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TO: Mr. Benard C. Rusche

FROM: Duke Power Company
Charlotte, North Carolina
Mr. William O. Parker, Jr.

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REACTOR VESSEL OVERPRESSURIZATION
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PLANT NAME:
Oconee Units 1-2-3
RJL

(1-P)

ENCLOSURE

Attanhment 1

Response to NRC Request for Additional Information for Measures to Protect Against Reactor Vessel Overpressurization...

Attachment 2

Revised Evaluation of Potential Reactor Vessel Overpressurization...

(27-P)

FOR ACTION/INFORMATION

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NRC FORM 195 (2-76)

DUKE POWER COMPANY
POWER BUILDING
422 SOUTH CHURCH STREET, CHARLOTTE, N. C. 28242

WILLIAM O. PARKER, JR.
VICE PRESIDENT
STEAM PRODUCTION

TELEPHONE: AREA 704
373-4083

April 1, 1977

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

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

Dear Mr. Rusche:

Your letter dated December 13, 1976 requested additional information needed for the completion of your evaluation of the measures proposed to prevent overpressurization of the Oconee Nuclear Station reactor vessels. Attachment 1 provides responses to those questions identified in your letter. Also, Attachment 2 provides a discussion concerning the evaluation of reactor vessel overpressurization which is a revision of my October 14, 1976 submittal.

It is our conclusion that the design and operation of the Oconee Nuclear Station described herein are adequate to mitigate the consequences of a postulated reactor vessel overpressurization incident.

Very truly yours,

William O. Parker

William O. Parker, Jr.

MST:ge

Attachments

770950104

ATTACHMENT 1

RESPONSE TO NRC REQUEST FOR

ADDITIONAL INFORMATION

FOR

MEASURES TO PROTECT AGAINST REACTOR VESSEL OVERPRESSURIZATION

RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION
MEASURES TO PROTECT AGAINST REACTOR VESSEL OVERPRESSURIZATION

QUESTION 2

The criteria discussed at the November 5 meeting are listed below:

1) Credit for operator action
2) Single failure criteria
3) Testability
4) Seismic design and IEEE 279 criteria

Provide information regarding how you intend to meet the design criteria as identified by the staff during the November 5th meeting. Where deviations from the criteria are contemplated, please provide a detailed justification including the technical basis for not meeting the criteria and, when significant, the impact on the schedule for implementation. Describe all redundant and diverse systems which are available to provide overpressure protection.

RESPONSE:

Credit for operator action - One of the redundant methods which provides overpressure protection is operator action to terminate the event before an overpressure condition is reached. As conservatively shown in Attachment 2, the operator has more than 10 minutes to take action for the most rapid event (Makeup valve failing full open). If this event were to actually occur under realistic conditions rather than the conservative assumptions and initial conditions used for this evaluation, operator action would not be necessary for even longer periods of time.

Single Failure criteria - The two methods which provide overpressure protection as described in Attachment 2 are redundant and diverse; thus the single failure criteria is satisfied.

Testability - The pilot actuated relief valve is tested prior to establishing a stean bubble to demonstrate its operational capability. This is done by opening and closing the valve using the remote controls in the control room. Additionally, the pressure transmitter is calibrated each refueling outage.

Seismic design - Detailed stress analyses have been performed for the pilot actuated relief valve in accordance with ASME Section III, Class 1 requirements. The valve design has been found to be adequate for Class 1 application. Stresses are shown to be within the allowances as specified in ASME Section III, 1971 Edition. Through conservative calculations, the natural frequency is shown to be greater than 500 Hz, well above seismic excitation frequencies, and the maximum axial plus bending stress in the pilot assembly connection pipe due to seismic motion of 3.0 g horizontal and 3.0 g vertical is significantly lower than the allowable. Testing with simulated seismic loadings has not been performed as this was not a requirement at the time this plant was designed and constructed.

The Makeup System is the source of a potential increasing pressure transient but it can increase pressure to 550 psig only if the pressurizer level is initially above normal, as shown in Attachment 2. The Makeup System is not normally operated with the plant in a cold shutdown condition. It is operating for only a few hours during the initial stage of plant heatup and the latter stage of cooldown operations when the RCS temperature is below the reactor vessel RT_{NDT}. In order for a major seismic event to create an overpressure condition by the failure of the pilot operated relief valve, it would require that the following conditions occur simultaneously.

1. Plant is in initial stage of plant heatup or latter stage of plant cooldown with temperature below the RT_{NDT} of vessel.

2. A seismic event of large magnitude occurs.

3. The pressurizer water level is above normal.

4. The makeup tank water level is above normal.

5. The makeup valve fails full open.

6. The control room operator fails to take action.

7. The pilot actuated relief valve fails to open.

The Makeup System would be operating for a total of approximately 2 days per year when temperature is below the vessel RT_{NDT}. It is considered incredible that all seven conditions above would occur concurrently in a specific several hour period.

<u>IEEE 279 criteria</u> - The installed electrical control circuit for the pilot actuated relief valve was not designed to meet the requirements of IEEE 279. This was not a requirement when the plant was designed and constructed, nor is it necessary to do so now. The overall overpressure protection system for postulated events during shutdown conditions consists of (1) a steam or nitrogen bubble in the pressurizer which provides the control room operator sufficient time to terminate an event, and (2) the pilot actuated relief valve located on the pressurizer. The two sub-systems are separate and independent and together they are single failure proof. The actuation of the relief valve is testable and its relief capacity has been determined by test. Thus, the overall protection system meets the intent of IEEE-279. There is no need or requirement for one of the two redundant sub-systems individually to meet the intent of IEEE-279.

QUESTION 3

Provide schematic piping and instrumentation diagrams of all systems which are utilized during plant shutdown and startup operations, indicate primary and alternate flow paths, fluid and heat sources, pressure and flow controllers, RCS pressure protection systems, and ECCS and makeup systems.

RESPONSE:

Five copies of the appropriate P&ID's were provided at the first meeting on reactor vessel overpressurization on July 8, 1976.

QUESTION 4

Provide a failure modes and effects analysis of the overpressure protection system for startup, shutdown, and testing operations which defines the limiting combination of initiating event and additional single failure or operator error subsequent to initiation of the overpressure transient.

RESPONSE:

The limiting single failure would be the failure of the pilot actuated relief valve to open. With failure of this subsystem of the overpressure protection system, the redundant subsystem, which is operator action, will terminate the transient produced by an initiating event. The initiating event which produces the fastest rate of pressure increase will result in the shortest time available for the operator to terminate the transient. Thus, the limiting combination of initiating event and additional single failure would be an initiating event with the fastest rate of pressure rise combined with single failure of the pilot actuated valve.

For plant cooldown and heatup operations, the limiting combination is failure of the makeup control valve to the full open position combined with failure of the pilot actuated valve to open. For the most limiting set of initial conditions, the operator has ten minutes, which is more than sufficient, to terminate the transient. This transient is shown in Attachment 2.

In the plant shutdown condition with the Makeup System shutdown, the limiting combination is temporary loss of decay heat removal combined with failure of the pilot actuated relief valve to open. Attachment 2 shows that the operator has 30 minutes to terminate the transient based on an initial RCS temperature and pressure of 250°F and 275 psig.

QUESTION 5

Indicate for your low temperature overpressure protection system how the system has been designed to handle common failure modes such as those resulting from loss of offsite power and seismic events. Describe the failure mode of the air operated makeup flow control valve and the letdown flow control valve upon loss of air supply. Identify the events/failure modes which could result in loss of air supply.

RESPONSE:

The two subsystems (or methods) of the overpressure protection system are sufficiently independent and diverse so that there is not a known failure mode which commonly could defeat both subsystems. A loss of offsite power will not affect the pressurizer steam bubble or the operator's action ability. A loss of off-site power also will not affect operation of the pilot actuated relief valve. Power for the instrumentation which controls the pilot actuated relief valve and other parameter indications and alarms will be supplied either by the emergency power source or batteries for a loss of offsite power. A seismic event will not affect the pressurizer steam bubble or the operators' action ability. A seismic event also should not affect operation of the pilot actuated relief valve; refer to the Response to Question 2 for further discussion.

The air operated makeup flow control valve and the letdown flow control valves all fail closed upon loss of air supply. This failure mode is a safe mode for loss of an air supply.

QUESTION 6

Discuss the basis for determining the most limiting initial conditions for analysis of the overpressure transient. Items that must be considered include but should not be limited to: RCS pressure, valve opening time, steam generator temperature difference, reactor coolant pump seal pressures, pressurizer level, makeup tank level, accumulator pressure, relief valve water relief capacity, and pump heads and flows.

RESPONSE:

This information is contained in Attachment 2 and in the response to Question 7. The following is other information which is not contained in the locations noted above. Any valve involved in injection to the RCS has been assumed to open instantaneously. Actual opening would require a finite time. RC pump seal pressure is not involved in the initial condition other than the fact that the Makeup System should be in operation to supply seal injection whenever RC pressure is above 100 psig. The liquid relief capacity of the pilot actuated relief valve has been determined by the basic formula for liquid capacity using a conservative value for backpressure. The resulting subcooled liquid relief rate of 550 gpm was confirmed by an isentropic expansion analytical model. Pump heads and flows used were taken from the manufacturers' certified test curve.

QUESTION 7

Please provide a transient analysis of the reactor coolant system response to inadvertent actuation of a single train of high pressure injection pumps. Describe what administrative controls and procedures are used during startup and shutdown, and during component and/or system testing to justify the assumption that inadvertent injection by more than one high pressure train is not credible. Provide a similar discussion and analysis of a core flood tank discharge. For both situations indicate the basis for identifying the limiting single failure or common failure mode.

RESPONSE:

Figure A-1, attached, presents the analysis requested. The pressure response of the RCS for actuation of one HPI train is shown for initial pressurizer water levels at the hi level alarm (260") and at normal level (220") for initial pressures of 275 psig and 100 psig. Letdown flow was not used in the calculation. The pilot actuated relief valve has a steam (or nitrogen) relief capacity greater than the injection rate of two HPI trains and a liquid relief capacity equal to or greater than the injection rate of one HPI train. This event is considered not credible because the circuit breakers for the normally closed HP injection motor operated valves are "racked out" during the plant cooldown prior to startup of the Decay Heat Removal System. The breakers would not be "racked in" during plant heatup until RCS temperature reaches 250°F.

An analysis of a core flood tank discharge was performed. The conservative initial conditions used were:

1. 640 psia CF tank pressure (Tech. Spec. maximum pressure)

2. 400 ft^3 CF tank nitrogen volume (Tank Spec maximum level)

3. 315" (Hi Hi level alarm) pressurizer water level

4. 275 psig RCS pressure (middle of pressure "window" or higher-pressure "window" is allowable pressure band for startup of the Decay Heat Removal System during plant cooldown).

The calculation was performed without steam condensation in the pressurizer or nitrogen temperature decrease in the CF tank during the surge, both of which are conservative. The equilibrium pressure reached (at the end of the discharge) is 450 psig which is significantly less than the 550 psig allowable. This event also is considered not credible because the CF tank discharge valve is closed and racked out during the plant cooldown before the RCS pressure is decreased to 600 psig.

It is difficult to identify a limiting single failure for an event that is not considered credible. If, somehow, HPI could be actuated, the limiting single failure would be failure of the pilot actuated relief valve to open. The control room operator would stop the HPI pumps to terminate the transient. This chain of events would require the following to occur:

1. Operators fail to "rack out" circuit breakers for the motor operators of the HP injection valves during plant cooldown even though this operation is under strict administrative control.

2. HP injection is erroneously actuated.

3. The pilot actuated relief valve fails to open.

This chain of events requires three failures; this is not required by the design criteria. However, even with these failures, the control room operator is able to terminate the transient. There is not a known common failure mode affecting both the pilot actuated relief valve and the control room operator(s). Since CF tank discharge does not require action by the control room operator or the pilot actuated relief valve to limit the RCS pressure to 550 psig, a discussion of limiting single mode or common failure mode is not applicable.

<u>QUESTION 8</u>

Does your plant have relief capacity installed in the decay heat removal system that could provide additional protection in the event of an overpressure transient. What is the water relief capacity of the valve? Is the decay heat removal system automatically isolated on RCS high pressure. What are the pressure setpoints for the DHR relief valve opening and its automatic isolation?

RESPONSE:

The Decay Heat Removal Systems do have some relief capacity which could provide additional protection in the event of an overpressure transient. It should be noted, however, that credit was not considered for these valves in the analyses of these transients. The Decay Heat Removal System is not automatically isolated from the Reactor Coolant System.

A listing of Low Pressure Injection System relief valves is provided below:

For Oconee Units 1& 2

Valve	Location	Setpoint psig	Capacity at Overpressure gpm @ %
LP-25	Decay Heat Line	370	2 @ 3%
LP-26	Decay Heat Line	200	2 @ 3%
LP-27	Decay Heat Line	200	2 @ 3%
LP-36	Decay Heat Cooler	370	2 @ 3%
LP-37	Decay Heat Cooler	370	2 @ 3%

For Oconee Unit 3

Valve	Location	Setpoint psig	Capacity at Overpressure gpm @ %
LP-25	Decay Heat Line	388	2 @ 3%
LP-26	Decay Heat Line	388	2 @ 3%
LP-27	Decay Heat Line	388	2 @ 3%
LP-36	Decay Heat Cooler	505	30 @ 10%
LP-37	Decay Heat Cooler	505	30 @ 10%

QUESTION 9

During the November 5th meeting, the possibility of limiting the volume of water in the RCS makeup tank was discussed. It was stated that this could preclude filling the pressurizer if the makeup control valve should fail full open. Is this procedure a viable option at your facility? Is water level in the Makeup Tank generally controlled automatically? Specify your assumptions for initial pressurizer level, makeup tank water volume, and other design considerations which would result in limiting RCS pressure to within Appendix G limits.

RESPONSE:

A study has been performed to determine the maximum water volume in the makeup tank, combined with an initial volume in the pressurizer, which would prevent Reactor Coolant System pressure from exceeding 550 psig for the event of the makeup valve failing fully open. This water volume has been calculated as follows:

Initial pressurizer level	260" (Hi)	315" (Hi Hi)
Initial RCS pressure	275 psig	100 psig
Max. makeup tank liquid	2640 gal.	2880 gal.
Indicated level	66.5"	74.2"

This makeup tank liquid volume is approximately 7 in. below the "normal" level of 73 inches. The advantage of maintaining the makeup tank level at 66 inches or below is not apparent. With this level maintained in the letdown tank and the pressurizer at the hi level alarm or below, two redundant methods of overpressure protection are provided. During cooldown, the letdown tank is very involved in the operations. The pressurizer level controller is automatically removing water from the tank to makeup for RCS contraction. The operator is remote manually adding feed to the makeup tank to maintain its inventory. A more restrictive limit on makeup tank inventory would appear to unnecessarily hinder the operator in controlling makeup tank inventory and ensuring that proper suction conditions exists for the makeup pump.

QUESTION 10

Describe what instrumentation and alarms are available to the operator to aid in detection and termination of an overpressure transient.

RESPONSE:

There are several indications and alarms present which would alert the operator to a possible overpressure transient. These include three wide range pressure transmitters (0-2500 psig) used for the Engineered Safeguards system; a pressure transmitter on the pressurizer sample line that controls that power operated relief valve (0-600 psig); pressurizer level instruments (2) and associated high and high high level alarms; a letdown storage tank low level alarm; makeup system flowrate indication and makeup valve position indication.

QUESTION 11

What precautions are taken during startup, shutdown and testing to verify that critical procedural steps are performed to reduce the likelihood of inadvertently initiating an overpressure transient and minimizing the impact of the transient on the RCS. Would steps such as lock out of pumps and accumulators and reducing the water level in the pressurizer and makeup tank be accomplished by double check off and sign off procedures to insure against error? What procedures normally are followed for altering the status of pumps or valves under administrative restriction?

RESPONSE:

During startup, shutdown and testing, written procedures are utilized. These procedures are specifically written to assure that critical steps are performed at the proper sequence in the evolution. Physical sign off of these critical steps are required as well as the entry of information such as tag numbers when certain equipment is positioned. It is our position that a double check off and sign off of steps critical to overpressurization accidents to insure against error is not warranted. All steps of procedures are important in one way or another and this action would only complicate the completion of necessary procedures without appreciably increasing the probability of proper actions. As described in Question 2, it is considered extremely remote that all conditions necessary to create an overpressure situation in addition to an operator error could occur simultaneously.

In order to assure that the status of pumps or valves under administrative controls are both controlled and known by cognizant personnel, procedures have been established to cover these "out of normal" conditions.

Any pumps or valves that are to be taken out of their normal status for the unit condition are recorded on an "Out of Normal" procedure stating what the component is, why it is to be changed, any restrictions imposed by this change, the present position to be out of normal and the position needed to be placed back to normal. These "Out of Normal" procedures are signed by the person performing the task, signed by the control room operator and by the unit supervisor then they are kept in a book in the control room affected by the change of status and are logged in the Reactor Operator's logbook with a stamp "Issued Out of Normal" and a description. When returned to service, the positioning of valves or pumps are signed off, any testing described, and the procedure is turned in to the shift supervisor.

QUESTION 12

If power is removed from valves as part of administrative controls used for overpressure protection, what status lights and indicators are available to verify their proper alignment? When administrative controls call for removing power from a valve or a pump, is this accomplished from the control room or from a motor control center?

RESPONSE:

The only components which have power removed in order to lessen the probability of an overpressurization accident are the core flood tank isolation valves and the high pressure injection system isolation valves or pumps. Position indication is available immediately prior to removal of power to assure their proper position. Power is removed from the motor control center.

QUESTION 13

Describe any testing procedure proposed to insure operation of overpressure protection devices. At what times would these tests be performed?

RESPONSE:

The power operated relief valve setpoint is verified annually to assure proper operation of this device. Additionally, the power operated relief valve is cycled as a part of the precritical checklist whenever a unit startup is performed.

QUESTION 14

The problem of pressurizer relief valve maintenance was also discussed at the November 5th meeting. The relief valve is normally isolated and removed during shutdown conditions if maintenance is required. This would reduce the level of protection available to mitigate the consequences of a pressure transient. Please discuss what measures will be taken at your plant to provide overpressure protection when the relief valve is removed from service and indicate how the criteria enumerated at the November 5th meeting will be met.

RESPONSE:

If the pilot actuated relief valve has been removed from service during a plant cooldown because of malfunction or untolerable high leakage, this does remove one of the two redundant overpressure protection methods. For all credible pressure increasing events, the control room operator has sufficient time to terminate the event before 550 psig pressure is reached. It is considered that infrequent operation in this condition does not significantly increase the probability of an overpressurization accident due to the methods of operation and the design of the facility.

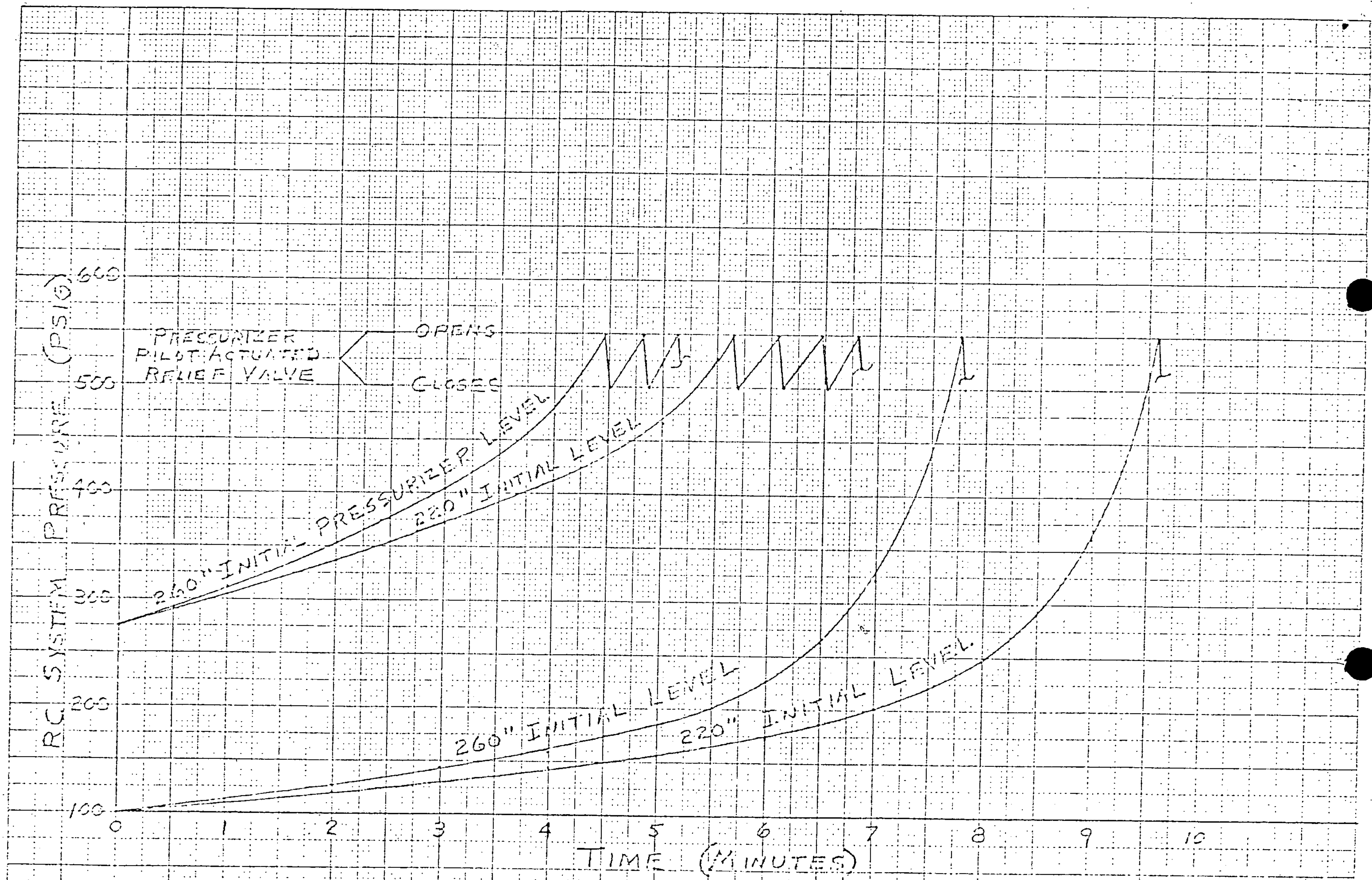


FIGURE A-1
PRESSURE TRANSIENT FOR ACTUATION OF ONE HPI TRAIN

ATTACHMENT 2

REVISED EVALUATION OF POTENTIAL REACTOR

VESSEL OVERPRESSURIZATION

ATTACHMENT 2

REVISED EVALUATION OF POTENTIAL REACTOR VESSEL OVERPRESSURIZATION

1. Purpose

The purpose of this evaluation is to examine the system design and operation for susceptability to overpressurization events during start-up and shutdown and to determine the pressure response of the Reactor Coolant System (RCS) to potential events which 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 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.

Two redundant and diverse methods will provide overpressure protection for postulated events. These are: (1) operator action to terminate the event, and (2) the pilot actuated relief valve located on the pressurizer. The steam or gas space in the pressurizer will provide a time period of 10 minutes or more before the pressure will exceed 550 PSIG thus providing the control room operator with ample time to terminate an event before an overpressurization condition is reached. The pilot actuated relief valve will terminate the pressure increase at 550 PSIG for an event without operator action. The overpressure

(continued)

protection provided complies with single failure criteria because the two methods are redundant and diverse. Considering the modest rate of pressure rise (because of non-solid pressurizer) from the events and the high level alarms in the pressurizer and other alarms 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, thus preventing an overpressurization condition.

The original evaluation, submitted by Mr. Wm. O. Parker, Jr.'s letter dated October 14, 1976 indicated less than 10 minutes for the pressure to exceed 550 PSIG in the event of the makeup valve to the RCS failing full open. Two changes have been made to this analysis which lengthen the time necessary for operator action to 10 minutes or more, these are:

(1) The original evaluation of the pressurizer pressure response assumed no condensation of the pressurizer steam on the cooler vessel walls or on the cooler liquid interface with the steam during the compression of the steam bubble. The pressure response for the makeup valve failing full open event has been re-evaluated. This evaluation accounts for the heat transfer from the higher temperature steam bubble to these cooler surfaces. No mixing of the cooler insurge water with the hotter pressurizer liquid was used.

(2) The original evaluation of the pressurizer pressure response was based on the initial pressurizer water level being at the high-high level alarm point. In this re-evaluation, the initial pressurizer water level has been changed to the high level alarm point in certain cases.

During the startup and shutdown conditions at temperatures below the Decay Heat Removal System "cut-in" temperature, a level above the high-high level alarm point will be permitted only at RC pressures of 100 PSIG or less.

A dual setpoint is utilized for the pilot actuated relief valve to provide overpressure protection during startup and shutdown conditions. The lower setpoint is enabled by actuation of a switch in the control room during the plant cooldown prior to startup of the Decay Heat Removal System at 250°F RCS temperature. Characteristics of this valve at the lower setpoint are:

(continued)

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	550 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 initially at high levels. For the pressurizer an initial water level at the high level alarm setpoint was used for an initial pressure above 100 PSIG and an initial water level at the high alarm setpoint was used for an initial pressure of 100 PSIG or below. The relationship of these levels to the other pressurizer water level setpoints are:

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 level 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 affects the rate of pressure increase; the lower the initial level, the slower the pressure increase will be. The initial pressurizer level used does not affect the peak pressure reached except for events involving injection to the RCS; lower levels can result in peak pressures less than 550 PSIG where the source of injection water is exhausted before the pressure reaches the relief valve setpoint of 550 psig.

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

(continued)

valves are HP-26 and HP-27 on FSAR 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. Nitrogen is added to the pressurizer during plant cooldown at an RCS pressure of 50 psig or less. 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 PSI) 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 FSAR Figure 9-2 and is automatically controlled by the pressurizer level controller. The pressure response of the RCS to this event is shown on Figures 1 and 1A. 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. 260" pressurizer water level (high alarm setpoint) for 275 PSIG initial pressure

b. 315" pressurizer water level (high-high alarm setpoint) for 100 PSIG initial pressure

c. 86" makeup tank water level (high level alarm)

d. 32" GPM total seal injection flow to RC pumps (automatically controlled)

e. 45 GPM letdown flow from RCS to makeup tank

f. no spray into pressurizer (normally there would be during cooldown).

Figure 1 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. Figure 1 depicts two pressure response curves. One pressure response curve is for the initial pressurizer water level at the high

(continued)

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

alarm setpoint (260") and the other pressure response curve is for the initial level at the normal level (220"). At this pressure (275 PSIG) during the startup or shutdown operation, the level would normally be below the normal level of 220" which would result in emptying of the makeup tank and termination of the transient at a pressure much lower than 550 PSIG.

Figure 1A is for an initial RCS pressure of 100 PSIG which is about the lowest RCS pressure at which the makeup system would be in operation. Two pressure response curves are depicted; one for an initial level at the high-high alarm setpoint (315") and one at the normal level (220"). The level during the cooldown operation at a pressure of 100 PSIG could be above the normal level of 220". The pressure response for Figures 1 and 1A was determined by using the computer code DYSID as described previously.

Relief through the pressurizer relief valve will be terminated by operator action (stop makeup pump or close makeup line isolation valve) or without operation 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 Figures 1 and 1A, other alarm 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

(continued)

3.6 All Pressurizer Heaters Erroneously Energized *(continued)*

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 oeprator 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 pressure)

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 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. 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. 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 120 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 260 inches, normally it would be near 220 inches

(continued)

3.7 Temporary Loss of Decay Heat Removal Systems Capability to Remove Decay Heat From the RCS *(continued)*

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 form RCS to makeup tank with no increase due to increasing pressure

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.

(continued)

3.8.1 Start of an RC Pump Under Type A Condition *(continued)*

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 of starting an RC pump. The initial pressure is 300 PSIG, which is well above 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°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°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 >250°F (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 50°F, which is below the minimum value of RC temperature less 120°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°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

(continued)

3.8.2 Start of an RC Pump Under Type B Condition *(continued)*

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 fluid and a decrease in system pressure at final equilibrium conditions). The pressurizer level increases during the transient by 13 inches; the level would have to rise an additional 87 inches before entering the upper head.

The pressure response calculation for Figures 4 and 5 did not assume any steam condensation during compression of the pressurizer steam bubble.

4. Conclusions

The preceding evaluation and analysis demonstrates that the reactor vessel is protected from overpressurization during events which cause increasing pressure combined with an assumed single failure of either of the two redundant methods of overpressure protection.

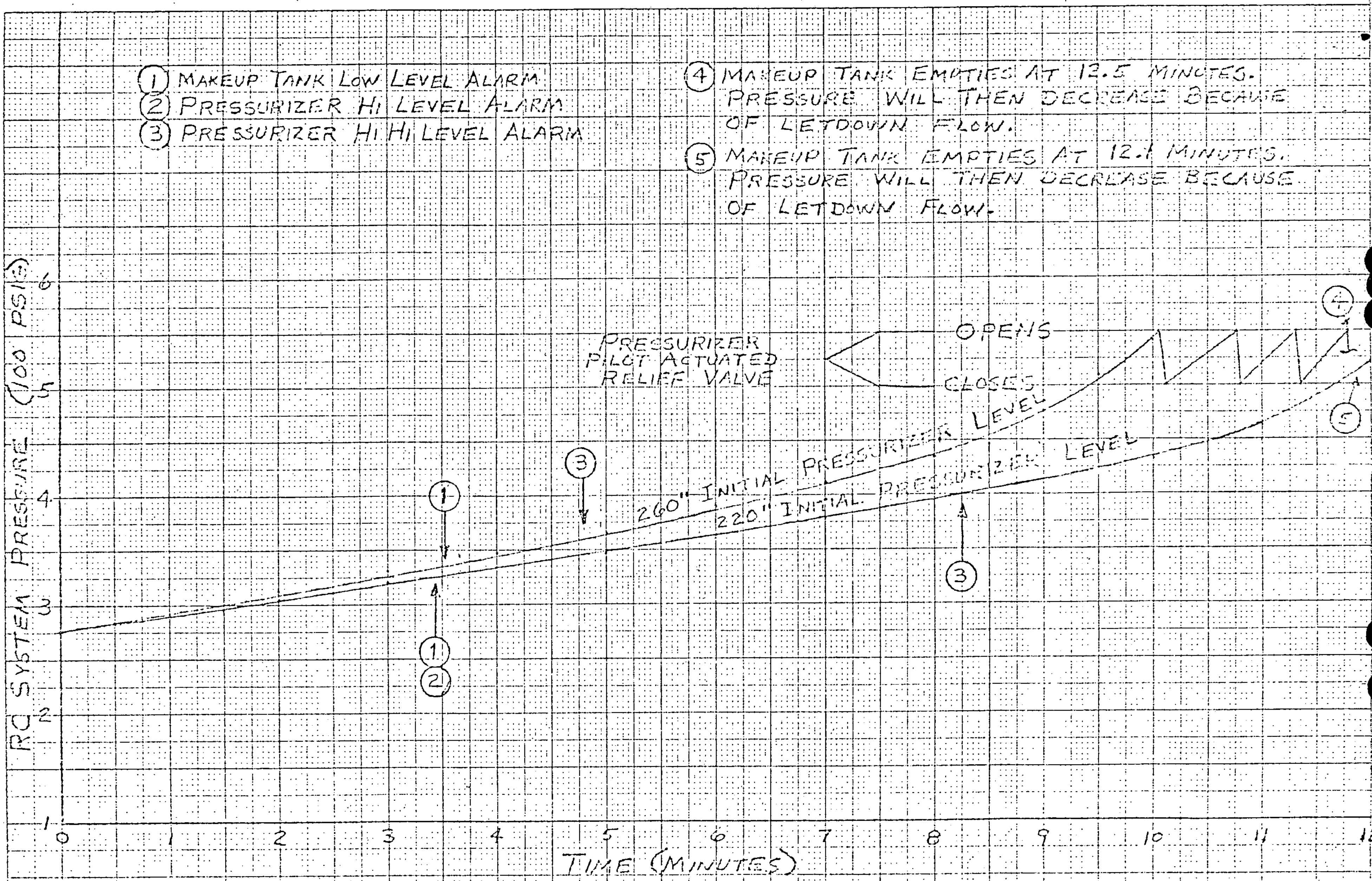


FIGURE 1

PRESSURE TRANSIENT FOR MAKEUP VALVE (TO RCS) FAILING FULL OPEN
(275 PSIG INITIAL RC SYSTEM PRESSURE)

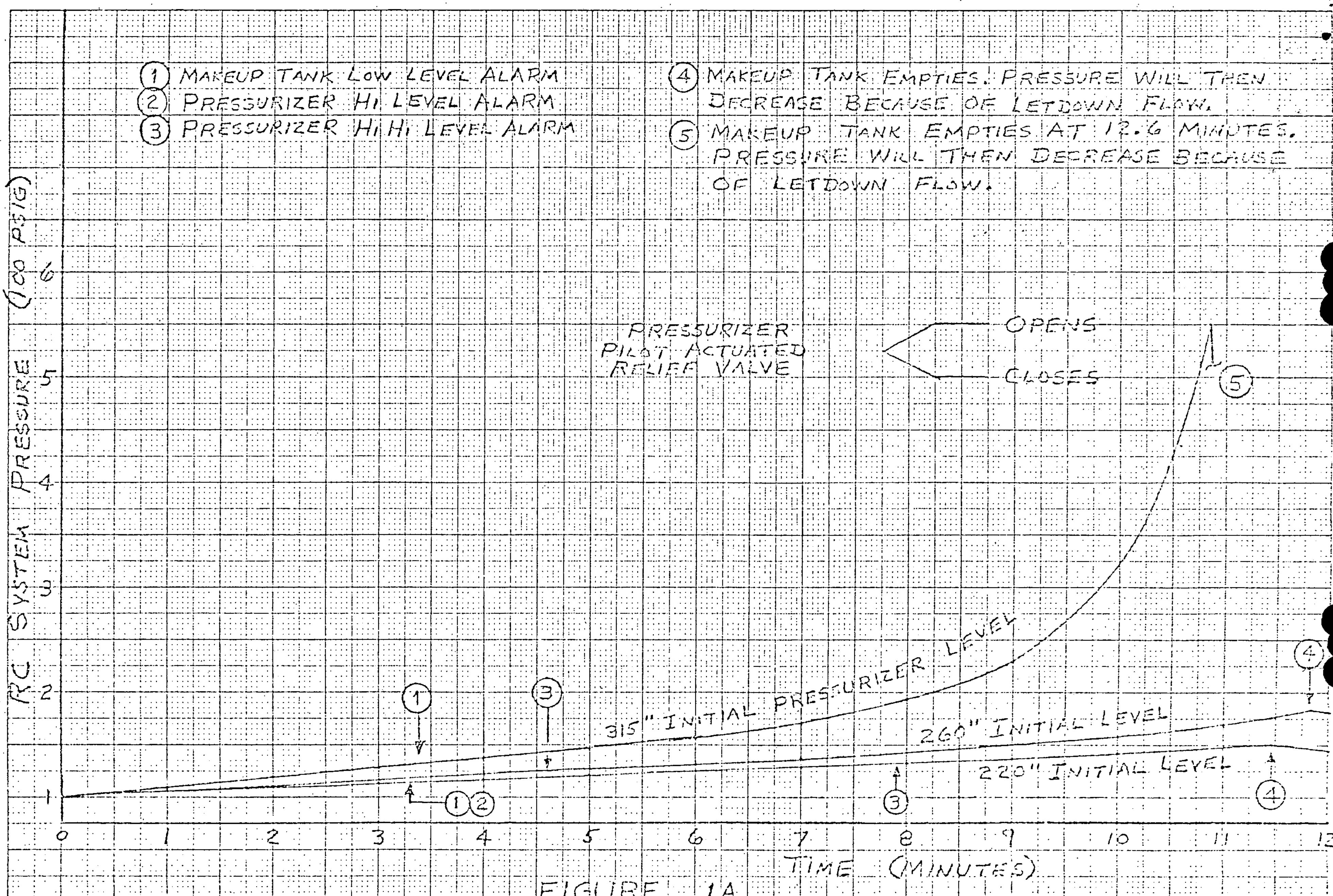


FIGURE 1A

PRESSURE TRANSIENT FOR MAKEUP VALVE (TO RCS) FAILING FULL OPEN
(100 PSIG INITIAL RC SYSTEM PRESSURE)

K+E 10 X 10 TO 1/2 INCH • 7 1/2 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A. 46 1470

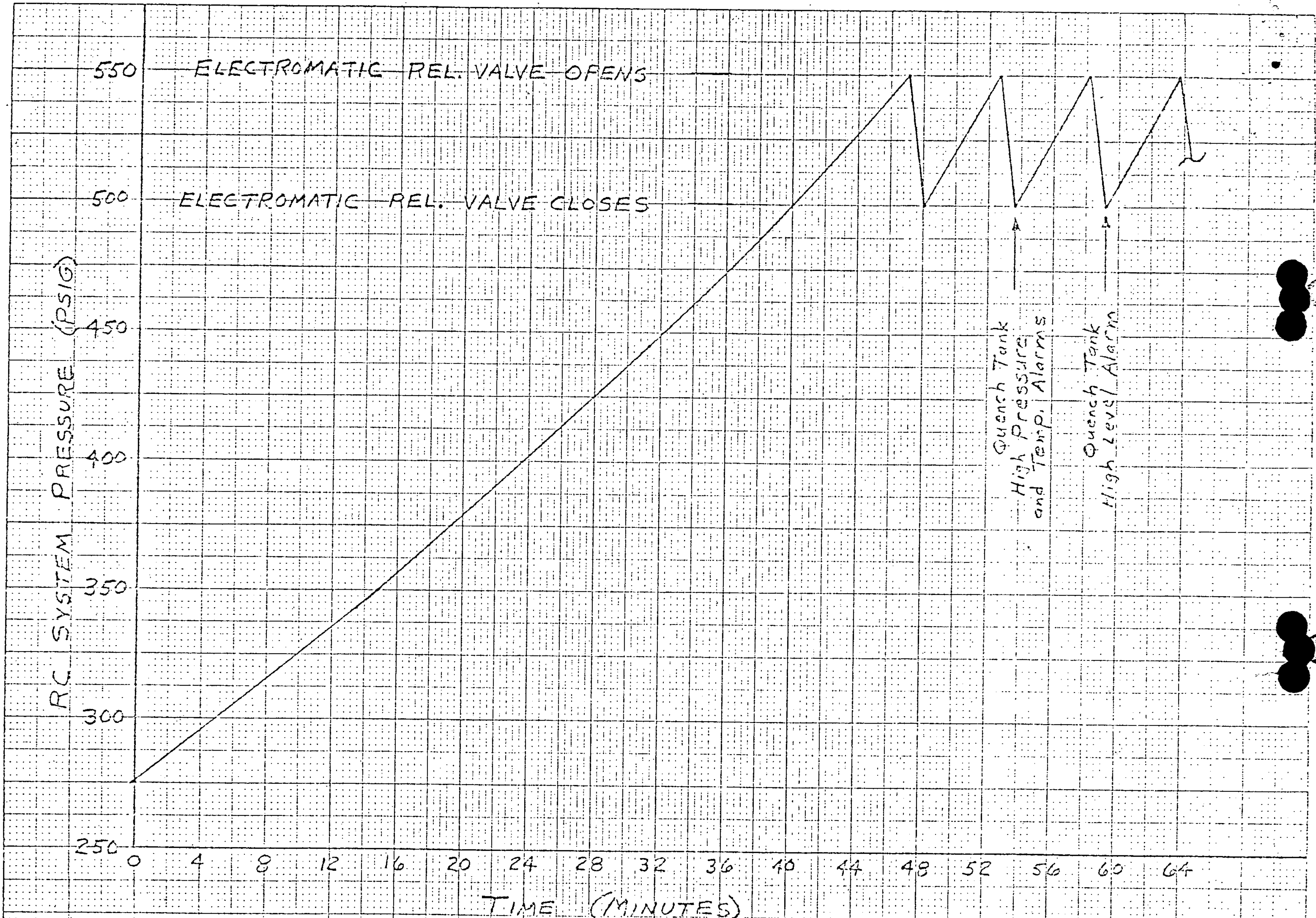


FIGURE 2

PRESSURE TRANSIENT FOR ALL PRESSURIZER HEATERS ENERGIZED

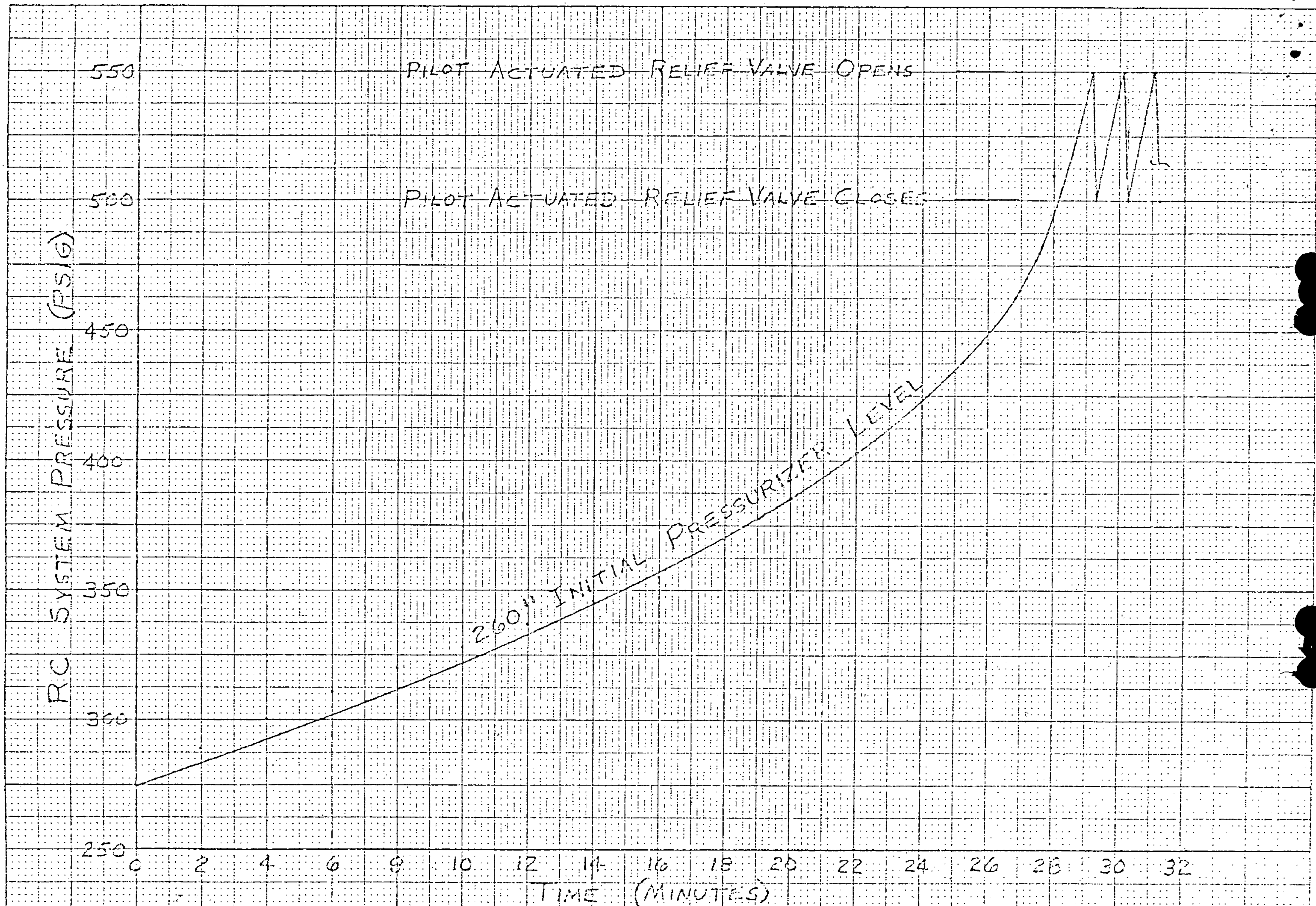


FIGURE 3

PRESSURE TRANSIENT FOR LOSS OF DECAY HEAT REMOVAL

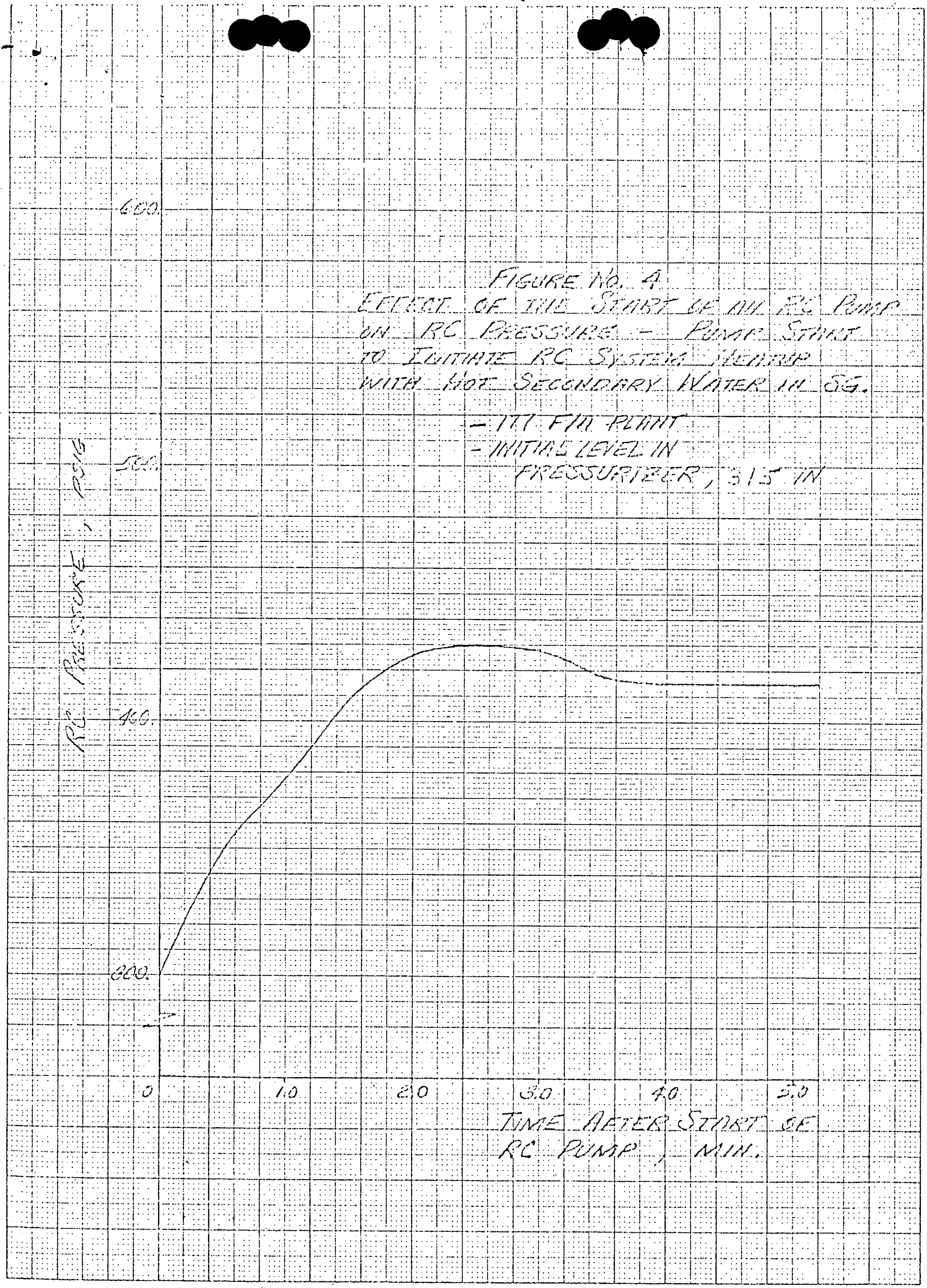
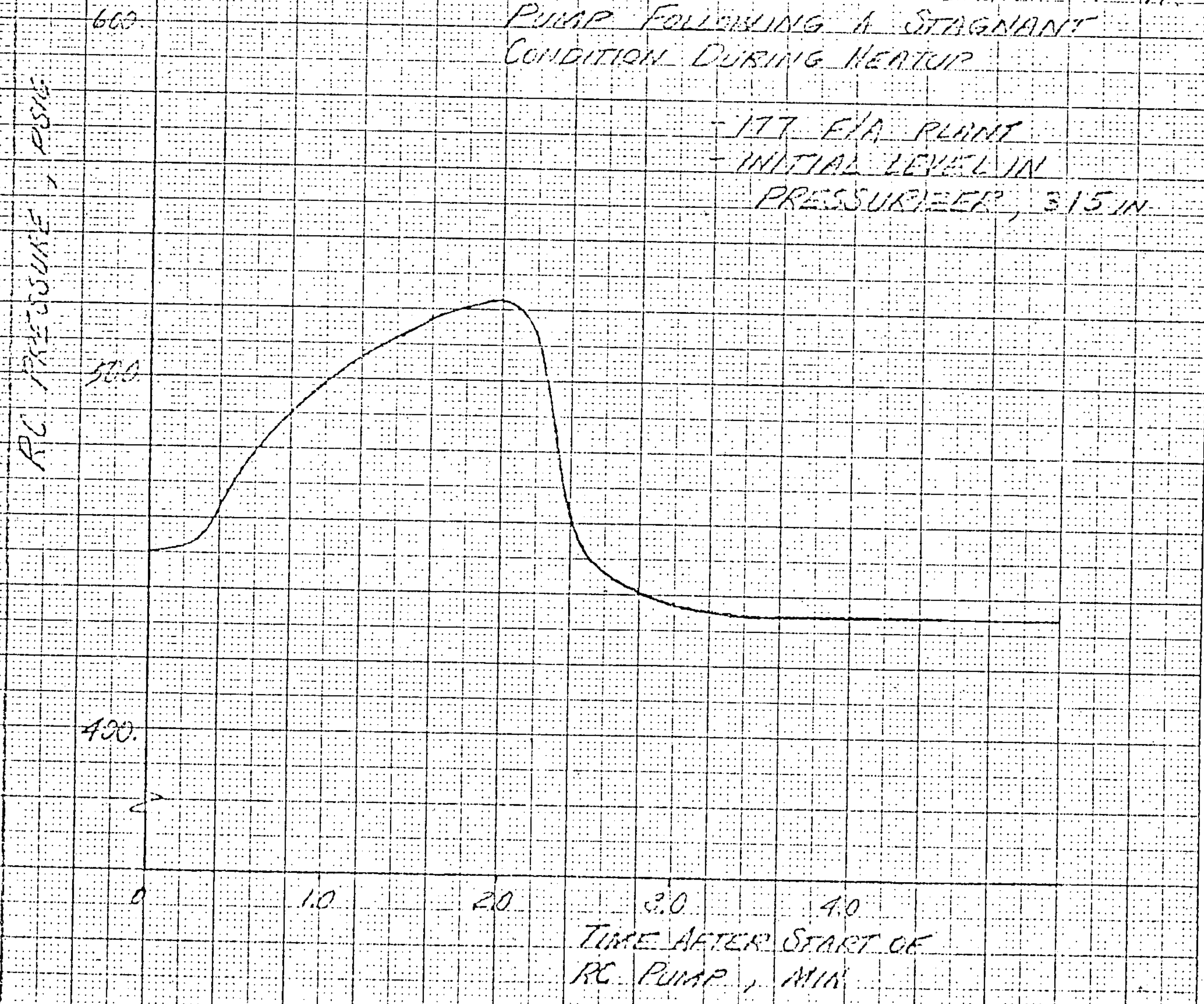


FIGURE NO. 4
EFFECT OF THE START OF AN RC PUMP
ON RC PRESSURE - PUMP START
TO INITIATE RC SYSTEM HEATUP
WITH HOT SECONDARY WATER IN SG.
- 177 FA PLANT
- INITIAL LEVEL IN
PRESSURIZER, 315 IN
RC PRESSURE, PSIG
600.
500.
400.
300.
0
10
20
30
40
50
TIME AFTER START OF
RC PUMP, MIN.

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 F/A PLANT
- INITIAL LEVEL IN PRESSURIZER, 315 IN.



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