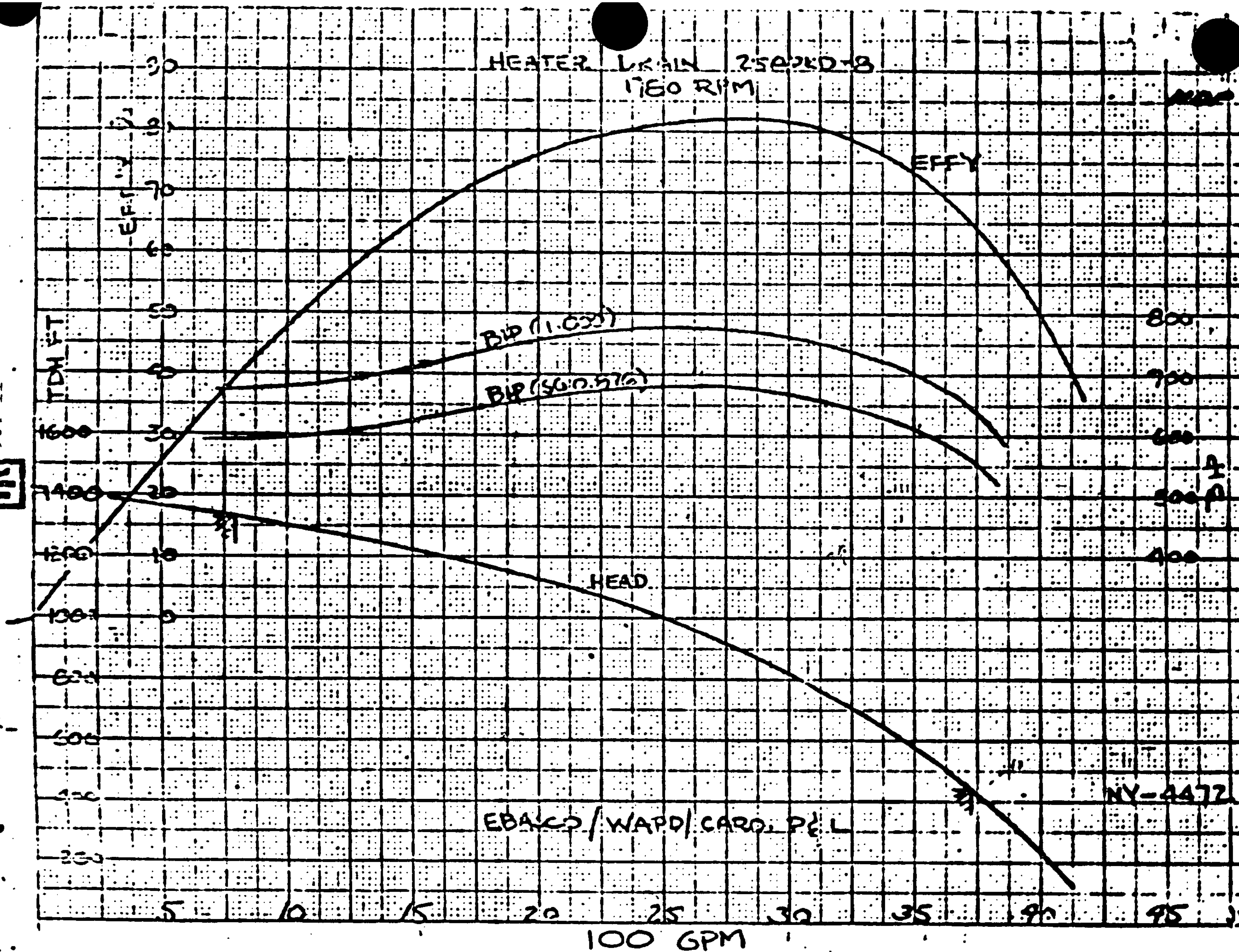
PUMP:	HEATER DRAIN PUMP	
NUMBER:	TWO (2)	
MANUFACTURER:	INGERSOLL RAND	
MODEL NUMBER:	25 APKD - 8 STG	
DESIGN FLOW:	3710 GPM	750 GPM
TOTAL DYNAMIC HEAD:	440 FT	1330 FT
PUMP SPEED:	1780 RPM	
PUMP EFFICIENCY:	66 %	44 %
DESIGN BRAKE HORSEPOWER:	625	572
MAXIMUM BRAKE HORSEPOWER:	779 BHP	2750 GPM @ 920'
PUMP PERFORMANCE CURVE:	40436	

CURVES FOR BOTH PUMPS A & B INCLUDED

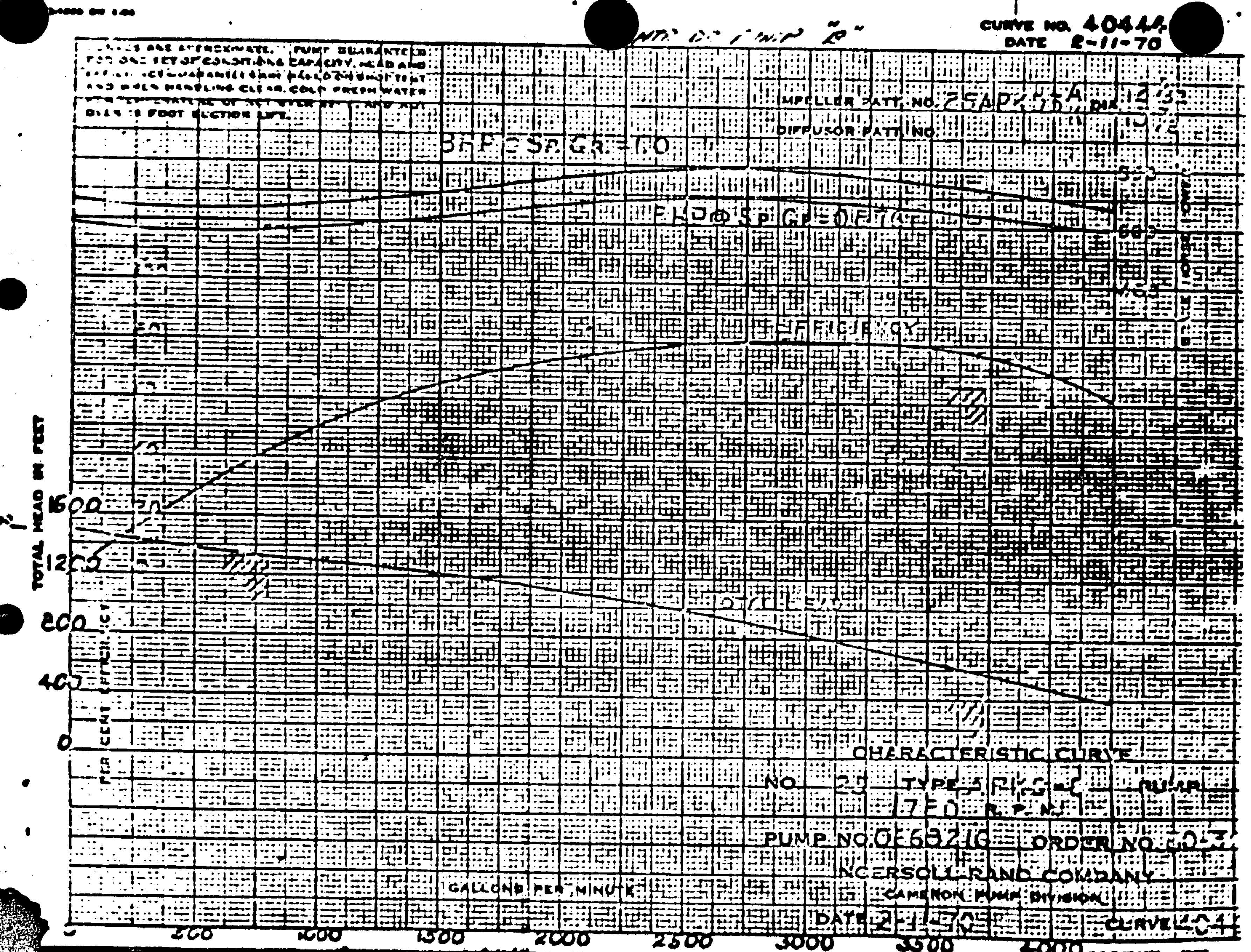
HEATER DRAIN TANK PUMP "A"

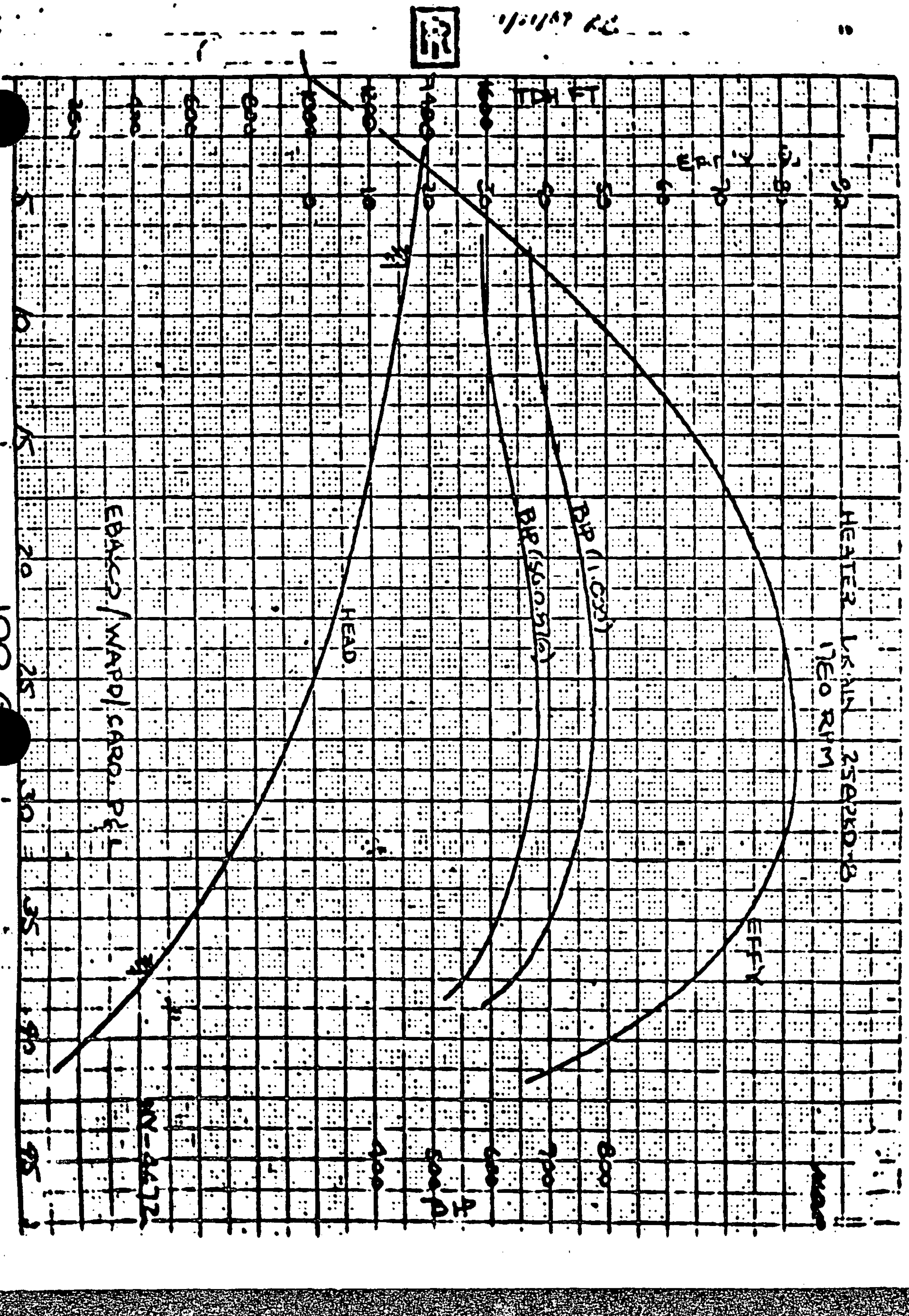


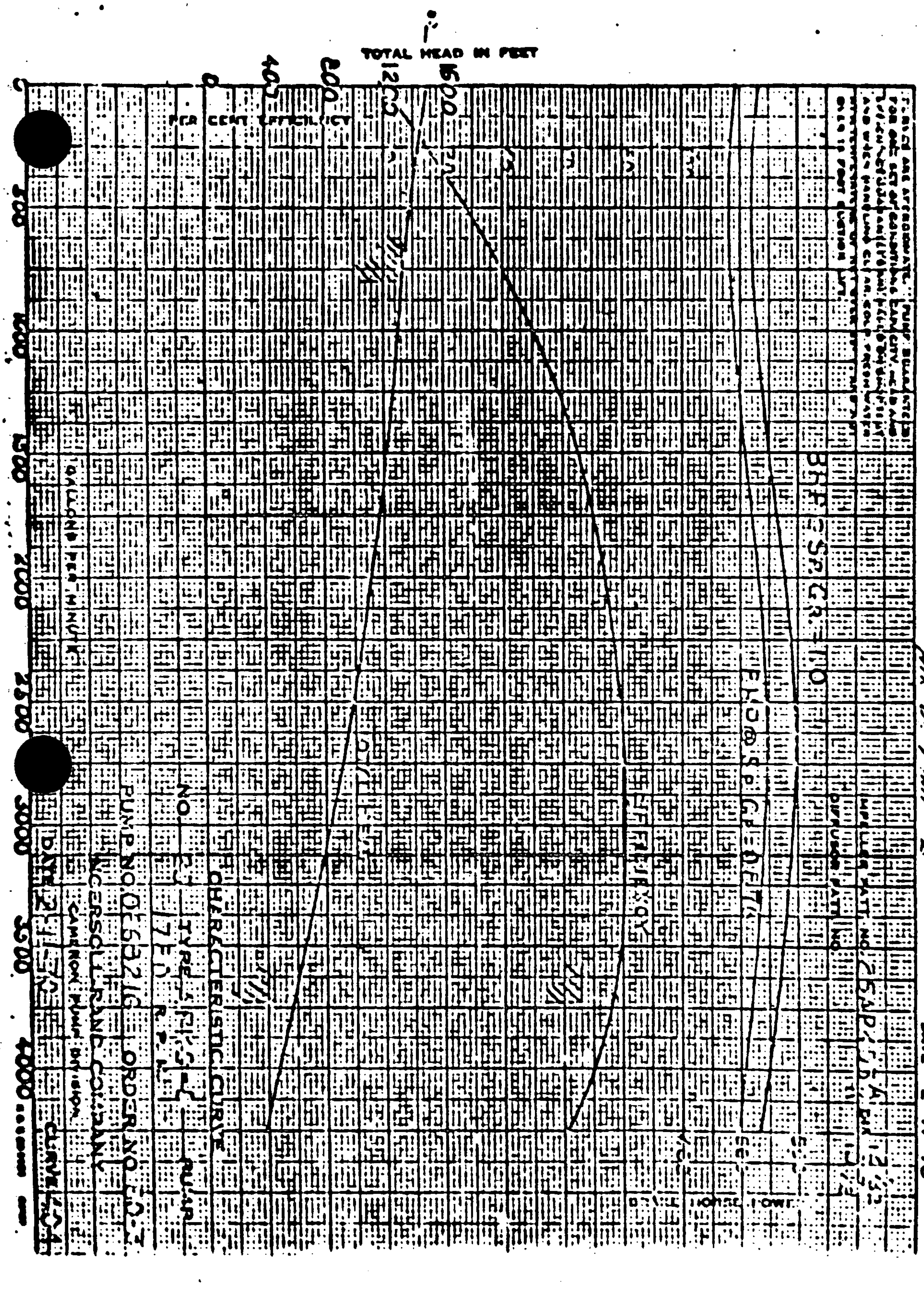

HEATER DRAIN TANK PUMP
"A"
DATE 1-7-70
IMPELLER PATT. NO. 25APKD3 A 12 1/32
K 13 7/8
BHP @ Sp. Gr. = 1.0
BHP @ Sp. Gr. = 0.876
600
500
400
BRAKE HORSE POWER
100
80
60
40
20
0
EFFICIENCY
TOTAL HEAD
PER CENT EFFICIENCY
CHARACTERISTIC CURVE
NO. 25 TYPE APKD-8 PUMP
R.P.M.
PUMP NO 0668215 ORDER NO. 80-30041
INGERSOLL-RAND COMPANY
GALLONS PER MINUTE



HEATER DRAIN 2502RD-8
1760 RPM
EFFY
B.HP (1.033)
B.HP (SP.GR. .576)
HEAD
EBASCO / WAPD / CARO. P&L
NY-4472
TDH FT
EFF
100 GPM
5
10
15
20
25
30
35
40
45
1600
1400
1200
800
700
600
500
400


CURVE NO. 40444
DATE 2-11-70
IMPELLER PATT. NO.
DIFFUSOR PATT. NO.
EFFICIENCY
TOTAL HEAD IN FEET
PER CENT EFFICIENCY
1600
1200
800
400
0
CHARACTERISTIC CURVE
R.P.M.
PUMP NO.
ORDER NO.
INGERSOLL-RAND COMPANY
CAMERON PUMP DIVISION
GALLONS PER MINUTE
CURVE
500
1000
1500
2000
2500
3000
3500
4000


TDH FT
HEAD
EFF'Y
1760 RPM


TOTAL HEAD IN FEET
PER CENT EFFICIENCY
GALLONS PER MINUTE
CHARACTERISTIC CURVE
INGERSOLL-RAND COMPANY
CAMERON PUMP DIVISION
CURVE NO. 40446
DATE 2-11-70

[illegible] CORPORATION

[illegible]

[illegible]	[illegible]	Freq.	[illegible]	Amps.	Type	[illegible]	Temp. Rise	[illegible]	[illegible]	[illegible]
[illegible]	3	60	[illegible]	[illegible]	CSP	[illegible] P20	[illegible]°C	24 hr.		[illegible]

TEST CHARACTERISTICS

[illegible]	No Load					Heaters [illegible]					Open Circuit Voltage [illegible]	Dielectric Test
	Volts	Freq.	[illegible]	Amps.	[illegible]	Volts	Amps.	[illegible]	Vibration	[illegible]		
1	[illegible]	60	[illegible]	15.4	15.0	120		2.07	7 -	[illegible]		[illegible]
				16.3					8 -	[illegible]		
				15.[illegible]								
	[illegible]	60	[illegible]	[illegible]	12.1	120		2.[illegible]	7 -	[illegible]		[illegible]
				16.[illegible]					8 -	[illegible]		
				16.[illegible]								

APPROVED BY [illegible] DATE [illegible]

PUMP: STEAM GENERATOR FEED PUMPS

NUMBER: TWO (2)

MANUFACTURER: PACIFIC PUMPS

MODEL NUMBER: 18 x 23 HVCN

DESIGN FLOW: 12640 GPM

TOTAL DYNAMIC HEAD: 1665 FT

PUMP SPEED: 3570 RPM

PUMP EFFICIENCY: 85%

DESIGN BRAKE HORSEPOWER: 5458 BHP @ SPECIFIC GRAVITY = 0.873

MAXIMUM BRAKE HORSEPOWER: 5800 BHP @ 16500 GPM [illegible] S.G. = 0.873

PUMP PERFORMANCE CURVE: 43571

SYSTEM HEAD CURVE AVAILABLE

CONTRACTOR EBASCO

CUSTOMER CAROLINA POWER & LIGHT

ITEM NO. ———— P.O. NY-434107

IMPELLER PATTERN D-2970

MAXIMUM DIAMETER 23

RATED DIAMETER 21 3/4

MINIMUM DIAMETER 18 1/2

FEEDWATER PUMP "A"

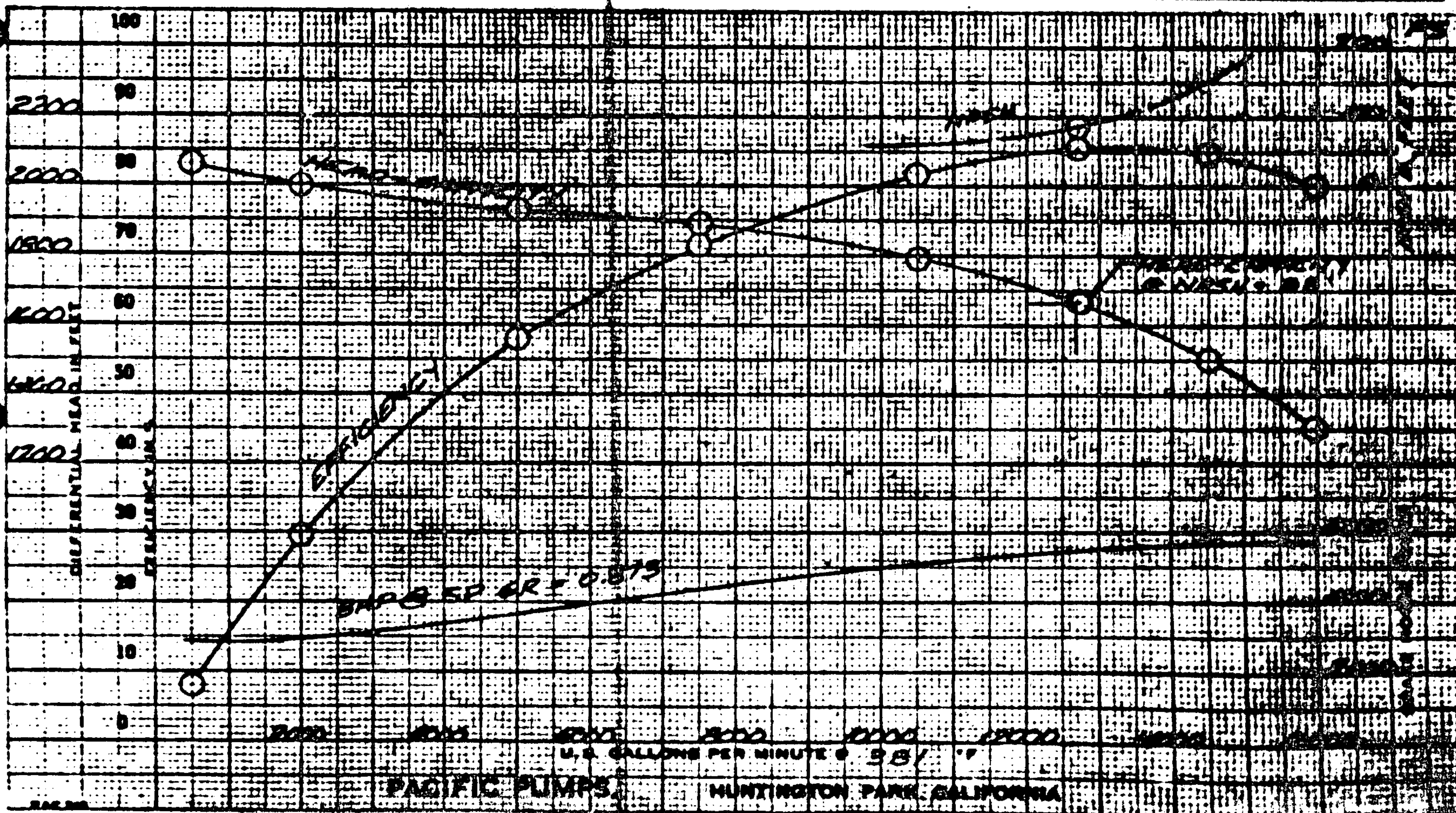
TEST PERFORMANCE CURVE NO. [illegible]

SIZE 18X23 TYPE HVCH STAGES 1

R.P.M. 3570 [illegible]

PUMP NUMBER 13570

PERFORMANCE ALSO APPLIES TO PUMP NUMBER [illegible]



PACIFIC PUMPS, INC., HUNTINGTON PARK, CALIF. — PUMP TEST DATA — TEST CURVE NO. 33292

SIZE 18X23 TYPE HYCH STAGES 1

P.P.I. ORDER NO. D45-283 SERIAL NO. 43520

CONTRACTOR: EBASCO
CUSTOMER: CAROLINA PWR & LIGHT
CUSTOMER'S P.O. NO. NY-434107
ITEM NO.
DATE: 7-31-68
TESTED BY: RMB FOR P.P.I.
WITNESSED BY: [illegible]
DRIVER: GE TURBINE

TEST EQUIPMENT 2332

TARE 5 800

REMARKS:

10 TORQUE METER

	ITEM NO.	NO. OF READING	1	2	3	4	5	6	7	8	9	10	11	12
POWER	23	R.P.M.	3571	3565	3570	3567	2530	2100	1839	1670		2103		
	24	TORQUEMETER—IN. LB.	11700	11500	6510	19970	6490	14590	7460	3060		14550		
	25	ADD TO TORQUE—IN.LB.	40M	40M	60M	60M	40M	20M	20M	20M		20M		
	26	TOTAL TORQUE—IN.LB. (INCLUDES TARE)	51700	54500	66510	79920	46490	34590	27450	23060		34550		
	27	NET TORQUE—IN.LB.	51400	54200	66210	79620	46190	34290	27150	22760		34250		
	28													
	29	BHP INPUT TO PUMP	2915	3070	3755	4510	1852	1142	794	604		1141		
	30	WATER HORSEPOWER (FROM PAGE 1)												
	31													
	32	PUMP EFFICIENCY—%	8.0	29.5	58.2	71.2	81.7	85.5	84.7	80.0		85.7		
	33													
	34	AVERAGE SP.GR. (FROM PAGE 1)	.890	.896	.896	.896	.896	.896	.896	.896		.896		
	35													
	36													
GPM	37	FLOW INDICATION												
	38	INDICATED GPM												
	39	CORRECTED GPM												
	40													
		CHARACTERISTIC CURVE CONDITIONS @ 3570 R.P.M. @ .873 SP. GR.												
	41	G.P.M.	500	2000	5015	7500	10500	12700	14500	15920		12730		
	42	TOTAL HEAD FT.	2060	2000	1925	1890	1790	1670	1500	1306		1668		
	43	B.H.P.	2860	2990	3655	4390	5060	5460	5660	5740		5450		

~~[illegible]~~ Serial # 435[illegible]

[illegible] ×8· HBR2-726
Reg file

PACIFIC PUMPS, HUNTINGTON PARK, CALIF. — **PUMP TEST DATA** — TEST CURVE NO. 33283

SIZE 12123 TYPE HVCN STAGES 1

P.P.I. ORDER NO. 1D 45-287 SERIAL NO. 43570

	SUCTION IMPELLER	RADIAL IMPELLER
NO	D-2970	
TEST DIA	21 3/4	
FINAL DIA	21 3/4	

CLEARANCES: WR. RING .026 / .024; SPACER CLR.: ; DRUM:

GUARANTEED PUMPING CONDITIONS

	RPM	GPM	T.D. HEAD	EFF	N.P.S.H.	SP. GR.
FIELD SPEED	3570	12640	1665	83	88	0.873
TEST SPEED	—	—	—	—	—	—

DIFFUSER MAT'L:

IMPELLER MAT'L: 11.5-14% CHR STEEL

BAROMETER:

CONTRACTOR: EBASCO

CUSTOMER: CAROLINA PWR & LIGHT

CUSTOMER'S ORDER NO. NY-421107

ITEM NO.

DATE 7-31-68

TESTED BY: KMS - PS FOR P.P.I.

WITNESSED BY: [illegible]

DRIVER: GE TURBINE

HEAD

ITEM NO	NO. OF READING	1	2	3	4	5	6	7	8	9	10	11	12
1	DISCHARGE GAGE	1045	1017	984	942	544	416	337	312		334		
2	DISCHARGE PRES.-PSIG												
3	SUCTION GAGE	251	244	243	222	206	205	196	214		123		
4	SUCTION PRES.-PSIG												
5	DIFFERENTIAL PRES-PSI	794	775	741	720	336	211	141	98		211		
6	SUCTION TEMP.-°F	344	344	344	344	345	345	345	345		345		
7	SUCTION SP. GR.	.896	.894	.896	.896	.895	.895	.895	.895		.895		
8	DISCHARGE TEMP.-°F	366	346	344	344	343	343	343	343		343		
9	DISCHARGE SP. GR.	.833	.895	.896	.896	.896	.896	.896	.896		.896		
10	AVERAGE SP. GR.	.890	.896	.896	.896	.896	.896	.896	.896		.896		
11	DIFFERENTIAL HEAD-FT	2060	1998	1910	1855	865	544	364	252		543		
12	DIFF. VEL. HEAD-FT.	—	2.4	15.9	34.5	34.0	34.2	34.1	34.2		34.3		
13	TOTAL HEAD-FT.	2060	2000	1925	1890	899	578	398	286		577		
14	WATER HORSEPOWER												
15	FLOW-CPS	69	277	690	1029	1022	1025	1029	1026		1029		
16	GPM	500	2000	5016	7500	7450	7475	7470	7480		7500		
17													
18													
19													
20													
21													
22													

TEST EQUIPMENT 2238

TEST GAGE: 1500 - 1

TEST GAGE: 300 - 1

DIFF. GAGE ELEV. 0 FT.

COLD SHOCK TEST

TEMP °F	TIME
120	2:55 PM
130	2:57
142	2:58
160	3:00
174	3:04
183	3:06
201	3:08
220	3:10
250	3:13
270	3:15
280	3:17
300	3:20
360	3:24
100	3:2[illegible]

PAC 170

CONTRACTOR EBASCO

CUSTOMER CAROLINA POWER & LIGHT Co

ITEM NO. —— P.O. NY-434107

IMPELLER PATTERN D-2970

MAXIMUM DIAMETER 23

RATED DIAMETER 21 3/4

MINIMUM DIAMETER 18 1/2

FEEDWATER PUMP "B"

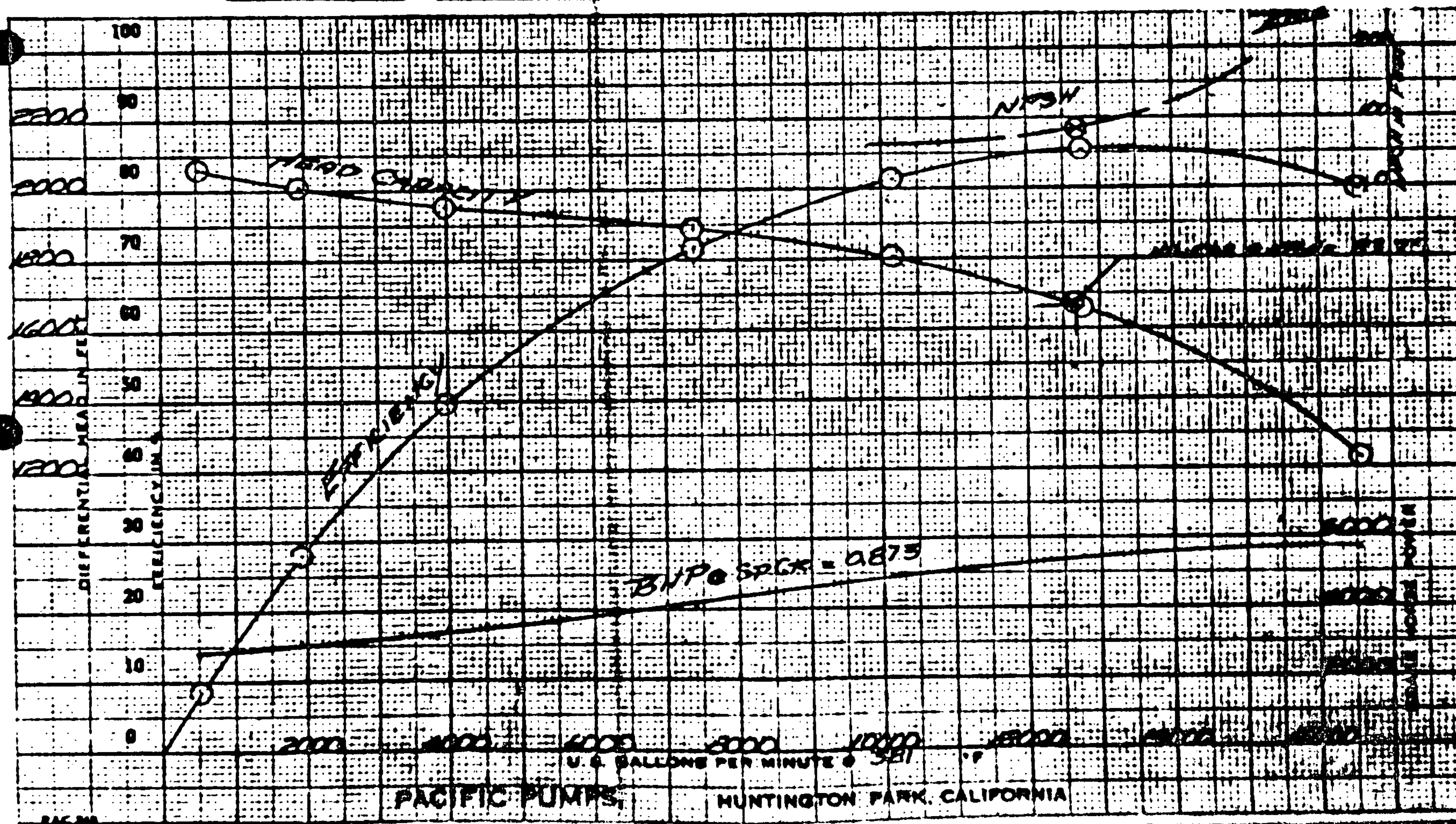
TEST PERFORMANCE CURVE NO. 33283-B

SIZE 16X23 TYPE MKN STAGES 1

R.P.M. 3570 DATE 8-23-68

PUMP NUMBER 43571

PERFORMANCE ALSO APPLIES TO PUMP NUMBER ——



TT-136

PACIFIC PUMPS, HUNTINGTON PARK, CALIF. — PUMP TEST DATA — TEST CURVE NO. 83283-8

SIZE 19x22	TYPE HVC
STAGES 1	
P.P.I. ORDER NO. 45283	SERIAL NO. 1

CONTRACTOR:	EBASCO
CUSTOMER:	[illegible]
CUSTOMER'S P.O. NO.	NY-434107
ITEM NO.	
DATE	8-23-63
TESTED BY:	[illegible] FOR P.P.I.
WITNESSED BY:	
DRIVER:	GE TURBINE

	ITEM NO.	NO. OF READING	1	2	3	4	5	6	7	8	9	10	11	12
POWER	23	R.P.M.	3298?	3598?	3571	3572	2434?	1965	1530?		1989			
	24	TORQUEMETER—IN. LB.	9400?	15200	3400?	14390	3600	10050	18550?					
	25	ADD TO TORQUE—IN. LB.	40M	40M	60M	60M	40M	00M?	0M?					
	26	TOTAL TORQUE—IN. LB. (INCLUDES TARE)	49400	55200	62800?	74390?	13600?	30050?	18550					
	27	NET TORQUE—IN. LB.	49300	55100	62300	74290	43500?	29950?	18450					
	28													
	29	BHP INPUT TO PUMP	2795	3120	3530	4210	1719	934	495					
	30	WATER HORSEPOWER (FROM PAGE 1)												
	31													
	32	PUMP EFFICIENCY—%	81.5	28.0	49.9	71.2	81.1	65.3	79.9					
	33													
	34	AVERAGE SP. GR. (FROM PAGE 1)												
	35	10x16 1/2	—	18.5	7.8	24.3	24.5	23.6	24.0					
	36	6x5 1/2-4	—	1.0	4.0	12.7	12.8?	12.5	12.8					
GPM	37	FLOW INDICATION												
	38	INDICATED GPM												
	39	CORRECTED GPM												
	40													
		CHARACTERISTIC CURVE CONDITIONS @ 3570 R.P.M. @ .873 SP. GR.												
	41	G.P.M.	510	1920	3990	7090	10150	12220	16510		12630			
	42	TOTAL HEAD FT.	2060	2010	1955	1900	1805	1660	1225		1665			
	43	B.H.P.	2745	3045	3430	4110	4960	5950	5620					

TEST EQUIPMENT 7338

TARE = 100

REMARKS:

VENTURI THROAT METER

HBR 2-226 Pai 6b

Serial # 43571

PACIFIC PUMPS, HUNTINGTON PARK, CALIF. — PUMP TEST DATA — TEST CURVE NO. [illegible]-8

Size 18x23 Type H VCH Stage 1

P.P.I. Order No. 45 193 Serial No. 43571

	Suction Impeller	Radial Impeller
No.	D-2970	
Test Dia.	21 3/4	
Final Dia.	21 3/4	

Guaranteed Pumping Conditions	G.P.M.	R.P.M.	T.D. Head	Eff.	N.P.S.H.	Sp. Gr.
Rated Order	5570	2690	1665	63	88	0.873
Test Speed	—	—	—	—	—	—

Clearances: Wear Ring .030; Spacer Slv.: ; Drum:

Diffuser Mat'l:

Impeller Mat'l: 11-149 Chrome

Barometer:

Contractor: EBASCO

Customer: Carolina P&L

Customer's Order No. NY-[illegible]

Item No.:

Date: 8-23-68

Tested By: [illegible] for P.P.I.

Witnessed By:

Driver: GE Turbine

Test Equipment: 2338

Test Gage: SRA

Test Gage: BFI-2

Disc. Gage Elev. 0 Ft.

Item No.	No. of Reading	1	2	3	4	5	6	7	8	9	10	11	12
1	Discharge Gage	1047	1020	984	920	522	379	269		319			
2	Discharge Press.-PSIG												
3	Suction Gage	254	243	232	196	196	190	194		130			
4	Suction Press.-PSIG												
5	Differential Press.-PSI	793	777	752	724	326	188	75		189			
6	Suction Temp.-°F	344	346	345	346	346	346	345		350			
7	Suction Sp. Gr.	.896	.896	.896	.895	.895	.895	.895		.892			
8	Discharge Temp.-°F	369	352	350	349	353	347	346		351			
9	Discharge Sp. Gr.	.882	.891	.892	.893	.894	.894	.895		.892			
10	Average Sp. Gr.	.889	.894	.894	.894	.895	.895	.895		.892			
11	Differential Head-Ft.	2060	2010	1945	1870	842	472	193		483			
12	Diff. Vel. Head-Ft.	.2	2.3	9.7	30.2	30.4	30.1	30.3		30.2			
13	Total Head-Ft.	2060	2012	1955	1900	872	502	223		513			
14	Water Horsepower												
15	Flow-CPS	70	266	552	966	969	963	967		960			
16	GPM	570	1920	3980	7040	7040	7020	7050		7040			
17													
18	RPM									1989			
19													
20													
21													
22													

HEAD

PAC 170

NCR3 - 726
Pass. Fan

[illegible]UCTION MOTOR DATA SHEET

[illegible]

1	PROJECT	[illegible]	S.O NO
2	[illegible]	[illegible]	DATE	BY R. L. Hayford
3	MARK OR ITEM NO	S G [illegible] [illegible]	Revised 9/29/67

No.	PURCHASER'S REQUIREMENTS		DATA FURNISHED BY SELLER
5	SERVICE	[illegible] Generator Feedwater Pump	MAKE
6	TYPE	[illegible]	FRAME NO.
7	NO. OF UNITS	2	HORSEPOWER
8	MOUNTING	[illegible]	SERVICE FACTOR
9	ELEC CHARACTERISTICS	[illegible] V [illegible] 3 PH [illegible] CY	FULL LOAD RPM
10	SYNCH. SPEED, RPM	3600	FULL LOAD AMP
11	HORSEPOWER	6000	LOCKED ROTOR AMP
12	SERVICE FACTOR	1.15	STARTING TORQUE, % F.L.
13	ENCLOSURE	Weather Prot. Type 1	PULL-OUT TORQUE, % F.L.
14	INSULATION CLASS	B	EFF.-FULL LOAD, %
15	INSULATION TREATMENT	[illegible] Treatment	EFF.-3/4 LOAD, %
16	AMBIENT TEMP.-C	[illegible]	EFF.-1/2 LOAD, %
17	STATOR TEMP RISE-C	[illegible]	P.F.-FULL LOAD, %
18	BEARING TYPE	Split Sleeve	P.F.-3/4 LOAD, %
19	BEARING TEMP RELAY	- -	P.F.-1/2 LOAD, %
20	BEARING THERMOCOUPLE	1/[illegible]	P.F.-LOCKED ROTOR
21	HALF COUPL. OR SHEAVE MTD. BY	Motor Supplier	SPACE HTRS. TOTAL WATTS
22	ROTATION*	CCW	RADIAL BEARING-TYPE
23	WK² OF DRIVEN EQUIP.	67 lb.-ft.²	THRUST BEARING-TYPE
24	BRKWY. TORQ. DRVN. EQUIP.	[illegible] ft.-lb.	BEARING SERVICE-HR.
25	OVERSIZE COND. BOX	24"Lx18"Wx18"D min.	NORMAL BRG. OPER. TEMP-C
26	COND. BOX LOCATION*	Pump 2A-LHS, Pump 2B-[illegible]	NET WEIGHT-LB.
27	SPACE HEATERS, VOLTAGE, PHASE	120V 1ϕ 60 CPS	OIL COOL. SYS. REQ'D
28	SPLIT END BELLS		BRG. OIL PRESS. RANGE, PSI
29	TERMINAL LUGS, TYPE	Burndy Type YA, 3-750 MCM per phase	BRG. OIL REQ'D EA. BRG. GPM
30	STATOR HIGH TEMP DEVICE	RTD's	NAME PLATE CODE LETTER
31	ADJUSTABLE SLIDE RAILS	Not Req'd.	PERMISSIBLE STARTS PER HR.
32	SOLEPLATES	Not Req'd.	MOTOR AT AMBIENT TEMP
33	PROJECT ELEV., FT.	225	MOTOR AT RATED TOTAL TEMP
34	SHAFT (HOLLOW, SOLID)		TYPE SEALED INSUL. SYS.
35	COUPLING (SELF-RELEASE)		DESCRIPTION OF INSUL. SYS.
36	SOLID, NONREVERSING		
37	ADJUSTABLE, FLEXIBLE		
38	VERT. MAX DOWNTHRUST		
39	VERT. MAX UPTHRUST		
40	VERT. MIN UPTHRUST		
41	VERT. MIN DOWNTHRUST		
42	(WITH MOTOR RUNNING)		
43	SIDE THRUST		
44	MAX REVERSE SPEED		
45	DRAIN PLUG AND VENT		
46	AIR INTAKE SCREENS	Yes	
47	Outlet Screens	Yes	
48	Disposable Filters	Yes	
49			
50			
51			

52 REMARKS

53 ALL PERFORMANCE DATA BASED ON NORMAL RATED
54 VOLTAGE AND FREQUENCY
55 ITEMS 34-44 APPLY TO VERTICAL MOTORS ONLY

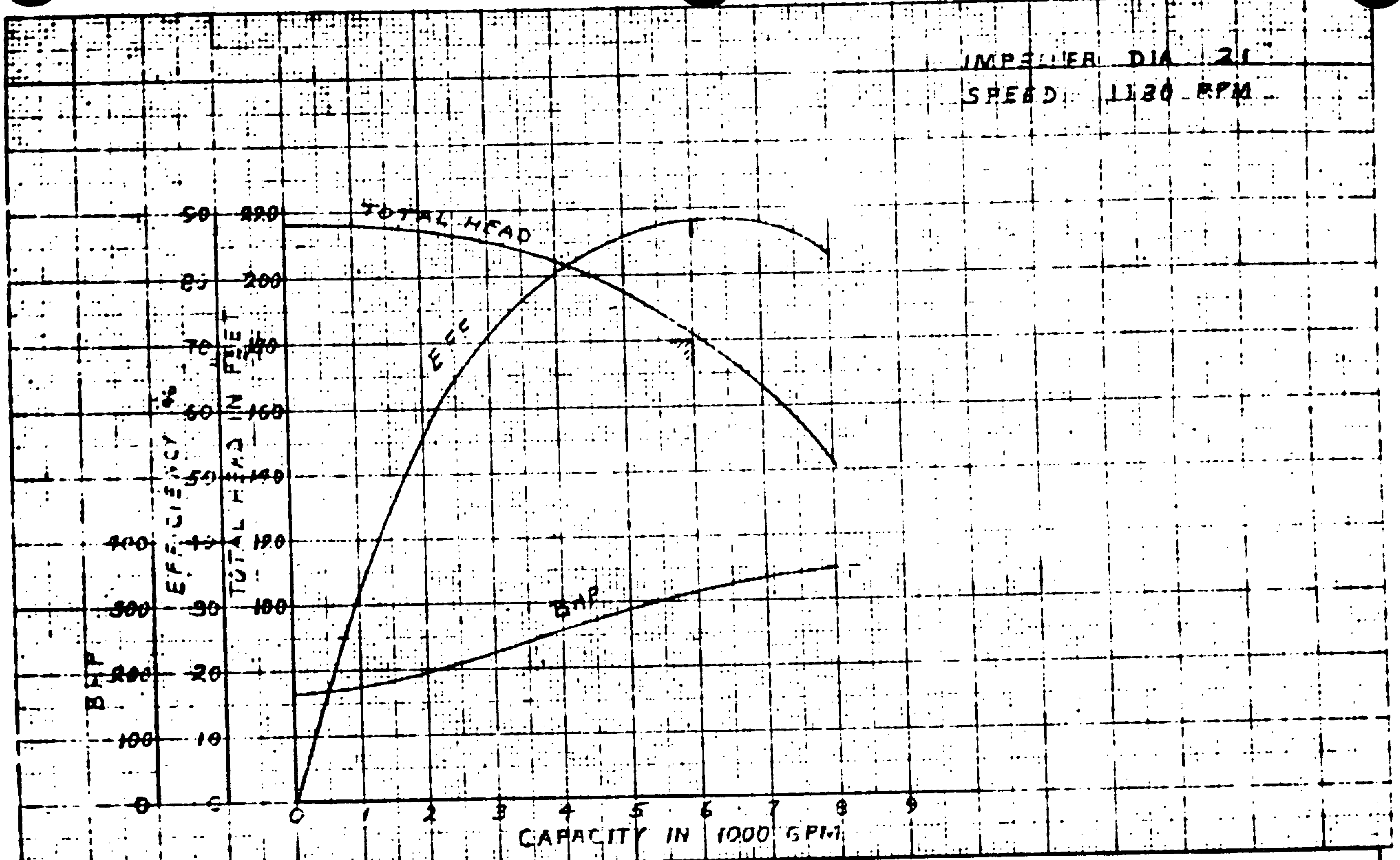
REMARKS

ALL PERFORMANCE DATA BASED ON NORMAL RATED
VOLTAGE AND FREQUENCY
INDICATE [illegible] DATA IS ESTIMATED

57
58 ** Capable of starting with voltage drop
59 to 80%.
60 * VIEWED FROM END OPPOSITE COUPLING END

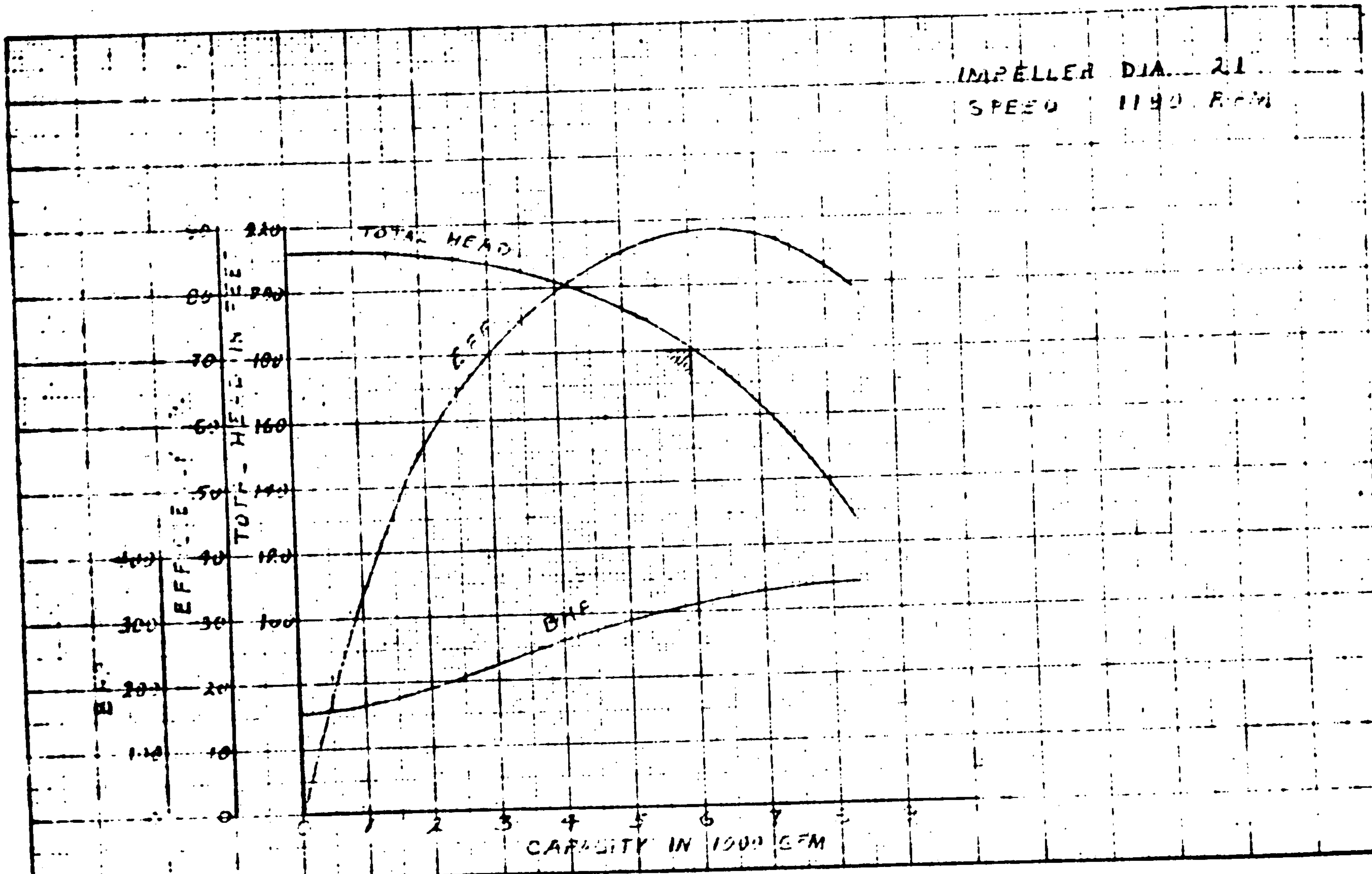
PUMP :	COMPONENT COOLING PUMPS
NUMBER :	THREE (3)
MANUFACTURER :	WORTHINGTON CORPORATION
MODEL NUMBER :	12-LN-21
DESIGN FLOW :	6000 GPM
TOTAL DYNAMIC HEAD :	180 FT
PUMP SPEED :	1180 RPM
PUMP EFFICIENCY :	89 %
DESIGN BRAKE HORSEPOWER :	309 BHP
MAXIMUM BRAKE HORSEPOWER :	342 BHP (@ 9000 GPM – [illegible])
PUMP PERFORMANCE CURVE :	E-195931

II-140



HOW TESTED: CAPACITY. VENTURI DRIVER TEST MOTOR SPEED 1125-1135 DRIVE DIRECT

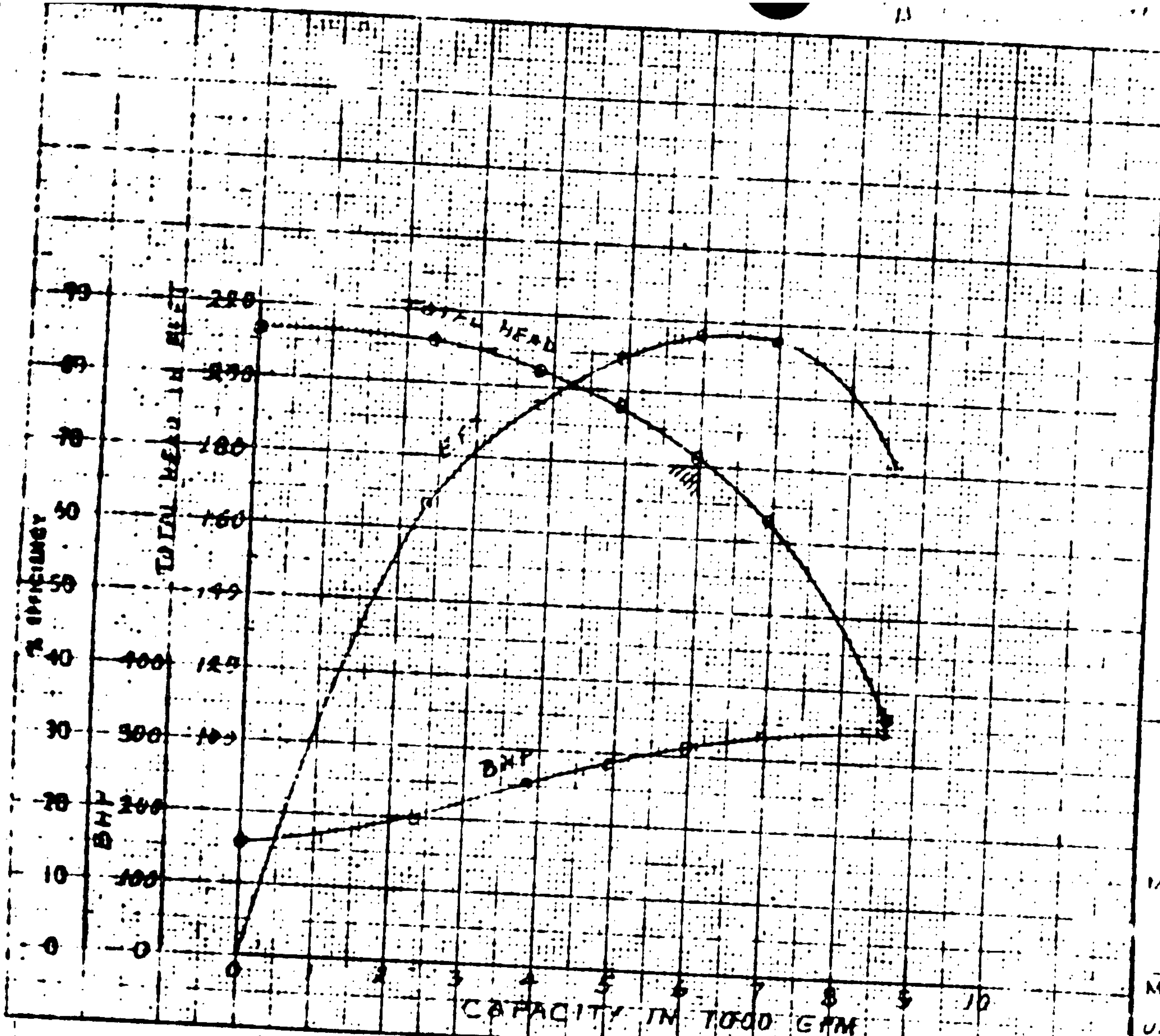
SHOP TEST CURVE	WORTHINGTON CORPORATION		NEW YORK		C-45346l ORDER No.	TEST No.
APPROVED	DATE 8-15-68	SIZE 12	TYPE LN-21	STYLE VOLUTE	MACHINE 1,620,649	RPM 1130
					B-3	E-195931



HOW TESTED:	CAPACITY. VENTURI	DRIVER TEST MOTOR		SPEED [illegible]	DRIVE [illegible]	
SHOP TEST CURVE	WORTHINGTON CORPORATION		NEW YORK		F-4[illegible] ORDER No.	TEST No.
7-23-68 DATE	12 SIZE	LN-21 TYPE	VOLUTE STYLE	1 620 647 MACHINE	1190 RPM	B-5 COMB No.
APPROVED						E-155923 CURVE No.

HBR-7[illegible]

II-142



WORTHINGTON CORPORATION

PUMP TEST DATA

RPM	GPM	HD.	BHP	EFF.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1111	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	114	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	0	[illegible]	[illegible]	0

CASING DATA

MATERIAL	FINISH	TONGUE
C.I.		

IMPELLER DATA

MATERIAL	FINISH	DISC. TIPS
[illegible]	[illegible]	[illegible]

PATT. NO.	COMB. NO.	DIA.
U6-4934	B-3	21

PUMP	STAGES	ORDER NO	SERIAL NO.	DATE TESTED	TEST	APPROVED	TEST DRIVER	VENTURI	PLOT	RPM	CURVE NO
12 LN 21	1	P-45246!	1.620 646	7-23-6[illegible]	W	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	E-95925

PUMP :	AUXILIARY FEEDWATER PUMPS
NUMBER	TWO MOTOR DRIVEN - ONE TURBINE DRIVEN
MANUFACTURER :	PACIFIC PUMPS
MODEL NUMBER :	2 1/2" JTCH 10
DESIGN FLOW :	300 GPM
TOTAL DYNAMIC HEAD :	3050 FT
PUMP SPEED :	3550 RPM
PUMP EFFICIENCY :	71 %
DESIGN BRAKE HORSEPOWER :	325 HP
MAXIMUM BRAKE HORSEPOWER :	385 BHP @ 550 GPM - 2100'
PUMP PERFORMANCE CURVE :	44095

PUMP TEST REPORT ATTACHED

Auxiliary Feedwater Pumps

CONTRACTOR EBASCO

CUSTOMER CAROLINA POWER & LIGHT CO

ITEM NO. —— P.O. NY-434107

IMPELLER PATTERN M-6146 M-6147/4B

MAXIMUM DIAMETER 8½ 8½

RATED DIAMETER 8½ 8½

MINIMUM DIAMETER 7½ 7½

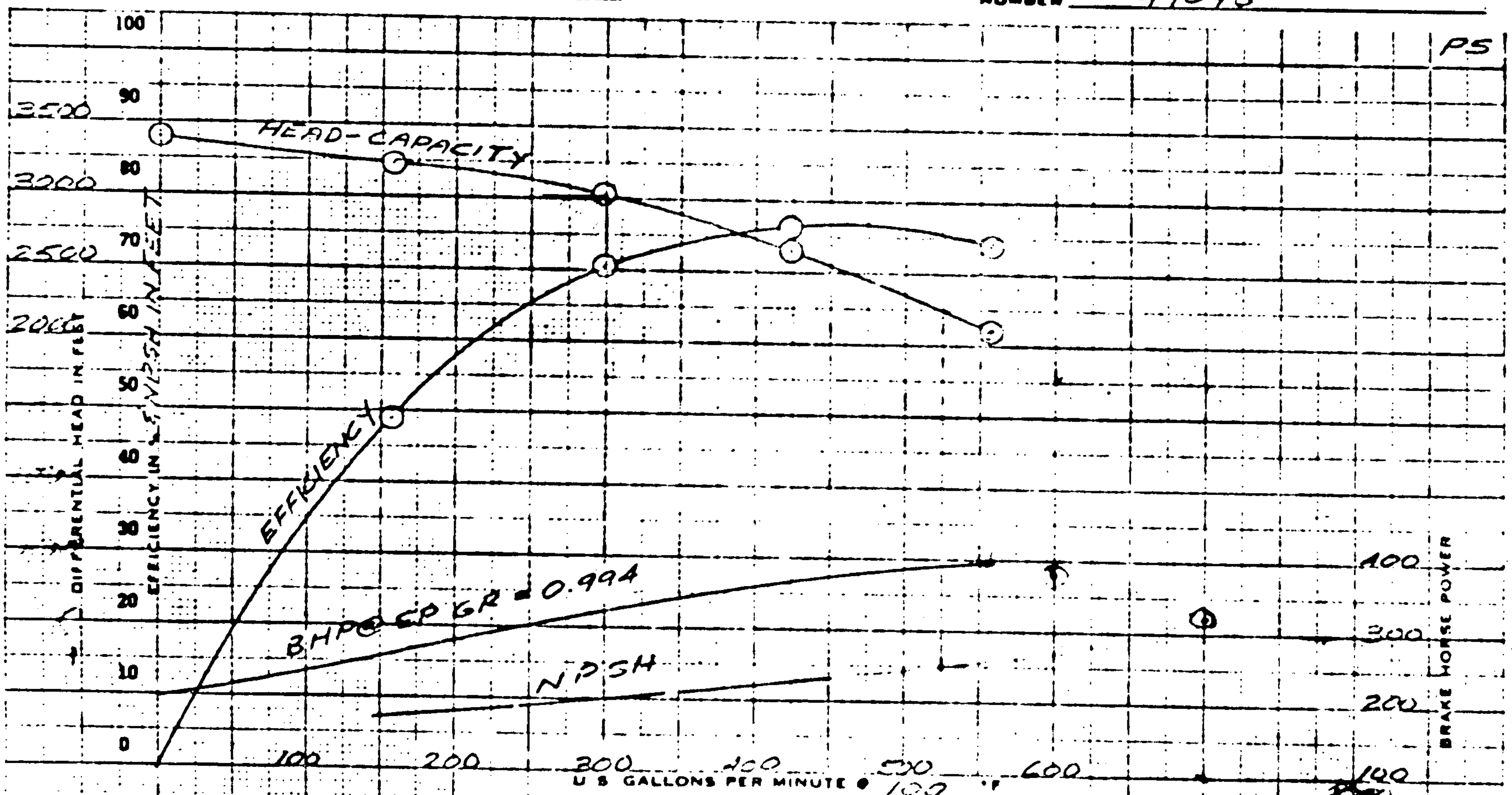
TEST PERFORMANCE CURVE NO. 33622

SIZE 2½ TYPE JTCH STAGES 10

R.P.M. 3550 DATE 7-15-68

PUMP NUMBER 44097

PERFORMANCE ALSO APPLIES TO PUMP NUMBER 44098



PACIFIC PUMPS. HUNTINGTON PARK, CALIFORNIA

PAC 248

CONTRACTOR EBASCO

CUSTOMER CAROLINA POWER & LIGHT CO

ITEM NO. —— P.O. NY-484107

IMPELLER PATTERN M-6146 M-6147/48

MAXIMUM DIAMETER 8½ 8½

RATED DIAMETER 8½ 8½

MINIMUM DIAMETER 7½ 7½

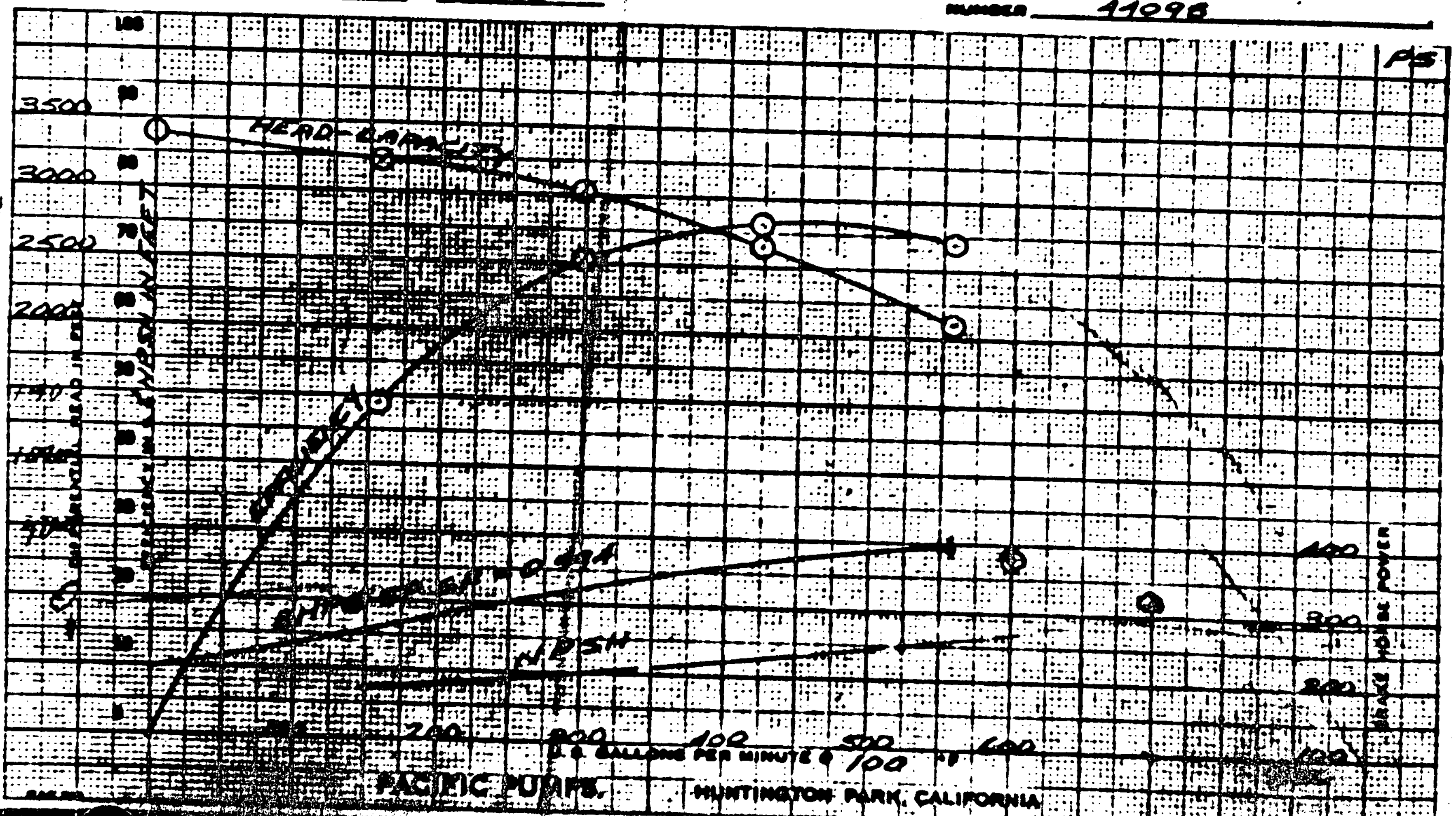
TEST PERFORMANCE CURVE NO. 38633

SIZE 2½ TYPE ITCH STAGES 10

R.P.M. 3550 DATE 7-15-68

PUMP NUMBER 44097

PERFORMANCE ALSO APPLIES TO PUMP NUMBER 44098



CONTRACTOR [illegible]

CUSTOMER CAROLINA POWER & LIGHT CO

ITEM NO. [illegible] P.O. [illegible]

IMPELLER PATTERN [illegible] [illegible]

MAXIMUM DIAMETER [illegible] [illegible]

RATED DIAMETER [illegible] [illegible]

MINIMUM DIAMETER [illegible] [illegible]

TEST PERFORMED [illegible]

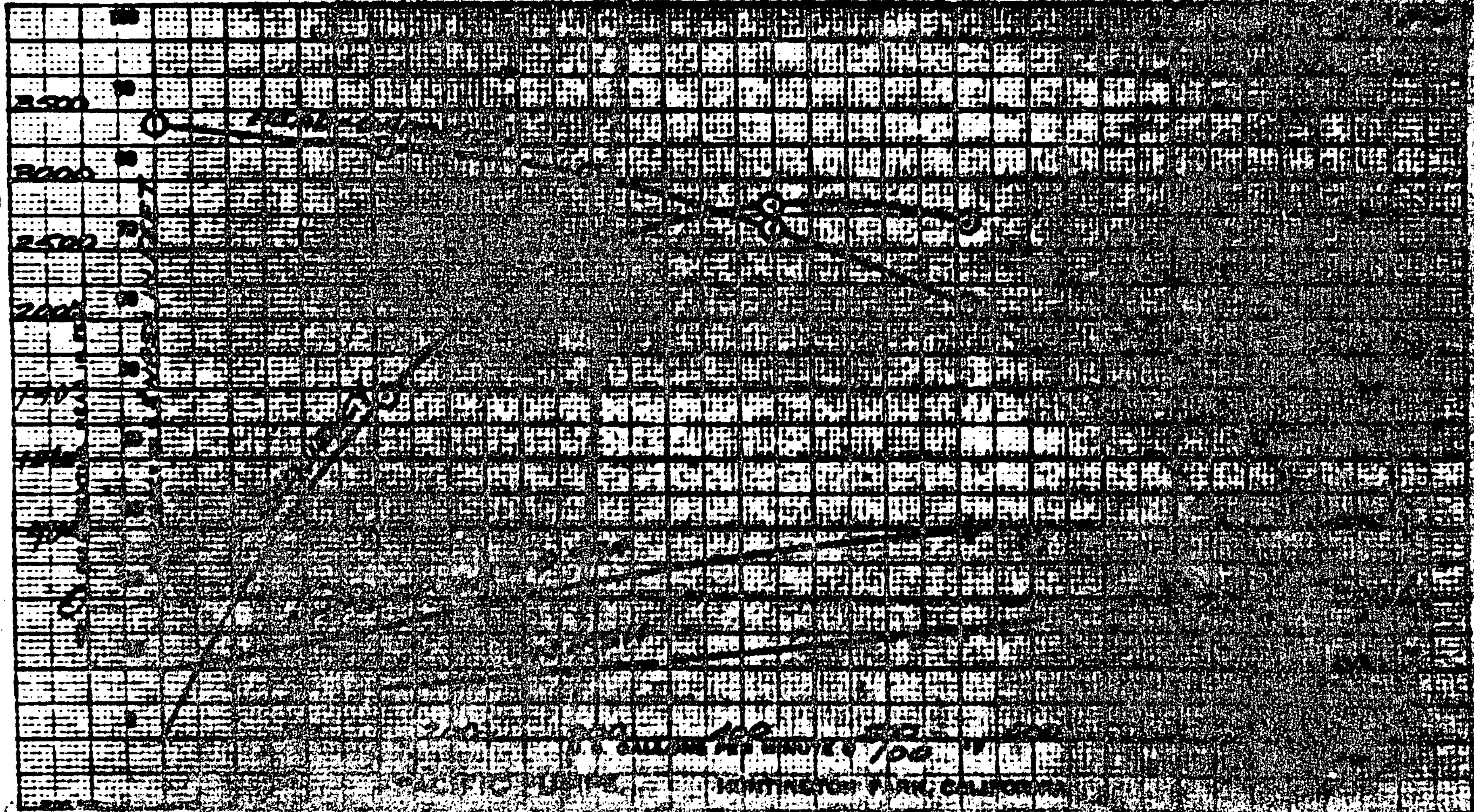
SIZE [illegible]

R.P.M. [illegible]

SHOP NUMBER [illegible]

[illegible]

[illegible]



PUMP TEST DATA — TEST CURVE NO. [illegible]

SIZE	2 1/2
TYPE	ITCH
STAGES	10
P.P.I. ORDER NO.	9J45-683
SERIAL NO.	[illegible]

GUARANTEED PUMPING CONDITIONS

	R.P.M.	G.P.M.	T.D. HEAD	EFF.	N.P.S.H.	SP. GR.
FIELD SPEED	3550	300	2030	70	11	0.994
TEST SPEED	3570	302	2035	—	—	—

	SUCTION IMPELLER	STAGE IMPELLER
NO.	M-6146	M-6147/48
TEST DIA.	8 1/2	8 1/2
FINAL DIA.	8 1/2	8 1/2

CLEARANCES	
RING	.017
DIV.	
SEAL	

CASE MAT'L: CARBON STEEL
IMPELLER MAT'L: CAST IRON
BAROMETER: IN. HG.
SUPPRESSION TEST: OPEN / CLOSED @ IN. HG.

CONTRACTOR: EBASCO
CUSTOMER: CAROLINA P&L
CUSTOMER'S ORDER NO. NY-131107
ITEM NO. —— JOB/REQ. NO.
TESTED BY: PS FOR P.P.I.
WITNESSED BY: [illegible]
DRIVER: VENDOR'S 500 HP. 2 POLE 3Ø - 60 CY. - NO.

ITEM NO.	NO. OF READING	1	2	3	4	5	6	7	8	9	10	11	12
1	TIME												
2	R.P.M.	3570											
3	WATTMETER												
4	K. W. INPUT												
5	B.H.P. OUTPUT												
6	WATTMETER	.324	.396	.366	.262	.203							
7	K. W. INPUT	259.2	316.8	292.8	209.6	162.4							
8	B.H.P. OUTPUT												
9	TOTAL B.H.P. OUTPUT	328	404	373	265	203							
10	DISCHARGE GAGE	1342	930	1168	1430	1500							
11	DIS. PRESS. - P.S.I.												
12	SUCTION GAGE	22.9	21.0	22.6	24.1	23.4							
13	SUCTION PRESS.-P.S.I.												
14	DIFF. PRESS.-P.S.I.	1319	909	1146	1406	1477							
15	TEST WATER TEMP.-°F.	99	100	102	103	103							
16	SP. GR. OF WATER	.995	.995	.994	.994	.994							
17	DIFF. HEAD - FT.	3060	2105	2660	3260	3430							
18	DIFF. VEL. HD. - FT.	6.1	17.6	10.2	1.4	0							
19	DIFF. GAGE ELEV.-FT.	0	0	0	0	0							
20	TOTAL HEAD - FT.	3066	2123	2670	3266	3430							
21	FLOW INDICATION 1/6	5.60	19.48	11.20	1.55	0							
22	RANGE MULTIPLIER												
23	G.P.M.	300	560	425	153	0							
24	EFFICIENCY - %	70.5	73.9	76.8	48.9	0							
	CHARACTERISTIC CURVE CONDITIONS @ 3550 R.P.M. @ 0.994 SP. GR.												
25	G.P.M.	298	557	423	157	0							
26	TOTAL HEAD - FT.	3016	2100	2640	3225	3395							
27	B.H.P.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]							

TEST EQUIPMENT & CALIB. NOS.

DATE OF TEST 7-15-68
C.T. OF PUMP COUNTER / HASSLER TACHOMETER 7338
WESTON NO.
WATTMETER RATIO TO 1
CALIB. CURVE NO.
WESTON NO. 3144
WATTMETER RATIO 800 TO 1
CALIB. CURVE NO.
TEST GAGE NO. 25-25
CALIB. CURVE NO.
TEST GAGE NO. 60 V
CALIB. CURVE NO.
R.H.E. THERMOCOUPLE / L. & N. MICROMAX
CURVE NO. 188 REV.
CURVE NO.
PRESSURE TEST 0 FT. TEMPERATURE TEST - FT.
SIZE: 5X2 1/2 VENTURI-METER

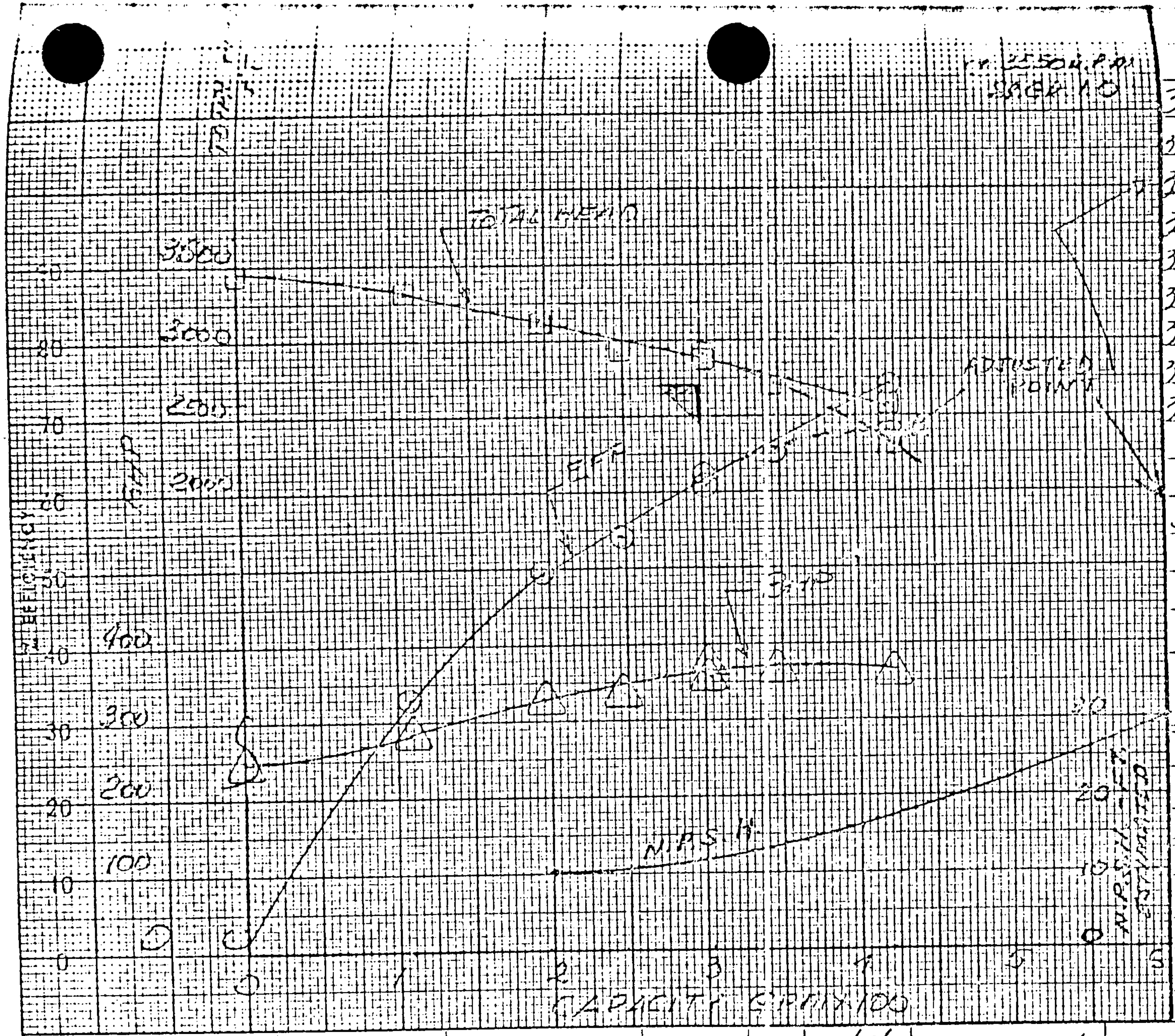
REMARKS: VIB = 0.5 MIL

PAC 382

FORM E-3

II-147

PUMP :	SAFETY INJECTION PUMPS
NUMBER :	THREE (3)
MANUFACTURER :	WORTHINGTON CORPORATION
MODEL NUMBER :	3WTS-811
DESIGN FLOW :	300 GPM
TOTAL DYNAMIC HEAD :	2700 FT
PUMP SPEED :	3550 RPM
PUMP EFFICIENCY :	62 %
DESIGN BRAKE HORSEPOWER :	366 HP
MAXIMUM BRAKE HORSEPOWER :	377 HP @ 430 GPM - 3550 F
PUMP PERFORMANCE CURVE :	E - 207401



RPM	GPM	[illegible]	BHP	EFF.
3583.3	305	2917.7	366.6	60.9
3582.7	350	2738.5	372.7	65.3
3582.4	427	2601.1	376.9	74.8
3583.0	305	2917.7	366.5	61.2
3583.6	251	2970.6	347.8	54.1
3584.6	200	3221.4	331.1	49.1
3586.4	110	3390.7	289.3	32.5
3587.5	0	3503.6	223.7	0
3583.3	305	2929.2	364.4	61.8
3582	427	2373	376.9	68.8

CASING DATA

MATERIAL	FINISH	TONGUE

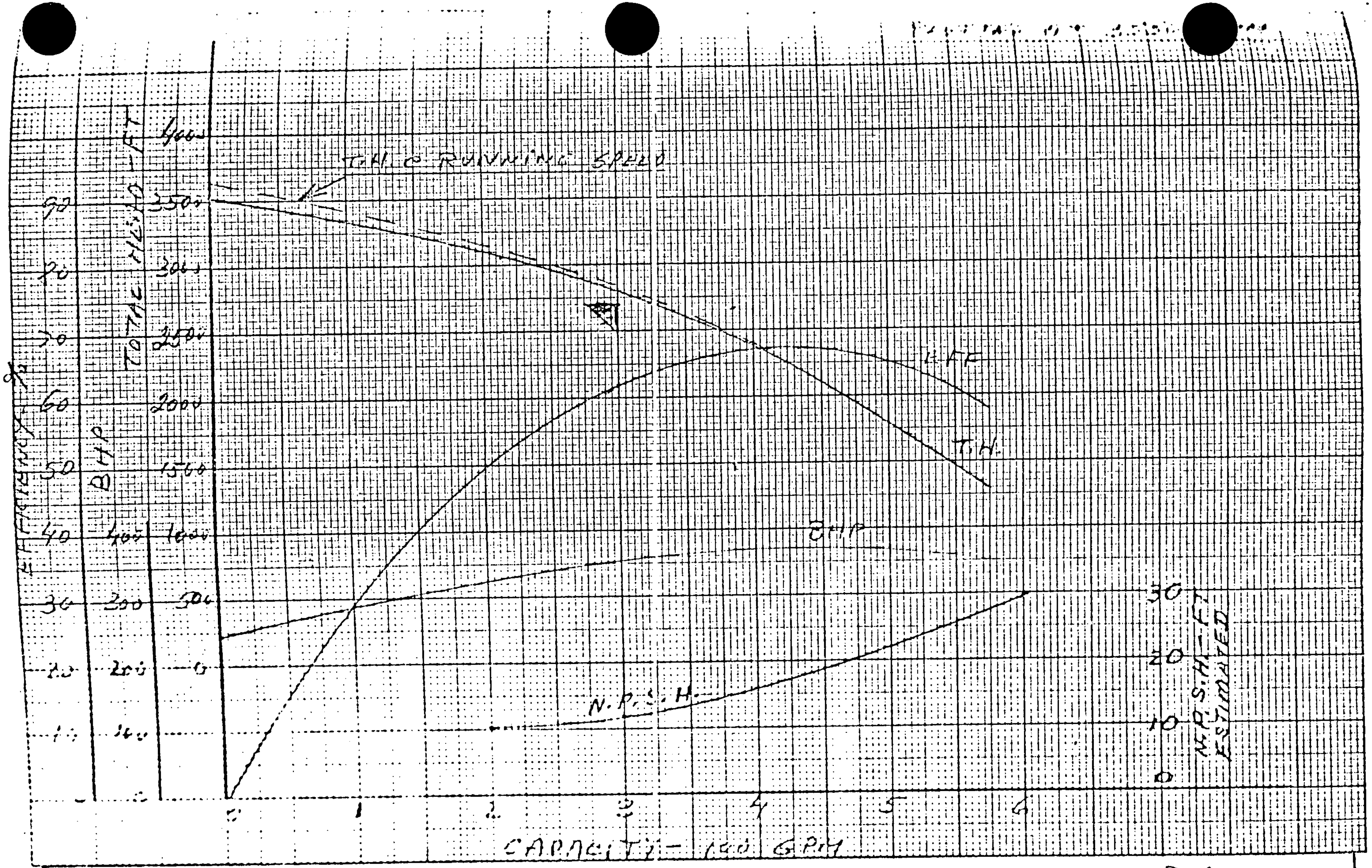
IMPELLER DATA

MATERIAL	FINISH	DISC. TIPS
		—

PATT. NO.	COMB. NO.	DIA.
	D-1	8 3/4

PUMP	STAGES	ORDER NO.	SERIAL NO.	DATE TESTED	TEST	APPROVED	TEST DRIVER	VENTURI	PLOTTED RPM	CURVE NO.
3 WTS-811		P-450117	1613244	6-10-68	N	AHB	600 HP T/M	SSA	3550	E-207401

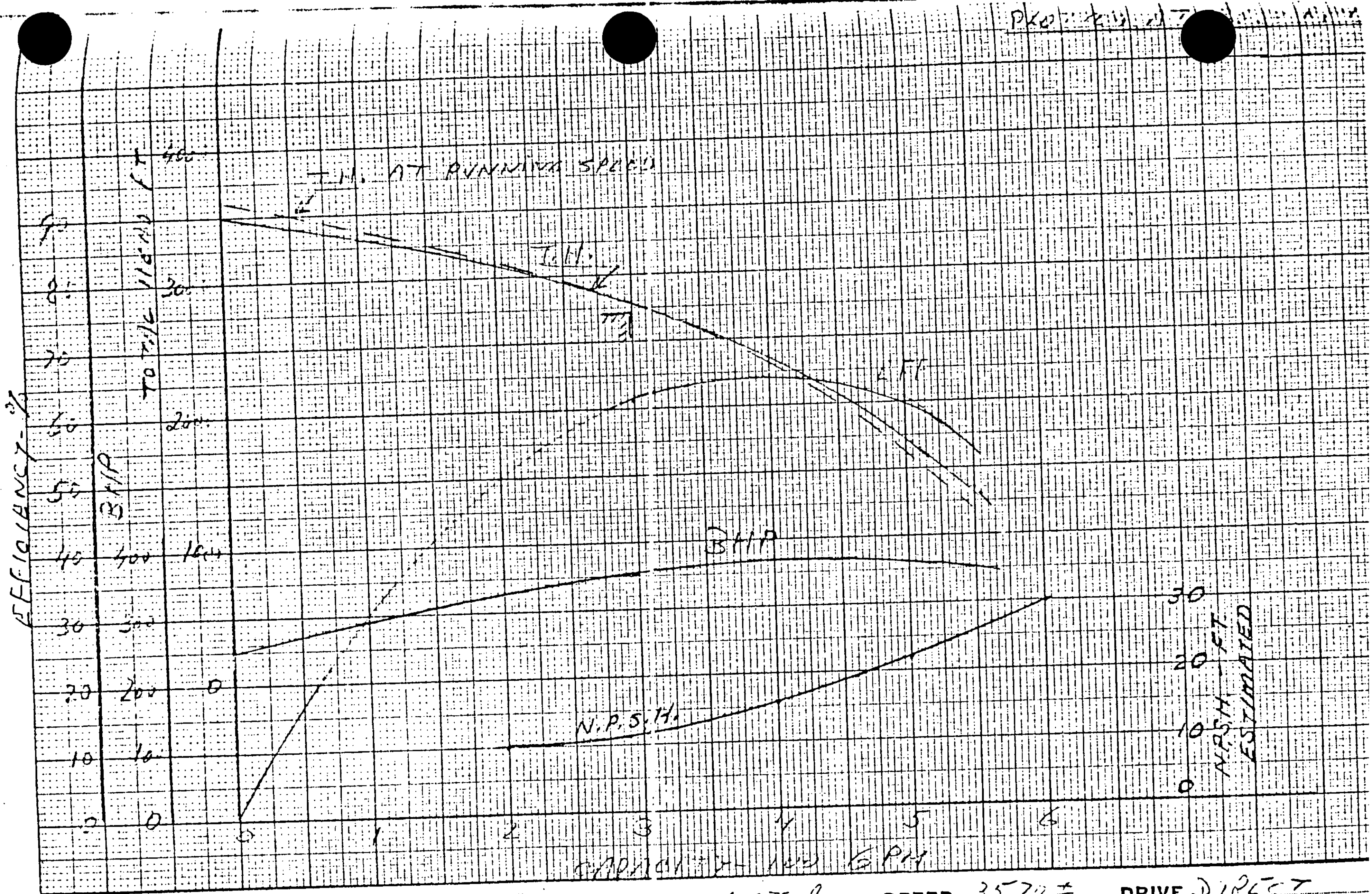
W1215R1 A167M.5



HOW TESTED: CAPACITY VENTURI DRIVER MOTOR SPEED 3580 ± DRIVE DIRECT

SHOP TEST CURVE	WORTHINGTON CORPORATION			NEW YORK		P-450417 ORDER No.	A TEST No.
[illegible] APPROVED	5-20-68 DATE	3 SIZE	WTS-811 TYPE	STYLE	1613245 MACHINE	3550 RPM.	D-1 COMB No.	B-207390 CURVE No.

W1119 A1062M4



HOW TESTED: CAPACITY. VENTURI DRIVER MOTOR SPEED 3570± DRIVE DIRECT

WORTHINGTON CORPORATION				NEW YORK		P-45-3667 ORDER No.	A TEST No.
SHOP TEST CURVE	11-25-74 DATE	3 SIZE	WTS-811 TYPE	STYLE	1618286 MACHINE	3550 RPM.	D-1 COMB No.
							B-209295 CURVE No.

W1119 A765

E-15568-SH. 1

Engineering Data Sheets

3 WTS-811 Centrifugal Pumps For Safety Injection

Cooling Systems In Nuclear Reactors

Customer - Westinghouse Electric Corporation
Atomic Power Division

Cust. Order 546-AZ-169460-BN

Worthington Order LOE-721004
(Orig. P-450415, P-453667)

For
Florida Power & Light

No. of Pumps	4	
Serial No's & Test Curves	1613237	E-209010
	1613238	E-209011
	1613239	E-209012
	1618286	E-209295
Spin No's	FPL SIAPSI-1	
	-2	
	-3	
	-4	
Elevation	RX-147796	
Section	RW-159221	
Parts List	RY-162583	
Motor Data	Westinghouse 350 HP 3-60-4000 V, 3600 RPM DWG. 857-C-323	

Conditions of Service

Capacity, U.S. GPM	300
Total Head, Feet	2700
Temperature, °F	50-291
SP. GR.	1.0-.924
EFF %	61
BHP	338-312
RPM	3550
NPSH Avaialble	30 Ft. (Injection Phase) 250 PSIG. Max. (Recirculation Phase)
NPSH Required, Feet	13

Rev. 9-11-72

Min. Flow (Recirculation) 50 GPM For Thermal Protection (Max. 5 minutes)

150 GPM For Continuous Operation

Max. Flow These pumps can deliver a flow of 600 GPM, providing the NPSH requirement of 30 feet is met.

E-15568- SH. 2

Material Of Construction And Recommended Spares - Refer To Parts List RY-162583

Clearances - Refer to Section RW-159221

Type of Seal - John Crane Mechanical Seal
Type-1 2 1/2 Bellows Shaft Seal
DWG. F-SP-13208 - Parts List & Recommended Spares Incl.

Flow & Temp. Limitations

Seal Leakage per Seal 0-10 cc/hr

Temp. 285°F. Max. Press. 20-250 PSI

Nozzles				
	Suction	4"	ASA FLG.	600 LBS.
	Discharge	3"	ASA FLG.	1500 LBS.

Pump Design - Ball Bearing Type
Shaft Dia. At Impellers 2.249 DIA.
BRG. Span 69.22
Critical Speeds: First 1350 RPM-Second 5100 RPM

Bearing Temp. Range °F (Measured by surface Pyrometer on upper half of housing.)	Normal	Max.
	120F-140F	160F

Vibration Limits	Normal	Excessive
	1-2 Mils	3 Mils

Factory Tests - Performance At 3575 RPM - Witnessed

Hydrostatic To 2625 PSIG - Witnessed

E-153587 SH. 1

Engineering Data Sheets

3 WTS-811 Centrifugal Pumps For Safety Injection

Cooling Systems In Nuclear Reactors

Customer - Westinghouse Electric Corporation
Atomic Power Division

Cust. Order 546-AZ-169460-BN

Worthington Order LOE-721004
(Orig. P-450417)

For
Carolina Power & Light

No. of Pumps	3	
Serial No's & Test Curves	1613243	E-207379
	1613244	E-207401
	1613245	E-207390
Spin No's	CPL SIAPSI-1	
	-2	
	-3	
...vation	RX-147780	
...ection	RW-159221	
...rts List	RY-162583	
...tor Data	Westinghouse 350 HP 3-60-460 V, 3600 RPM DWG. 208-C-552	

Conditions of Service

...acity, U.S. GPM	300
...tal Head, Feed	2700
...perature, °F	50-291
... Gr.	1.0-.924
... %	61
...	338-312
...	3550
... Available	30 Ft. (Injection Phase) 250 PSIG. Max. (Recirculation Phase)
... Required, Feet	13

E-153587 SH. 2

Min. Flow (Recirculation) 50 GPM For Thermal Protection (Max. 5 minutes)

150 GPM For Continuous Operation

Max. Flow These pumps can deliver a flow of 600 GPM, providing the NPSH requirement of 30 feet is met.

Material Of Construction
And Recommended Spares - Refer To Parts List RY-162583

Clearances - Refer to Section RW-159221

Type Of Seal - John Crane Mechanical Seal
Type-1 2 1/2 Bellows Shaft Seal
DWG. F-SP-13208 - Parts List & Recommended Spares Incl.

Flow & Temp. Limitations

Seal Leakage per Seal 0-10 cc/hr
Temp. 285°F. Max. Press. 20-250 PSI

Nozzles	Suction	4" ASA FLG.	600 LBS.
	Discharge	3" ASA FLG.	1500 LBS.

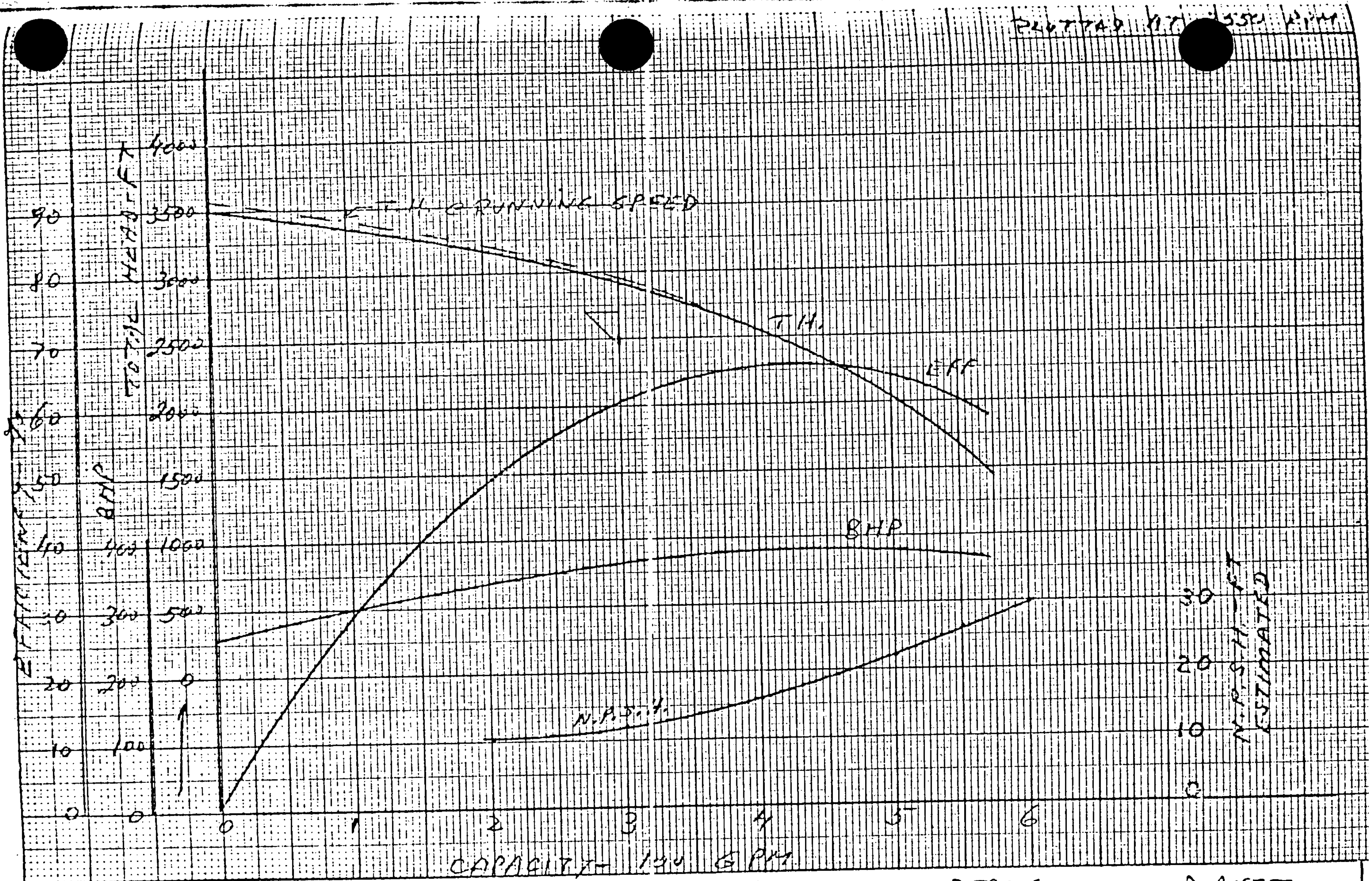
Pump Design - Ball Bearing Type
Shaft Dia. At Impellers 2.249 DIA.
BRG. Span 69.22
Critical Speeds: First 1350 RPM-Second 5100 RPM

Bearing Temp. Range °F	Normal	Max.
(Measured by surface Pyrometer on upper half of housing.)	120F-140F	160F

Vibration Limits	Normal	Excessive
	1-2 Mils	3 Mils

Factor Tests - Performance At 3575 RPM - Witnessed

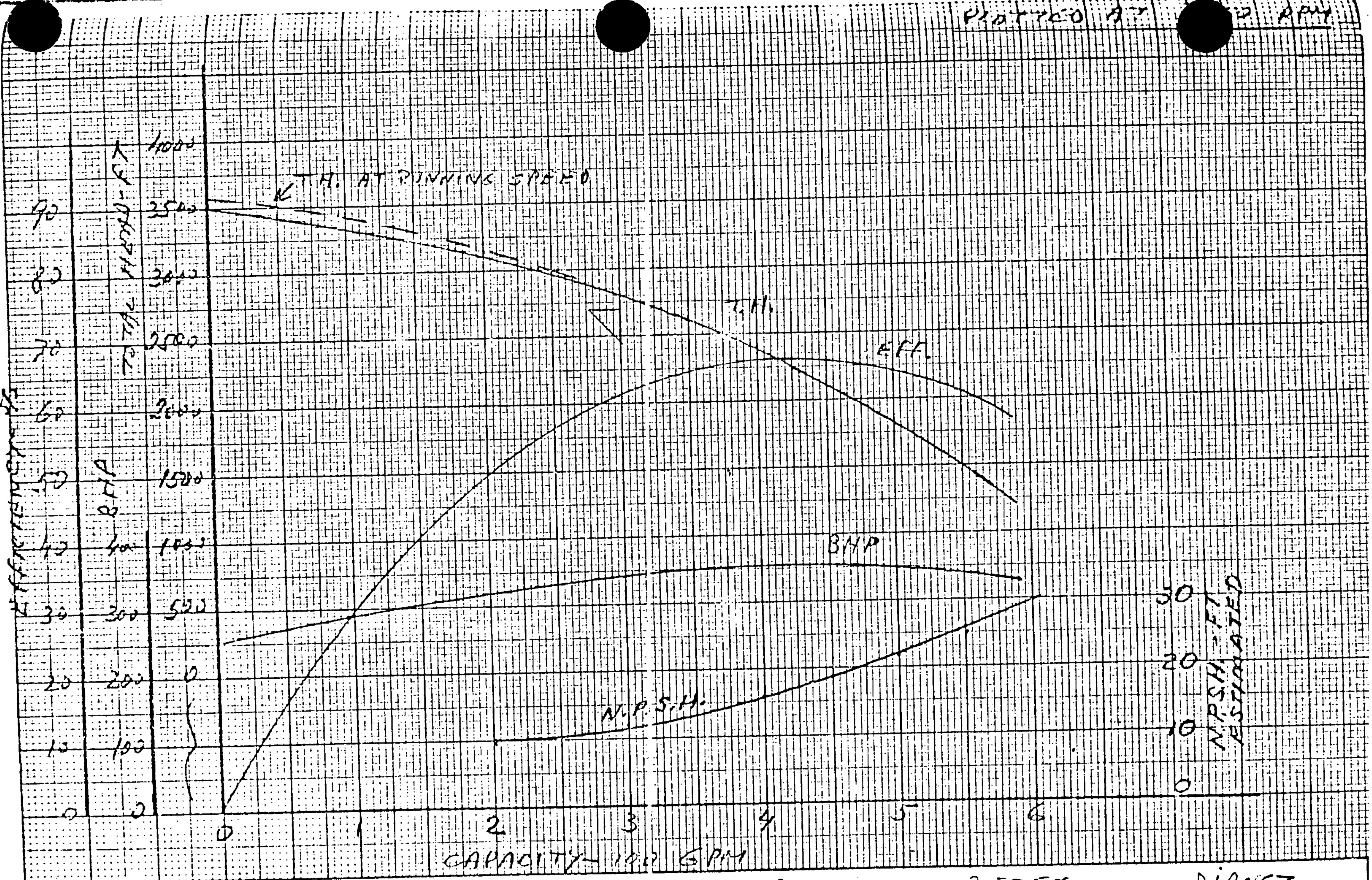
Hydrostatic To 2625 PSIG- Witnessed



HOW TESTED: CAPACITY. VENTURI DRIVER MOTOR SPEED 3580 I DRIVE DIRECT

SHOP TEST CURVE	WORTHINGTON CORPORATION NEW YORK				P-450415 ORDER No.	TEST No.
AHB APPROVED	10-17-68 DATE	3 SIZE	WTS-811 TYPE	STYLE	1613237 MACHINE	3550 RPM.	D-1 COMB No.	E-209010 CURVE No.

W1119 A1062M4

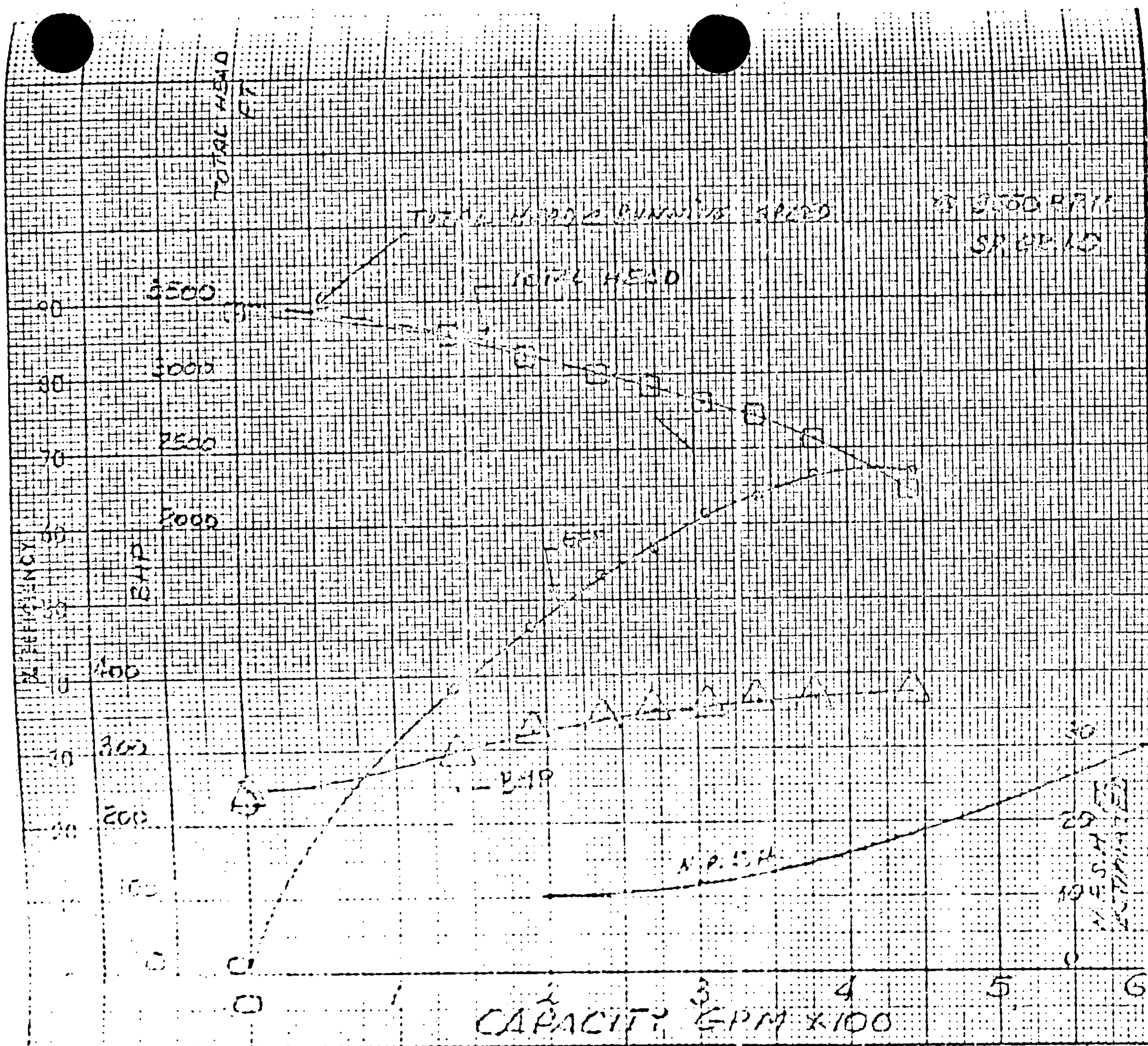


HOW TESTED: CAPACITY. VENTURI DRIVER MOTOR SPEED 3575 I DRIVE DIRECT

WORTHINGTON CORPORATION NEW YORK

SHOP TEST CURVE							P 450415 ORDER No.	TEST No.
113 APPROVED	10-17-64 DATE	3 SIZE	WTS-811 TYPE	STYLE	1613238 MACHINE	3550 RPM.	D-1 COMB No.	E-209011 CURVE No.

W1119 A1062M4



WORTHINGTON CORPORATION
PUMP TEST DATA

RPM	GPM	HD.	BHP	EFF.
3580	309.4	2874.3	365.5	61.2
80	341.9	2767.	375.1	63.9
77	380.1	2618.2	377.8	66.3
77	446.	2271.	383.3	66.9
80	309.1	2870.8	365.5	61.1
80	275.3	2962.6	361.4	56.8
80	240.6	3066.	349.1	53.2
81	193.3	3181.4	332.7	46.6
81	140.4	3292.9	305.3	38.2
81	0	3489.2	253.1	0

CASING DATA

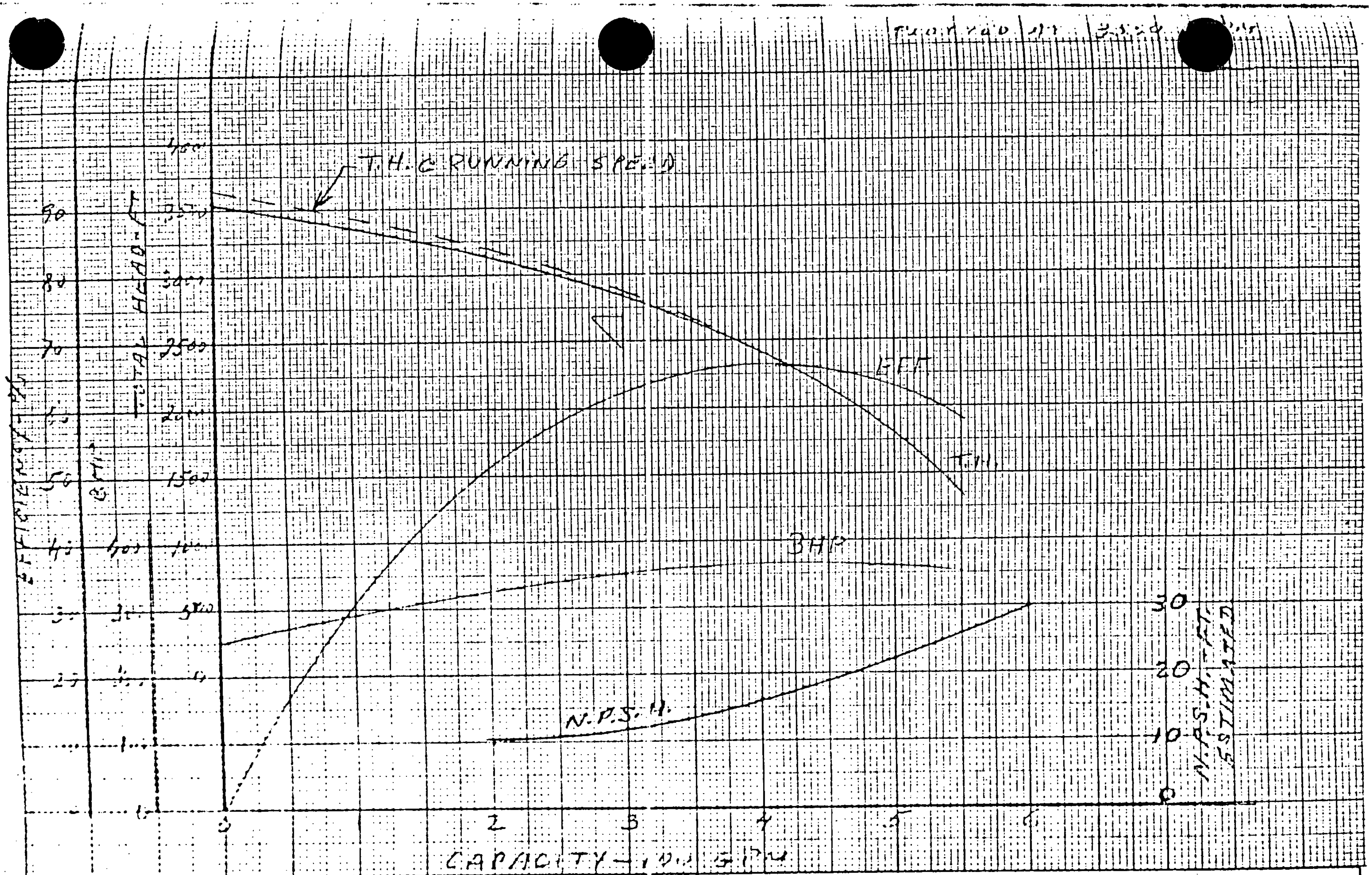
MATERIAL	FINISH	TONGUE

IMPELLER DATA

MATERIAL	FINISH	DISC. TIPS
	D-1	8 3/4"
PATT. NO.	COMB. NO.	DIA.

PUMP	STAGES	ORDER NO.	SERIAL NO.	DATE TESTED	TEST	APPROVED	TEST DRIVER	VENTURI	PLOTTED RPM	CURVE NO.
3WTS-811		P450415	1613239	10-16-68	W.T. Test	[illegible]	600HP T/M	5.047×2.819	3550	E-209012

W1215R1 A167MS



HOW TESTED:	CAPACITY. Venturi		DRIVER Motor		SPEED 3580±	DRIVE Direct
Shop Test CURVE	WORTHINGTON CORPORATION			NEW YORK	P-450417 ORDER No.	A TEST No.
APPROVED [illegible]	DATE [illegible]	SIZE 3	TYPE WTS-811	STYLE	MACHINE 1613243	RPM. 3550
					COMB No. D-1	CURVE No. E-207379

W1119 A1062M4

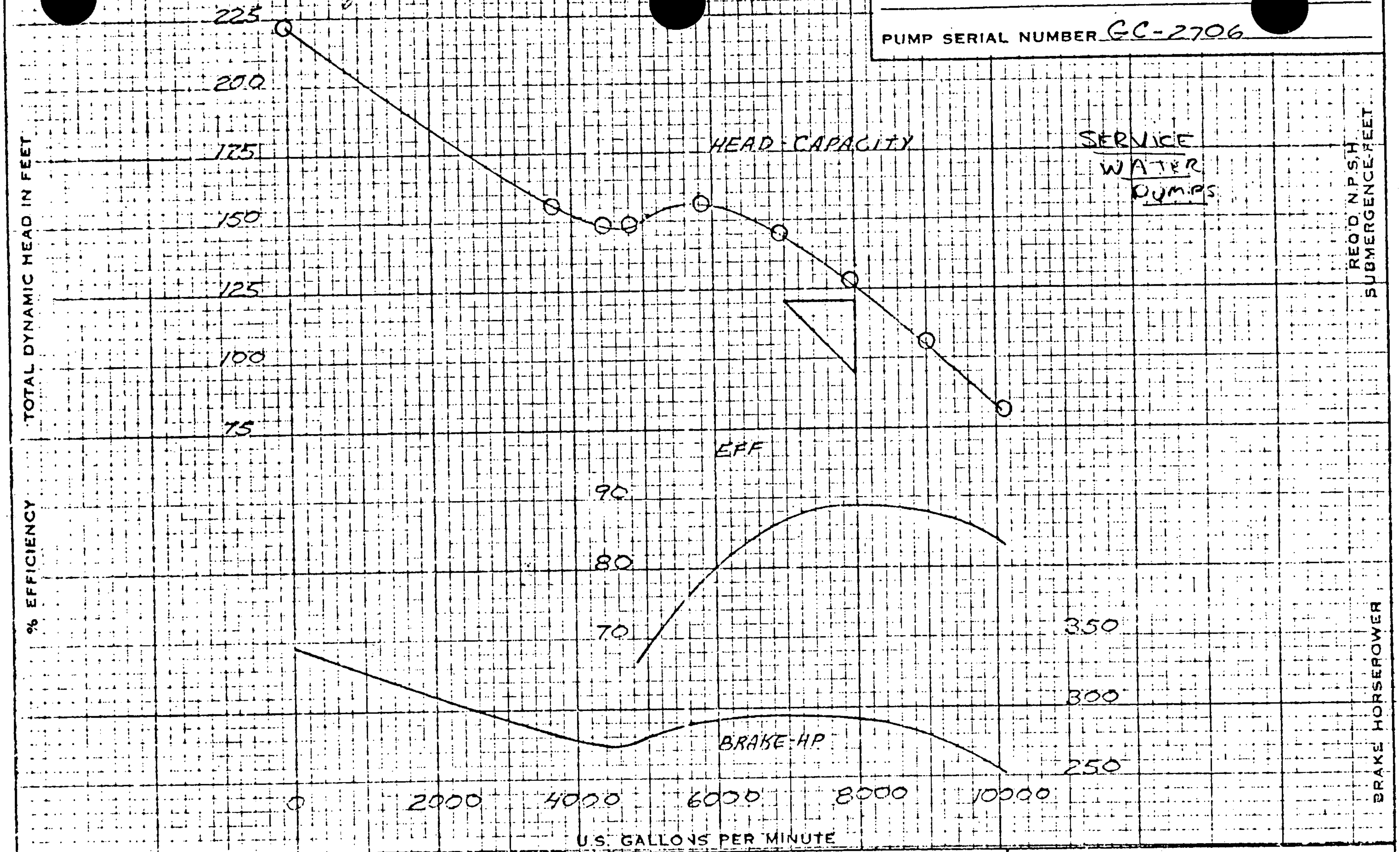
PUMP:	SERVICE WATER PUMPS
NUMBER:	FOUR (4)
MANUFACTURER:	JOHNSON PUMP CO
MODEL NUMBER:	16 PS - 3 STAGE
DESIGN FLOW:	8000 GPM
TOTAL DYNAMIC HEAD:	120 FT
PUMP SPEED:	1180 RPM
PUMP EFFICIENCY:	88.5 %
DESIGN BRAKE HORSEPOWER:	275 HP
MAXIMUM BRAKE HORSEPOWER:	< 300 HP ABOVE 2500 GPM *
PUMP PERFORMANCE CURVE:	TC - 1284

* PUMPS NOT EXPECTED TO OPERATE BELOW THIS LEVEL

CE[illegible]ED BY: DATE 8-4-70

CUSTOMER CAROLINA POWER & LIGHT

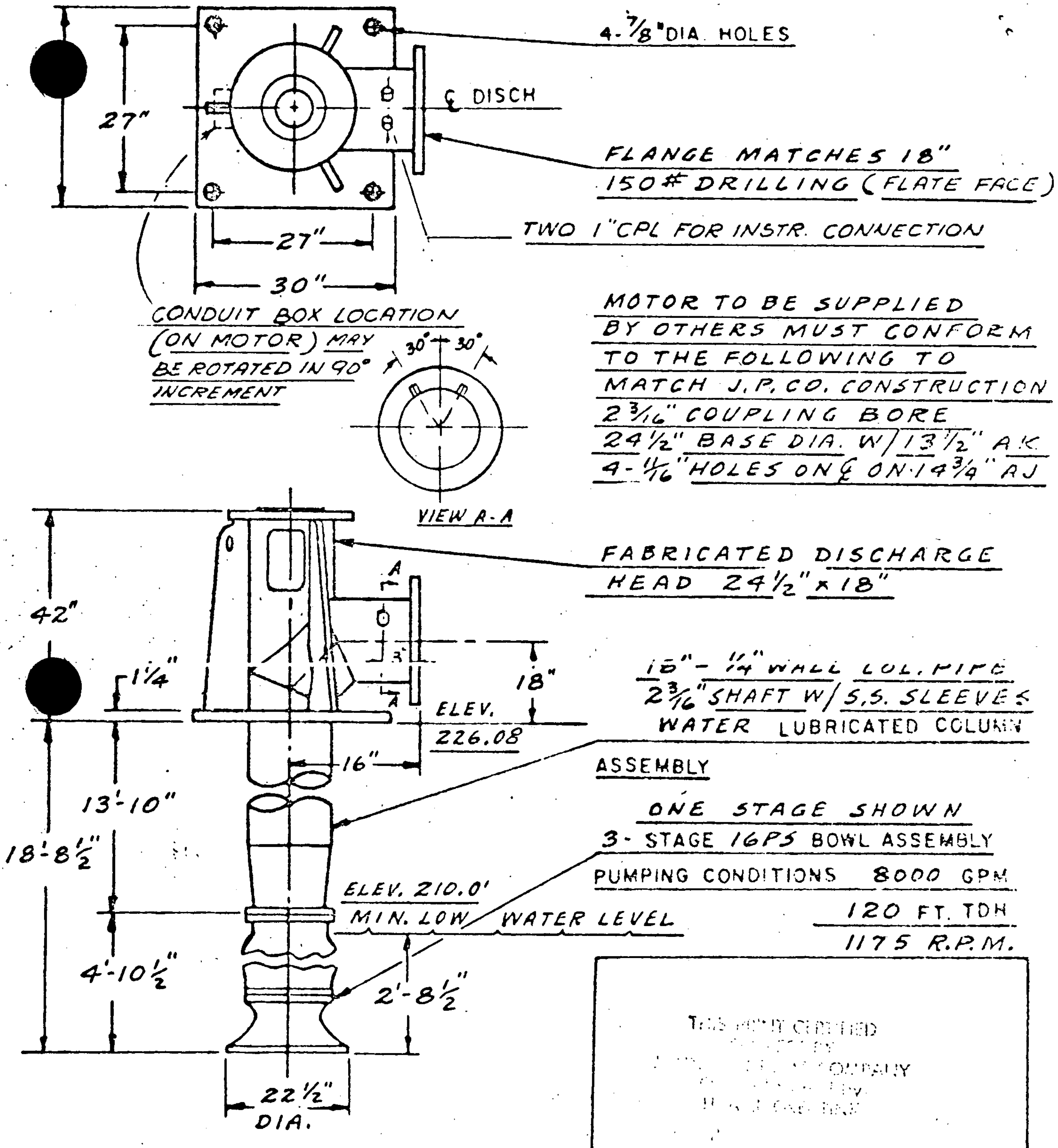
PUMP SERIAL NUMBER GC-2706



THE CAPACITY, HEAD AND EFFICIENCY GUARANTEE IS FOR THE DESIGNATED POINT ONLY; IT IS BASED ON SHOP TESTS, WHEN HANDLING CLEAR, FRESH WATER AT A TEMPERATURE OF NOT OVER 85 F. AND UNDER SUCTION CONDITIONS AS SPECIFIED IN THE CONTRACT.	IMPELLER BRZ DIA 10 5/16 BOWLS C.I. LIQUID WATER SP. GR. 1.00 DATE 8-3-70 BY TPV	JOHNSTON PUMP CO. VERTICAL PUMPS GLENDORA · CALIFORNIA · U. S. A.	MIXED FLOW LAB PERFORMANCE 3 STAGE 16PS PUMP 1180 R.P.M. CURVE NO TC-1284

JP-157

JOHNSTON MIXED FLOW PUMP



DEALER- CAROLINA POWER & LIGHT CO.

FOR- H.B. ROBINSON STEAM ELEC. PLANT

PO# 532017

J STON SERIAL NO GC 2706

DO NOT USE FOR CONSTRUCTION UNLESS CERTIFIED ABOVE

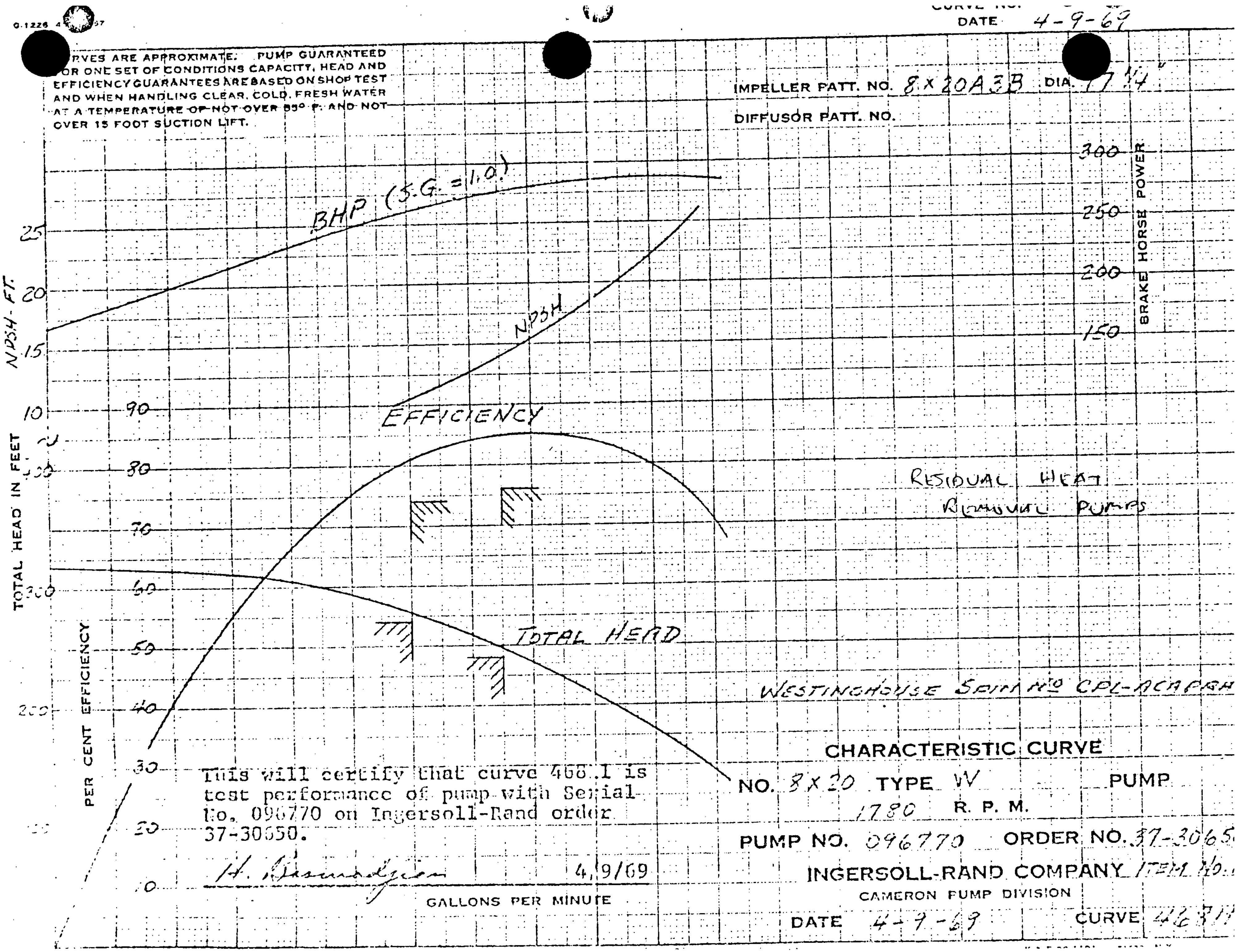
WEIGHT = APPROX. 3500#

W.D. 6-2-70 ✓R.K.S.

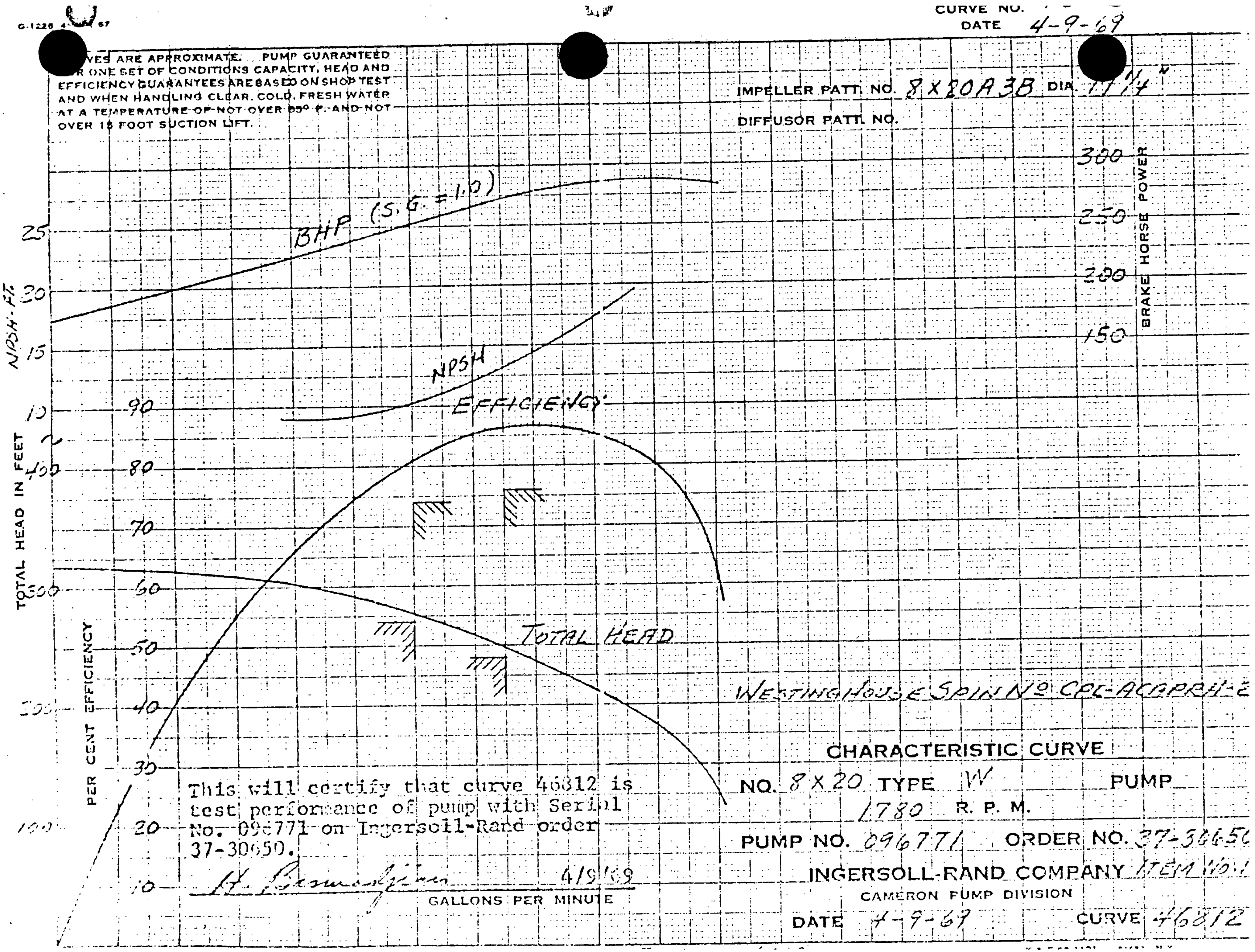
DRWG. DP-J | H-1753-A

PUMP:	RESIDUAL HEAT REMOVAL PUMPS
NUMBER:	TWO (2)
MANUFACTURER:	INGERSOLL-RAND COMPANY
MODEL NUMBER:	8 x 20 TYPE W
DESIGN FLOW:	4000 GPM
TOTAL DYNAMIC HEAD:	240 FT
PUMP SPEED:	1780 RPM
PUMP EFFICIENCY:	85%
DESIGN BRAKE HORSEPOWER:	285 HP
MAXIMUM BRAKE HORSEPOWER:	290 HP
PUMP PERFORMANCE CURVE:	46811

MOTOR DATA ALSO INCLUDED



DATE 4-9-69
CURVES ARE APPROXIMATE: PUMP GUARANTEED FOR ONE SET OF CONDITIONS CAPACITY, HEAD AND EFFICIENCY GUARANTEES ARE BASED ON SHOP TEST AND WHEN HANDLING CLEAR, COLD, FRESH WATER AT A TEMPERATURE OF NOT OVER 85° F. AND NOT OVER 15 FOOT SUCTION LIFT.
IMPELLER PATT. NO. 8X20A3B DIA. 17 1/4"
DIFFUSOR PATT. NO.
BHP (S.G. = 1.0)
NPSH
EFFICIENCY
TOTAL HEAD
NPSH - FT.
TOTAL HEAD IN FEET
PER CENT EFFICIENCY
BRAKE HORSE POWER
GALLONS PER MINUTE
RESIDUAL HEAT REMOVAL PUMPS
WESTINGHOUSE SERIAL NO CPL-ACAPRH
This will certify that curve 468.1 is test performance of pump with Serial No. 096770 on Ingersoll-Rand order 37-30650.
4/9/69
CHARACTERISTIC CURVE
NO. 8X20 TYPE W PUMP
1780 R. P. M.
PUMP NO. 096770 ORDER NO. 37-3065
INGERSOLL-RAND COMPANY ITEM No.
CAMERON PUMP DIVISION
DATE 4-9-69 CURVE 4687


C-1226 4 67
CURVE NO.
DATE 4-9-69
VES ARE APPROXIMATE. PUMP GUARANTEED
R ONE SET OF CONDITIONS CAPACITY, HEAD AND
EFFICIENCY GUARANTEES ARE BASED ON SHOP TEST
AND WHEN HANDLING CLEAR, COLD, FRESH WATER
AT A TEMPERATURE OF NOT OVER 85° F. AND NOT
OVER 15 FOOT SUCTION LIFT.
IMPELLER PATT. NO. 8 X 20 A 3B DIA. 11 1/4"
DIFFUSOR PATT. NO.
BHP (S.G. = 1.0)
NPSH
EFFICIENCY
TOTAL HEAD
NPSH - FT.
TOTAL HEAD IN FEET
PER CENT EFFICIENCY
BRAKE HORSE POWER
300
250
200
150
25
20
15
10
400
300
200
100
90
80
70
60
50
40
30
20
10
WESTINGHOUSE SPIN No CPL-ACGPRH-E
CHARACTERISTIC CURVE
NO. 8 X 20 TYPE W PUMP
1780 R. P. M.
PUMP NO. 096771 ORDER NO. 37-30650
INGERSOLL-RAND COMPANY ITEM NO. 1
CAMERON PUMP DIVISION
DATE 4-9-69 CURVE 46812
This will certify that curve 46812 is test performance of pump with Serial No. 096771 on Ingersoll-Rand order 37-30650.
4/9/69
GALLONS PER MINUTE

FORM 54082

PROJECT | S.O. NO. 67F68605 G.O. NY35820 it G

FURNISHED BY | DATE | BY

MARK OR ITEM NO.

PURCHASER'S REQUIREMENTS		DATA FURNISHED BY SELLER	
SERV		MAKE	(W)
TY	Induction	FRAME NO.	506 UP
NO. O NITS		HORSEPOWER	300
MOUNTING	~~Horizontal~~ VERTICAL	SERVICE FACTOR	1.15
ELEC. CHARACTERISTICS	460 V. 3 PH 60 CY	FULL LOAD RPM	1777
SYNCH. SPEED, RPM		FULL LOAD AMP	331.6
HORSEPOWER		LOCKED ROTOR AMP	1865.4
SERVICE FACTOR	1.15	STARTING TORQUE, % F.L.	120
ENCLOSURE	Open Driproof	PULL-OUT TORQUE, % F.L.	242
INSULATION CLASS	B	EFF.-FULL LOAD, %	93.9
INSULATION TREATMENT	Powerhouse	EFF.-3/4 LOAD, %	94.0
AMBIENT TEMP-C	40	EFF.-1/2 LOAD, %	93.5
STATOR TEMP RISE-C	90	P.F.-FULL LOAD, %	90.2
BEARING TYPE		P.F.-3/4 LOAD, %	89.3
BEARING TEMP RELAY		P.F.-1/2 LOAD, %	85.0
BEARING THERMOCOUPLE		P.F.-LOCKED ROTOR	28.8
HALF COUPL. OR SHEAVE MTD. BY		SPACE HTRS., TOTAL WATTS	—
ROTATION*		RADIAL BEARING-TYPE	BALL
WK 2 OF DRIVEN EQUIP.		THRUST BEARING-TYPE	BALL
BRKWY. TORQ. DRVN. EQUIP.		BEARING SERVICE-HR.	44000 HRS - B-10
OVERSIZE COND. BOX		NORMAL BRG. OPER. TEMP-C	60°C total
COND. BOX LOCATION*		NET WEIGHT-LB.	2465
SPACE HEATERS, VOLTAGE, PHASE		OIL COOL. SYS. REQ'D	—
SPLIT END BELLS		BRG. OIL PRESS. RANGE, PSI	—
TERMINAL LUGS, TYPE		BRG. OIL REQ'D EA. BRG. GPM	—
STATOR HIGH TEMP DEVICE		NAME PLATE CODE LETTER	E
AD BLE SLIDE RAILS		PERMISSIBLE STARTS PER HR:	
SO TES		MOTOR AT AMBIENT TEMP	2
PRO ELEV., FT.	Less than 3300	MOTOR AT RATED TOTAL TEMP	1
SHAFT (HOLLOW, SOLID)		TYPE SEALED INSUL. SYS.	Class B
COUPLING (SELF-RELEASE)		DESCRIPTION OF INSUL. SYS.	Thermolastic Epoxy
SOLID, NONREVERSING			
ADJUSTABLE, FLEXIBLE			
VERT. MAX DOWNTHRUST		WNES-P.O# 70491-B	
VERT. MAX UPTHRUST			
VERT. MIN UPTHRUST		SPIN# CPL-ACAPRH-1&2	
VERT. MIN DOWNTHRUST			
(WITH MOTOR RUNNING)			
SIDE THRUST			
MAX REVERSE SPEED			
DRAIN PLUG AND VENT			
AIR INTAKE SCREENS			
Location - Outside Containment			

REMARKS:	REMARKS:
ALL PERFORMANCE DATA BASED ON NORMAL RATED VOLTAGE AND FREQUENCY	ALL PERFORMANCE DATA BASED ON NORMAL RATED VOLTAGE AND FREQUENCY
ITEMS 34-44 APPLY TO VERTICAL MOTORS ONLY	INDICATE IF DATA IS ESTIMATED CALCULATED DATA NOT GUARANTEED

* VIEWED FROM END OPPOSITE COUPLING END

G7F 68605   G.O. NY35820   ω Ⓖ

CALCULATED DATA - NOT GUARRANTEED

SLIP	RPM	EFF	P.F.	(HP)OUT	(T)OUT	(I)L
100.00	0.0	0.0	28.8	0.0	1058.56	1865.426
95.00	90.	3.2	29.0	18.39	1073.32	1857.044
90.00	180.	6.4	29.4	37.34	1089.35	1846.010
85.00	270.	9.7	29.7	56.90	1106.81	1836.254
80.00	360.	13.1	30.1	76.87	1121.43	1824.124
75.00	450.	16.6	30.4	97.29	1135.50	1807.553
70.00	540.	20.1	30.8	118.45	1152.04	1789.937
65.00	630.	23.7	31.3	140.53	1171.50	1771.750
60.00	720.	27.5	31.9	163.75	1194.46	1752.631
55.00	810.	31.3	32.5	188.42	1221.66	1732.373
50.00	900.	35.3	33.3	214.91	1254.06	1710.679
45.00	990.	39.0	33.5	236.47	1254.43	1693.236
40.00	1080.	43.4	34.7	268.31	1304.76	1667.114
35.00	1170.	48.0	36.2	304.44	1366.54	1637.558
30.00	1260.	52.9	38.2	346.33	1443.55	1603.028
25.00	1350.	58.2	40.8	396.17	1541.20	1560.824
20.00	1440.	64.0	44.4	457.06	1666.94	1505.743
15.00	1530.	70.4	49.8	535.02	1836.50	1429.172
10.00	1620.	77.7	59.5	621.82	2048.30	1301.426
9.50	1629.	78.5	59.7	641.37	2067.77	1282.724
9.00	1638.	79.2	60.4	648.49	2079.24	1269.159
8.50	1647.	80.1	62.1	659.06	2101.57	1241.014
8.00	1656.	81.0	63.8	668.28	2119.39	1210.092
7.50	1665.	82.0	65.6	675.70	2131.34	1176.046
7.00	1674.	83.0	67.5	680.77	2135.78	1138.486
6.50	1683.	83.9	69.4	682.80	2130.68	1096.968
6.00	1692.	84.9	71.4	680.97	2113.68	1051.021
5.50	1701.	85.9	73.6	675.82	2086.58	1001.138
5.00	1710.	86.9	75.9	666.90	2048.21	947.067
4.50	1719.	87.9	78.1	650.43	1987.18	886.516
4.00	1728.	88.9	80.5	627.06	1905.79	820.153
3.50	1737.	90.0	82.8	593.95	1795.82	746.606
3.00	1746.	91.0	85.0	549.49	1652.82	665.395
2.50	1755.	91.9	87.0	492.12	1472.67	576.215
2.00	1764.	92.9	88.8	422.30	1257.29	479.838
1.50	1773.	93.6	90.1	338.11	1001.92	375.328
1.00	1782.	94.1	89.6	237.77	700.75	264.266
0.50	1791.	93.0	81.5	123.40	361.65	152.473

1832807

WNES - P.O. # 70491-B

SPIN # CPL-ACAPRH-1&2

UNIT :	REACTOR CONTAINMENT FAN COOLER	
MANUFACTURER :	WESTINGHOUSE - STURTEVANT DIVISION	
MODEL NUMBER :	8566-C	
DESIGN CAPACITY :	85,000 CFM	
STATIC PRESSURE :	6 IN. WG	
FAN SPEED :	720 RPM	
FAN EFFICIENCY :	NOT AVAILABLE	
	<u>NORMAL MODE</u>	<u>ACCIDENT MODE</u>
DESIGN BRAKE HORSEPOWER :	117	244
MAXIMUM BRAKE HORSEPOWER :	117	264
FAN PERFORMANCE CURVE :	NOT AVAILABLE	

7. Brief Resume of Key Persons, Specialists, and Individual Consultants Anticipated for this Project

a. Name & Title:	a. Name & Title:
b. Project Assignment:	b. Project Assignment:
c. Name of Firm with which associated:	c. Name of Firm with which associated:
d. Years experience: With This Firm ___ With Other Firms ___	d. Years experience: With This Firm ___ With Other Firms ___
e. Education: Degree(s) / Year / Specialization	e. Education: Degree(s) / Years / Specialization
f. Active Registration: Year First Registered/Discipline	f. Active Registration: Year First Registered/Discipline
g. Other Experience and Qualifications relevant to the proposed project:	g. Other Experience and Qualifications relevant to the proposed project:

4nd

Westinghouse

OCTOBER 1969

TECHNICAL MANUAL

REACTOR CONTAINMENT FAN COOLER

PREPARED FOR

H.B. ROBINSON
STEAM ELECTRIC PLANT
UNIT NO. 2
CAROLINA POWER AND LIGHT COMPANY
HARTSVILLE, SOUTH CAROLINA

WESTINGHOUSE ELECTRIC CORPORATION
NUCLEAR ENERGY SYSTEMS
P.O. BOX 355 PITTSBURGH, PENNSYLVANIA 15230

FOREWORD

This Technical Manual is provided to familiarize personnel with the installation, operation, and maintenance aspects of the Reactor Containment Fan Cooler which is an Engineered Safeguard System.

This Manual is up to date as of October 1969. If amendments are made, pertinent sections will be forwarded.

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It is anticipated that skilled tradesmen familiar with the types of equipment used will be installing, operating, and maintaining the equipment. These instructions are not intended to give every detail. If questions arise which are not covered in these instructions, it is anticipated that Westinghouse NES will be contacted for clarification. At that time, additional details will be made available where required.

SECTION 1 - INTRODUCTION

1.1 General Description

The Reactor Containment Fan Cooler (RCFC) units are designed to remove heat from the containment building during both normal operation and in the event of a loss of coolant accident. The RCFC unit is an engineered safeguard system.

During normal operation air from the containment atmosphere enters the unit through a roughing filter. The air is then drawn through the cooling coils and discharged by the fan into the ventilation duct work.

During accident mode operation, air enters the unit through a butterfly valve. From this point the air flows through the cooling coils and is discharged by the fan into the ventilation duct work. Space is provided up stream of the butterfly valve for the possible future addition of carbon filters, HEPA filters, and moisture separators.

The cooling coils remove heat from the air with the fan providing the required air flow rates. Cooling water is supplied by the service water system. Drain troughs and piping are provided to remove condensate from the cooling coils and the heat exchanger attached to the fan motor.

There are a total of four units operating in parallel. During normal operation a maximum of three units are required to remove the design heat load. For post accident operation a minimum of two units must function to satisfy safeguards requirements. Since the units are engineered safeguards they are located outside of the missile shield.

Each RCFC unit is composed of the following subassemblies:

1. Fan Assembly
2. Motor Assembly
3. Cooling Coil Assembly
4. Transition Module
5. Roughing Filter Module
6. Carbon Filter Module
7. HEPA Filter Module

1.2 General Data

The RCFC design characteristics are listed in Table 1-1.

TABLE 1-1 SUMMARY OF GENERAL DATA

Fan Assembly

Number of fans	4	
Fan type	Centrifugal	
Bearing monitors	Vibration and thermocouples	
Fan housing drain type	1.5 I.P.S.	
	Normal Mode Operation	Accident Mode Operation
Speed (rpm)	720	720
Capacity (cfm)	85,000	65,000
Static pressure (in. wg)	6	20.3
Containment atmosphere pressure (psig)	0	42
Containment atmosphere temperature (°F)	120	263
Containment atmosphere density (lb/ft^3)	0.0685	0.1617
Brake horsepower at specified conditions	117	244
Max. fan brake horsepower	117	264

Motor Assembly

Number	4	
Type	460V, 3 phase, 60 CY single speed	
Bearing monitors	Vibration	
Winding monitors	None	
Service factor	1.15	
Heat Exchanger cooling media	Service water	
Number of Heat Exchanger relief ports	2	
Relief port diameter (inches)	3	
Max. relief port pressure differential (in.of w.g.)	30	
Relief port opening pressure (in. of w.g.)	5	
Relief port flow coefficient (C_v @ 60° open)	360	
	Normal	Accident
Speed (rpm)	720	720
Horsepower	350	350

TABLE 1-1 (cont.)

Motor Assembly (cont.)	Normal	Accident
Containment atmosphere temperature (°F)	120	263
Containment atmosphere pressure (psig)	0	42
Containment atmosphere density (lb/ft^3)	0.0685	0.1617
Cooling water flow (gpm)	50	50
Cooling water inlet temperature (°F)	95	95
Maximum allowable cooling water pressure loss (psi) max.	2.0	2.0

Cooling Coil Assembly

Number	4
Type	Plate finned
Tube material	Copper
Fin material	Copper
Fins per inch	8.5
Tube thickness (in.)	0.049
Fin thickness (in.)	0.008
Tube nominal OD (in.)	5/8
Tube length (in.)	108
Vertical drain pan spacing (ft.)	3
Pan drain diameter (in.)	2
Assembly drain diameter (in.)	6
Drain type (sch.)	10
Assembly frame material	Galvanized steel
Drain pan material	Stainless steel
Accident transient differential pressure loading on coil face (psi)	0.05
Total fin area per assembly (ft^2)	21,481
Total tube inside area per assembly (ft^2)	1221

	Normal Operation	Accident Operation
Heat removal (Btu/hr)	$1.75 \times (10)^6$	$40 \times (10)^6$
Steam-air flow (cfm)	85,000	65,000
Steam-air inlet temperature (°F)	120	263
Steam-air outlet temperature (°F)	99	261.7
Total pressure (psig)	0	42
Coil design air density (lb/ft^3)	0.0685	0.0685
Coil design steam density (lb/ft^3)	0	0.093
Condensate rate (gpm)	0	100
Static pressure drop (in. wg)	0.5	1.6

TABLE 1-1 (Cont.)

Cooling Coil Assembly (cont.)	Normal Operation	Accident Operation
Cooling water flow (gpm)	800	800
Cooling water inlet temperature (°F)	95	95
Cooling water outlet temperature (°F)	99	201.6
Water pressure drop (psi) max.	5	5
Coil tube side fouling factor	0.001	0.001

Roughing Filter Assembly	
Total flow through filter assembly (cfm)	85,000
Normal operating maximum static pressure drop across filter assembly (in. wg)	0.3
Design air density (lb/ft^3)	.075
Sealing material	Silicone rubber
Media material	Fiberglass
Frame material	Stainless steel
Frame surface coating	None
Design maximum differential pressure (psi)	0.5

Roughing Filter Module Relief Door	
Port area (ft^2)	8
Maximum door area density (lb/ft^2)	6
Maximum door swing radius (ft)	2.0
Minimum pressure across door required to begin door opening (psi)	0.5

1.3 Description

1.3.1 Fan Assembly

The RCFC Fan is a Westinghouse Sturtevant designation 8566-C, airfoil bladed, single width, single inlet, centrifugal fan, arrangement 8, Class 900 RPM, clockwise rotation, up-discharge type. The fan assembly consists of vibration isolators, a steel sub-base, the centrifugal fan, a Thomas coupling and coupling guard, orifice plate, a Vibraswitch, and a thermocouple in each bearing. The motor and motor heat exchanger are mounted on the fan sub-base but are covered under a separate heading herein.

The fan housing is welded steel and is split for wheel removal. An access door and a plugged (removable) drain connection is provided in the fan housing. The fan wheel is welded steel and the fan has a fabricated steel hub. The fan bearings are Link Belt Roller bearings greased with a special lubricant to assure proper operation and protection during a possible post accident condition. The fan has a hot rolled steel shaft with key. The flexible coupling is provided with a guard. Special paint is used to coat the exposed steel, the paint being Carbo-Zinc 11 primer and Phenoline 305 finish. For additional information see W Sturtevant Drawing Number 5296D73, Sub 3, in the Appendix.

1.3.2 Motor Assembly

The Reactor Containment Fan Cooler Motor Assembly must function satisfactorily during both normal and post-accident operation.

A. Motor

The motors are NEMA Totally Enclosed, Pipe-Ventilated motors per MG1-1.26F, with integral air-to-water heat exchangers. The motor heat exchanger is designed to use the same cooling water source as the ventilation unit cooling coils. The motor heat exchanger cooling water requirements are 50 gpm per unit maximum.

The motors are designed so that the motor and heat exchanger housings together serve as an enclosure which isolates the major functional elements of the motor from the containment environment. The objective is to exclude the environment which would exist in the containment building under post-accident conditions and thus maintain an environment within the motor which is comparable to the normal operating environment for which there is a large background of motor performance experience.

The vital functional elements of the motor are designed specifically for additional assurance of reliable post-accident performance. Special features are incorporated in the motor bearing system to assure that proper lubrication and freedom from containments, such as moisture and caustics, are achieved. The motor insulation is form wound Thermalastic Epoxy Insulation, which is a sealed, vacuum-pressure impregnated system having superior moisture resistance

For additional information see the W pamphlet I.L. 3100-24, and Westinghouse Buffalo Drawing Number 2748D26, Sub 2, in the Appendix.

B. Motor Heat Exchanger

The motor heat exchanger assembly consists of three (3) main components: the cooling coil, the duct work, and the relief valves.

The heat exchanger is an air-to-water, finned unit. Cooling water is circulated in the tubes and the air is forced over the fins and outer surface of the tubes to transfer heat from the air to the water. The motor heat exchanger cooling coil has high temperature alloy brazed joints and is designed to maintain the RCFC motor environmental temperature and humidity. The motor heat exchanger is designed to have sufficient capacity to absorb all motor assembly heat losses and external effects under all operating conditions, while limiting the maximum thermal environment consistent with the motor design.

The motor heat exchanger cooling coil consists of the following:

1) 5/8" OD copper tubes with 0.049" wall thickness.

2) Plate copper fins, 0.008" thick, 8-1/2 fins per inch of coil length.

3) 90-10 cupro-nickel headers with 0.25" dia. couplings plugged with a 0.25" square head bronze pipe soldered plug for vent and drain connections.

4) Header nozzles are 90-10 cupro-nickel 1.5 inch, schedule 40 pipe, prepared for socket welding in the field.

The air duct assembly is specially painted sheet metal formed and shaped to direct air from the motor through the heat exchanger and back into the motor brackets. A fitting is provided in the end panel of the assembly to drain any condensate present in the heat exchanger assembly. The portion of the air duct assembly

inertia capability of the motor to start a fan and accelerate it, varies as the **square** of the fan-motor speed ratio. This is advantageous for the motor since a relatively low motor inertia capability is required due to the effect of the square of th[illegible] motor speed ratio. However, a fan directly connect[illegible] motor does not have this speed difference and the [illegible]nical advantage of the drive ratio is non-existant. The driving motor, must, of necessity, be larger than that indicated in the performance tables and must be reviewed with the motor supplier.

Whenever inlet vanes or outlet dampers are used, the starting load and motor heating are reduced, if such devices are kept closed until after the fan has accelerated to operating speed.

FAN LAWS

Two basic fan laws relate performance variables for any fan of a given design (such as the Silentvane Series 8000). An understanding of these relationships is necessary to select fans when they are handling air or gas which is different than standard or when fan performance adjustments must be made on existing systems. Both of these laws apply to a ***given unchanged duct system.***

Fan Law #1

SPEED VARIABLE — CONSTANT AIR DENSITY

A. Volume (cfm) . . . Varies directly as the ratio of the speeds.

$$CFM_2 = CFM_1 \times \frac{RPM_2}{RPM_1}$$

B. Pressure (sp or tp) . . . Varies directly as the square of the speed ratio.

$$Pressure_2 = Pressure_1 \times \left(\frac{RPM_2}{RPM_1}\right)^2$$

C. Brake Horsepower . . . Varies directly as the cube of the speed ratio.

$$BHP_2 = BHP_1 \times \left(\frac{RPM_2}{RPM_1}\right)^3$$

Fan Law #2

AIR DENSITY VARIABLE — CONSTANT SPEED

A. Volume (cfm) — Remains unchanged

B. Pressure (sp or tp) . . . Varies directly as the ratio of the air densities.

$$Pressure_2 = Pressure_1 \times \frac{\text{Air Density}_2}{\text{Air Density}_1}$$

C. Brake horsepower . . . Varies directly as the ratio of the air densities.

$$BHP_2 = BHP_1 \times \frac{\text{Air Density}_2}{\text{Air Density}_1}$$

CORRECTION OF FAN PERFORMANCE FOR OTHER THAN STANDARD AIR CONDITIONS

Air volumes to be handled by the fan must be calculated to satisfy the application. A fan operating on a given system at a given speed is a constant volume machine. The density of air entering the fan (affected by temperature and/or altitude) can vary, but the air volume delivered will remain unchanged. The system resistance, the fan pressure capability and brake horsepower will vary directly with the air density.

In general practice, the design system resistance is calculated in the usual manner using standard air density and the fan pressure requirements are determined for "standard" conditions. This is sometimes known as the "cold" pressure. Select the fan from the catalog in the normal manner using the "cold" pressure, noting the fan RPM and BHP. As previously indicated by fan law #2, the design air volume and selected fan speed will remain unchanged, but the fan pressure and horsepower will vary with the air density. (The system resistance will also vary with the air density, which is the reason the volume flow remains unchanged).

The design of many systems involve the calculation and specification of air quantities by weight as in product drying or combustion. Before a fan can be selected, the air quantity must be converted to an air volume based upon standard air density entering the fan inlet. The system resistance ("cold" fan static pressure) must be determined using this air volume. The fan selection is now made from the catalog, using the calculated air volume and the "cold" static pressure. Fan brake horsepower corrections are made for air density variations as indicated above.

For ease in calculations, the table below contains air density ratios for temperatures from −20 to 900F and barometric pressures from 29.92 to 13.75" HG.

SAMPLE CORRECTION

A size 8060, SWSI fan must deliver 37,280 CFM at 1½ inches static pressure. The fan must perform at an altitude of 4000 feet with air entering the fan inlet at 300F.

1. Obtain density correction factor from table below.
   For 300F air at an altitude of 4000 feet the factor is 0.604.
2. Correct static pressure for new conditions.
   1½ ÷ 0.604 = 2½" "cold" static pressure.
3. Use specified air volume and corrected static pressure to obtain fan speed and brake horsepower requirements from fan tables.

Air Density Ratios at Various Altitudes and Air Temperatures

AIR TEMPERATURE F	ALTITUDE IN FEET ABOVE SEA LEVEL 0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	15000	20000
	BAROMETRIC PRESSURE IN INCHES OF MERCURY 29.92	28.86	27.82	26.81	25.84	24.89	23.98	23.09	22.22	21.38	20.58	16.88	13.75
−20°	1.204	1.16	1.12	1.08	1.04	1.00	.965	.930	.895	.860	.828	.678	.554
0°	1.152	1.10	1.07	1.03	.995	.958	.923	.888	.856	.822	.792	.650	.530
70°	1.000	.964	.930	.896	.864	.832	.801	.772	.743	.714	.688	.564	.460
100°	.946	.912	.880	.848	.818	.787	.758	.730	.703	.676	.651	.534	.435
150°	.869	.838	.808	.770	.751	.723	.696	.671	.646	.620	.598	.490	.400
200°	.803	.774	.747	.720	.694	.668	.643	.620	.596	.573	.552	.453	.369
250°	.747	.720	.694	.669	.645	.622	.598	.576	.555	.533	.514	.421	.344
300°	.697	.672	.648	.624	.604	.580	.558	.538	.518	.498	.480	.393	.321
350°	.654	.631	.608	.586	.565	.544	.524	.505	.486	.467	.450	.369	.301
400°	.616	.594	.573	.552	.532	.513	.493	.476	.458	.440	.424	.347	.283
450°	.582	.561	.542	.522	.503	.484	.466	.449	.433	.416	.401	.328	.268
[illegible]	.552	.532	.513	.495	.477	.459	.442	.426	.410	.394	.380	.311	.254
[illegible]	.525	.506	.488	.470	.454	.437	.421	.405	.390	.375	.361	.296	.242
[illegible]	.500	.482	.465	.448	.432	.416	.400	.386	.372	.352	.344	.282	.230
650°	.477	.460	.444	.427	.412	.397	.382	.368	.354	.341	.328	.269	.219
700°	.457	.441	.425	.410	.395	.380	.366	.353	.340	.326	.315	.258	.210
800°	.421	.406	.392	.377	.364	.350	.337	.325	.313	.301	.290	.238	.194
900°	.390	.376	.363	.350	.337	.325	.322	.301	.290	.278	.268	.220	.180