I-04/14/78

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SUBJECT:
FORWARDING LICENSEE NO DPR-67 APPL FOR AMEND: APPENDIX A PROPOSED TECH SPEC CHANGE CONCERNING REVISIONS TO THE OPERABILITY AND SURVEILLANCE OF SUBJECT FACILITY, UNIT 1, OVERPRESSURE MITIGATING SYSTEM...W/ATT SAFETY EVALUATION... NOTARIZED 04/13/78.

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P. O. BOX 013100, MIAMI, FL 33101
FLORIDA POWER & LIGHT COMPANY

April 13, 1978
L-78-129

Director of Nuclear Reactor Regulation
Attention: Mr. Victor Stello, Director
Division of Operating Reactors
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Stello:

Re: St. Lucie Unit 1
Docket No. 50-335
Proposed Amendment to
Facility Operating License DPR-67

In accordance with 10 CFR 50.30, Florida Power & Light Company submits herewith three (3) signed originals and forty (40) copies of a request to amend Appendix A of Facility Operating License DPR-67.

The proposed amendment, which addresses the operability and surveillance of the St. Lucie Unit 1 Overpressure Mitigating System (OMS), is described below and shown on the accompanying Technical Specification pages bearing the date of this letter in the lower right hand corner.

Page 1-6

New Specification 1.29 is added to define the "LOW TEMPERATURE RCS OVERPRESSURE PROTECTION RANGE".

Page 3/4 1-8

A note is added to Specification 3.1.2.1.b to limit the establishment of a high pressure safety injection pump flow path under certain conditions.

Page 3/4 1-12

A note is added to Specification 3.1.2.3 to limit the establishment of a high pressure safety injection pump flow path under certain conditions.

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3/40 CHANGE TO B.C. 4 CYS

Page 3/4 4-58

New Specifications 3.4.12 and 4.4.12 are added to incorporate a limit on the maximum primary-to-secondary differential temperature that is permitted prior to starting a reactor coolant pump.

Page 3/4 4-59

New Specifications 3.4.13 and 4.4.13 are added to incorporate new requirements on the operability of power operated relief valves.

Page 3/4 5-7

Specifications 3.5.3 and 4.5.3 are revised to incorporate requirements on the positioning of certain safety injection valves.

Page B 3/4 4-14

A new page is added to provide the bases for new Specifications 3/4.4.12 and 3/4.4.13.

This submittal has been prepared in response to a December 23, 1977 letter from Mr. Don K. Davis, Acting Chief, Operating Reactors Branch 2, which required that we address the subject of Technical Specifications pertaining to our Overpressure Mitigating System. Since the proposed Technical Specification changes are being submitted at the behest of the Commission, this amendment falls in the category described by Footnote 2 of 10 CFR 170.22 and is therefore exempt from the facility license amendment fee schedule. Four other NRC concerns (in addition to the Technical Specification concern) that were expressed in the December 23 letter are also discussed in the attached safety evaluation. The safety evaluation provides the requisite analysis of Overpressure Mitigating System operation.

The proposed amendment has been reviewed by the St. Lucie Facility Review Group and the Florida Power & Light Company Nuclear Review Board. They have concluded that it does not involve an unreviewed safety question.

Very truly yours,

for Robert E. Uhrig
Vice President

REU:MAS:sl
Attachment

cc: Mr. James P. O'Reilly, Region II
Harold F. Reis, Esquire

STATE OF FLORIDA)
) ss.
COUNTY OF DADE)

A. D. Schmidt, being first duly sworn, deposes and says:

That he is Vice President of Florida Power & Light Company, the licensee herein;

That he has executed the foregoing document; that the statements made in this said document are true and correct to the best of his knowledge, information, and belief, and that he is authorized to execute the document on behalf of said Licensee.

A D Schmidt
A. D. Schmidt

Subscribed and sworn to before me this

13 day of April, 1978

Theresa M. Miranda
NOTARY PUBLIC, in and for the County of Dade, State of Florida

NOTARY PUBLIC STATE OF FLORIDA at LARGE
MY COMMISSION EXPIRES MAY 5, 1981
BONDED THRU MAYNARD BONDING AGENCY

My commission expires:

REACTOR TRIP SYSTEM RESPONSE TIME

1.26 The REACTOR TRIP SYSTEM RESPONSE TIME shall be the time interval from when the monitored parameter exceeds its trip setpoint at the channel sensor until electrical power is interrupted to the CEA drive mechanism.

ENGINEERED SAFETY FEATURE RESPONSE TIME

1.27 The ENGINEERED SAFETY FEATURE RESPONSE TIME shall be that time interval from when the monitored parameter exceeds its ESF actuation setpoint at the channel sensor until the ESF equipment is capable of performing its safety function (i.e., the valves travel to their required positions, pump discharge pressures reach their required values, etc.). Times shall include diesel generator starting and sequence loading delays where applicable.

PHYSICS TESTS

1.28 PHYSICS TESTS shall be those tests performed to measure the fundamental nuclear characteristics of the reactor core and related instrumentation and 1) described in Chapter 14.0 of the FSAR, 2) authorized under the provisions of 10 CFR 50.59, or 3) otherwise approved by the Commission.

LOW TEMPERATURE RCS OVERPRESSURE PROTECTION RANGE

1.29 The LOW TEMPERATURE RCS OVERPRESSURE PROTECTIVE RANGE is that operating condition when (1) the cold leg temperature is ≤ 275°F and (2) the reactor coolant system has pressure boundary integrity. The reactor coolant system does not have pressure boundary integrity when the reactor coolant system is open to containment and the minimum area of the reactor coolant system opening is greater than 1.75 square inches.

3/4.1.2 BORATION SYSTEMS

FLOW PATHS - SHUTDOWN

LIMITING CONDITION FOR OPERATION

3.1.2.1 As a minimum, one of the following boron injection flow paths and one associated heat tracing circuit shall be OPERABLE:

a. A flow path from the boric acid makeup tank via either a boric acid pump or a gravity feed connection and charging pump to the Reactor Coolant System if only the boric acid makeup tank in Specification 3.1.2.7a is OPERABLE, or

b. The flow path from the refueling water tank via either a charging pump or a high pressure safety injection pump* to the Reactor Coolant System if only the refueling water tank in Specification 3.1.2.7b is OPERABLE.

APPLICABILITY: MODES 5 and 6.

ACTION:

With none of the above flow paths OPERABLE, suspend all operations involving CORE ALTERATIONS or positive reactivity changes until at least one injection path is restored to OPERABLE status.

SURVEILLANCE REQUIREMENTS

4.1.2.1 At least one of the above required flow paths shall be demonstrated OPERABLE:

a. At least once per 7 days by:

1. Cycling each testable power operated or automatic valve in the flow path required for boron injection through at least one complete cycle of full travel, and

2. Verifying that the temperature of the heat traced portion of the flow path is above the temperature limit line shown on Figure 3.1-1 when a flow path from the boric acid makeup tanks is used.

*When the RCS temperature is less than 165°F, the flow path from the RWT to the RCS via the HPSI pumps shall only be established if the reactor coolant system pressure boundary integrity does not exist, or if no charging pump is operable.

CHARGING PUMP - SHUTDOWN

LIMITING CONDITION FOR OPERATION

3.1.2.3 At least one charging pump or one high pressure safety injection pump*in the boron injection flow path required OPERABLE pursuant to Specification 3.1.2.1 shall be OPERABLE and capable of being powered from an OPERABLE emergency bus.

APPLICABILITY: MODES 5 and 6.

ACTION:

With no charging pump or high pressure safety injection pump OPERABLE, suspend all operations involving CORE ALTERATIONS or positive reactivity changes until at least one of the required pumps is restored to OPERABLE status.

SURVEILLANCE REQUIREMENTS

4.1.2.3 At least the above required charging pump or high pressure safety injection pump shall be demonstrated OPERABLE at least once per 31 days by:

a. Starting (unless already operating) the pump from the control room,

b. Verifying pump operation for at least 15 minutes, and

c. Verifying that the pump is aligned to receive electrical power from an OPERABLE emergency bus.

*When the RCS temperature is less than 165°F, the flow path from the RWT to the RCS via the HPSI pumps shall be established only if the reactor coolant system pressure boundary integrity does not exist, or if no charging pump is operable.

REACTOR COOLANT PUMP - STARTING

LIMITING CONDITION FOR OPERATION

3.4.12 If the steam generator temperature exceeds the primary temperature by more than 45°F reactor coolant pump(s) shall not be started unless the pressurizer liquid level is less than 40%.

APPLICABILITY: MODES 4# and 5.

ACTION:

If a reactor coolant pump is started when the steam generator temperature exceeds primary temperature by more than 45°F & the pressurizer liquid level exceeds 40%, evaluate the subsequent transient to determine compliance with Specification 3.4.9.1.

SURVEILLANCE REQUIREMENTS

4.4.12 Prior to starting a reactor coolant pump, verify either that the steam generator temperature does not exceed primary temperature by more than 45°F or that a pressurizer bubble is drawn and the pressurizer level is equal to or less than 40%.

#Reactor Coolant System Cold Leg Temperature is less than 275°F.

POWER OPERATED RELIEF VALVES

LIMITING CONDITION FOR OPERATION

3.4.13 Two power operated relief valves (PORV's) shall be OPERABLE, with their setpoints selected to the low temperature mode of operation.

APPLICABILITY: MODES 4# and 5*.

ACTION:

(a) With less than two PORV's OPERABLE and while at Hot Standby during a planned cooldown, both PORV's will be returned to OPERABLE status prior to entering the applicable MODE unless:

1) The repairs cannot be accomplished within 24 hours or the repairs cannot be performed under hot conditions, or

2) Another action statement requires cooldown, or

3) Plant and personnel safety requires cooldown to Cold Shutdown.

With less than two PORV's OPERABLE, the plant will proceed to Cold Shutdown with extreme caution.

(b) With less than two PORV's OPERABLE while in COLD SHUTDOWN, both PORV's will be returned to OPERABLE status prior to startup.

SURVEILLANCE REQUIREMENTS

4.4.13 The PORV's shall be verified OPERABLE by:

a) Verifying the isolation valves open when the PORV's are reset to the low temperature mode of operation.

b) Performance of a CHANNEL FUNCTIONAL TEST of the Reactor Coolant System overpressurization protection system circuitry up to and including the relief valve solenoids once per refueling outage.

c) Performance of a CHANNEL CALIBRATION of the pressurizer pressure sensing channels once per 18 months.

#Reactor Coolant System cold leg temperature below 275°F.

*PORV's are not required at Reactor Coolant System temperatures below 165°F when all HPSI pumps and respective injection or header isolation valves are disabled and if a pressurizer bubble is formed with a pressurizer liquid level less than or equal to 40%. PORV's are also not required below 140°F when RCS does not have pressure boundary integrity.

ECCS SUBSYSTEMS - T_{avg} < 300°F

LIMITING CONDITION FOR OPERATION

3.5.3 As a minimum, one ECCS subsystem comprised of the following shall be OPERABLE:

a. In MODES 3* and 4, one ECCS subsystem composed of one OPERABLE high pressure safety injection pump and one OPERABLE flow path capable of taking suction from the refueling water storage tank on a safety injection actuation signal and automatically transferring suction to the containment sump on a sump recirculation actuation signal.

b. Prior to decreasing the reactor coolant system temperature below 215°F a maximum of only one high pressure safety injection pump is to be OPERABLE with its associated header stop valves open.

c. Prior to decreasing the reactor coolant system temperature below 165°F all high pressure safety injection pump will be disabled and their associated header stop valves closed.

APPLICABILITY: MODES 3*, 4#, and 5.

ACTION:

a) With no ECCS subsystems OPERABLE in MODES 3* and 4, immediately restore one ECCS subsystem to OPERABLE status or be in COLD SHUTDOWN within 20 hours.

b) With RCS temperature below 215°F and with more than the allowed high pressure safety injection pumps OPERABLE or injection valves and header isolation valves open, immediately disable the high pressure safety injection pump(s) or close the header isolation valves.

c) In the event the ECCS is actuated and injects water into the Reactor Coolant System, a Special Report shall be prepared and submitted to the Commission pursuant to Specification 6.9.2 within 90 days describing the circumstances of the actuation and the total accumulated actuation cycles to date.

SURVEILLANCE REQUIREMENTS

4.5.3.1 The ECCS subsystem shall be demonstrated OPERABLE per the applicable Surveillance Requirements of 4.5.2.

4.5.3.2 The high pressure safety injection pumps shall be verified inoperable and the associated header stop valves closed prior to decreasing below the above specified Reactor Coolant System temperature and once per month when the Reactor Coolant System is at refueling temperatures.

*With pressurizer pressure < 1750 psia.
#REACTOR COOLANT SYSTEM cold leg temperature below 275°F.

3/4.4.12 REACTOR COOLANT PUMP - STARTING AND 3/4.4.13 POWER OPERATED RELIEF VALVES

The low temperature reactor coolant system overpressure mitigating system is provided to prevent RCS overpressurization above the 10CFR50, Appendix G, operating limit curves (Figure 3.4-2b or 3.4-2c, as applicable) at RCS temperatures below 275°F. The RCS overpressurization system is based on the use of the pressurizer power-operated relief valves (I-V-1402 & I-V-1404) for the design basis mass injection transient, and the formation of a 60% pressurizer bubble by volume for the design basis energy addition transient. For the case when no pressurizer steam bubble is formed, protection against the design basis energy addition transient is derived by limiting the secondary-to-primary temperature differential below 50 °F. The operability of the RCS overpressurization protection system will only be required during periods of heatup and cooldown below RCS temperatures below 275°F and periods of cold shutdown when the RCS has pressure boundary integrity.

ANALYSIS OF

OVERPRESSURE MITIGATING SYSTEM (OMS)

ST. LUCIE UNIT NO. 1

April 13, 1978

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Attachment 1

I. SYSTEM DESCRIPTION

The Overpressure Mitigating System (OMS) for St. Lucie Unit 1 uses the pressurizer power operated relief valves (PORV's) with a variable low pressure set point as the pressure relief mechanism. The variable low set point is energized and de-energized from the main control board through the PORV normal mode selector switch. The PORV normal mode selector switch has three positions, normal set point (2335 psig), variable low set point and override.

The variable low pressure set point for the OMS is derived from the reactor coolant system (RCS) wide range temperature using redundant transmitters. The reactor coolant pressure signal is obtained from redundant low range pressure transmitters.

Various alarms are included in the OMS. An alarm alerts the operator to energize the variable low set point when either RCS pressure or temperature decreases to below its set point. This alarm will not clear unless the PORV mode selector switch is in the low set point position and the MOV's upstream of the PORV's indicate "open". This assures proper alignment of the OMS. When both RCS pressure and temperature exceed specified set points, an alarm alerts the operator to return the PORV's to their normal set point. This alarm will not clear unless the PORV mode selector switch is moved from the low set point position. If the reactor coolant pressure comes within 25 psi of the variable low pressure set point, an alarm will alert the operator of pending PORV actuation. Should the reactor coolant pressure exceed the variable low pressure set point, an existing alarm will inform the operator that the PORV's have received a signal to open.

Figure 1 is a functional representation of the OMS.

II. DESIGN BASIS

The Overpressure Mitigating System was designed to mitigate mass input and heat input induced transients while the plant is in cold shutdown with a water solid pressurizer. The transients result from a single failure caused by either an equipment failure or operator error. In addition, a single failure was assumed within the OMS; therefore, only one of the two PORV's in the OMS was assumed operable for the design basis analysis. The expected OMS operation with both PORV's operable was also analyzed.

The following overpressurization mass input events were considered.

1. Inadvertent mismatch of charging and letdown flow.
2. Inadvertent start of a single High Pressure Safety Injection (HPSI) pump;
3. Inadvertent Safety (SI) actuation.

A review of past industry experience indicates that the most common mass input initiated overpressure transient is a loss of letdown with continued charging. In most of these cases, letdown was lost due to isolation of the shutdown cooling loop while letdown was being taken from the shutdown cooling system for solid plant control. At St. Lucie, letdown is independent of shutdown cooling; therefore, the probability of this transient is significantly reduced. However, loss of air or operator error could potentially result in loss of letdown. Inadvertent mismatch of charging and letdown is accommodated for in the St. Lucie OMS design. Because of the low capacity of a charging pump (44 gpm), this was not a limiting transient for the design. Additionally, it should be noted that the PORV's at St. Lucie do not require air to operate. Loss of air may cause a loss of letdown, but it will not impair the OMS.

The remaining mass input initiated transients experienced throughout industry to date were the result of abnormal actuation of portions of the safety injection system. One event resulted from an operator inadvertently starting a safety injection pump with flow aligned to the reactor coolant system. The remaining events were initiated by opening of the accumulator isolation valves.

In the design of the OMS for St. Lucie, inadvertent operation of a single HPSI pump was considered. Inadvertent SI events considered included actuation of two HPSI pumps with all three charging pumps, actuation of a single HPSI pump with three charging pumps, and actuation of three charging pumps when all HPSI pumps are disabled. The Low Pressure Safety Injection (LPSI) pumps and SI accumulator tanks are not considered as contributing SI mass inputs since the LPSI pump shut-off head and SI tank design pressures are below P-T limits.

Among the few past events attributed to the heat input, five of the events reported were those in which an unacceptable temperature differential was allowed to develop in the reactor coolant system, generally due to insufficient mixing. When a reactor coolant pump was started, the cooler volumes of reactor coolant circulated around the system and were heated in the steam generators. These heat input events are self-limiting in that the temperatures eventually equalize. Past experience had indicated that the magnitude of the pressure transient is not great. The only other heat input event resulted when heat was removed from the coolant and the temperature fell below the minimum allowable temperature for the coolant pressure being maintained.

In the design of the OMS for St. Lucie, the following overpressurization energy input events were considered:

1. Decay heat addition due to shutdown cooling system isolation;
2. Inadvertent pressurizer heater input; and
3. Energy input from the steam generator secondary to the primary coolant subsequent to operation of a reactor coolant pump (RCP) when the steam generators are at a higher temperature than the reactor vessel inventory.

For all mass input and heat input events considered, overpressurization analyses were performed in the following manner:

1. The worst case overpressurization events were determined;
2. The effectiveness of low setpoint PORV's to terminate an overpressurization event were evaluated.

The accompanying report by Combustion-Engineering, Inc. (CE) discusses the water solid system mass and energy input analyses, the models used, and the analysis which investigated the effect of low setpoint PORV discharge.

In addition to the above performance criteria for the OMS, the NRC has recommended additional design criteria. The following is a listing of these criteria and a description of how they have been incorporated in the St. Lucie OMS design:

1. <u>Operator Action</u>

   The OMS is designed to automatically perform its intended function for at least 10 minutes without operator action.

2. <u>Single Failure Criteria</u>

   The OMS provides complete redundancy and meets the design objectives assuming a single failure in the OMS. One of the two PORV's provides the required relief capacity for the OMS; the second PORV provides redundant capacity. The OMS set points and RCS pressure signals are derived from redundant temperature and pressure transmitters. Two enable/disable switches are installed on the main control board. The installation of the OMS is in accordance with the separation criteria used in the design of St. Lucie Unit 1. From instrumentation through the PORV's, power supply is maintained in two separate trains.

3. Testability

Adequate testing is provided by assuring that an input signal operates the PORV solenoid pilot control. In conjunction with the above, a channel functional test of the associated instrumentation and control hardware will be conducted once per cold shutdown to confirm the design logic. Valve testing and frequency will be conducted consistent with the applicable requirements of ASME Code Section XI - Subsection IWV. Instrumentation surveillance will be performed using the same methods and schedule followed for safety-related instrumentation.

4. IEEE-279 Criteria

The OMS meets the intent of IEEE-279. The OMS is designed against single failure, is electrically separate, and, as appropriate, maintains physical separation throughout the circuitry. In addition, testing of OMS operability prior to the need for operation is included to enhance system reliability.

5. Seismic Criteria

The seismic design of equipment presently installed will be maintained. The PORV's were designed and manufactured with ASME Boiler and Pressure Vessel Code Section III and are Class I valves. Additional electronic equipment is installed so as not to compromise the present seismic qualification of existing safety systems.

III. SETPOINT SELECTION

Figure 2 show the selected setpoints for the OMS plotted with the reactor coolant system pressure temperature limitations for 0 to 10 years of full power operation (Figure 3.4-2D of the St. Lucie Unit 1 Technical Specifications). Below an RCS temperature of 160°F the PORV setpoint is a constant 465 psia. Above 160°F the PORV setpoint follows the MPT cooldown curve, with 75 psi between the PORV setpoint and the cooldown curve. At a reactor coolant temperature of 275°F, high temperature interlock removes OMS from service. This interlock provides assurance that the OMS will not be inadvertently actuated at power. This RCS temperature is the highest temperature anticipated for OMS operation. (The isothermal pressure limit at 275°F is approximately 1800 psia, which is well above the shutoff head of the HPSI pumps.)

The accompanying CE report (Section 4.0) shows that, in combination with administrative controls, the setpoints chosen provide assurance that reactor vessel MPT limits will not be exceeded. The OMS with two PORV's operable provides adequate relief capability for all postulated mass and heat events without administratively limiting the temperature differential between the steam generator and reactor coolant system or disabling nonessential components. Various alarms are also included in the OMS. These alarms inform the operator to energize or de-energize the OMS and alert him if reactor coolant pressure is approaching the PORV variable low setpoint. Setpoints for the various alarms are as follows:

1. "Select RCS Low Range Operation" alarm

   PRCS $\leq$ 400 psig or T $\leq$ 275°F

2. "Select RCS Normal Range Operation" alarm

   PRCS $\geq$ 425 psig and T > 275°F

3. "Pressure Relief Valve Anticipatory Alarm"

   PORV setpoint - 25 psi

IV. ADMINISTRATIVE CONTROLS

As part of the interim overpressure mitigating system solution, St. Lucie has been operating with conservative administrative controls to decrease the potential for low temperature overpressurization. These controls include the disabling of non-essential components and minimizing the ΔT between the steam generator and the RCS. These conservative controls will be continued as part of the final overpressure mitigating system solution. The accompanying CE report recommends administrative controls that are necessary to provide adequate overpressure mitigation assuming a single failure in the OMS. Technical specifications are proposed (See Section VI) to assure that these necessary controls are exercised.

With both PORV's operating as designed, no administrative controls are required to provide adequate overpressure mitigation.

V. SCHEDULING

The hardware and procedures described were implemented at St. Lucie Unit 1 prior to December 31, 1977 as the interim overpressure mitigation system. This submittal and the accompanying CE report provide the information required by NRC to qualify the interim system as the final solution for low temperature overpressurization. All interim measures are retained in this final solution. Proposed technical specifications are included with this submittal to provide assurance that all conditions for overpressure mitigation are met.

VI. TECHNICAL SPECIFICATIONS

The following technical specifications are proposed to provide assurance that all conditions for overpressure mitigations at St. Lucie Unit 1 are met. These specifications address the following:

1. Operability and surveillance of the OMS with action required if any OMS components are found inoperable.
2. Disabling of non-essential mass input components.
3. Limitation on the maximum ΔT between steam generator and RCS prior to starting a reactor coolant pump with the RCS water solid.

VII. NRC CONCERNS

The following NRC concerns specific to St. Lucie Unit 1 were discussed with NRC representatives during a phone conversation on November 21, 1977, and later included in an NRC letter dated December 23, 1977. Responses to these concerns are tabulated below with references, where appropriate, to other sections of the submittal and the accompanying CE report.

CONCERN 1 - Technical Specifications which address the following:

a. Operability, including the enabling and disabling, of the OMS,
b. Limiting the maximum ΔT between the steam generator and reactor vessel,
c. Disabling of ECCS components during cooldown,
d. Surveillance requirements for the OMS components, and
e. Action required during inoperability of any OMS components.

RESPONSE 1 - Technical specifications addressing all these areas are described in Section VI of this submittal.

CONCERN 2 - The method of monitoring temperature differential in the reactor coolant system must be clearly stated, including the uncertainties due to instrument inaccuracy and differences between the steam generator shell side and bulk fluid temperature.

RESPONSE 2 - At St. Lucie steam generator blowdown temperature is measured and not the temperature of the steam generator shell. Blowdown is taken from the bottom of the steam generator tube region and is therefore indicative of steam generator bulk fluid temperature. The indication of blowdown temperature used is the same as used in calorimetric power determination with instrumentation accuracy of $\pm$ 2.5°F.

CONCERN 3 - The upstream OMS isolation valves must be included in the OMS enabling circuitry to ensure that these valves are open when the system is required.

RESPONSE 3 - "Open" indications of the motor operated isolation valves upstream of the PORV's have been included in the OMS actuation alarm circuitry. As discussed in Section I of the submittal, the actuation alarm will not clear unless the OMS is properly aligned. This includes an open indication of the motor operated isolation valves.

CONCERN 4 - The most limiting pump startup, mass addition transient must be analyzed regardless of procedures which preclude such an event.

RESPONSE 4 - The accompanying CE report includes an inadvertent SI and inadvertent actuation of a HPSI pump although administrative controls (Section IV) and technical specifications (Section VI) preclude these postulated events.

CONCERN 5 - The rate of automatic isolation of the shutdown cooling system should be compared with the rate of pressure increase due to the limiting overpressure transients to ensure that the design pressure of the shutdown cooling system is not exceeded.

RESPONSE 5 - The rate of pressure rise of limiting postulated overpressure transients is discussed in the CE report. The closure time of the automatic isolation valves for the shutdown cooling system is 60 seconds.

In addition to the automatic isolation feature, separate relief valves provide protection for the SDC suction lines. In previous NRC submittals we had stated that each of two shutdown cooling suction lines had relief valves with a capacity of 155 gpm each; this is the design value for the valves. The rated capacity of the installed valves with a 300 psig setpoint is 222 gpm at 10% accumulation and 370 gpm at 25% accumulation. The combined capacity of both valves at 25% accumulation (740 gpm) exceeds the assumed capacity of one PORV at the low pressure setpoint of 465 psia.

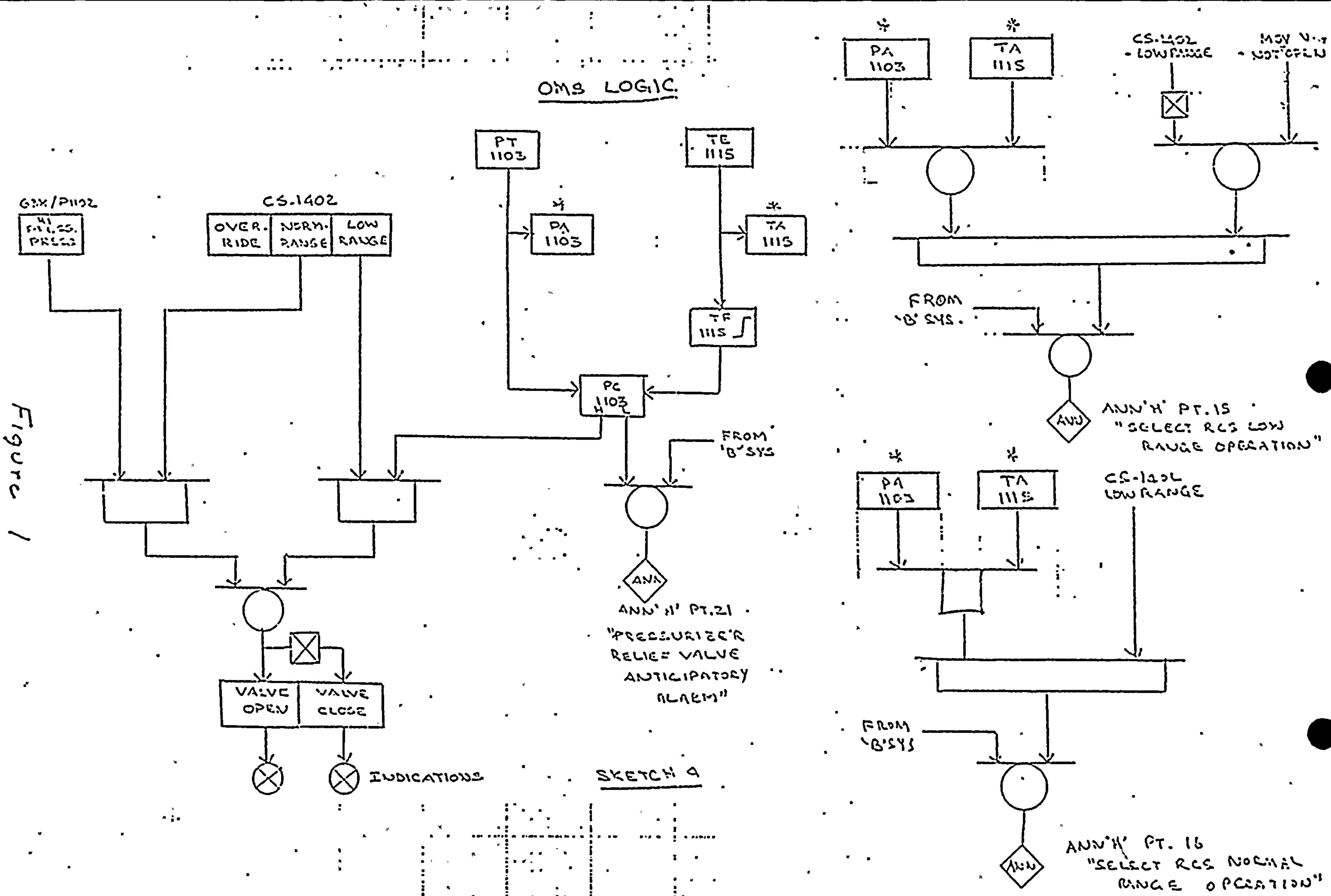

Figure 1

REV. NO.	DATE

EBASCO SERVICES INCORPORATED	FLORIDA POWER & LIGHT CO. ST. LUCIE PLANT UNIT NO. 1	BCS-34-3-337
DIV. DR. SCALE CH. DATE APPROVED	OMS - LOGIC	
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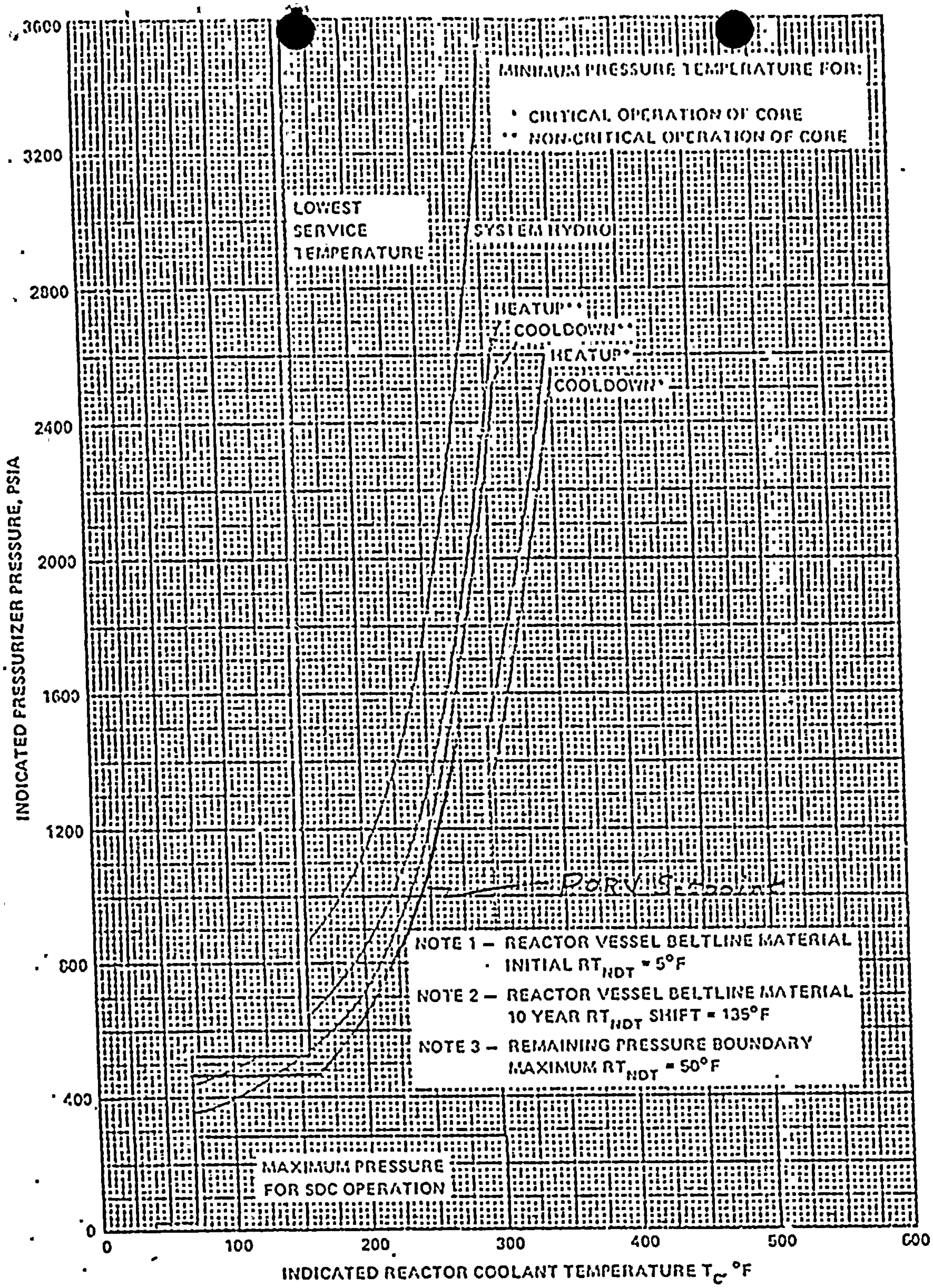

FIGURE 1: 10 Year Pressure-Temperature Curve

Figure 2

SPECIFIC PLANT REPORT

Low Temperature

Reactor Coolant System

Overpressure Mitigation

for

St. Lucie Unit 1

April 10, 1978

Prepared by

COMBUSTION ENGINEERING, INC.

for

Florida Power and Light Co.

ABSTRACT

A study concerning overpressure mitigation during low temperature operating modes is presented for St. Lucie Unit 1 of the Florida Power and Light Company. Included in this report are descriptions and results of the analyses which modeled the overpressurization events.

The study shows that preventive measures are available to mitigate overpressurizations in the St. Lucie Reactor Coolant System. These measures include certain administrative controls and modification of the existing pressurizer electromatic relief valves to include a low-pressure setpoint capability.

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Listing of Figures and Tables

1.0 INTRODUCTION

On December 3, 1976, a generic report on Reactor Coolant System [RCS] overpressure protection at low temperatures [Reference (1)] was presented by Combustion Engineering to an ad hoc group of CE utility customers, of which Florida Power & Light Co. [FP&L] is a member. This generic effort resulted in recommendations for prevention of RCS overpressurization during water-solid operations. The recommendations included both administrative and hardware oriented modifications. The plant specific study for FP&L's St. Lucie Unit No. 1 is presented herein and should be considered an extension of the generic report.

The generic study determined that liquid pressure relief is required during low temperature RCS operations to prevent overpressurization incidents. The analyses indicated that the required relief capacity could be provided by either the existing pressurizer power operated relief valves [PORVs], modified to incorporate a low-pressure setpoint, or by spring-loaded relief valves added to the RCS. Analyses discussed in this report are based on use of the existing St. Lucie Unit 1 PORVs for low temperature overpressure mitigation.

The objective of this report is to present a discussion of the analytical models employed in the study and provide the results relevent to low temperature overpressure mitigation.

Plant parameters specific to St. Lucie Unit 1 have been incorporated in the models previously developed for the generic analyses. The modeled events are the same as in the generic report; i.e., letdown isolation, charging pump start, safety injection [SI] pump start, spurious safety injection actuation signal [SIAS], reactor coolant [RCP] start, shutdown cooling isolation, and full pressurizer heater actuation. The assumptions and initial conditions considered in the analyses are similar to those discussed in the generic report. The figures and tables referenced in this report are contained in Appendix A.

2.0 LOW TEMPERATURE OVERPRESSURE MITIGATION

The analyses performed show that a combination of administrative and hardware modifications are necessary to provide assurance that RCS MPT limits will not be exceeded. These modifications include the following:

1. Addition of procedural controls and precautions;
2. Disabling of non-essential components during the cold shutdown mode of operation;
3. Incorporation of a low-pressure setpoint to the existing PORV control logic.

Specific discussions of these recommended changes are presented in later sections.

2.1 Design Criteria

The basic criteria to be satisfied in determining the adequacy of overpressure mitigation is that no single equipment failure or operator error should result in violation of the operating curve limitations. This is in accordance with the criteria as originally stated in Reference (2). Subsequently, Reference (3) expanded the design criteria relative to operator inaction time, single failure, seismic and IEEE 279 design, and protection system testability. No operator action was assumed to mitigate the transients in these analyses. In addition to expected mitigation with two PORVs operating, analyses are provided which assume a single failure that defeats one PORV.

2.2 Basis for Pressure Limits

The P-T operating curves from Reference (4) for the 0 to 10 year period of full power operation are used to define maximum allowable pressure. These pressure limits provide a reasonable conservatism for current plant operation. The 0 to 10 year curve is shown as Figure (1).

3.0 DESCRIPTION OF ANALYTICAL MODELS

The overpressurization analyses were performed in the following manner:

1. The worst case overpressurization events were determined;
2. The effectiveness of low setpoint PORVs to terminate an overpressurization event were evaluated.

To determine the worst case transients, water-solid RCS conditions were considered. This is a conservative assumption since the time delay in the transient due to a non-solid system is eliminated. Also, all letdown flow paths which could mitigate or terminate a particular overpressurization event were considered isolated.

The following sub-sections discuss the water-solid system mass and energy input analyses, the models used, and the analysis which investigated the effect of low setpoint PORV discharge. The initial conditions applicable for each event are shown in Table (1).

3.1 Solid RCS Mass Input Analyses

The following overpressurization mass input events were considered for water-solid RCS conditions without PORV protection:

1. Inadvertent Safety Injection [SI] actuation;
2. Inadvertent start of a single High Pressure Safety Injection [HPSI] pump;
3. Inadvertent mismatch of charging and letdown flow.

3.1 Solid RCS Mass Input Analyses - continued.....

The analyzed inadvertent SI events included actuation of two HPSI pumps with all three charging pumps, actuation of a single HPSI pump with three charging pumps, and actuation of only three charging pumps when all HPSI pumps are disabled. The inadvertent operation of a single HPSI pump as well as a charging/letdown mismatch was also analyzed. The charging/letdown mismatch results from either loss of letdown or the inadvertent operation of an additional charging pump. The Low Pressure Safety Injection [LPSI] pumps and SI accumulator tanks are not considered as contributing SI mass inputs since the LPSI shut-off head and SI tank design pressures are below P-T limits. Applicable pump design parameters are listed in Table (2). HPSI and LPSI pump/system delivery curves for St. Lucie Unit 1 are shown on Figure (2) and Figure (3).

The mass input analyses determined the delivery of the various pumps in a water-solid RCS as a function of the RCS pressure and time. After each time increment the RCS pressure is determined as a function of the average RCS specific volume and temperature. The specific volume changes according to the integrated mass input rates. Assumptions conservatively include no expansion of the system pressure boundaries and isolated letdown. The resulting unmitigated transients shown on Figure (6) reflect the upper bounds of the anticipated RCS pressure excursion.

3.2 Solid RCS Energy Input Analyses

The following overpressurization energy input events were considered for water-solid RCS conditions without PORV protection:

1. Decay heat addition due to shutdown cooling system isolation;
2. Inadvertent pressurizer heater input; and,
3. Energy input from the steam generator secondary to the primary coolant subsequent to operation of a reactor coolant pump [RCP] when the steam generators are at a higher temperature than the reactor vessel inventory.

3.2 Solid RCS Energy Input Analyses - continued.....

Energy addition analyses determined the RCS pressure response as a function of time. After each time increment the RCS pressure is determined as a function of the average liquid system enthalpy and average liquid specific volume. The system enthalpy changes according to the heat addition rate. For analyses which assume no liquid relief capability, the specific volume of the system is considered a constant since pressure boundaries are assumed fixed and system mass remains constant. Other conservative assumptions include isolated letdown and no sensible heat absorption by the RCS component metal mass. These assumptions provide the results on Figure (6) which are considered as upper bounds of postulated RCS overpressurizations caused by energy addition.

Energy additions which are constant with time include inadvertent pressurizer heater actuation and decay heat addition. An energy addition rate which is not constant with time occurs when a RCP is started with a positive secondary to reactor vessel ΔT [item 3 above]. This event requires a model which accounts for the changing secondary to primary heat transfer rates. A description of the model is provided in the following sub-section.

3.3 RCP Start Trnasient Model

In a water-solid RCS, a pressure transient results if a RCP is operated when the steam generators are at a higher temperature than the reactor vessel, which is cooled by shutdown cooling. A computer model [the same as was used for the Millstone, Calvert Cliffs and Fort Calhoun submittals] was used to simulate the resulting water-solid RCS pressure response.

During the RCP start transient, the steam generator located in the operating RCP loop initially provides the greatest heat addition rate. The non-operating loop steam generator trails in heat addition and never attains the addition rate of its counter part. The resulting transient varies with time. As RCP circulation continues equilibrium between the primary and

3.3 RCP Start Transient Model - continued.....

secondary side is attained. Assuming an initial primary to secondary ΔT, an instantaneous RCP start, and no heat absorption or metal expansion at the primary pressure boundaries, a conservative upper bound RCS pressure was computed as a function of time. As shown on Figure (4), the model represents the RCS by the following five nodes:

1. Operating RCP loop steam generator;
2. Non-operating RCP loop steam generator;
3. Reactor vessel annulus region;
4. Reactor core; and,
5. Reactor vessel upper plenum.

The representation of steam generator heat transfer by single nodes is considered conservative for heat transfer from the steam generator secondary side to the primary coolant. The overall heat transfer coefficients for each steam generator are flow dependent, based upon initial steam generator properties. This results in conservatively high coefficients which are then assumed constant throughout the transients. Considered in the model are the loop flow splits resulting from a single RCP operation, as shown on Figure (5). In addition, full pressurizer heater input and one-percent decay heat was included.

3.4 Liquid Relief Analyses

The PORVs at St. Lucie are electrical solenoid actuated relief valves and are assumed to open instantaneously [actual opening times are approximately 3 milliseconds resulting in no effect upon RCS pressure accumulation]. The orifice area of each St. Lucie PORV is 1.354 in^2. Valve flow rates were modeled to vary with the inlet to backpressure differentials. The temperature of the discharging liquid is assumed to be at the saturated temperature corresponding to the initial pressurizer pressure; thus, considerable subcooling results once RCS pressure rises to above the PORV setpoint.

3.4 Liquid Relief Analyses - continued.....

For the case of SI mass additions, the equilibrium pressures at which the SI System delivery matches PORV discharge are determined. Valve discharges are modeled as a function of RCS pressure and variable backpressure [calculated as a function of valve discharge].

For the RCP Start transient, the analyses examine the effect of a single PORV [assuming one PORV fails]. A backpressure of 100 psig is calculated as the maximum expected during the transient. Thus, valve discharge is conservatively modeled as a function of RCS pressure assuming the backpressure remains constant at the maximum calculated value.

4.0 RESULTS OF ANALYSES

4.1 Limiting Water-Solid Transients

Shown on Figure (6) are the results of water-solid mass and energy input analyses when the RCS is without low temperature overpressure mitigation. The most rapid pressure transients result from:

1. A RCP start with hot steam generator [energy addition]
2. An inadvertent SI actuation [mass addition]

These postulated overpressurizations are the limiting transients in the design of the overpressure mitigation system.

4.2 PORV Overpressure Mitigation

4.2.1 RCP Start

With both PORV's functioning properly, the maximum allowable ΔT between the RCS and the steam generator is approximately 150°F. However, for this analysis, a single failure was assumed so that only a single PORV is considered.

4.2.1 RCP Start - continued.....

Figure (7) shows the RCS pressure transient resulting from the start of a RCP with a 50°F ΔT between the RCS and the steam generator. This transient was initiated with an RCS temperature of 150°F and assumes a single PORV opens at a set pressure of 465 psia. The peak RCS pressure attained is 490 psia which corresponds to minimum RCS temperature of 105°F based on the isothermal [heatup] pressure-temperature limits. Figure (8) shows the same transient initiated at an RCS temperature of 200°F. A single PORV is assumed to operate at the programmed set pressure of 640 psia. The peak RCS pressure attained is 650 psia, well below the isothermal [heatup] pressure temperature limit of 850 psia at 200°F. This demonstrates that when assuming a single failure in the mitigating system, a 50°F ΔT limitation provides ample assurance that RCS MPT limits will not be exceeded.

Cyclic PORV discharge results during a RCP Start event since the heat transfer from each steam generator varies according to the changing secondary to primary temperature differential. Figures (7) and (8) illustrate the first of these cycles. The magnitude of the transient is the greatest during the first cycle when heat transfer rates are at a maximum.

The RCP Start transient is one of the most severe transients during water-solid operations. However, even assuming a 100°F ΔT, a normal [i.e., $\geq$ 800 ft^3] pressurizer steam bubble mitigates the transient before it reaches the low pressure PORV setpoint.

4.2.2 Inadvertent SI Actuation

As shown on Figure (6), inadvertent SI actuation is one of the most severe postulated overpressurization events. Analyses were performed assuming one PORV and two PORVs were available to discharge the SI input. Table (3) lists the equilibrium pressurizer pressures that result when the discharge of one and two PORVs balances with SI mass inputs. Sufficient

4.2.2 Inadvertent SI Actuation - continued.....

overpressure mitigation exists for a given temperature when the equilibrium pressure does not exceed the P-T isothermal curve.

Once the PORV[s] open, the valve will remain open when the equilibrium pressure is above the valve blowdown closure setting. If the blowdown setpoint is greater than the equilibrium pressure the peak RCS pressure will equal the valve set pressure and valve cycling will occur. For equilibrium pressures above the closure setpoint, the valve[s] will remain open until operator action secures the input flow.

Comparisons of the Figure (1) P-T isothermal [heatup] curve with the equilibrium pressures are also summarized in Table (3). This table shows the following for a single PORV discharge:

1. A single PORV provides overpressure mitigation for a full SI [i.e., two HPSI, three charging pumps] for all temperatures above 195°F.
2. Below 195°F all but one HPSI pump should be disabled such that a single PORV is capable of relieving the remaining HPSI pump and three charging pumps input.
3. Below 155°F the remaining HPSI pump should be disabled.
4. For inputs resulting from three charging pumps or a single HPSI pump, a single PORV is adequate for all RCS temperatures.

Also shown in Table (3) is the following which concerns the equilibrium pressures resulting from the discharge of two PORVs:

1. Two PORVs provide sufficient relief to mitigate a full SI actuation for temperatures above 95°F.
2. Additionally, two PORVs provide adequate protection for all other mass input events at all RCS temperatures.

4.3 Summary of Results

In summary, the PORVs provide the ultimate means of low temperature overpressure mitigation in conjunction with a minimum of administrative controls. These controls limit the secondary to primary ΔT to 50°F, and limit the maximum attainable SI input during low temperature operation.

5.0 CONCLUSIONS

The overpressurization events applicable to the St. Lucie Unit 1 RCS result from inadvertent SI, charging/letdown imbalances, pressurizer heater actuation, shutdown cooling isolation, and a RCP start with a positive steam generator to reactor vessel temperature difference. The limiting transients are identified as an inadvertent SI actuation and a RCP start.

Low temperature overpressure mitigation is provided at St. Lucie through a programmed low pressure setpoint for the existing pressurizer PORV's in conjunction with administrative controls. These administrative controls include minimizing the ΔT between the steam generator and RCS and disabling of system components which are non-essential to plant operation. With these administrative controls and assuming a single failure in the mitigating system the existing PORVs will provide sufficient liquid relief. It is emphasized, however, that with two PORVs operable, as designed, no administrative controls are necessary to provide adequate overpressure mitigation.

In conclusion, the results presented in this report demonstrate that adequate mitigation exists at St. Lucie Unit 1 to preclude violations of the Appendix G limits.

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Low temperature overpressure mitigation is provided at St. Lucie through a programmed low pressure setpoint for the existing pressurizer PORV's in conjunction with administrative controls. These administrative controls include minimizing the ΔT between the steam generator and RCS and disabling of system components which are non-essential to plant operation. With these administrative controls and assuming a single failure in the mitigating system the existing PORVs will provide sufficient liquid relief. It is emphasized, however, that with two PORVs operable, as designed, no administrative controls are necessary to provide adequate overpressure mitigation.

In conclusion, the results presented in this report demonstrate that adequate mitigation exists at St. Lucie Unit 1 to preclude violations of the Appendix G limits.

6.0 REFERENCES

1. Generic Report, Overpressure Protection for Operating CE NSSSs, December 3, 1976.

2. NRC Letter to FP&L, Docket #50-335, August 13, 1976.

3. Meeting Minutes of November 3, 1976 between NRC and CE Operating Plants.

4. Technical Specifications, St. Lucie Unit 1.

APPENDIX A

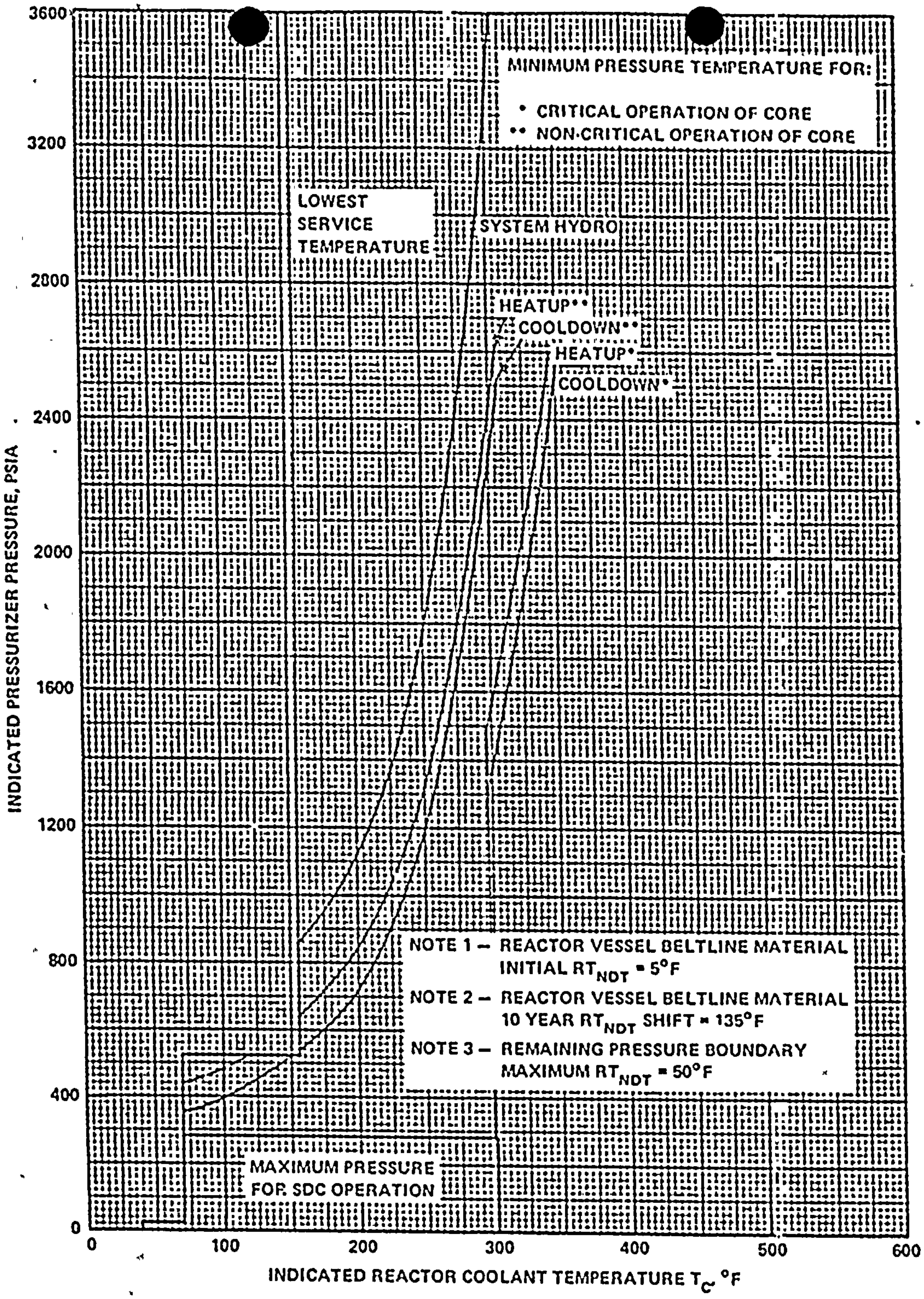


FIGURE 1: 10 Year Pressure-Temperature Curve

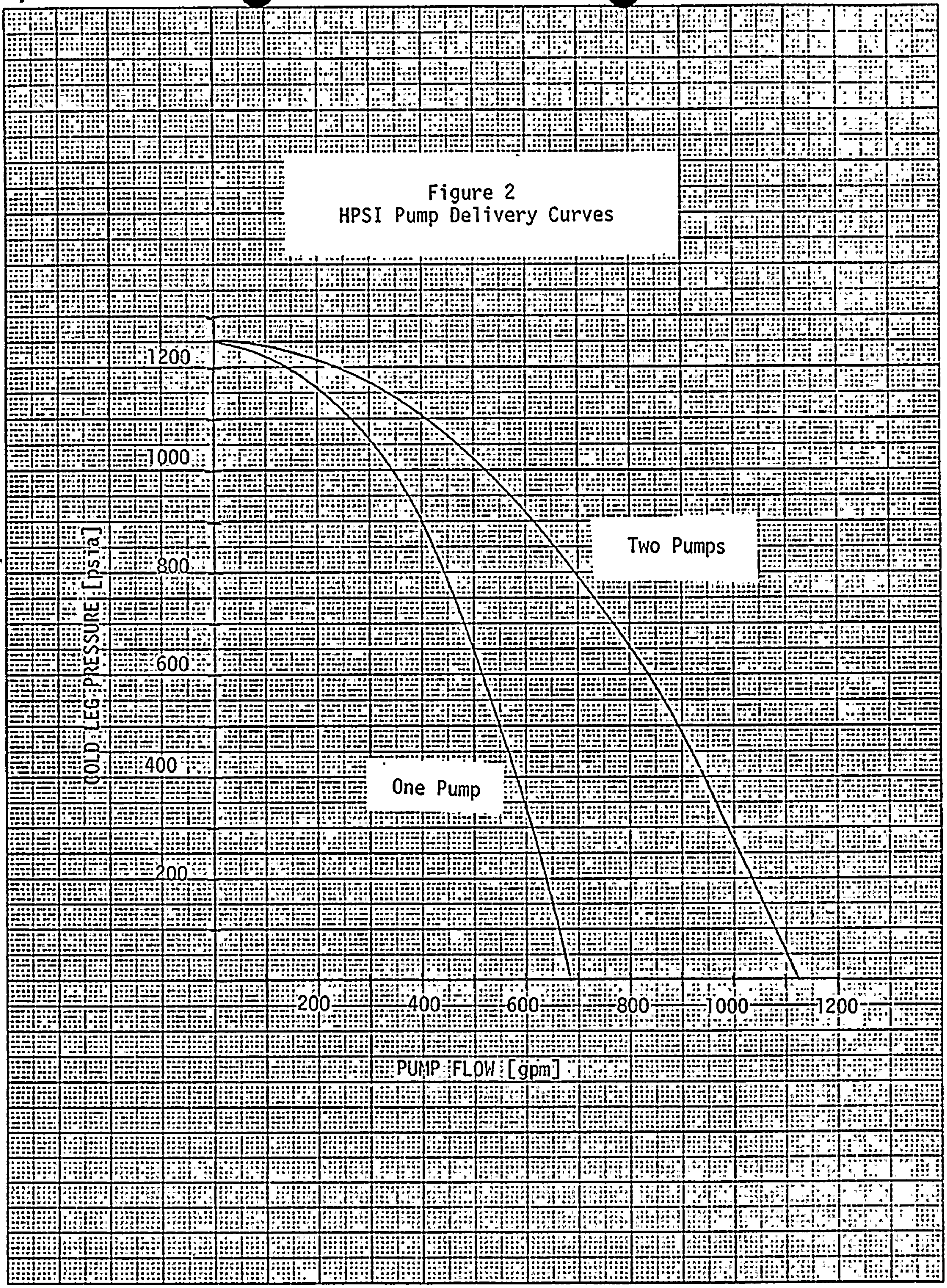


Figure 2
HPSI Pump Delivery Curves

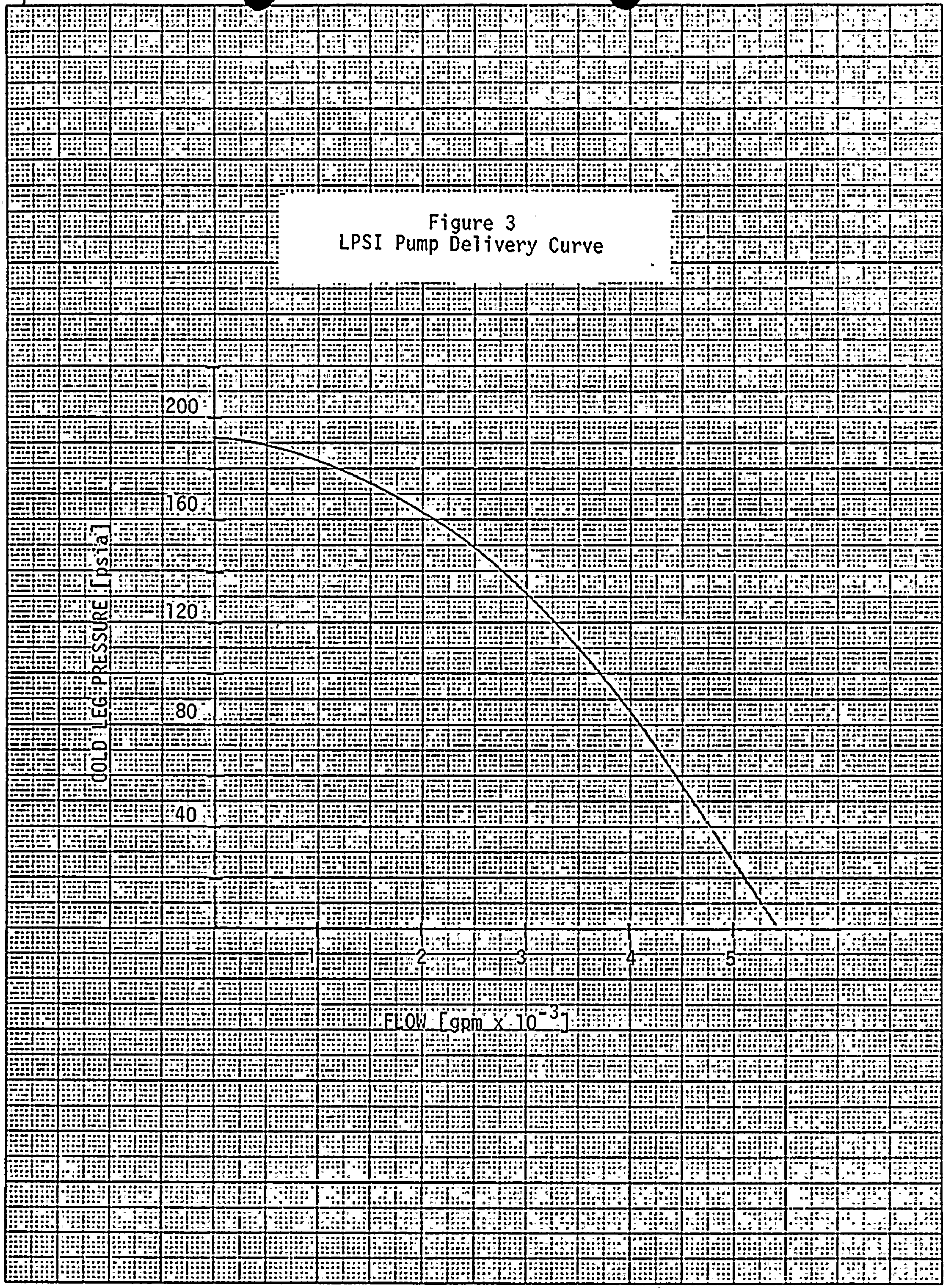
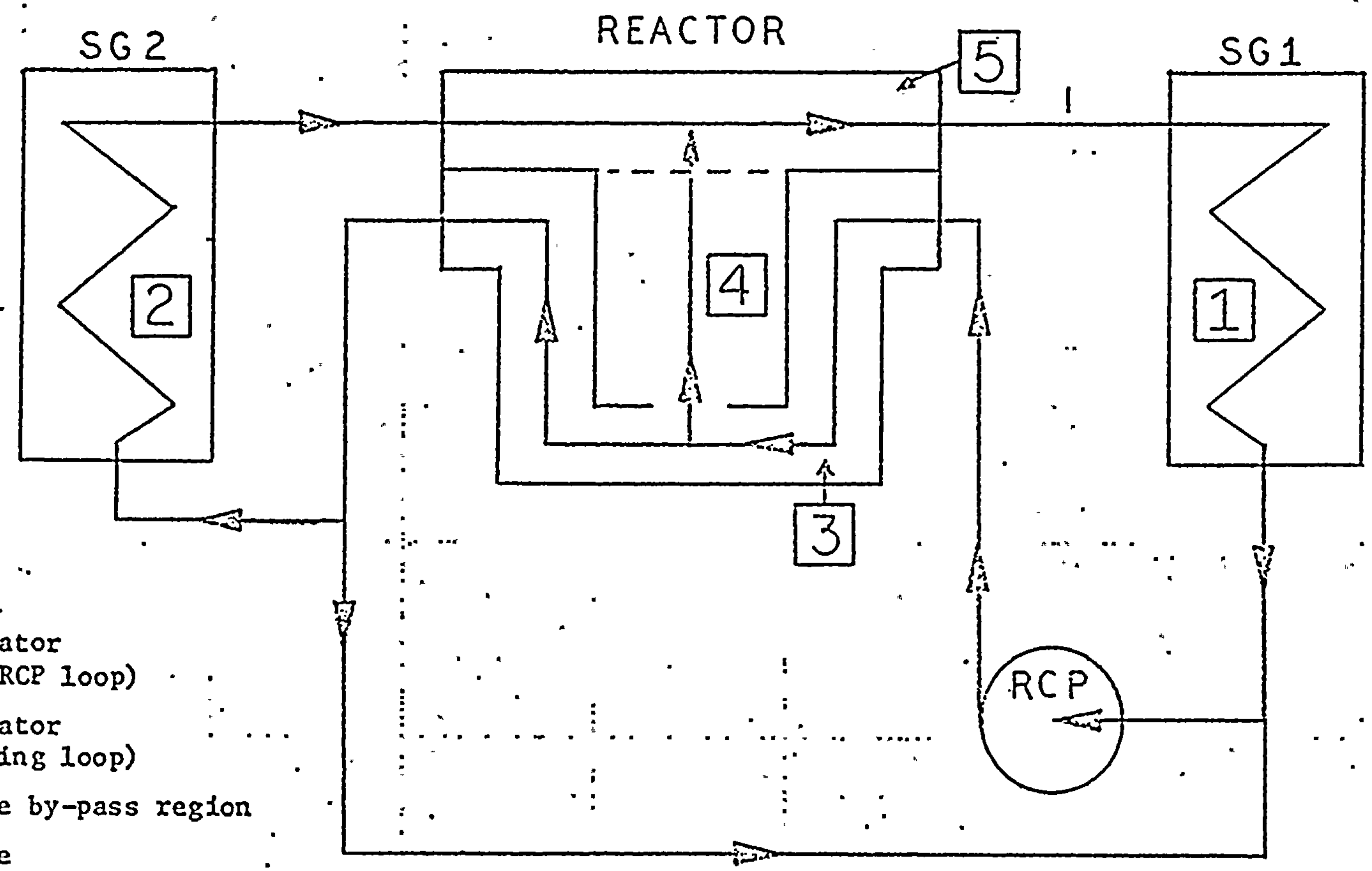


Figure 3
LPSI Pump Delivery Curve
200
160
120
80
40
COLD LEG PRESSURE [psia]
1
2
3
4
5
FLOW [gpm x 10^-3]

FIGURE 4 : MODEL NODES FOR RCP START TRANSIENT



Node	Description
1	steam generator (operating RCP loop)
2	steam generator (non-operating loop)
3	annulus core by-pass region
4	reactor core
5	upper plenum

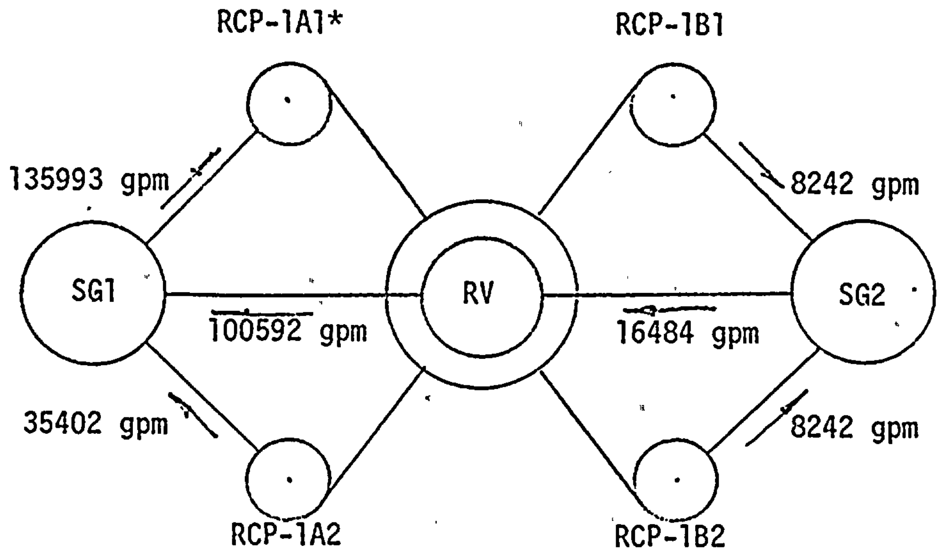
NOTE:

1. Flow split values are indicated in Figure 5

FIGURE 5

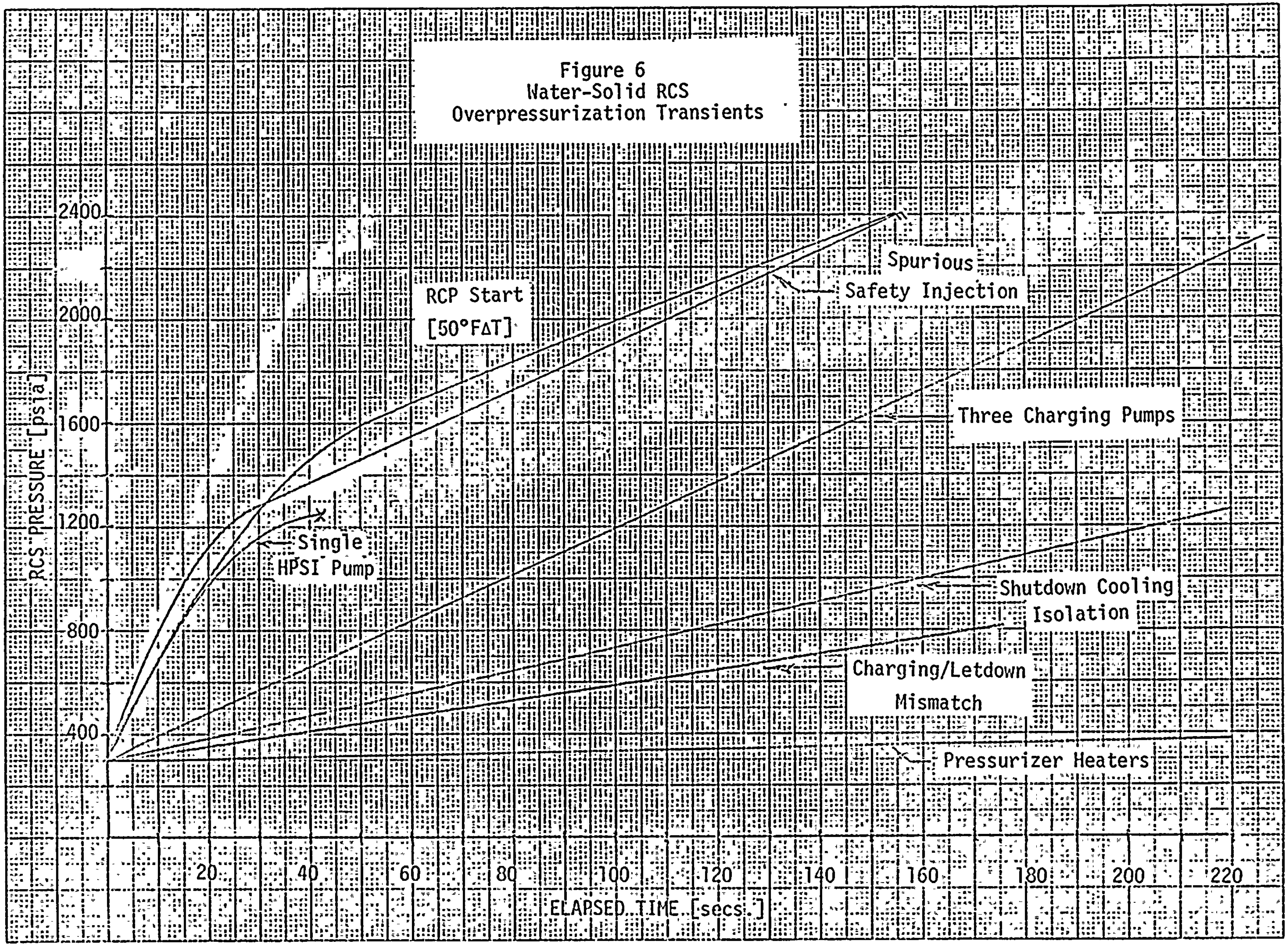
Single Pump Operation

Flow Splits



* Operating Pump

K&E 10 X 10 TO THE CENTIMETER 18 X 25 CM. KEUFFEL & ESSER CO. MADE IN U.S.A. 46 1512



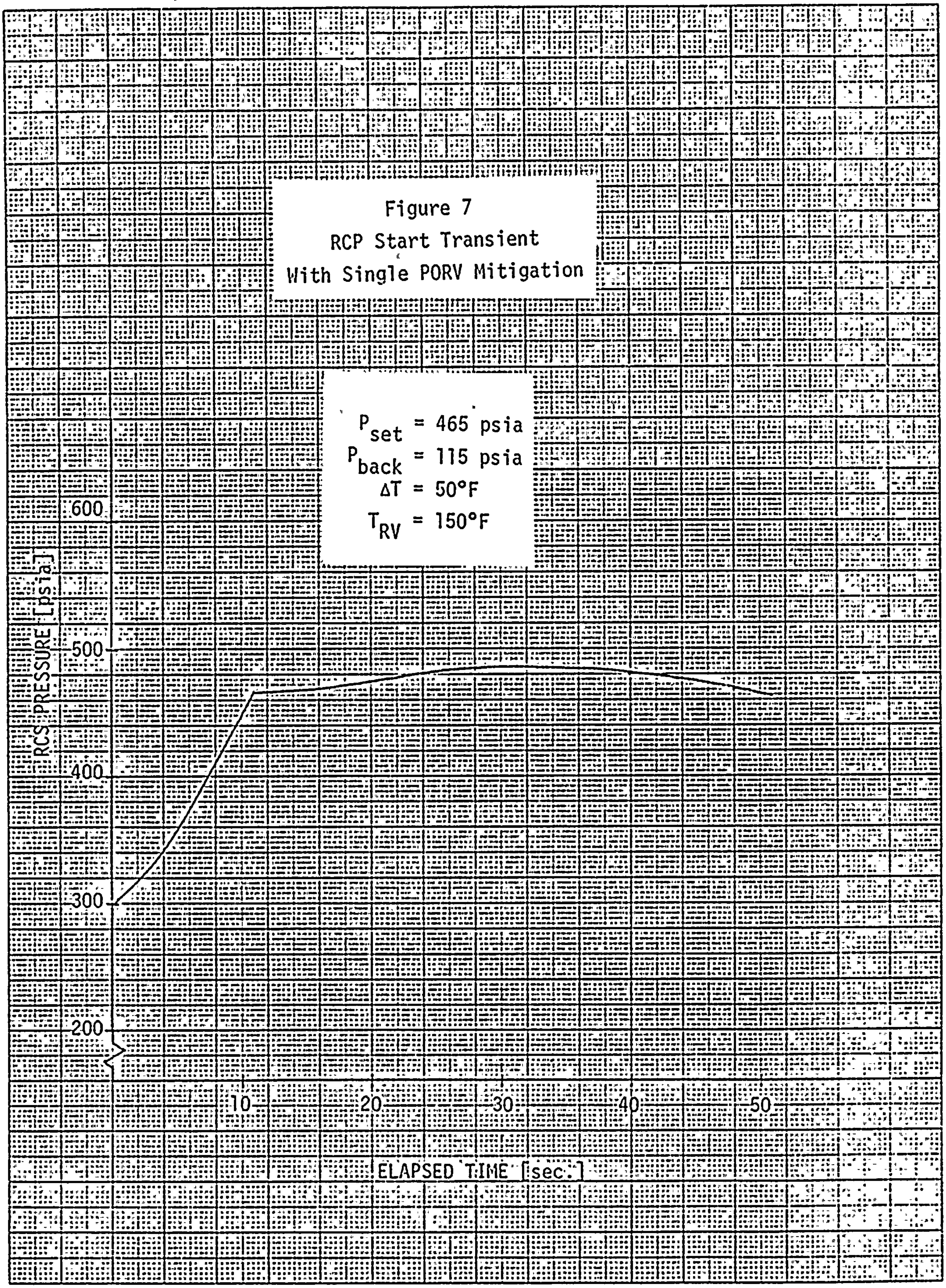


Figure 7
RCP Start Transient
With Single PORV Mitigation
P_{set} = 465 psia
P_{back} = 115 psia
ΔT = 50°F
T_{RV} = 150°F
RCS PRESSURE [psia]
600
500
400
300
200
10
20
30
40
50
ELAPSED TIME [sec.]

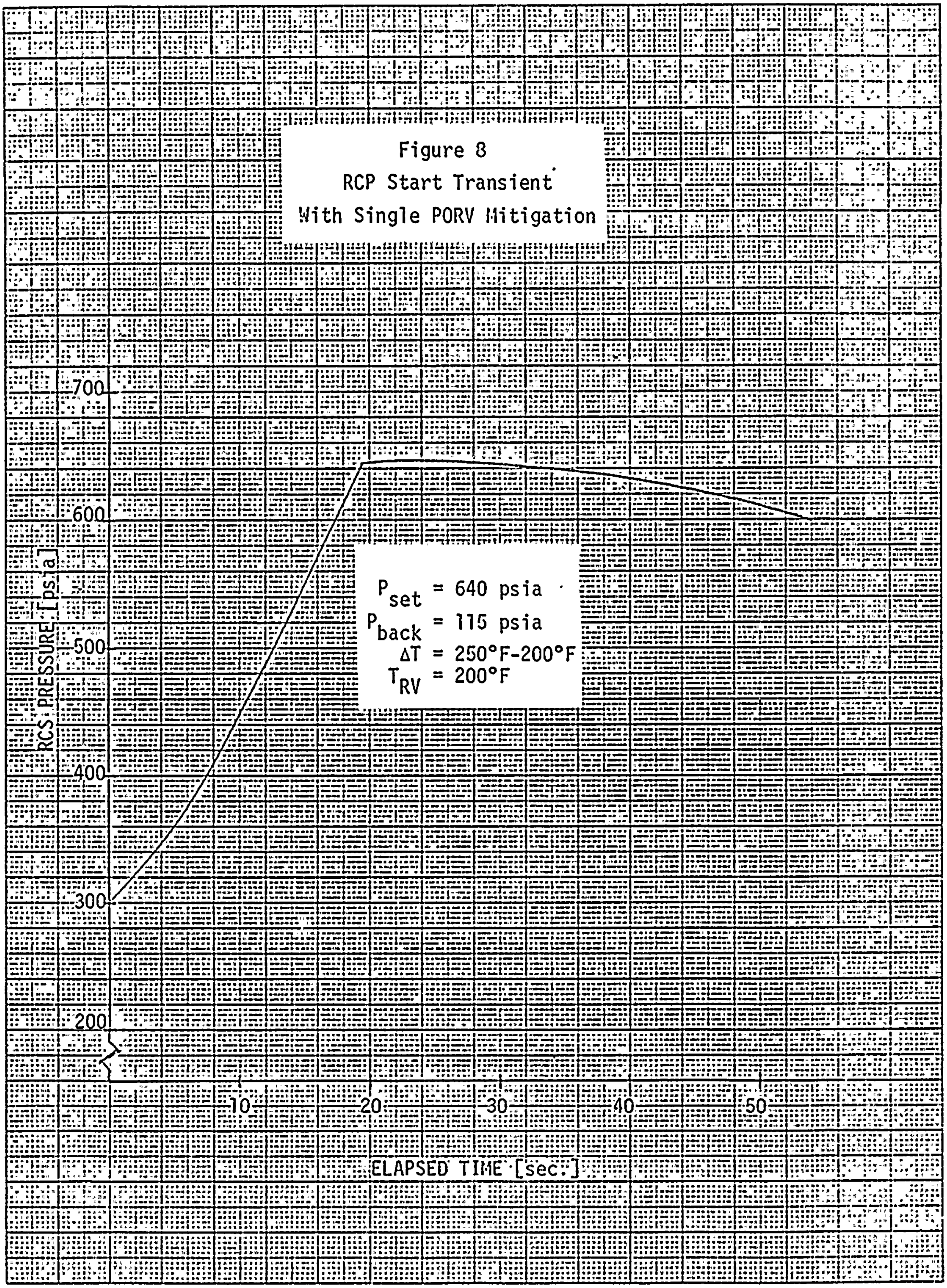


Figure 8
RCP Start Transient
With Single PORV Mitigation
P set = 640 psia
P back = 115 psia
ΔT = 250°F-200°F
T RV = 200°F
RCS PRESSURE [psia]
700
600
500
400
300
200
10
20
30
40
50
ELAPSED TIME [sec.]

TABLE 1

INITIAL CONDITIONS

Event	Pressure	Temperature	Mass/Energy Input
Pressurizer Heater Actuation	300 psia	T_{avg} = 120°F T_{pzr} = 417°F	1500 KW
SDC Isolation	300 psia	T_{avg} = 120°F	25.6MWt
RCP Start	300 psia	T_{RV} = 150°F T_{SG} = 200°F	SG Heat Transfer 25.6 MWt Decay Heat
Charging/Letdown Imbalance	300 psia	T_{avg} = 120°F	44 gpm/charging pump
Single HPSI Pump Start	300 psia	T_{avg} = 120°F	See Figure (2)
SI Actuation			
a) Two HPSI and Three Charging Pumps	300 psia	T_{avg} = 300°F	2 HPSIP: See Figure (2) 3 Charging Pumps: 132 gpm
b) One HPSI and Three Charging Pumps	300 psia	T_{avg} = 200°F	1 HPSIP: See Figure (2) 3 Charging Pumps: 132 gpm
c) Three Charging Pumps	300 psia	T_{avg} = 120°F	132 gpm

TABLE 2

COMPONENT DATA SUMMARY

Pump Data

	Type	Design Pressure	Capacity	Shut-Off Head
HPSI	Multi-Stage Horizontal Centrifugal	1600 psig	See Fig. 2	2840 ft. [1235 psig @ 60°F]
LPSI	Single Stage Horizontal Centrifugal	500 psig	See Fig. 3	392 ft. [170 psig @ 60°F]
Charging Pump	Positive Displacement	2735 psig	44 gpm	3010 psig

SI Tank Data

Total Volume	2020 ft^3
Water Volume	1090 [min] ft^3
Design Pressure	250 psig
Operating Pressure	200 psig

TABLE 3

SI INPUT/PORV DISCHARGE

EQUILIBRIUM PRESSURES

Input	One PORV Equilibrium Pressure	One PORV P-T Curve* Temperature	Two PORVs Equilibrium Pressure	Two PORVs P-T Curve* Temperature
Two HPSI and Three Charging Pumps	800 psia	195°F	470 psia	95°F
One HPSI and Three Charging Pumps	550 psia	155°F	295 psia**	<70°F
Three Charging Pumps	135 psia**	<70°F	135 psia**	<70°F
Single HPSI Pump	435 psia**	<70°F	240 psia**	<70°F

* Minimum allowable temperature so as not to exceed 0-10 year P-T isothermal [heatup] curve pressure limit. for the equilibrium pressures indicated.

** In those cases where the equilibrium pressure is less than the PORV setpoint, the peak RCS pressure will equal the valve set pressure and the valve[s] will cycle. The minimum allowable isothermal temperature corresponding to the valve set pressure of 465 psia is 95°F.