NSP

NORTHERN STATES POWER COMPANY

MINNEAPOLIS, MINNESOTA 55401

October 7, 1974

Mr. J F O'Leary, Director
Directorate of Licensing
Office of Regulation
U S Atomic Energy Commission
Washington, DC 20545

Dear Mr. O'Leary:

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
Docket No. 50-282 License No. DPR-42

Submittal of Results of Cooling Water System Tests

Attached you will find 40 copies of the test report, "Cooling Water System Tests - October 7, 1974". This report is submitted in accordance with Prairie Island Technical Specification 6.7.B.3 (Table TS.6.7-1, Item 8).

Yours very truly,

L. O. Mayer

L O Mayer, PE
Director of Nuclear Support Services

LOM/DMM/kn

cc: J G Keppler
G Charnoff
Minnesota Pollution Control Agency
Attn. E A Pryzina

Attachment

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

SAFETY EVALUATION OF STARTUP TEST RESULTS FOR DIESEL GENERATORS AND COOLING WATER SYSTEMS, PRAIRIE ISLAND NUCLEAR GENERATING PLANT, UNITS 1 AND 2

INTRODUCTION

In its Safety Evaluation Report for the Prairie Island Nuclear Generating Plant, the Regulatory staff concluded that the onsite emergency power system was acceptable subject to confirmation that adequate provisions be made for sharing the onsite power system between the two units and subject to the successful completion of qualification testing of the onsite power systems[1]. (References are listed at the end of this evaluation).

The onsite emergency power system includes four diesel engines. Emergency ac power is supplied to engineered safety features by two diesel generators, each rated at 2750 kW for continuous operation. Emergency cooling water for engineered safety features, including the diesel-generators, is supplied by two diesel-driven cooling water pumps, each rated at 13,000 gpm at 242 feet head. The Regulatory staff requires that these systems be capable of automatically supplying adequate power and cooling water for the engineered safety features required to mitigate design basis accidents, including the loss of coolant accident (LOCA), and anticipated operational occurrences, including loss of offsite power, assuming a single failure after the accident or occurrence.

Tests and analyses of the onsite emergency power system were performed by NSP and reported to the Regulatory staff in accordance with Technical

Specifications.[2] These tests were:

(1) Diesel generator and diesel pump qualification tests,[4]

(2) Tests of diesel generators for two unit operation,[6] and

(3) Cooling water system tests.[7]

Evaluation

The Regulatory staff reviewed the test reports of the onsite emergency power system identified above. In addition, the licensing staff met with the NSP operations personnel at the plant site on February 15, 1974, to discuss the staff's review of Unit 1 preoperational tests and additional tests to be performed.[3]

1. Diesel Generator and Diesel Pump Qualification Tests

The required diesel generator qualification tests included 150 test starts of each diesel generator - 50 test starts followed by the starting of simulated full load, 80 test starts after installation, including 8 in which the diesel generator was loaded to 2700 kW for 15 minutes; and 20 integral system tests in which engineered safety features were started in proper sequence by a simulated safety injection signal[1]. During the preoperational tests for Unit 1,[4] the 150 tests were successfully completed for each diesel generator with no failures to start. However, the 20 integral system tests were run with the generator voltage regulator set at 4300 volts to match the no-load emergency bus voltage existing at that time. During most of the time when the plant is fully operational, the bus will be near the nominal 4160 volts.

At the staff's request[3] integral system tests were run at 4160 volts during the Unit 2 preoperational tests to demonstrate that engineered safety feature loads would be started with the lower voltage setting. The startup test inspector in the Directorate of Regulatory Operations has verified that these additional tests were successfully completed.

The required diesel pump qualification tests included 150 test starts of each diesel pump[1]. During the Unit 1 preoperational tests[4], 300 start tests for the two diesel pumps were successfully completed without a failure to start.

Based on its review of these preoperational tests, the Regulatory staff concluded that the tests adequately demonstrated the starting reliability of the diesel generators and diesel pumps and the adequacy of cooling water flow for Unit 1 operation. The adequacy of tests for two-unit operation are evaluated in paragraphs 2 and 3 below.

2. Tests of Diesel Generators for Two Unit Operation

The staff's SER required that prior to two unit operation, an analysis be performed to provide assurance that a false accident signal in one unit followed by an accident in the other unit and a loss of offsite power would not result from anticipated plant transients, since such an occurrence would probably result in overloading both diesel generators.[1,2] Subsequently, the staff concurred with the licensee's proposal in lieu of an analysis to demonstrate by tests that the diesel generators have adequate capacity to start the engineered safety features loads resulting from a false accident signal in one unit and a real accident in the other unit. Tests were run[4] in which the two largest pumps associated with each diesel generator (the two 800-horsepower safety injection pumps) were manually started simultaneously from the control room. Based on its review of these tests, the staff recommended[5] additional tests in which the automatic sequential loading of all engineered safety features was tested by simulating a false accident signal in one unit and simultaneously simulating a real accident signal in the other unit. Such tests were completed during the Unit 2 preoperational tests.[6]

The Regulatory staff has reviewed the results of these tests and has concluded that the diesel generators have adequate capacity to start engineered safety feature loads caused by a false accident signal in one unit and a real accident signal in the other unit.

3. Cooling Water System Tests

The licensee has completed cooling water system tests and analyses made to demonstrate that the emergency cooling water flow automatically provided by a diesel driven pump following a loss of offsite power is adequate, assuming one of the two diesel pumps fails to start.[7]

During normal two-unit operation two electric-motor-driven pumps discharge to the cooling water system headers. Following loss of offsite power and the subsequent trip of both units with only one diesel pump starting, the pressure in the cooling water system header will decrease below design pressure until water flow to equipment that is not essential has been automatically reduced by temperature-controlled valves. The largest such temperature-controlled valve is the hydrogen cooler outlet control valve, that closes within 10 minutes following loss of offsite power. More rapid closure of motor-operated isolation valves to non-essential equipment following loss of offsite power can be achieved manually. However, the Regulatory staff does not consider manual actions at such short time intervals following an accident to be an acceptable means for mitigation of the accident. Therefore, the tests were run to demonstrate that adequate cooling water to engineered safety features, including the diesel generators would be automatically provided following the loss of offsite power.

The demonstration of adequate cooling water supply for this occurrence was made by calculating the cooling water system header pressure, using measured reduction of cooling water flow to non-essential equipment following a main generator trip from full power and using the results of a special test that determined the minimum cooling water system header pressure required to adequately cool a fully-loaded diesel generator.[7] The results of the diesel generator tests showed that for the present condition of the cooler, 10 psig cooling water system header pressure is required to provide adequate cooling of the diesel generators. For an aged cooler, assuming 10% higher friction factors, and assuming maximum air and cooling water temperature, the required header water pressure is 13.3 psig. The results of the cooling water system analyses and water flow reduction tests showed that, for the present system, a minimum header water pressure of 45 psig would exist immediately after loss of power and that it would increase to 73 psig when the hydrogen cooler valve closed 9.5 minutes following plant trip. For an aged system, assuming 10% loss of water supply due to pump wear, and assuming maximum water temperature, the minimum calculated header pressure immediately after loss of power is 24 psig and the calculated pressure after 9.5 minutes is 43 psig.

The Regulatory staff has reviewed the results of these analyses and tests and concluded that they provide adequate demonstration that the cooling water system will provide sufficient cooling water to the diesel generators following a loss of offsite power assuming a single failure following the accident or occurrence.

During Unit 2 startup tests additional data will be available to determine two-unit cooling water system requirements. The startup test inspector in the Directorate of Regulatory Operations will verify, based on these startup test results and analyses, that adequate cooling water will be automatically provided to plant equipment required for safe plant shutdown following a loss of offsite power, assuming a single failure following the occurrence.

Conclusions

Based on its review of the licensee's tests and analyses, the Regulatory staff has concluded:

(1) That the diesel generator and diesel pump qualification tests have been satisfactorily completed.

(2) That the diesel generators have adequate capacity to supply power to engineered safety features started by a false accident signal in one unit and those started by a simultaneous real accident (LOCA) in the other unit.

(3) That the cooling water system has adequate capacity to automatically supply the cooling water required for the diesel generators and other essential equipment following a loss of offsite power assuming a single failure following the occurrence.

L. L. Kintner
Senior Project Manager

Karl Kniel, Chief
LWR Branch 2-2

REFERENCES

1 Safety Evaluation of the Prairie Island Nuclear Generating Plant, Units 1 and 2, USAEC, Directorate of Licensing, September 28, 1972 Sections 8.3 and 9.3.3.

2 Appendix A to Facility Operating License DPR-42, Technical Specifications for Prairie Island Nuclear Generating Plant, Issued August 9, 1973, Specification TS 6.7.B.3 (Table TS 6.7-1, Items 7, 8, and 10).

3 February 27, 1974 letter from Karl Kniel (USAEC) to L. O. Mayer (NSP) Regarding Directorate of Licensing Evaluation of Qualification Tests for Diesel Generators and Diesel Driven Pump System.

4 March 15, 1974 letter from L. O. Mayer (NSP) to AEC "Diesel Generator and Diesel Driven Pump Reliability Tests and Diesel Tests for Two Unit Operation," Northern States Power Company Report to the USAEC, March 15, 1974.

5 May 10, 1974 letter from Voss A. Moore (USAEC) to L. O. Mayer (NSP) Regarding Directorate of Licensing Evaluation of March 15, 1974 Test Report on Diesel Reliability Tests and Diesel Tests for Two Unit Operation.

6 July 1, 1974 letter, L. O. Mayer (NSP) to AEC Transmitting Supplement No. 1 to Report of Diesel Generator and Diesel Driven Pump Reliability Tests and Diesel Tests for Two Unit Operation, Northern States Power Company, July 1, 1974.

7 October 7, 1974 letter from L. O. Mayer (NSP) to AEC transmitting Cooling Water System Tests, Northern States Power Company, October 7, 1974.

NORTHERN STATES POWER COMPANY

Prairie Island Nuclear Generating Plant
Docket No.s 50-282 & 50-306 License No. DPR-42

Cooling Water System Tests

Date: October 7, 1974

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Figures and Tables

1.0 Introduction

1.1 Background

The purpose of this report is to present an evaluation of the testing conducted at the Prairie Island Nuclear Generating Plant to demonstrate the ability of the Cooling Water System to supply the diesel generators in the event of a loss of all offsite power during two unit operation. This testing satisfies the requirements of Table TS.6.7-1 (Item 8) of the Prairie Island Technical Specifications, Section 9.6 (p.9.6-13a) of the Prairie Island Final Safety Analysis Report, and Section 9.3.3 (p. 9-9) of the Prairie Island AEC Safety Evaluation Report.

In the event of loss of all off-site power and subsequent trip of both units, the emergency diesel cooling water pumps will start and supply all Cooling Water System loads. If one diesel cooling water pump fails to start, the remaining diesel cooling water pump must supply all cooling water demands. In the presence of a Safety Injection (SI) signal, the Cooling Water System ring header is automatically split into two parts, thereby reducing the requirements on a single diesel driven pump. Normally, however, an SI signal will not be present and the demands on a single pump could potentially reduce Cooling Water System header pressure below that needed to adequately cool the diesel generators at full load. We have conducted an analysis of this event and conclude that the hydraulic characteristics of the Cooling Water System, the conservative sizing of the diesel generator cooling system, and the automatic reduction in main generator hydrogen cooler flow that occurs will guarantee sufficient cooling water supplies to the diesel generators with no operator action required.

1.2 Description of the Cooling Water System

The Cooling Water System (Figure 1) is a safeguard system consisting of 5 pumps (2 horizontal and 3 vertical) feeding a ring header which is shared by Units 1 and 2. This header can be isolated automatically or manually to provide two redundant supplies.

The design requirements satisfied by the system are:

a. Each supply header is designed to supply the needs of all required safeguards services for both units. This is accompanied by automatic isolation of the supply headers such that half the safeguards services for both units come off supply header A and the other half come off supply header B.

b. The system will operate continuously at the record low river level because the inlet canal and cooling water pump suctions are below this level.

c. The system is protected against the maximum hypothetical flood.

d. The system is capable of tolerating the failure of a single active component without impairing its ability to function as the plant heat sink.

e. The system is capable of tolerating a single passive failure in the long term operating condition following an accident.

f. Any one of the pumps is capable of satisfying the post-accident cooling requirements of one unit and the hot standby requirements of the other unit.

g. The system is designed so that the safeguards pumps have two separate sources of river water supply assuring that water will always be available to these pumps. The normal source of water is supplied to the cooling water pumps via an open cut channel to the Screenhouse. The backup source of water is supplied to the vertical motor and diesel driven cooling water pumps via a 36" underground line from the river to the emergency bay. This will ensure a supply of water in the event of an earthquake, which could block the normal source of water (open cut channel), or a failure of Lock & Dam No. 3.

h. The system is capable of operating with a loss of all off-site power. Two of the vertical cooling water pumps are diesel driven and are started by air.

i. At least one emergency bay traveling screen is operable during an accident or loss of normal power. Each screen is powered from a separate safeguards bus in case one of the diesel generators fails to start.

j. The system pressure in the component cooling heat exchangers is such that in case of leakage in the tubes, the flow will be from the cooling water system to the component cooling water system.

The normal water supply for the system is from an open cut intake canal to the Screenhouse. From the canal, the water passes through trash racks, traveling screens, and into the screen wells. Two horizontal motor driven cooling water pumps take suction from the screen wells and discharge into a common discharge header. Three vertical cooling water pumps (1 motor driven, and 2 diesel driven) take suction from the emergency pump bay and also discharge into the common discharge header. The emergency bay is supplied through 2 normally open bay gates from the screen wells and a 36" underground line from the river. If a seismic event blocks the circulating water intake canal, the bay gates are manually closed and the emergency pump bay is supplied by the 36" pipe only. The water supplied from the 36" pipe passes through the emergency pump bay traveling screens. As illustrated in Figure 1, the system is provided with 4 motor operated isolation valves which can divide the header and pumps so that the two supply headers are isolated. Each supply header has 2 strainers arranged in parallel. The supply headers are joined by 2 normally closed motor operated isolation valves downstream of the strainers to form the ring header.

Cooling water supply for both units branches out of the supply headers and serves the following nonsafeguards equipment:

Condensate pump oil coolers
Heater drain pump oil coolers
Generator bus duct coolers
Heating system boiler feed pumps

Makeup demineralizer degas vacuum pumps
Hydrogen seal oil unit cooler
Generator hydrogen coolers
Generator exciter coolers
Turbine oil reservoir cooler
Feedwater pump oil coolers
Turbine HP fluid reservoir oil coolers
Circulating water pump seals
Pump priming exhauster
Various equipment heat removal coolers
Backup Screenhouse fire protection
Station air compressor and aftercooler system
Backup diesel generator fire protection
Chlorine System

The following safeguards equipment is provided with a cooling water supply from each of the supply headers. Check valves in each supply line prevent a reverse flow of water in the event of a loss of water to one supply header:

Diesel generators
Filtered Water System

Supply header A serves the following safeguards equipment:

#11 and #21 Component Cooling Heat Exchangers
#11, #13, #21 and #23 Containment Fan Coil Units
#121 Control Room Chiller
#11 and #21 Auxiliary Feed Pumps
#11 Steam Generator Blowdown Heat Exchanger and Radiation Monitor Cooler
#121 Traveling Screens
#12 Cooling Water Pump Jacket Cooler and Pump Gear Oil Cooler

Supply header B serves the following safeguards equipment:

#12 and #22 Component Cooling Heat Exchangers
#12, #14, #22, and #24 containment Fan Coil Units
#122 Control Room Chiller
#12 and #22 Auxiliary Feedwater Pumps
#21 Steam Generator Blowdown Heat Exchanger and Radiation Monitor Cooler
#122 Traveling Screen
#22 Cooling Water Pump Jacket Cooler and Pump Gear Oil Cooler
Backup auxiliary feedwater pumps fire protection

Cooling water discharged from all safeguards and nonsafeguards equipment supplied from header A flows into the Unit 1 circulating water outlet line via the Unit 1 cooling water discharge header. Cooling water discharged from all safeguards and nonsafeguards equipment supplied from header B flows into the Unit 2 circulating water outlet line via the Unit 2 cooling water discharge header. These discharge headers are joined through 2 normally closed motor operated valves with an emergency dump to grade between the valves. Each header is provided with a standpipe with overflow to the ground outside each turbine building. The standpipe outlet discharges to the circulating water discharge piping. The discharged water will normally be recycled through the cooling towers via the cooling tower pumps, and back to the intake canal. Makeup water to the intake canal will be withdrawn from the river under the barrier wall. Supply to the auxiliary feed pumps, safeguards traveling screens, circulating water pump seal, and filtered water supplies are not for cooling water purposes and do not have return lines.

The emergency bay, vertical cooling water pumps, emergency traveling screens, and cooling water strainers are all housed in the Class I section of the Screenhouse.

2.0 Cooling Water System Tests

2.1 Purpose

The purpose of this testing was to obtain sufficient data to evaluate the adequacy of cooling water flow to the emergency diesel generators under the following circumstances:

a. Loss of all off-site power followed immediately by reactor and turbine trips in both units.

b. Failure to start of one diesel driven cooling water pump.

c. No SI signal to split the Cooling Water System ring header.

d. No operator action taken to reduce Cooling Water System flow to non-essential components.

e. Both diesel generators fully loaded (several times expected loading).

2.2 Conduct of the Tests

The testing was conducted in two segments. The first segment consisted of measuring Unit 1 Cooling Water System flows as a function of time following a plant trip from 100% reactor power. This data was collected in conjunction with the Generator Trip from Full Power Test (Unit 1 Phase III Test PO 13). It was used to conservatively estimate the two unit system head characteristic curve following the trip of both units. The second segment consisted of a determination of the minimum Cooling Water System header pressure required to supply adequate cooling water to a fully loaded diesel generator. This testing was conducted as an adjunct to a weekly diesel generator surveillance test (SP 1093).

2.2.1 Determination of Cooling Water Requirements Following a Plant Trip

On July 26, 1974 data was recorded in conjunction with Unit 1 Phase III Test PO 13 to determine cooling water requirements at 100% power and immediately after a plant trip from one unit operation. The primary objective was measurement of closure time o No. 11/12 Hydrogen Cooler Outlet Control Valve (CV-31360), which is the only automatic temperature control of any size in the turbine building cooling water system.

Prior to the trip, Unit 1 was operating at 100% reactor power (463 MWe). In preparation for the test, a recorder was connected to Loop A and B cooling water header flow and pressure transmitters (FT-23066, FT-26067, PT-21005 and PT-21006) to note trends in cooling water demand. In addition, data was recorded from local indicators throughout the plant. The closure of CV-31360 was timed (stopwatch) from the time of trip signal until the valve closed. The parameters recorded prior to the trip were recorded following the trip. Pertinent data is included in Table 4. The data is consistent with FSAR predictions of Cooling Water System requirements (Table 3).

Data taken during the trip test related to reduction in flow through the hydrogen cooler was confirmed in additional testing performed the morning of June 27, 1974 at which time cooling water flow requirements were stabilized (Unit 1 shutdown, no flow thru hydrogen coolers) at 8500 gpm. CV-31360 was then manually opened (Controller in manual) to the position of the valve prior to the trip (position had been marked on valve body). With the valve in essentially the same position, the 3.5 psig pressure differential across the coolers was duplicated, although at a somewhat higher inlet pressure. This resulted in an increase in cooling water flow to 10,700 gpm. This confirmed the 2200-2300 gpm reduction in hydrogen cooler flow measured during the test.

2.2.2 Diesel Generator Operability Test with Reduced Cooling Water Supply Pressure

On September 30, 1974 a special test was conducted to determine how far cooling water supply pressure to a fully loaded diesel generator can be permitted to fall. The test was conducted in the following manner:

1. D-1 diesel generator was run fully loaded at normal cooling water supply pressure for ½-hour.

2. Cooling water supply pressure was reduced in 5-psi increments by throttling supply valve CW-62-1. At each incremental reduction, the engine and generator temperatures were permitted to stabilize and were recorded.

3. When an alarm or limiting temperature was encountered the minimum permissible supply pressure was determined. Cooling water flow was returned to normal.

Data from this test is summarized in Table 5.

2.3 Analysis and Results

Adequacy of the cooling water system for supplying the diesel generators following loss of offsite power and failure of one diesel driven pump during two unit operation will be demonstrated in the following manner:

1. The cooling water flow measurements taken during Test PO 13 will be used to conservatively extrapolate the two unit system head-capacity curve. This curve is then used in conjunction with the diesel pump performance curve to determine the operating point following the event. Two operating points will be considered - the most limiting condition immediately after trip of both units (t=0) and the condition when hydrogen cooler flow has been automatically reduced to zero (t=9.5 min.).

2. The operating points determined in (1) will be used to determine supply pressure available at the diesel generators. These pressures will be compared to the minimum pressure required to adequately cool a fully loaded diesel generator determined by actual test. Correction factors for pipe aging, worst case temperatures, and diesel pump wear will be applied to demonstrate that the cooling requirements will be satisfied under all conditions.

Two Unit System Characteristic Following Loss of Offsite Power

From the data presented in Table 4, the two unit head capacity curve is determined using the assumptions:

1. Cooling water requirement immediately after trip of both units (t=0) is equal to twice the total flow measured for Unit 1 at 100% reactor power (corrected for rated generator KVA hydrogen cooler flow).

2. Circulating water intake elevation is 674.5 ft. This elevation is maintained by Lock and Dam No. 3.

3. Other important elevations:

Vertical pumps	654.5'
Supply header instrument tap	701'
Inlet to diesel coolers	699'
Discharge Standpipe	701'

Using the data from Table 4, the two unit cooling water requirement corrected for rated generator KVA at t=0 becomes:

$$Q(\text{gpm @ 93 psig}) = 10200+2300(659/467)^2$$

$$= 14780$$

Based on this point a conservative two unit system characteristic at t=0 is:

$$H(\text{ft}) = 26.5 + 2.46\times10^{-7}Q(\text{gpm})^2$$

The cooling water requirement at t=9.5 minutes when all flow to the hydrogen coolers has been shut off can be conservatively estimated from the data in Table 4 as:

$$Q(\text{gpm @ 105 psig}) = 10200$$

Based on this point a conservative two unit system characteristic at t= 9.5 minutes is:

$$H(\text{ft}) = 26.5 + 5.82\times10^{-7}Q(\text{gpm})^2$$

Plotting H(t=0) and H(t=9.5 min) system characteristics in conjunction with the diesel driven pump performance curve yields the pump operating points The vendor's performance curve for pump No. 12 (Figure 2) is used in this plot since it was determined to be slightly less efficient than pump No. 22 (Figure 3). The operating points (Figure 4) become:

Time(min)	Pump Head (psig)	Header Pres (psig)	Flow (gpm)	Pump BHP
0	56.3	44.8	20700	1000
9.5	84.4	72.9	17100	930

Therefore, immediately after loss of offsite power and trip of both units, header pressure will fall to 45 psig with one diesel driven pump available. Header pressure will gradually build up to 73 psig over the 9.5 minutes it takes for hydrogen control valve closure. These results are based on new pumps and clean pipe, however, as well as 86°F cooling water supply temperature.

To conservatively determine the system operating points under worst case conditions, the following assumptions are made:

a. Pump wear results in 10% additional internal leakage. This is a conservative estimate of the maximum degradation in performance expected between pump overhauls. Pump capacity is effectively reduced 10% at each point along the performance curve.

b. Maximum cooling water temperature (95°F) results in 10% additional cooling water requirements at full load over the values determined for 86°F.

The pump performance curve and system load curves are redrawn in Figure 5 for these worst case conditions. The operating points become:

Time(min)	Pump Head (psig)	Header Pres (psig)	Flow (gpm)	Pump BHP
0	44.6	33.1	19800	1000
9.5	70.0	58.5	17100	950

Taking into account estimated pressure drops in the diesel supply pipe and fittings and static pressure differences, this results in a pressure at the inlet to the diesel coolers under worst case conditions of:

Time(min)	Pressure at Inlet to Diesel Coolers (psig)
0	24.3
9.5	42.6

Comparison with Measured Diesel Cooling Water Supply Pressure Requirements

As shown in Table 5, cooling water supply pressure was reduced to as low as 10 psig during full load testing of the diesel generators without reaching a limiting condition. No attempt was made to further reduce the supply pressure, but it is clear from the data that at 10 psig, lube oil and coolant temperatures were still near the bottom of their controlled bands. The diesel heat exchangers are very conservatively rated. This result is also consistent with the original specifications for the diesel coolers (Tables 6, 7, and 8) in which a pressure drop of 7.4 psi across the coolers at 95°F cooling water supply temperature provides full design flow.

The data in Table 5 is only applicable, however, for clean pipes and coolers, 55°F supply temperature, and 45°F air temperature. As the system ages, the minimum required supply pressure will rise. The minimum supply pressure also increases as cooling water supply and air temperatures increase. The required supply pressure for worst case conditions of system aging, cooling water supply temperature, and air temperature can be conservatively estimated based on the following assumptions:

a. Aging factor of 1.1
(friction factors are 10% greater than as-tested).

b. 95°F cooling water and 100°F ambient air temperatures result in 10% increase in required cooler flow rate.

Based on these assumptions, the required minimum supply pressure at the inlet to the coolers becomes:

$$P(\text{worst case}) \leq (1.1)(1.1)^2 \; P(\text{test conditions})$$

$$\leq 13.3 \text{ psig}$$

This pressure is available at the inlet to the diesel coolers at all times under worst case conditions following the loss of offsite power and failure of one diesel driven pump to start.

3.0 Conclusions

In the event of loss of offsite power and subsequent trip of both units, one diesel driven cooling water pump has sufficient capacity to supply adequate cooling water to the diesel generators.

A conservative analysis has shown that immediately after the two unit trip, sufficient pressure is available at the inlet to the diesel coolers to provide adequate cooling at the maximum expected cooling water supply temperature with conservative factors applied to account for diesel driven pump wear and system aging. In addition, tests have demonstrated that in less than 10 minutes cooling water is automatically isolated to the main generator hydrogen coolers. This provides additional cooling water which can be made available to the diesels.

During the Unit 2 Startup Testing Program additional data will be available to determine actual two unit cooling water system requirements. Because of the factors of conservatism used in this analysis, it is expected that this additional information will further increase the margin of acceptability of the cooling water system to supply plant requirements following a loss of offsite power.

Finally, it must be emphasized that this analysis assumes no operator initiated reduction of cooling water flow to non-essential components. Such action would be rapidly and routinely initiated in the event of an actual loss of offsite power.

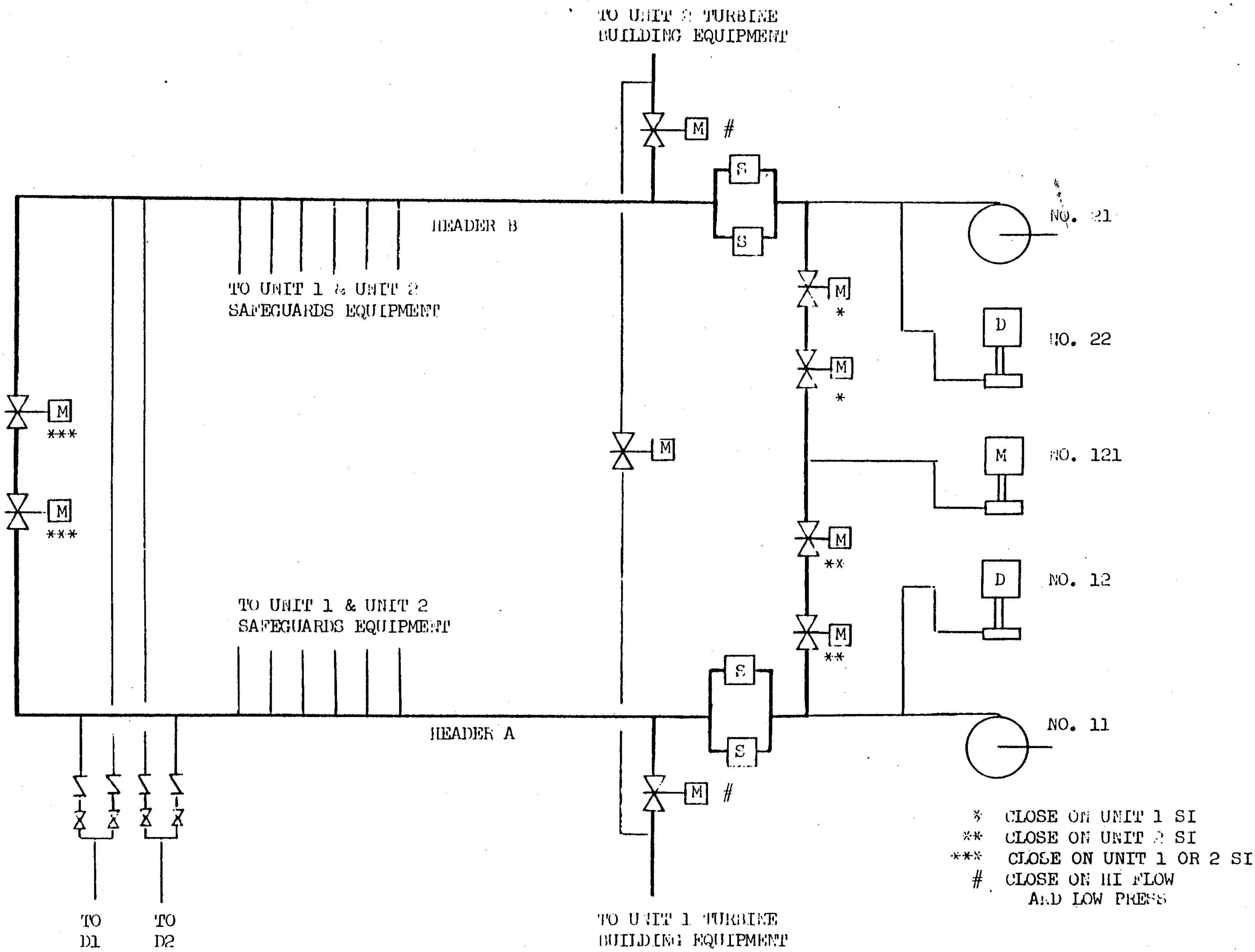

Figure 1. Simplified flow diagram of Cooling Water Supply Header.

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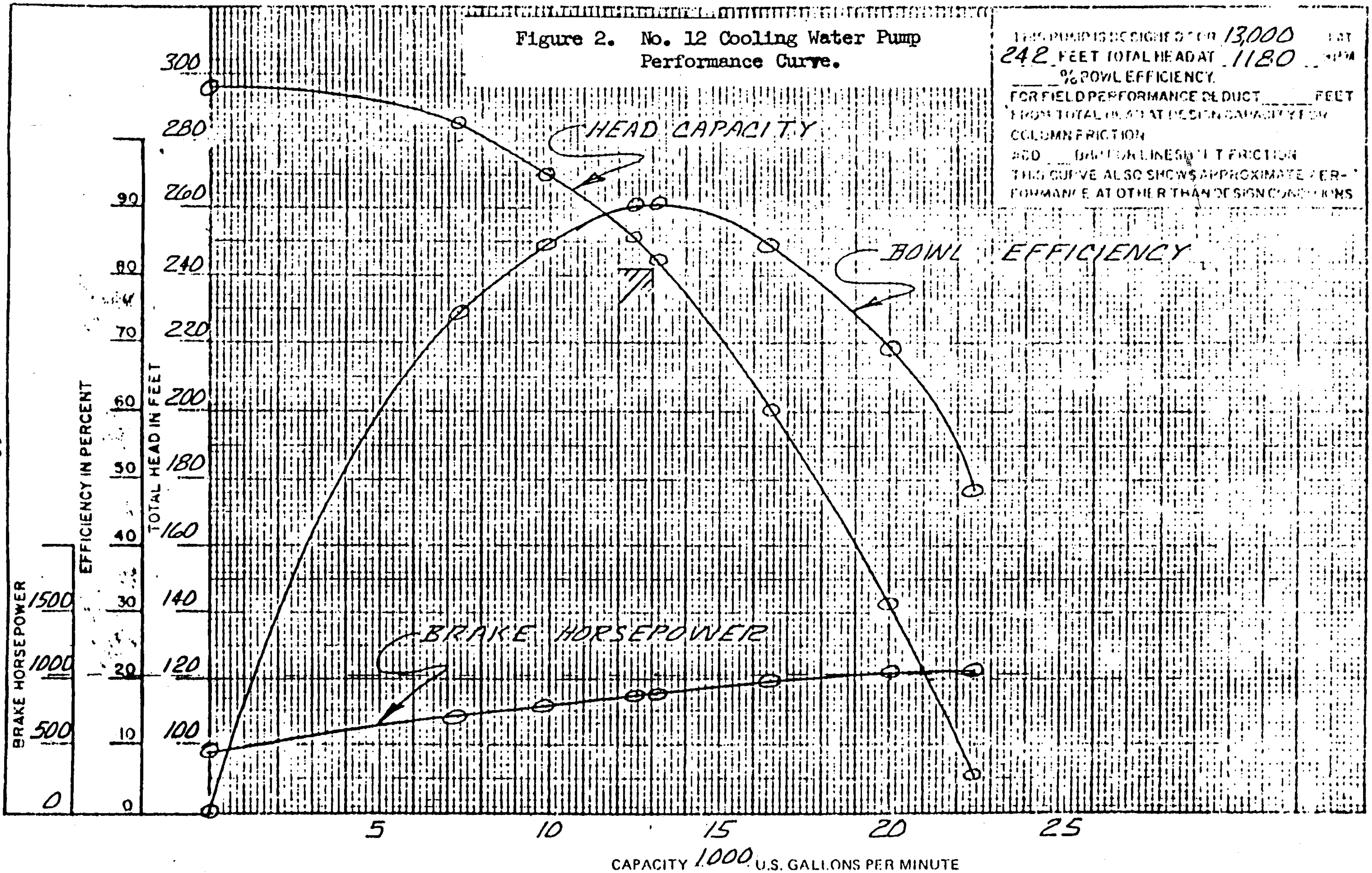

Figure 2. No. 12 Cooling Water Pump Performance Curve.

AMPCO-18	DUCTILE IRON	20QL-26	WORTHINGTON PUMP INTERNATIONAL	8-11-72	VTP-30533
IMP. MAT'L.	BOWL MAT'L.	PUMP	VERTICAL PUMP OPERATIONS	DATE	SERIAL NO.
24 1/8"	150 H.P. TEST	1	DENVER, COLORADO, U.S.A.		DTP-35106
IMP. DIA.	DRIVER	NO. OF STAGES	WORTHINGTON	CUST. NO.	ORDER NO.
3476	1180	L.A.L.			

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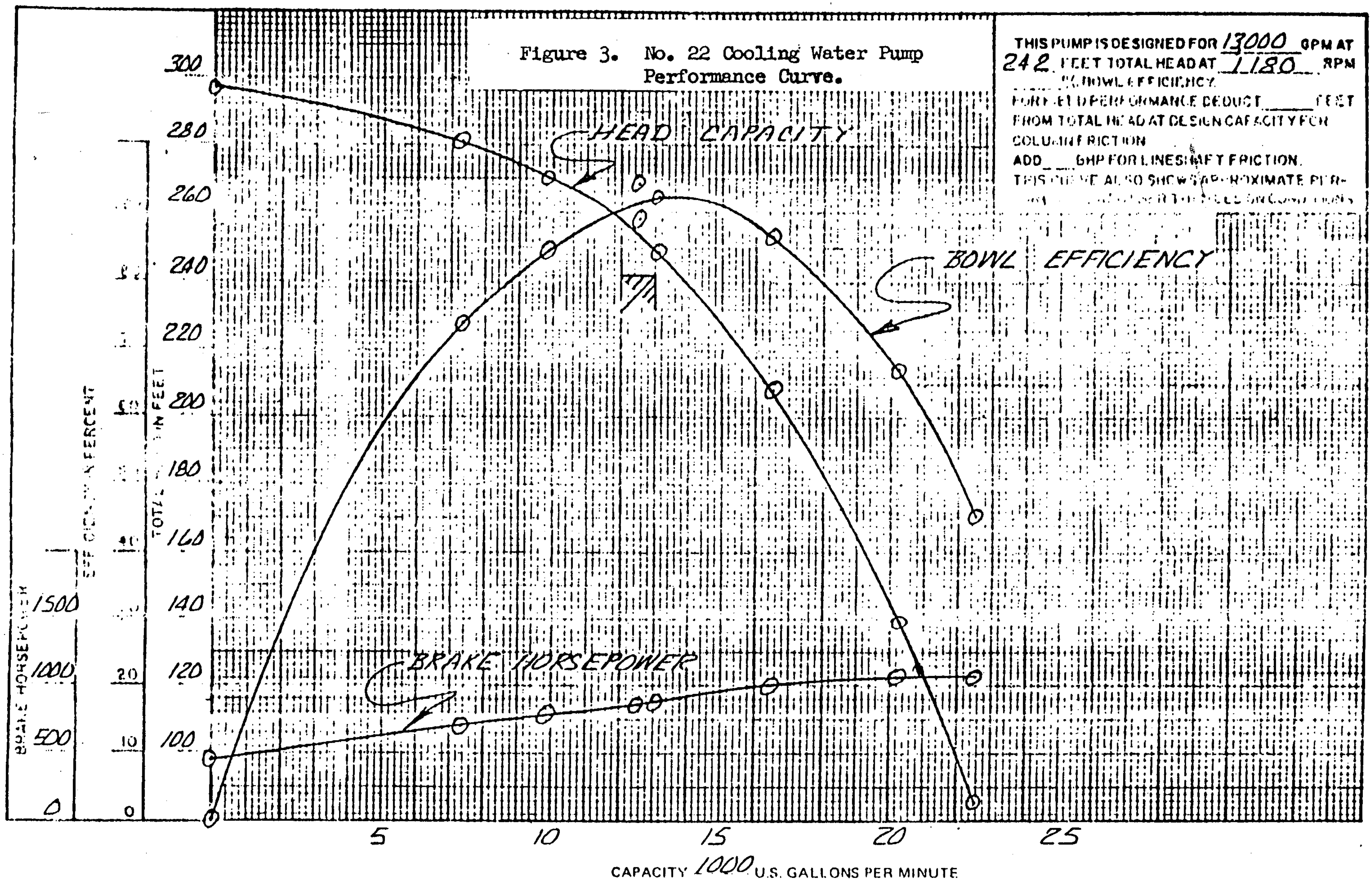

Figure 3. No. 22 Cooling Water Pump Performance Curve.

AMPCO-18	DUCTILE IRON	20QL-26	WORTHINGTON PUMP INTERNATIONAL	8-31-72	VTP-30534
IMP. MAT'L.	BOWL MAT'L.	PUMP		DATE	SERIAL NO.
24 1/8"	150 H.P. TEST	1	VERTICAL PUMP OPERATIONS		DTP-35106
IMP. DIA	DRIVER	NO. OF STAGES	DENVER, COLORADO, U.S.A.	CUST. NO.	ORDER NO.

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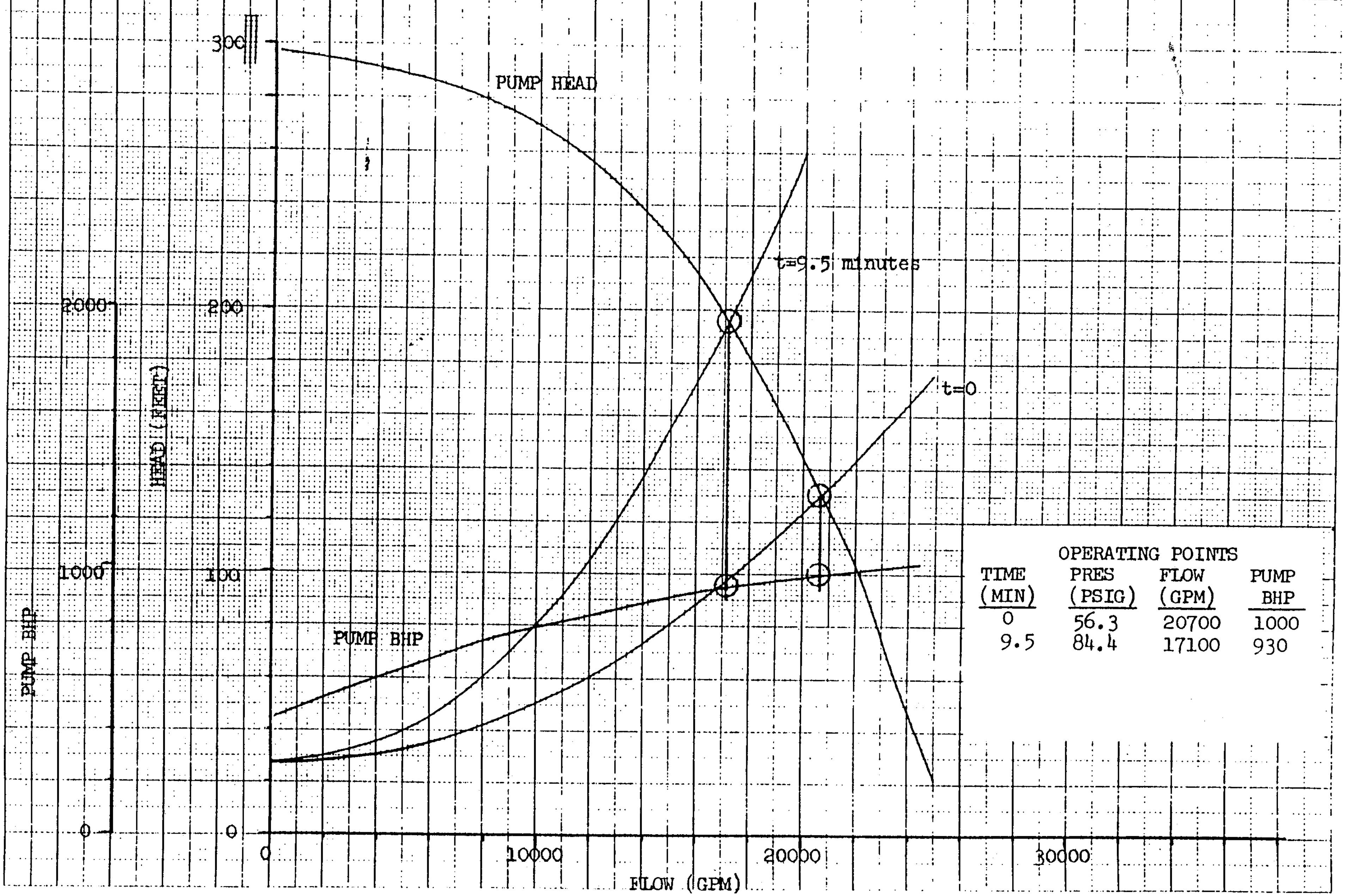
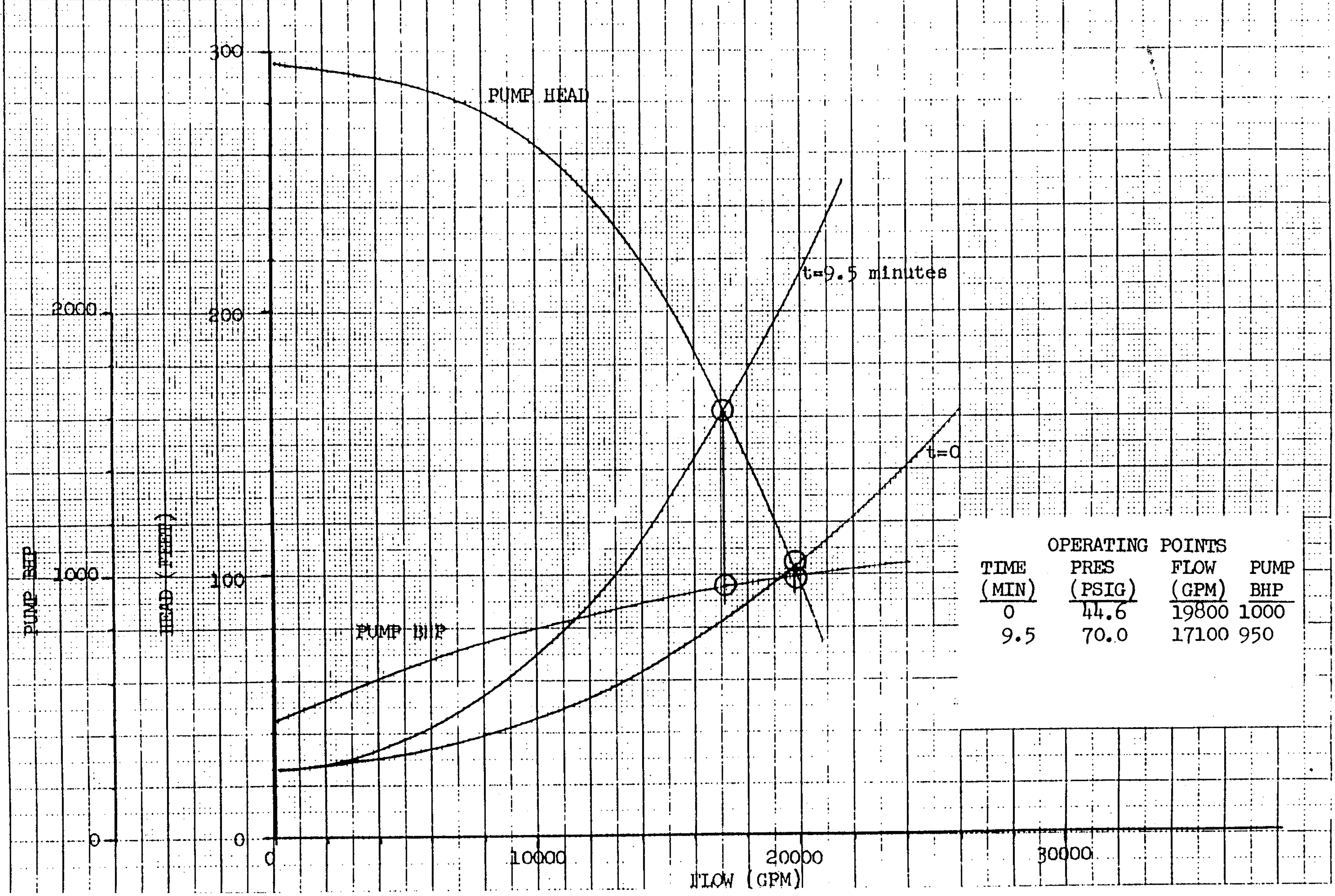
Figure 4. Determination of System Operating Point Following Loss of Offsite Power (Two Unit Operation)



OPERATING POINTS

TIME (MIN)	PRES (PSIG)	FLOW (GPM)	PUMP BHP
0	56.3	20700	1000
9.5	84.4	17100	930

Figure 5. System Operating Point with Worn Pump and Increased Cooling Water Demand
(10% Additional Internal Pump Leakage and 10% Additional Demand)



OPERATING POINTS

TIME (MIN)	PRES (PSIG)	FLOW (GPM)	PUMP BHP
0	44.6	19800	1000
9.5	70.0	17100	950

TABLE 1. EMERGENCY DIESEL GENERATOR SPECIFICATIONS

Engine	
Nameplate Data	Fairbanks Morse, opposed piston Model 38TD8-1/2 Serial Nos. 38D870057TDSM12 38D870059TDSM12
Cylinders	12
Horsepower	3600 at 900 rpm
Displacement	12,443 in^3
Compression Ratio	13.8
Generator	
Nameplate Data	Fairbanks Morse, synchronous generator Type TGZJ, Frame 956-34 Serial Nos. 502169R1, 502169R2
Phase	3
Frequency	60 HZ
Power Factor	0.8
KVA, rated	3750
KW, rated	3000
Service Factor	1.0
Field Volts	265 VDC
Field Amps	68.5
Voltage	4160

TABLE 2. DIESEL COOLING WATER PUMP SPECIFICATIONS

Engine	
Type	Caterpillar D399
Cylinders	16
Displacement	3928 in^3
Horsepower	1215
RPM	900-1300
Pump	
Type	Worthington Type QL Vertical Double Suction
Nominal Characteristics	13000 GPM, 1180 RPM, 242 Ft head
Impeller Diameter	24-1/8 inches

TABLE 3. FSAR COOLING WATER REQUIREMENTS FOR SINGLE UNIT OPERATION (GPM)

Heat Load	Normal Operation	Loss of Offsite Power with Slow Cooldown
Component Cooling	4500	4500
Fan Coil Units	900	900
Diesel Generators (fully loaded)	0	700
Aux Feed Pumps	0	0
Air Compressors	50	50
Control Room Air Cond	320	320
Admin Bldg Air Cond	320	320
Cooling Water Pump Cooling	25	25
Feedwater Pump Oil Coolers	50	50
Circ Water Pump Seals	25	25
Steam Gen Blowdown Heat Exchanger/Radiation Monitor Cooler	150	0
Miscellaneous Equipment Ventilation	600	600
Turbine:		
Oil Coolers	1470	300
Hydrogen Coolers	4345	0
Hydrogen Seal Oil Coolers	150	150
Bus Duct Coolers	50	0
Exciter Air Coolers	400	0
TOTAL FLOW REQUIRED	13355	7940

*Operator action required in most cases to reduce cooling water flow to indicated values.

TABLE 4. MEASURED COOLING WATER REQUIREMENTS AT 100% POWER VS 0% POWER (UNIT 1 OPERATION ONLY)

Parameter	Before Plant Trip	After Plant Trip (Note 1)
Date	7/26/74	7/27/74
Time	2349	0028
Load (MWe/KVA) (Note 3)	463.5/466,800	0
Total Loop A Flow (GPM)	9500	6000 (Note 4)
Loop A Flow to Aux Bldg (GPM)	5000	5100
Loop A Pressure (PSIG)	93	105
Loop A Temperature (°F)	86.0	86.1
Total Loop B Flow (GPM)	3000	3000
Loop B Flow to Aux Bldg (GPM)	2800	2800
Loop B Pressure (PSIG)	91	103
Loop B Temperature (°F)	86.9	86.8
Hydrogen Cooler Cooling Water Inlet Temperature (°F)	95	95
Outlet Temperature (°F)	109	102
Inlet Pressure (PSIG)	79.5	89
Outlet Pressure (PSIG)	76	89
Control Valve Closure Time (min-sec)		9-35 (Note 2)
Flow (GPM)	2300	0

Notes:

1. Plant trip at 0004 on 7/27/74.
2. 9 min and 35 seconds for control valve closure as determined by measured dp across the cooler, valve position indication, and flow noise.
3. Warranted gross output is 560MWe (659,000 KVA). Temporary repairs to turbine limited electrical generation to 463MWe for 100% reactor thermal power output.
4. 3500 GPM reduction includes a 1000 GPM operator initiated reduction in flow to Turbine Oil Cooler. An estimated 200-300 GPM reduction also resulted from automatic cutback in flow to Krack Unit Coolers.

TABLE 5. DATA FROM DIESEL GENERATOR OPERABILITY WITH REDUCED COOLING WATER FLOW TEST

Parameter	Units	DATA (Note 1)								
		1	2	3	4	5	6	7	8	9(Note 5)
Cooling Water Pressure	PSIG	71.5	49	39	34	29.5	25.5	20.5	15	10
Lube Oil Temp fm Engine (Note 2)	°F	201.5	201	201.5	201.5	291.5	201.5	201.5	202	202
Lube Oil Temp to Engine (Note 2)	°F	180	180	180	180	180	180	180	180	181
Jacket Coolant fm Engine (Note 3)	°F	170	170	170	170	170	170	170	170	170
Jacket Coolant to Engine (Note 3)	°F	164	165	165	164.5	164	164	164	164.5	165
Air Coolant Temp (Note 4)	°F	98	98	98	98	98	98	98	96	100
Exhaust Stack Temp (Note 4)	°F	750	750	750	750	750	750	750	750	750
Cooling Water Temp In	°F	56	56	56	56	56	55.3	55.3	55	55
Cooling Water Temp Out	°F	65	65.5	67.5	68.3	69	70.8	72.8	79.8	91
Cooling Water Header Pressure	PSIG	99.5	99.5	100	100	99.5	99.5	100	101	101
Air to Engine Temp	°F	←				45				→

Notes:

1. Data point No. 1 taken after 1-hour running time at 2750 KW and 1925 KVAR with CW-62-1 fully open. Other data points taken 10-15 min following pressure change.
2. Temperature controller maintains oil leaving engine between 195-215°F.
3. Temperature controller maintains coolant leaving engine between 170-185°F.
4. Temperature controller begins to open port to heat exchanger at 100°F.
5. There was no attempt to test at supply pressures below 10 PSIG. No limiting engine condition was reached. No alarms were received other than low cooling water flow.