UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

MAY 5 1981

TO ALL LICENSEES OF OPERATING PRESSURIZED WATER NUCLEAR POWER REACTORS AND APPLICANTS FOR OPERATING LICENSES (EXCEPT FOR ST. LUCIE, UNIT NO. 1)

Gentlemen:

SUBJECT: NATURAL CIRCULATION COOLDOWN
(Generic Letter No. 81-21)

On June 11, 1980, the St. Lucie Plant, Unit No. 1, was forced to cool down on natural circulation as a result of a component cooling water malfunction. During the cooldown process, abnormally rapid increases in pressurizer level were observed. Subsequent analyses have confirmed that these abnormal level increases were produced by flashing of liquid in the upper head of the reactor vessel, forcing water out of the vessel and into the pressurizer. A more complete description of the event and circumstances involved is provided in the enclosure which includes a letter sent to the PWR NSSS vendors soliciting their opinions and comments on the significance of the event and phenomenon in general.

Point Beach has UPI which should mitigate effects

Based on our review of the event to date, we believe that core cooling was never lost during the St. Lucie, Unit No. 1 event. That specific event does not constitute a direct safety concern. We have, however, identified two areas of concern applicable to all pressurized water reactors requiring prompt action:

1. The Unacceptability of Vessel Voiding During Anticipated Cooldown Conditions (Natural Circulation Due to Loss of Offsite Power, Loss of Pumps, etc.)

   Cooldown with a significant steam void in the vessel requires controlling a "two pressurizer" system, which is an undesirable challenge to the operator. In fact, we are not aware of any training facilities (simulators) today which would allow an operator "hands on" experience in practicing such control. Moreover, it is our opinion that any significant vessel voiding produced during controlled cooldown conditions increases the susceptibility of the plant to more serious accidents. For these reasons reactor vessel voiding during controlled natural circulation cooldowns should be avoided.

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As described in the enclosure, vessel voiding at St. Lucie, Unit No. 1, was caused by the operator reducing system pressure such that the corresponding saturation temperature dropped to the temperature of the relatively stagnant fluid in the reactor vessel upper head. Presently, primary system cooldown rates are based on vessel structural integrity considerations and do not explicitly consider avoiding production of significant steam voids in the vessel. Moreover, cooldown rates are based on fluid temperatures measured in the primary piping. As the St. Lucie Unit No. 1 event has shown, these measured temperatures can in fact be on the order of 100 degrees Fahrenheit or more lower than the upper head fluid temperature, and, therefore, not indicative of the saturation pressure of all fluid in the primary system.

Under conditions which require cooldown on natural circulation and when rapid depressurization is not necessary there may be a number of ways to avoid reactor vessel voiding. For example, a low cooldown rate can be specified, coupled with "holding" the plant at intermediate conditions to allow the fluid in the upper vessel to equilibrate with the rest of the primary system. However, avoidance of vessel voiding by lower primary system cooldown rates can increase the time required to achieve shutdown cooling entry conditions and thus increase the time auxiliary feedwater is depended upon to remove decay heat (specifically, for the loss-of-offsite power case). Thus, supplies of condensate-grade auxiliary feedwater must be considered if cooldown times are extended.

2. <u>Failure of the Operator to Have Prior Knowledge and Training for This Event</u>

The cause of initial surges in pressurizer level at St. Lucie, Unit No. 1, was not immediately recognized or understood by the operator. We attribute this to the fact that long-term natural circulation cooldown under the specific circumstances of the event was never explicitly analysed by the NSSS vendor from the standpoint of trying to recognize a phenomenon such as that which occurred at St. Lucie, Unit No. 1. In the St. Lucie event, the operator ultimately recognized the cause of the level surges and was able to maintain control of the plant. Our concern, however, is the possibility of an operator taking incorrect action in an effort to correct for an unknown event or unrecognized phenomena.

We believe that proper procedures and training can provide the necessary guidance to the operators both to avoid reactor vessel voiding as well as recognize it when, and if, it occurs during controlled natural circulation cooldown. We are not sure if such procedures and training are in place at pressurized water reactor facilities.

Consequently, we request that you promptly review your current plant operations in light of the St. Lucie, Unit No. 1 event and the discussions above and implement, as necessary, procedures and training which will enable operators to avoid (if possible), recognize and properly react to reactor vessel voiding during natural circulation cooldown.

We conclude that the actions described above should be completed as soon as they reasonably can be (i.e., within 6 months for operating reactors). In addition, so that we may determine whether your license should be amended to incorporate these actions as requirements, licensees of operating pressurized water reactors are requested, pursuant to §50.54(f), to furnish, within 6 months of receipt of this letter, an assessment of your facility procedures and training program with respect to the matters described above. Your assessment should include:

1. a demonstration (e.g. analysis and/or test) that controlled natural circulation cooldown from operating conditions to cold shutdown conditions, conducted in accordance with your procedure, should not result in reactor vessel voiding;

2. verification that supplies of condensate-grade auxiliary feedwater are sufficient to support your cooldown method; and

3. a description of your training program and the provisions of your procedures (e.g. limited cooldown rate, response to rapid change in pressurizer level) that deal with prevention or mitigation of reactor vessel voiding.

Applicants for operating licensees are requested to implement the subject procedures and training and provide the requested assessment within 6 months of receipt of this letter or 4 months prior to the staff's scheduled issuance of its operating license Safety Evaluation Report, whichever is later.

Please refer to this letter in your response.

This request for information was approved by OMB under a blanket clearance number R0072 which expires December 31, 1981. Comments on burden and duplication may be directed to the Office of Management and Budget, Reports Management, Room 3208, New Executive Office Building, Washington, D.C. 20503.

Sincerely,

Darrell G. Eisenhut

Darrell G. Eisenhut, Director
Division of Licensing
Office of Nuclear Reactor Regulation

Enclosure: As stated

cc: Service list

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

Enclosure 1

AUG 12 1980

Letter sent to PWR NSSS Vendors:
Westinghouse, Combustion Engineering and
Babcock and Wilcox

Dear Mr.

SUBJECT: VOID FORMATION IN VESSEL HEAD DURING ST. LUCIE NATURAL CIRCULATION COOLDOWN EVENT OF 6/11/80

On June 11, 1980, the St. Lucie reactor was shutdown due to a loss of component cooling water to the reactor coolant pump seals. This also required shutdown of the reactor coolant pumps and cooldown was accomplished by natural circulation.

At approximately 4 hours into the event, charging flow, which was initially being divided between the cold legs and the auxiliary pressurizer spray, was diverted entirely to the auxiliary spray to enhance the depressurization and reduce the system pressure on the pump seals. At this time, abnormally rapid increases in pressurizer level were observed which could not be explained by the charging flow rate alone. Detailed evaluation and follow-up analyses by the licensee and NSSS supplier have indicated that a steam void was probably formed in the upper head region of the reactor vessel and displaced water from the vessel into the pressurizer.

Continued alternating realignment of charging flow between the cold legs and auxiliary spray line produced a "saw-tooth" pressurizer level behavior. Relevant information and data available to the staff to date are provided in the enclosure.

It has been postulated that the steam void in the upper vessel was produced when the system pressure dropped below the saturation pressure corresponding to the temperature of the fluid in the upper head. Because the measured hot and cold leg temperatures at the time of voiding were highly subcooled (~200°F), it appears that the fluid in the upper head was much hotter, relatively stagnant, and in poor communication with the fluid exiting the core and in the upper plenum. In addition, stored heat in the upper head structures most likely contributed to the voiding.

Because of the unexpected occurrence of the void, the failure of the operators to immediately recognize the void formation and take corrective action, and the question of whether such void formation is properly accounted for in safety analyses (Chapter 15), we have sent a list of questions documenting our concerns to the licensee. These questions are also provided in the enclosure for your information.

We are presently evaluating the need to pursue this issue generically with all PWR licensees. Prior to taking any definitive action however, we are soliciting your technical opinion and advise regarding the potential for void formation under similar circumstances in NSSS's designed by you. Specifically, we need to know if you can justify why the voiding phenomenon cannot occur in NSSS's designed by you (or can confirm that such phenomena can be properly predicted by your transient analysis models), and if it can occur, is properly accounted for in operating procedures (e.g., cooldown rates), operator guidelines, and operator training (including the simulator)

The urgency of this matter requires you advise us within fifteen (15) working days after receipt of this letter whether a supplemental information submittal by you on the subject would preclude the need to expeditiously pursue this issue generically with your customers.

Original Signed by
Paul S. Check

Paul S. Check, Assistant Director for
Plant Systems
Division of Systems Integration
Office of Nuclear Reactor Regulation

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

June 25, 1980

Docket No. 50-335

LICENSEE: Florida Power & Light Company (FP&L)

FACILITY: St. Lucie Unit No. 1

SUBJECT: SUMMARY OF MEETING WITH FP&L AND COMBUSTION ENGINEERING (CE) REGARDING ST. LUCIE UNIT NO. 1 COOLDOWN ON NATURAL CIRCULATION

On June 20, 1980 a meeting was held in Bethesda, MD regarding the June 11, reactor trip and cooldown on natural circulation at St. Lucie Unit No. 1.

Significant points discussed are summarized below. Enclosure 1 is a list of attendees.

Discussion

A brief chronology of the event was presented with traces of parameters enclosed as Enclosure 2. The plant experienced a complete loss of component cooling water (CCW) to the reactor coolant pumps (RCP). This loss was due to a direct short on the terminal board for a solenoid operated CCW common return valve from the RCP's. Plant procedures allow ten minutes to correct the problem before securing the RCP's. Subsequently, the reactor was tripped and the RCP's secured. About three minutes after shutdown one RCP was run briefly to aid natural circulation flow. The licensee stated that intermittent RCP leakoff flow alarms were actuated and that subcooled margin remained within the range 65 to 180°F subcooled during the cooldown.

The licensee indicated that a steam bubble had formed in the head of the reactor vessel during cooldown. This was indicated by abnormal pressurizer level changes during charging operations and was apparently due to elevated temperatures in the hydraulically stagnant area of the upper head.

The possibility of steam bubble formation was confirmed with an analysis by CE using an in-house model. This model decoupled the vessel head region from the rest of the reactor vessel with respect to temperature. As a result of the analysis CE issued an information bulletin (Enclosure 2) warning of the long vessel head cooldown times which may be required (10-15 hours) and recommending actions to maintain plant conditions until the vessel head has cooled should a bubble form.

The licensee indicated that while in the shutdown cooling mode of operation some primary coolant may have leaked to the refueling water tank through LPSI 1B pump's recirculation line. The isolation valve in this line was found not to be completely shut. The licensee stated that there were no indications of radioactivity release. While on shutdown cooling LPSI Pump 1B was operating in the injection mode with its recirc line open.

For corrective actions the licensee has modified its procedures to include the CE guidelines and installed backup means (additional air supplies and manual rachet) of opening the CCW containment isolation valves.

Conclusions

The NRC staff indicated the need for more detailed analyses of the natural circulation cooldown including consideration of secondary makeup supplies. In addition, the impact of steam bubble formation and its effects on depressurization rates may have to be considered in the analysis of other transients. This information will be requested of the licensee by separate letter and does not have to be resolved prior to restart.

The NRC's Office of Inspection and Enforcement will further review the licensee's corrective actions as well as the acceptability of operating one train of the shutdown cooling system in the injection mode with the other train operating in the shutdown cooling mode prior to plant restart.

Chris C. Nelson

Chris C. Nelson, Project Manager
Operating Reactors Branch #3
Division of Licensing

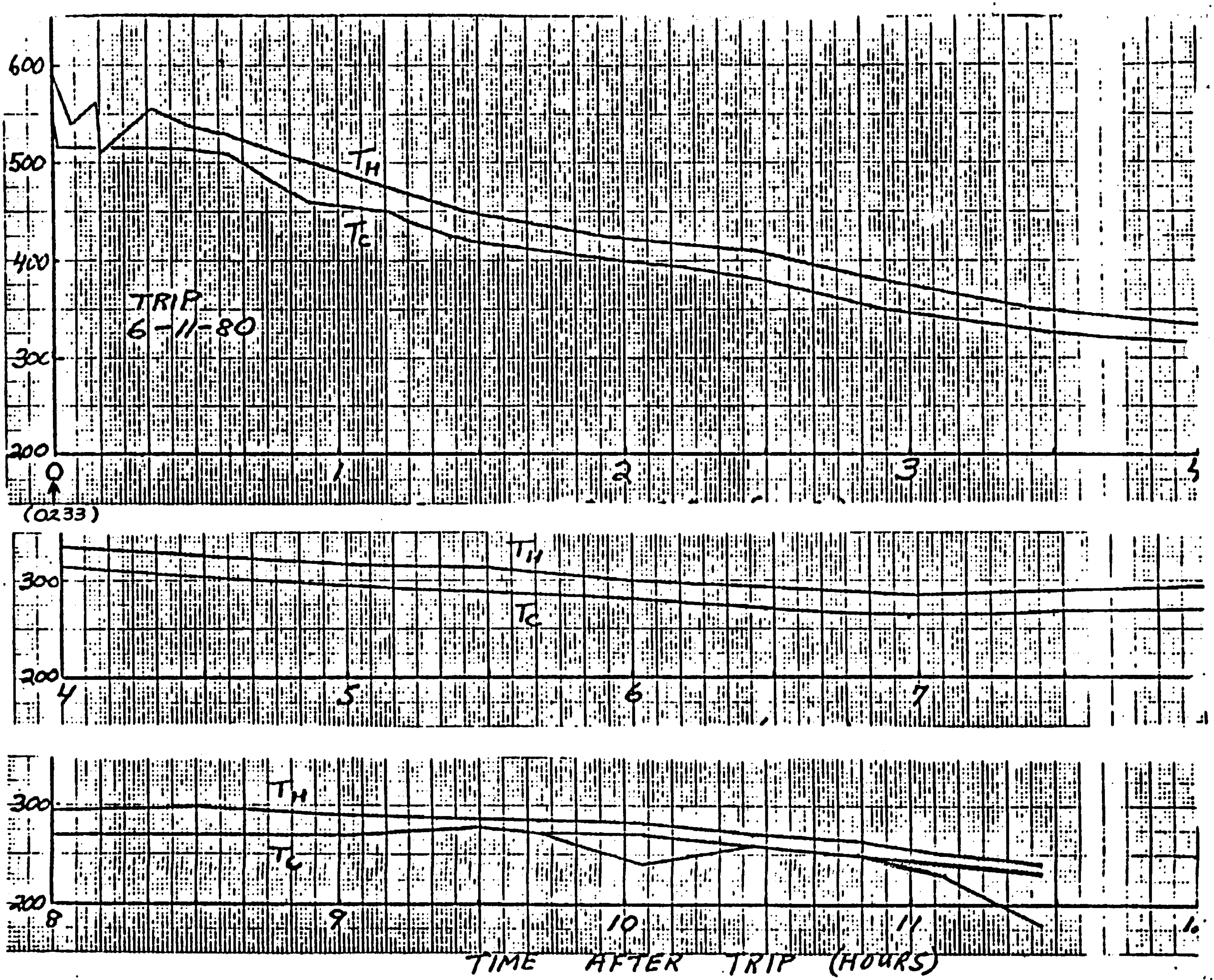
Enclosures:
1. List of Attendees
2. Chronology of Events, Evaluation, Actions Taken & Summary

cc w/enclosures:
See last page

Enclosure 1

JUNE 20, 1980 MEETING WITH FP&L - ST. LUCIE UNIT NO. 1 - ATTENDEES

| NRC | CE | FP&L |
|---|---|---|
| Chris C. Nelson | Charlie Brinkman | C. M. Wethy |
| Themis Speis | R. S. Turk | J. A. DeMastry |
| Brian Sheron | R. S. Daleas | H. N. Paduano |
| Ed Jordan | J. C. Mouhton | |
| Edward Blackwood | R. E. Wolf | |
| Jerry Mazetis | | |
| Kris Parczewski | | |
| Phil Matthews | | |
| George Lanik | | |
| E. V. Imbro | | |
| R. A. Clark | | |
| J. S. Cresswell | | |
| Monte Conner | | |
| Chang Li | | |
| Thomas R. Wolf | | |
| H. F. Conrad | | |



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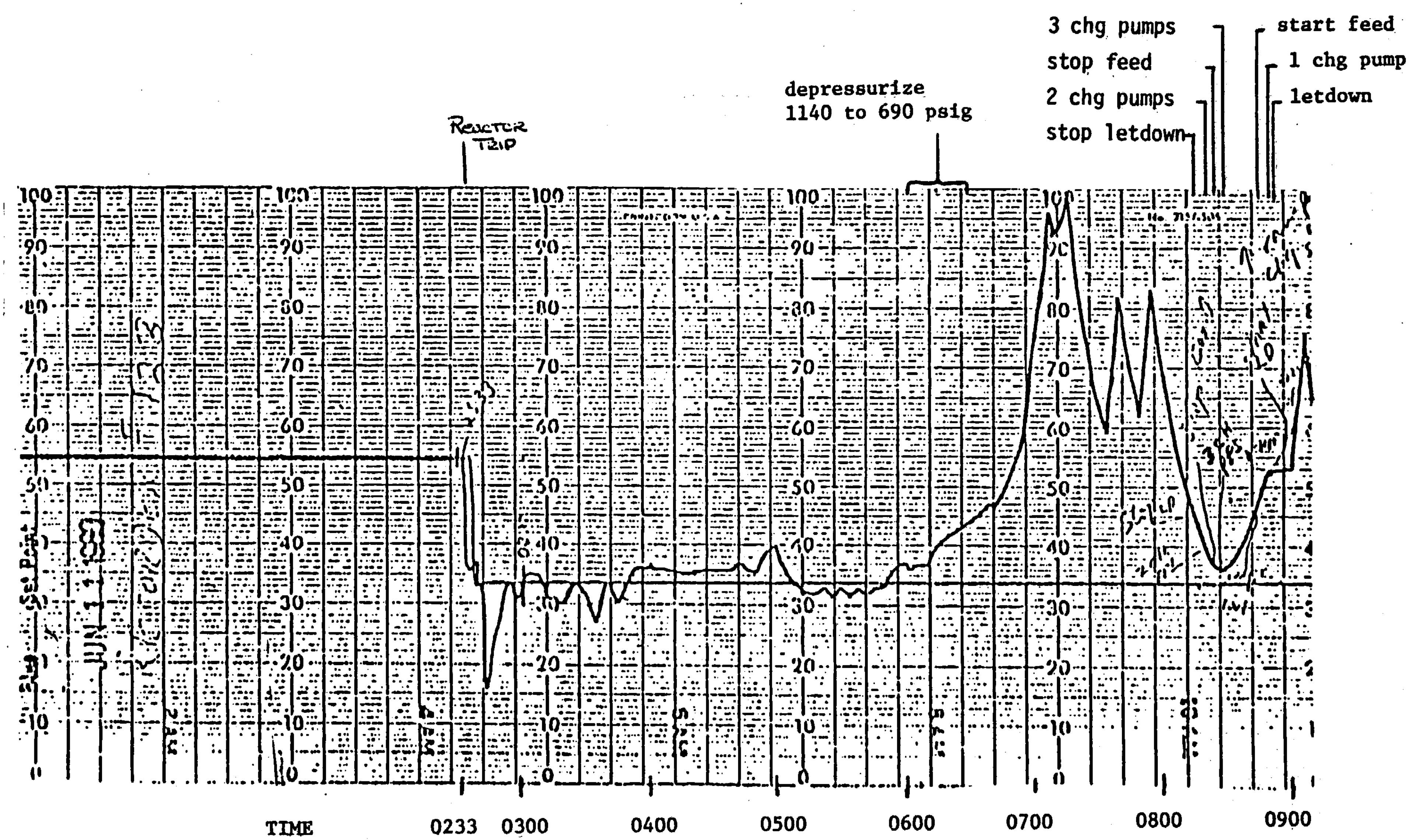
TIME AFTER TRIP (HOURS)

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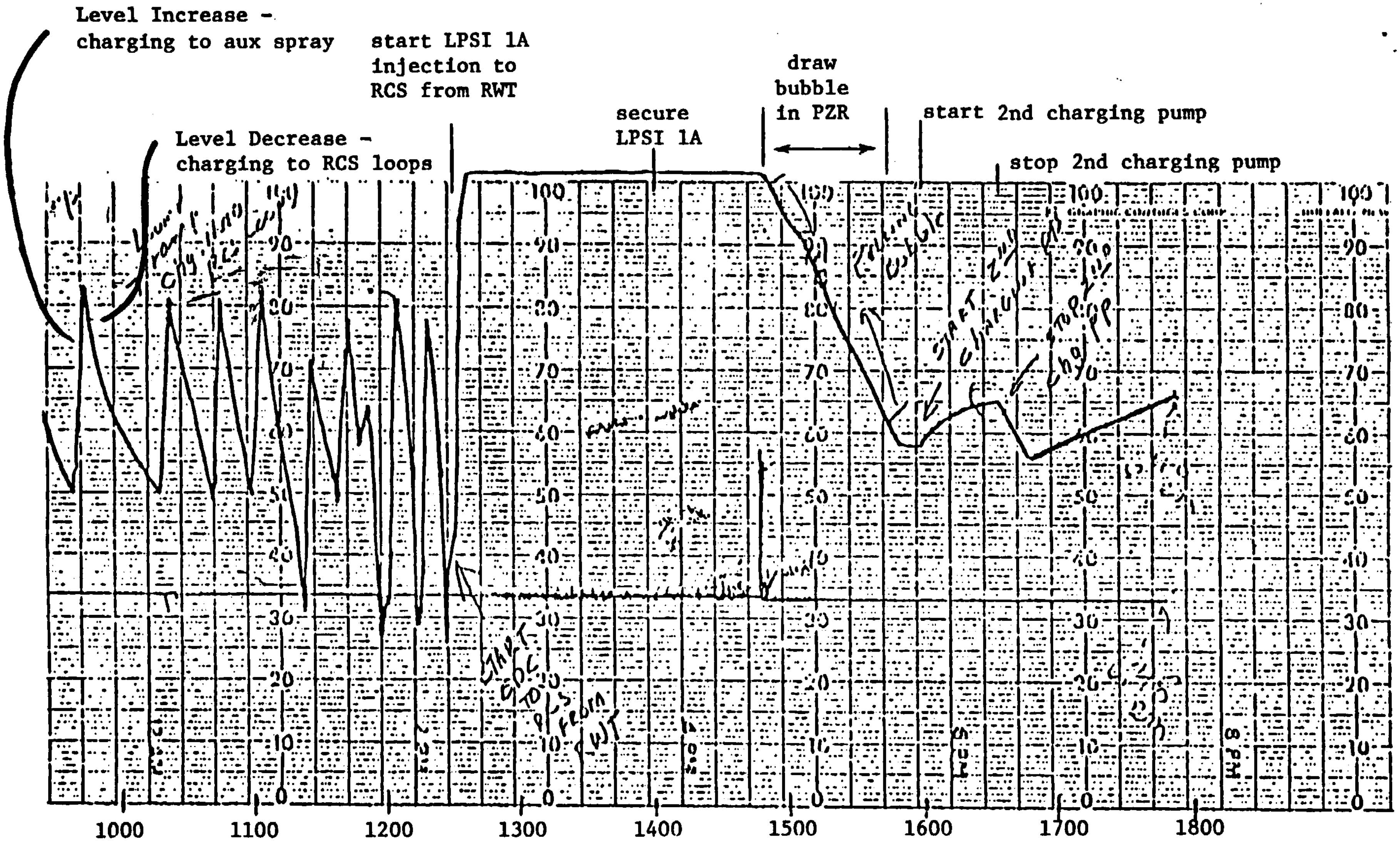

Level Increase - charging to aux spray
Level Decrease - charging to RCS loops
start LPSI 1A injection to RCS from RWT
secure LPSI 1A
draw bubble in PZR
start 2nd charging pump
stop 2nd charging pump
100
90
80
70
60
50
40
30
20
10
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1000
1100
1200
1300
1400
1500
1600
1700
1800

POWER SYSTEMS
COMBUSTION ENGINEERING, INC.

No. 80-003A

# AVAILABILITY DATA PROGRAM INFOBULLETIN

AN ADVISORY CONCERNING A TECHNICAL DEVELOPMENT RELATED TO THE APPLICATION OR OPERATION OF NUCLEAR PLANT EQUIPMENT SUPPLIED BY COMBUSTION ENGINEERING.

June 20, 1980

## NATURAL CIRCULATION COOLDOWN

INTRODUCTION: On June 12, 1980, C-E was informed by FP&L that unexpected variations in pressurizer level were observed while attempting to reduce plant pressure during a natural circulation cooldown at St. Lucie 1. The variations were determined to have resulted from the expansion and collapse of a steam void in the Reactor Vessel (RV) head region. This bulletin provides details currently known about this event and appropriate operational guidance for utilities with operating C-E NSSSs.

DISCUSSION: Following a loss of Component Cooling Water to the RCPs, St. Lucie 1 commenced an expeditious natural circulation cooldown to cold shutdown conditions. RCS depressurization via pressurizer auxiliary spray was initiated approximately 3.5 hours after the reactor trip. During depressurization, saturation conditions were reached in the RV head region which limited further depressurization until the head region had cooled off. Under natural circulation flow conditions there was minimal coolant flow in the upper head region and effectively all cooling was by heat loss to the ambient or by reactor coolant surge flow through the head region. An RCS pressure appropriate for initiating shutdown cooling (SCS) was attained approximately 9 hours following the reactor trip. During this event, the core region was always significantly subcooled.

In the event of a natural circulation cooldown it should be realized that cooling of the vessel head region may be limiting in establishing SCS entry conditions. Cooling of the RV head region may require as much as 10 to 15 hours. Periodic attempts to depressurize to SCS entry conditions can be made while watching for indications of void formation. When SCS entry conditions are achieved, the shutdown cooling system may be aligned in accordance with operating procedures.

During depressurization, formation of a steam void in the RV head would be indicated by a rapid increase in pressurizer level while delivering auxiliary spray, which may be followed by a decrease in pressurizer level when charging is realigned to the RCS loop. These responses are indicative of an expanding void in the RV head as the pressurizer is sprayed and collapse of the steam void in the RV head as charging is directed to the loop. These indications may be preceded by an indication of letdown flow in excess of charging flow if the pressurizer level control system has been in automatic during the cooldown. Upon indication of a steam void the following actions are recommended in order to maintain plant conditions until the RV head has cooled:

1. Isolate letdown.
2. Stop further RCS cooldown until indications of RV head steam void cease.
3. Energize pressurizer heaters to limit rate of depressurization.
4. Operate charging and auxiliary spray to maintain pressurizer level between 30% and 70% in order to limit void expansion.

STATUS: The event is currently being reviewed. Additional operator guidance will be incorporated into C-E training programs and forwarded to utility operating staffs as appropriate.