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ENCLOSURE: EVALUATION OF POTENTIAL REACTOR VESSEL OVER-PRESSURIZATION.......

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DUKE POWER COMPANY
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WILLIAM O. PARKER, JR.
VICE PRESIDENT
STEAM PRODUCTION

TELEPHONE: AREA 704
373-4083

October 14, 1976

Mr. Benard C. Rusche, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Mr. A. Schwencer, Chief
Operating Reactors Branch No. 1

Re: Oconee Nuclear Station
Docket Nos. 50-269, -270, -287

Dear Sir:

Your letter dated August 11, 1976 informed us of a number of reported instances of reactor vessel overpressurization in Pressurized Water Reactor facilities in which the Technical Specifications implementing 10CFR50 Appendix G limitations have been exceeded. It was requested that the Oconee Nuclear Station design and operating methods be examined to determine susceptability to overpressurization events.

The attached report is provided in response to your request. With the exception of a system hydro test, the Oconee reactors are not operated in a "solid water" condition. A steam space or gas space is always maintained in the pressurizer. The Oconee design also incorporates the use of a pilot actuated relief valve which has a dual setpoint to provide overpressure protection during startup and shutdown conditions. Additionally, the modest rate of system pressure increase from these highly unlikely initiating events and the alarm and indication features available will provide sufficient time for operator action to terminate any event prior to reaching the Technical Specification limits associated with the 10CFR50 Appendix G requirements.

It is our conclusion that the design and operating procedures which currently exist are adequate to mitigate the consequences of postulated reactor vessel overpressurization incidents.

Very truly yours,

William O. Parker, Jr.

MST:ge

10569

OCONEE NUCLEAR STATION
EVALUATION OF POTENTIAL REACTOR VESSEL OVERPRESSURIZATION

1. Purpose

   The purpose of this evaluation is to examine the Oconee Nuclear Station operation for susceptability to reactor vessel overpressurization events during startup and shutdown and to determine the pressure response of the Reactor Coolant System (RCS) to potential events which could cause pressure increases.

2. Events Evaluated

   The events examined in this evaluation were:

   a. Erroneous actuation of the High Pressure Injection (HPI) System.

   b. Erroneous opening of the core flood tank discharge valve.

   c. Erroneous addition of nitrogen to the pressurizer.

   d. Makeup control valve (makeup to the RCS) fails full open.

   e. All pressurizer heaters erroneously energized.

   f. Temporary loss of the Decay Heat Removal System's capability to remove decay heat from the RCS.

   g. Thermal expansion of RCS after starting an RC pump due to stored thermal energy in the steam generator.

3. Results of Event Evaluation

   3.1 General

   For events which could cause the RCS pressure to increase, the pressure will increase significantly faster in a "solid water" system than it will in a system with a steam or gas space. The RCS always operates with a steam or gas space in the pressurizer; no operations involve a "solid water" condition, other than system hydrotest.

   Considering the modest rate of pressure rise (because of non-solid pressurizer) from the events and the high level alarms in the pressurizer that would normally alert the operator, it is reasonable to expect the operator to terminate the event prior to reaching an overpressurization condition. However, without operator action, the pilot actuated relief valve located on the pressurizer will terminate any pressure increase. A dual setpoint is utilized for this valve to provide overpressure protection during startup and shutdown conditions. The lower setpoint is enabled by actuation of a switch in the control room. Characteristics of this valve at the lower setpoint are:

3.1 General (Cont'd)

Open Setpoint	550 Psig
Close Setpoint	500 Psig
Steam capacity at 550 psig	25,985 lb/hr
Equivalent liquid insurge volume rate into pressurizer	2,650 gpm
Liquid capacity @ 550 psig	500 gpm
Nitrogen capacity @ 550 psig	32,420 lb/hr
Equivalent liquid insurge volume rate into pressurizer	2,350 gpm

All events involving insurge to the pressurizer were evaluated with the pressurizer and makeup tank water levels initiating at high levels. For the pressurizer, a water level at the high high level alarm setpoint was used. The relationship of this level to the other pressurizer water level setpoints is:

0"-400"	Level Indicating range
315"	High high level alarm
260"	High level alarm
220"	Normal level
200"	Low level alarm
80"	Low level interlock (heater cut-out) and alarm

For the makeup tank, which is the normal suction source for the makeup/HPI pump, a water level at the high level alarm setpoint was used. The relationship of this level to the other makeup tank setpoints is:

0-100"	Level Indicating range
86"	High level alarm
73"	Normal level
55"	Low level alarm

The initial pressurizer level used for the event does not affect the peak pressure reached; it only affects the rate of pressure increase.

3.2 Erroneous Actuation of the HPI System

This event is not credible because the circuit breakers for the closed HP injection motor operated valves are "racked out" during the plant cooldown prior to startup of the Decay Heat Removal System. These valves are HP-26 and HP-27 on SAR Figure 9-2. Startup of the Decay Heat Removal System occurs at an RCS temperature of 250°F

3.3 Erroneous Opening of the Core Flood Tank Discharge Valve

This event is not credible because this valve is closed and the circuit breaker for the motor operator is "racked out" during the plant cooldown before the RCS pressure is decreased to 600 psig.

3.4 Erroneous Addition of Nitrogen to the Pressurizer

It is not credible that this event can overpressurize the RCS. The nitrogen addition system used for adding nitrogen to the pressurizer or the RCS is a regulated 125 psig system with a relief valve (set at 150 psig) located downstream of the regulator. So, maximum pressure that could be reached for this event is 150 psig.

3.5 Makeup Control Valve (makeup to the RCS) Fails Full Open

This valve is HP-120 on SAR Figure 9-2 and is automatically controlled by the pressurizer level controller. The pressure response of the RCS to this event is shown on Figure 1. If it is assumed that the operator does not take action to terminate the event during the pressure increase, the peak RCS pressure is limited to 550 psig by the pressurizer pilot actuated relief valve. Initial conditions used for the analysis were:

a. 315" pressurizer water level (high high alarm setpoint)
b. 86" makeup tank water level (high level alarm)
c. 32 gpm total seal injection flow to RC pumps (automtically controlled)
d. 45 gpm letdown flow from RCS to makeup tank
e. No spray into pressurizer (normally there would be)

Figure one depicts two pressure response curves. One is for an initial RCS pressure of 275 psig. This is the RCS pressure at which the Decay Heat Removal System is started up during plant cooldown or at which the RC pumps are started during plant heatup. Pressurizer water level would normally be about 220" instead of the 315" used in the analysis. The higher level used in the analysis increases the rate of pressure rise. The other pressure response curve on Figure 1 is for an initial RCS pressure of 100 psig. This is about the lowest RCS pressure at which the Makeup System would be in operation.

Relief through the pressurizer relief valve will be terminated by operator action (stop makeup pump or close makeup valve) or without operator action when the makeup tank water volume is exhausted. Peak insurge rate into the pressurizer is 245 gpm. In addition to the alarms shown on Figure 1, other alarms and indications which would alert and aid the operator in evaluating the event are:

a. Pressurizer high level alarm(s) (with initial level below high high setpoint which would be normal).
b. Higher than normal makeup line flow rate indication

c. Lower than normal makeup pump discharge pressure
d. Full open indicating light for makeup valve
e. High temperature alarm for relief valve discharge line (after relief valve relieves)
f. Higher than normal RCS pressure indication
g. Higher than normal pressurizer level indication

3.6 All Pressurizer Heaters Erroneously Energized

The pressure response of the RCS to this event is shown on Figure 2. If it is assumed that the operator does not take action to terminate the event during the pressure increase, the peak RCS pressure is limited to 550 psig by the pressurizer pilot actuated relief valve. An initial pressurizer water level of 90 inches (10 inches above low level heater cut-out interlock) was used because the lower water level results in the fastest pressure increase. Even with the low level, the pressure increase is very slow. The pressurizer water level will not change during this event as it is being automatically controlled. The heaters are generating 1625 lbs of steam per hour in the 500 to 550 psig range. In addition to the alarms shown on Figure 2, other alarms and indications which would alert and aid the operator in evaluating the event are:

a. Higher than normal RCS pressure indication.
b. Higher than normal letdown flow rate indication to makeup tank (due to increasing RCS pressurizer)
c. Higher than normal makeup line flow rate indication due to increasing letdown flow rate.
d. High temperature alarm for relief valve discharge line (after relief valve relieves)
e. The "On" indicating lights "lit" for all pressurizer heater banks.

Relief through the pressurizer relief valve will be terminated by operator action (de-energize heaters). Without operator action, the heaters will be de-energized when the pressurizer water level drops to the heater cut-out interlock setpoint. Since pressurizer water level is on automatic control, water is transferred automatically from the makeup tank to the RCS to replace that which is lost through the relief valve. For an initial makeup tank level at the high alarm setpoint, it would take six (6) hours to empty the makeup tank and thus result in pressurizer water level decreasing to the heater "cut-out" setpoint.

3.7 Temporary Loss of Decay Heat Removal Systems Capability to Remove Decay Heat From the RCS

The pressure response of the RCS to this event is shown on Figure 3. It it is assumed that the operator does not take action to terminate the event during the pressure increase, the peak RCS pressure is limited to 550 psig by the pressurizer pilot actuated relief valve. Loss of decay heat removal capability could only be caused by loss of flow in the Decay Heat Removal System or in the cooling water system serving the Decay Heat Removal System. Loss of flow in either

system would immediately actuate low flow alarm(s), thus alerting the operator. Relief through the pressurizer relief valve will be terminated by operator action restoring the decay heat removal function. Insurge rate into the pressurizer is 98 gpm in the 500 to 550 psig pressure range. Conditions used in this pressure response analysis were:

a. Event occurs during cooldown after startup of Decay Heat Removal System and shutdown of steam generators.
b. Pressurizer level at 315 inches, normally it would be near 220 inches.
c. Cooldown to the Decay Heat Removal System "cut-in" temperature at 100 F/Hr, this produces maximum decay heat generation rate.
d. All decay heat absorbed by reactor coolant, no heat absorbed by the metal components or by the steam generators. Actually, these are heat absorbing sinks.
e. 32 gpm total seal injection flow to RC pumps (automatically controlled).
f. 45 gpm initial letdown from RCS to makeup tank
g. No spray into pressurizer.

3.8 Start of an RC Pump with Stored Thermal Energy in OTSG Secondary

Several postulated situations have been examined which may lead to primary fluid expansion due to energy absorption from hot OTSG secondary water after start of an RC pump. The two types of situations which lead to possible RCS pressurization have been identified as follows:

Type A. Filling of OTSG secondary side with hot water with subsequent start of an RC pump, and

Type B. Restart of an RC pump during heatup following a period of stagnant (no flow) conditions.

3.8.1 Start of an RC Pump Under Type A Condition

Figure number 4 presents results of RCS pressure versus time for the worst case Type A (see above) condition. Initial conditions for this transient are a result of filling of the steam generators with feedwater at 420°F. This temperature is a result of the failure of the feedwater heating controls causing auxiliary steam flow to the heaters to produce a feedwater temperature in excess of the allowable value of 225°F for OTSG fill operations. The temperature of the feedwater in the OTSG secondary side following the filling operation reaches a temperature of 240°F as does the primary water contained in the RCS at elevations greater than the lower OTSG tubesheet. This is a result of the heating of OTSG tubes and primary water during OTSG filling where heated primary water circulates to a limited extent through the RCS. At the end of the filling operation, the RCS water located below the OTSG lower tubesheet remains at the initial value of 140°F.

3.8.1 (Cont'd)

The primary system pressure versus time as shown in Figure 4 is based on an initial pressurizer level at the maximum value of the high-high level alarm for a 177 FA plant. The initial pressurizer level is normally kept much lower to minimize the heating requirements for raising the pressurizer temperature and pressure in preparation for starting an RC pump. The initial pressure is 300 psig, the normal pressure required prior to starting an RC pump. No credit has been taken for pressurizer level control. The pressurizer level increased during the transient by 30 inches; the level would have to rise an additional 70 inches before entering the upper head.

Other conditions of primary and secondary temperatures which may exist prior to starting of an RC pump have been evaluated and are bounded by the results of Figure 4. These conditions include the situation where the feedwater temperature entering the OTSG's during filling operations is at the normal maximum value of 225^{o}F but the operator fills the steam generators beyond the maximum allowable level and completely fills the steam generators. In addition, the results presented here bound the case where the initial RCS temperature is 50^{o}F before filling the steam generators.

3.8.2. Start of an RC Pump Under Type B Condition

Figure number 5 presents results of RCS pressure versus time for the Type B conditions (see above). Initial conditions for this transient are a result of the accumulation of pump seal injection and makeup injection water in the RC cold leg piping during stagnant (no flow) conditions. Although the operator is required to initiate a cooldown of the RCS if RC pumps are inoperable and RC temperature >250F (Plant Limit and Precautions), the assumption is made that the operator fails to do so while allowing makeup and seal injection water temperature to drop to 50F, which is below the minimum value of RC temperature less 120^{o}F. The cold water is assumed to accumulate in the RC cold leg piping without mixing with hot RC water. The RC pump is started following a period of one hour of stagnant (no flow) conditions in the RC System.

The primary system pressure versus time as shown in Figure 5 is based on an initial pressurizer level at the maximum value of the high-high level alarm for a 177 FA plant. The initial pressure is 450 psig which is approximately midway between the Tech. Spec. and RC pump NPSH pressure limits at 275^{o}F. No credit has been taken for pressurizer level control. The decrease in pressure at approximately 2 minutes is a result of hot RC primary fluid entering a steam generator which has been cooled by the passage of the slug of low temperature RC fluid (the mixing of RC fluid and heat transfer through the OTSG tubing brings the RC fluid to a constant temperature and produces a net contraction of the gluid and a decrease in system pressure at final equilibrium conditions). The pressurizer level increases during the transient by 13 inches;

3.8.2 (Cont'd)

the level would have to rise an additional 87 inches before entering the upper head.

4. Conclusions

The preceding evaluation and analysis demonstrates that the reactor vessel is protected from overpressurization during any postulated event which could cause increasing pressure. No design or operating changes are considered necessary.

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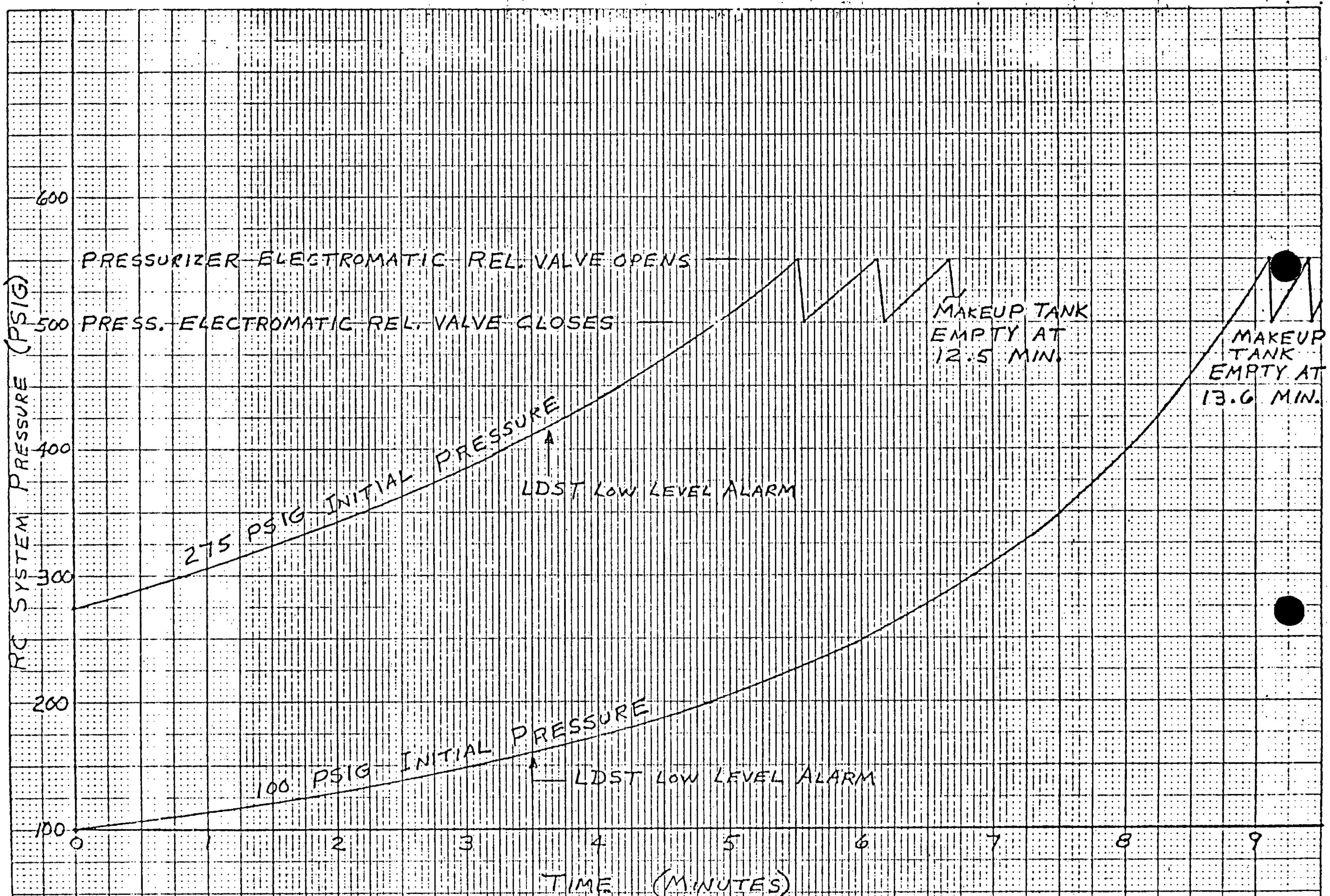

FIGURE 1

PRESSURE TRANSIENT FOR MAKEUP VALVE (HP-120) FAILING FULL OPEN

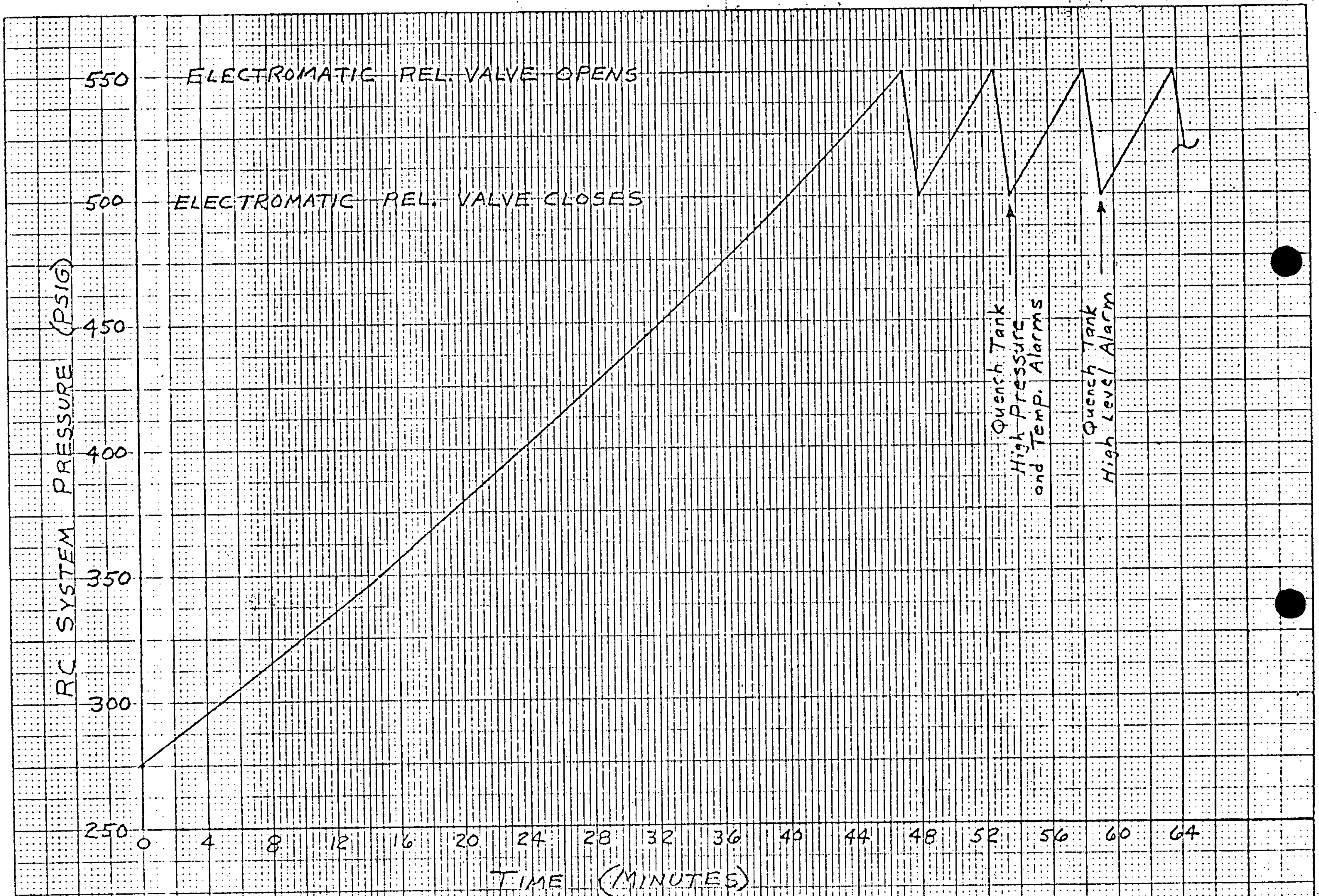

FIGURE 2

PRESSURE TRANSIENT FOR ALL PRESSURIZER HEATERS ENERGIZED

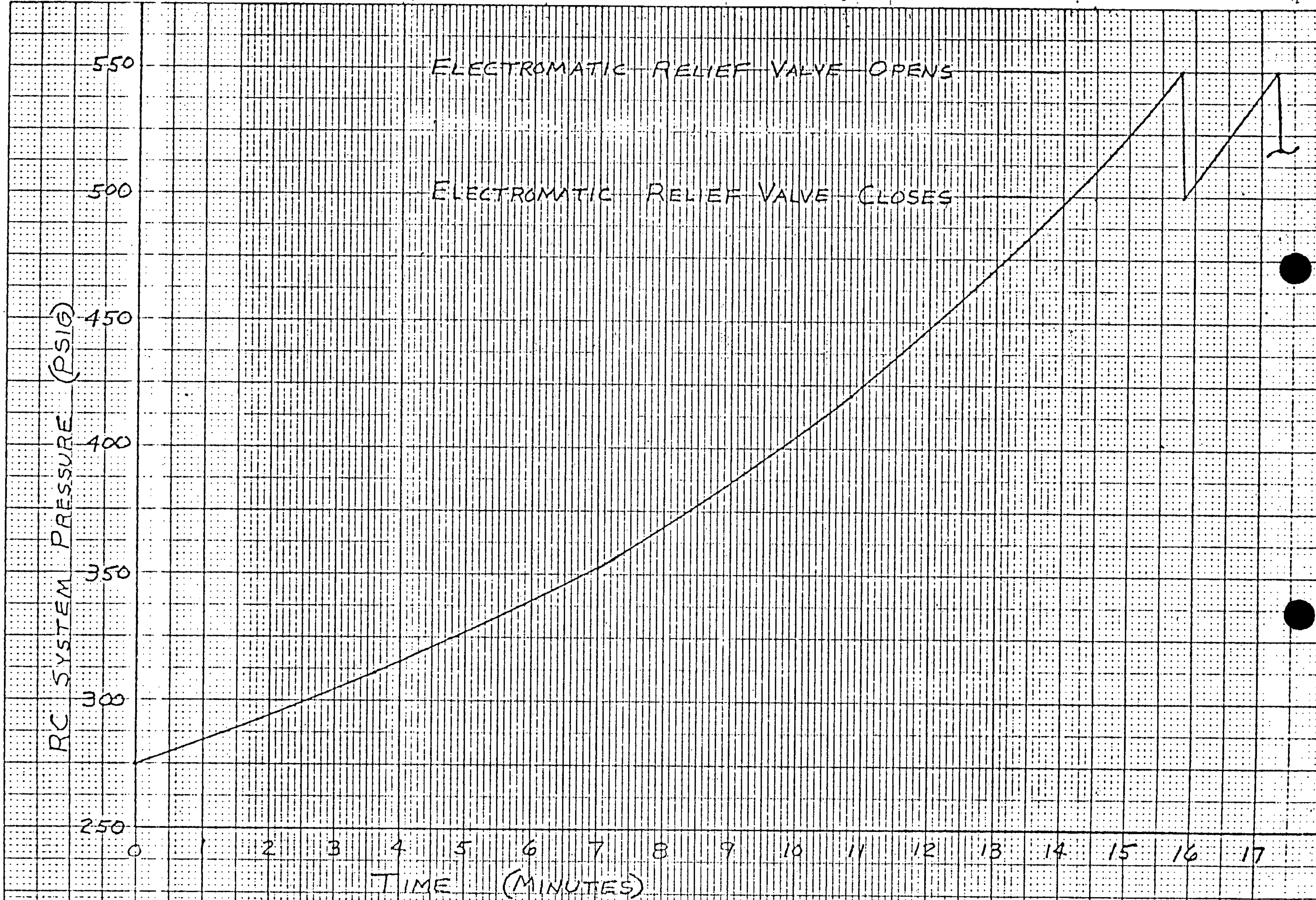

FIGURE 3

PRESSURE TRANSIENT FOR LOSS OF DECAY HEAT REMOVAL

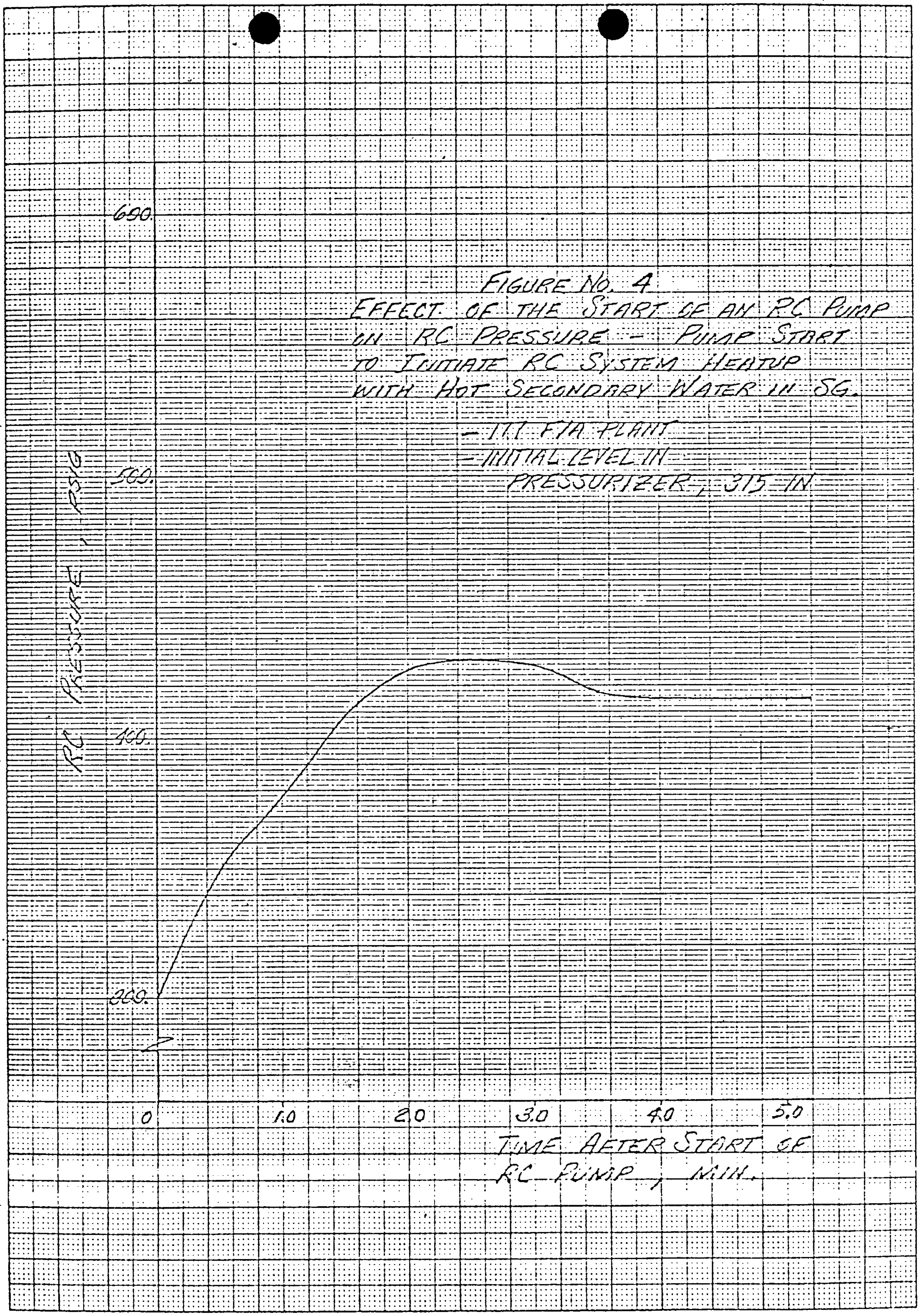

FIGURE NO. 4
EFFECT OF THE START OF AN RC PUMP ON RC PRESSURE – PUMP START TO INITIATE RC SYSTEM HEATUP WITH HOT SECONDARY WATER IN SG.

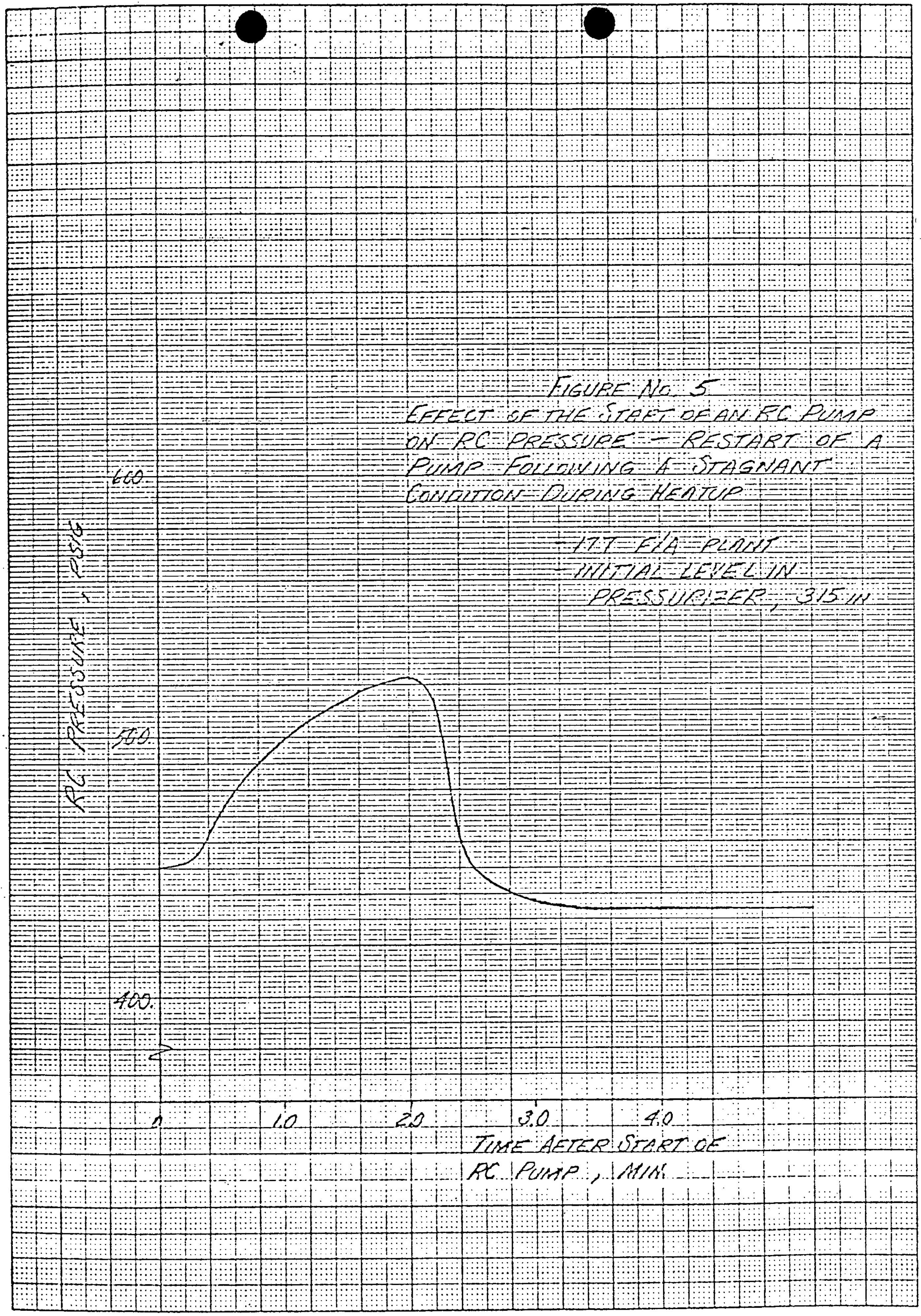
FIGURE No. 5
EFFECT OF THE START OF AN RC PUMP
ON RC PRESSURE - RESTART OF A
PUMP FOLLOWING A STAGNANT
CONDITION DURING HEATUP
- 177 FA PLANT
- INITIAL LEVEL IN
PRESSURIZER, 315 IN
RC PRESSURE, PSIG
600.
500.
400.
0
1.0
2.0
3.0
4.0
TIME AFTER START OF
RC PUMP, MIN