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SUBJECT: Forwards Rev 1 to Nuclear Problem Rept 96-008 re excess dilution of RCS on 960122 due to personnel error,presenting results of original cross-functional investigation re root cause & corrective actions

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FPL

L-96-61
March 6, 1996

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

Re: St. Lucie Units 1 and 2
Docket Nos. 50-335 and 50-389
Excess Dilution of the Reactor Coolant System Due to Personnel Error
Nuclear Problem Report 96-008, Revision 1

As the result of an event involving the excess dilution of the Reactor Coolant System at St. Lucie Unit 1 on January 22, 1996, Florida Power & Light Company (FPL) initiated a cross-functional investigation to determine root cause and corrective actions. On February 21, 1996, an interim Nuclear Problem Report (NP) 96-008 was issued discussing preliminary conclusions.

The purpose of this letter is to forward to the NRC Revision 1 to NP 96-008 which, in addition to presenting the results of the original cross-functional investigation concerning root cause and corrective actions, includes the event analysis and conclusions of an independent, non-FPL expert on nuclear plant operations and event analysis.

If you have questions on the attached report, please contact us.

Very truly yours,

W. H. Bohlke
Vice President
St. Lucie Plant

Attachment

WHB/EJW

cc: Stewart D. Ebneter, Regional Administrator, Region II, USNRC, Atlanta, GA
Senior Resident Inspector, USNRC, St. Lucie Plant

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ST. LUCIE PLANT
NP-700 PROBLEM REPORT 96-008

I. EVENT TITLE

Excess Dilution of the Reactor Coolant System Due to Personnel Error.

St. Lucie Unit 1 Event Date: 22 January, 1996

II. INITIAL PLANT CONDITIONS

Unit 1 was at 100 percent power, steady state operations.

III. EVENT SEQUENCE

At approximately 0220 on January 22, 1996 normal reactor fuel depletion resulted in an indicated reactor coolant cold leg temperature (T_c) of 548.7F. The Board Reactor Control Operator (BRCO) commenced a dilution to the Reactor Coolant System (RCS) in order to restore T_c to a temperature of 548.9F. He began a manual dilution with Primary Makeup Water (PMW) at approximately 38 gpm directed to the suction of the 1B Charging Pump at approximately 0225. According to the BRCO, shortly after the dilution was commenced annunciator E-9, "Lube Water Supply Strainer d/p Hi", was received. The BRCO at the controls left the vicinity of RTGB-105 (this is the location of the controls for the boration and dilution system) to acknowledge this alarm on RTGB 102. After responding to the alarm, the BRCO requested that the Desk RCO (DRCO) relieve him at the controls so he might go to the kitchen. The DRCO moved into the vicinity of RTGB-103. The dilution in progress was not communicated by the BRCO during the short term turnover process. The BRCO then left the "at the controls area" and went to the kitchen to prepare his meal.

Approximately five minutes later, the BRCO returned to the control room and heard the PMW integrator "clicking". The BRCO realized the addition of primary makeup water to the RCS was still in progress and immediately took corrective actions to secure the dilution and commenced borating the RCS. The BRCO commenced boration to the suction of the 1B Charging Pump for a total initial addition of approximately 26 gallons of boric acid and informed the DRCO and the Nuclear Plant Supervisor (NPS) of his actions. At approximately the same time the BRCO was taking corrective action, annunciator M-16 "RCP CONT BLDOFF PRESS HIGH" alarmed, due to a higher than normal Volume Control Tank (VCT) pressure from the increase in VCT level and Pressurizer level as a result of the expansion of RCS inventory from Tave increasing. The Assistant Nuclear Plant Supervisor (ANPS) was summoned by the NPS to the control room from the kitchen to assist in actions to return the plant to within normal operating parameters. T_c was observed to be greater than 549F.

With the boration started, the NPS and STA reviewed the Technical Specifications and

entered a two hour action statement to restore RCS T_c to less than or equal to 549F in accordance with Technical Specification Limiting Condition of Operation (LCO) 3.2.5, DNB Parameters. At 0314, indicated T_c was returned to less than 549F, and the LCO Action Statement was exited. All other parameters reached normal levels concurrently. As was later calculated, and confirmed by recorded plant indications, the highest reactor power and RCS cold leg temperature during the event was 101.13 percent and 550.8F (single point maximum).

Before the crew left the site that morning, several reviews of the event began. The crew shift supervision verbally counseled the BRCO for leaving his station while a dilution was in progress. The ANPS also wrote a notification of the event in the form of Data Sheet (DS) 7 (Operations Department Problem Report, Conduct of Operations procedure) and mailed a paper copy to the Operations Supervisor. The ANPS provided a verbal notification of the event to the Operations technical supervisor during his normal morning tour of the control rooms. The STA prepared a draft In House Event (IHE) summary 96-008 to convey the facts of the event to the site management and to initiate a STAR for root cause determination. The STA also requested that the Human Performance Evaluation System (HPES) Coordinator be called out to investigate the event. The HPES Coordinator arrived onsite at 0515, reviewed the draft IHE and conducted interviews with the personnel involved. At the 0740 morning management phone call, the Operations Supervisor and the Plant General Manager were provided with a copy of the IHE. On that same day, the Operations technical supervisor began an event review which included discussions with the relief crew, RCO chronological review, the DS 7, training and performance appraisals related to the BRCO. At the end of the day, the Operations technical supervisor recommended to the Operations Supervisor that the BRCO be removed from watch standing duties. He also notified the NRC Resident of the investigation status.

On the following day (January 23), the Operations technical supervisor conducted a fact finding meeting with the crew and bargaining unit representative. Following that meeting, the Operations Supervisor concurred in the suspension of the BRCO from watch standing duties. The Operations technical supervisor provided the NRC resident with an update to the event. On January 26, the IHE was updated by the HPES Coordinator to include all of the facts learned about the event during the week. At the direction of the Plant General Manager, on January 31, 1996, a cross functional team was formed to review the event and subsequent plant staff response.

IV. ANALYSIS

The team identified two primary problems for this event. They are discussed in detail below.

PROBLEM 1:

A reactivity evolution was initiated without adequate controls.

Root Cause:

Routine boron dilutions to maintain 100 percent power are not treated with the same importance as other reactivity management evolutions. This is particularly true toward the end of core life when frequent small additions of primary water are injected in to the RCS to maintain 100 percent power.

Contributing Factors:

1) Cognitive error on the part of the BRCO who initiated the dilution evolution. The BRCO, as part of his normal responsibilities, recognized the need to dilute the RCS and concluded it was necessary to inject approximately 30 gallons of primary makeup water (PMW) into the RCS. The PMW injection rate was to be about 38 gallons per minute; therefore, the entire dilution evolution was to have lasted less than one minute. Once this evolution was initiated, the BRCO failed to follow it to its proper completion in that he responded to an annunciator (E-9) and subsequently left the immediate area.

a. The operator's integrated performance was not adequately evaluated by supervision.

The BRCO's training and personnel records were reviewed for insight into his past performance. The subject received an "Unsatisfactory" rating in his May 1995 simulator evaluation (control board operations) and was placed on the operator non-qualified list. After remediation and reevaluation, the subject received an individual rating of "Sat/Marginal - Safety Significant." Upon further remediation the subject received an individual rating of "Satisfactory" (6/2/95). The BRCO was identified in a Training department memo (9/8/95) as a Historical Poor Performer due to failing a static exam in June 1995 and simulator performance exam in May 1995. In particular, the memo noted that he is "in too much of a hurry, and doesn't communicate well." Other noted observations taken from simulator evaluation summary forms and performance reviews:

- "need to work on communications" and "should mark time/level when monitoring containment sump" - simulator evaluation of 4/29/94;

- "failed to realize that pressurizer safety valve was open" - simulator evaluation of 11/6/95;

- "easily diverted and needs to improve in this area" - performance review 11/10/94.

This review of training and performance suggests that the qualification of the

individual should have been more closely scrutinized by Operations and Training Management.

b. There was no supervisory involvement at the start of the dilution.

Neither the dilution procedure, OP 1-0250020 "Boron Concentration Control - Normal Operation", nor the "Conduct of Operations" procedure require the BRCO to inform the ANPS or other watchstanders of the initiation of any boration or dilution evolutions. Borating or diluting the RCS changes the reactivity of the reactor core and should be considered a significant evolution. Given that there was no procedural requirements for any type of notification at St. Lucie, the BRCO was not deficient in this area. Had this been a plant policy, the ANPS (or other watchstanders) would have been aware of the evolution and may have recognized and corrected the error of the BRCO.

2) Conduct of Operations expectations are not fully understood or consistently applied.

The BRCO left the RTGB area and went "over the line" to the kitchen. During this transition, he turned over the RTGB watch to the DRCO who was returning from the kitchen. Appendix D of the "Conduct of Operations" procedure provides instructions for providing a turnover for "short term relief" which is defined as less than two hours. According to the procedure, minimum turnover requirements consist of providing: a general watch station status; off-normal conditions; and tests in progress. Operations management's expectation is that short term turnover is applied whenever a watchstander goes "over the line" and is out of line of sight of the board. However, based on interview of seven operators after the event, this expectation is not clearly understood by operators. A proper turnover may have prompted the BRCO to recall the dilution and take appropriate action. Misunderstanding of such a fundamental policy indicates a weakness in monitoring of the implementation of policies and expectations by management.

Management's expectation of "verbatim" compliance to procedure does not fully recognize the quality of current procedures nor accountability for instances of non compliance. Procedure OP-1-0250020 did not contain sufficient detail to permit "verbatim" compliance, yet none of the operators identified the need for a procedure change. In fact most of the operators interviewed after the event felt that this evolution should not require a procedure. They felt it was "skill of the craft."

3) Recent plant events involving operator personnel errors have been previously identified and corrective actions have not been completely effective.

A Q/A assessment, Technical Review Report #1TR 95-023, performed at the request of the site Vice President, reviewed sixteen events that occurred since August 1995, identified that many of the events' corrective actions did not go far enough to address all potential causal factors. It concluded that many similar events had a medium to high probability for recurrence.

4) The plant's Operating Experience Feedback program did not respond to similar reactivity management events at other nuclear plants.

Because of a number of industry events involving reactivity management, INPO issued a Significant Operating Experience Report (SOER) 94-2, which alerted the industry to the importance of reactivity management during normal operation. This report included a dilution event very similar to the St. Lucie event which occurred at Turkey Point in October 1993. In responding to the report, the plant did not identify routine dilutions as an evolution that required special attention.

5) Licensed Operator Requalification Training focuses principally on abnormal or emergency situations.

Lesson plans and simulator experience deal almost exclusively with abnormal or emergency situations. As a result, routine evolutions, which are often the precursor of abnormal or emergency events, tend to have less significance.

6) The plant's Self Assessment Programs have not been fully effective in preventing recurrence of problems.

As discussed earlier, the Quality Assurance organization has identified operator performance shortcomings where corrective actions have not been fully effective.

<u>Additional concerns identified during the event review which warrant further investigation include:</u>

1) Plant procedures do not specify the preferred method of making boration or dilution changes.

Operating Procedure OP 1-0250020 "Boron Concentration Control-Normal Operation" allows several flowpaths for dilution. The procedure does not state which flowpath is preferred for making boron concentration changes. A note in section 8.1.7 states that "Makeup from the Boron concentration control system can be directed to either the VCT (for long term effects, in any mode of operation) or the Charging Pump suction (for short term effects), in the MANUAL or BORATE modes of operation." Section 8.5 "Manual Mode of Operation" allows blending directly to the VCT or use of a direct path to the charging pump suction. Dilution via the Volume Control Tank provides a slower reactivity response and in this incident may have allowed for recovery prior to power escalation. Dilution via the VCT also lengthens the duration of the evolution. Operations must evaluate the various flowpath options for making boron concentration changes, identify the preferred methods and revise procedures accordingly.

2) The practice for operating at the Technical Specification limit for T_c provided no operating margin.

For PSL Unit 1, the limit for DNB considerations for cold leg temperature is less than or equal to 549F. The St. Lucie plant practice to operate cold leg temperature at the Technical Specification limit of 549F did not provide margin for error. Changing RCS boron concentration is a normal plant operation, compensating for long term reactivity effects, such as fuel depletion, xenon buildup and decay, plant startups, shutdowns, or changes in reactor power. As the cycle progresses, the RCOs are required to make more frequent reactivity manipulations, resulting in a higher chance of occurrence of an error due to lessened sense of awareness or importance.

3) Lack of annunciation and indication during this event.

A control room alarm responding to a dilution evolution in progress annunciates only when the dilution becomes excessive. The only alarm to annunciate in the control room as a result of this over-dilution event was M-16, RCP CONT BLDOFF PRESS HIGH, which was caused by rising Volume Control Tank (VCT) Pressure as reactor coolant inventory increased. An alarm for RCS high cold leg temperature is available, but to avoid nuisance alarms (operator distraction), the alarm setpoint is approximately 3F greater than the applicable Limiting Condition for Operation of 549F. Similarly, a Delta-T Power alarm (Point ID-742) on the plant DDPS computer is no longer maintained in a functional status.

4) The UFSAR has not been maintained current with regard to operating practices.

PSL-1 UFSAR Section 9.4.2.3 primarily discusses boration and dilution utilizing the automatic mode of operation. Little discussion is provided regarding the manual mode of operation. No specific discussion regarding dilution directly to the charging pump suction is provided in this section of the UFSAR. St. Lucie operators have historically made reactivity changes via the manual mode of operation. Discrepancies between the PSL UFSAR and existing operating practices are a recognized problem at St. Lucie. A recent QA audit Finding and an NRC deviation have provided examples of this issue. The UFSAR has been maintained current with regard to physical plant changes via the plant change/modification (PC/M) process. The UFSAR has not always been maintained current with regard to descriptions of operating practices, procedures and administrative details. The UFSAR has not been routinely referred to during the periodic review of plant procedures or during the procedure revision process to ensure continuing agreement with plant operating practices.

PROBLEM 2:

The plant staff's recognition of this event's significance was slow.

Root Cause:

The root cause of this problem is lack of a well defined threshold for recognizing safety significance. The operating crew quickly diagnosed the problem, took quick and appropriate corrective action prior to challenging any safety systems and reported the event in that

context. Management should have recognized that In House Event Reports and HPES interventions identify issues of safety significance which should be followed up more aggressively.

Contributing Factors:

The In-house Event summary had insufficient detail to gain management attention and management did not respond aggressively to an unplanned reactivity change event, regardless of significance. Specifically, the IHE did not contain the information that the BRCO had left a reactivity change unattended. Additionally, based on the observed indications of Digital Data Processing System (DDPS) digital display provided by the operating crew and NPS to the STA, the IHE reported that the peak reactor power as 100.2 percent. Subsequent detailed analysis revealed that reactor power peaked at 101.13 percent. Subsequent to the event, Plant and Operations management did not pursue details surrounding the dilution in a time frame consistent with the event's significance.

At approximately 0545, the Operations Supervisor made his routine phone call from offsite to the control rooms for a unit status. The NPS related details about the event per this phone conversation. The discussion included corrective actions, the Technical Specification LCO entered and exited, the RCO Chronological log entry, individuals involved, initiation of an IHE and DS 7. (Appendix E of the Conduct of Operations procedure requires the Shift Supervision to make prompt verbal notification for unexplained or unplanned reactivity changes.) As indicated above, the ANPS was prompt with completion of the DS 7 before he went off shift. Review of the DS 7 revealed that the specific detail related to the BRCO leaving a reactivity change unattended was not included in the report.

Additional concerns identified during the event review which warrant further investigation include:

1) The plant staff's initial investigation of this event was less than adequate.

There were several initial investigations into this event, all of which were independent of each other to a large degree. Prior to the end of the shift Monday, several independent event reviews took place. The Operations crew shift supervision evaluated the event as warranting documentation to the Operations Supervisor via a DS 7. The STA also wrote an IHE to site management for the event. The HPES coordinator interviewed the personnel involved. On Tuesday, Operations supervision conducted a fact finding meeting with the crew. On Wednesday, Operations management conducted a review of the event. Nine days after the event, a cross functional team was formed to review the event and subsequent plant response. Contributing causes to the slow and independent efforts included lack of site procedures for integrated event response investigation, root cause analysis, and self assessment. Additionally, the level of detail in existing procedures and guidelines is inadequate in that:

- DS 7 does not contain requirements for a significant level of detail,

- The HPES guideline does not contain reporting time or audience requirements, and,

- there is no procedural guidance on classifications of event severity and appropriate levels of resources required for event investigation.

2) The self assessment by the operating crew was less than adequate.

The Operations crew shift supervisor verbally counseled the RCO for leaving his station with a dilution in progress, but did not include this level of detail in the DS 7. A thorough self assessment of the event should have been conducted by the crew prior to their leaving the site on the day of the event. Contributing causes to this condition were the absence of a definitive site self assessment policy and procedure and no continuing training provided to operations personnel on self assessments and personnel error analysis.

3) The transfer of lessons learned from a similar event at Turkey Point to St. Lucie was less than adequate.

As previously discussed, a similar event to this one has previously occurred at Turkey Point, with similar countermeasures applied.

V. ANALYSIS OF PHYSICAL PLANT RESPONSE DURING EVENT

The key safety parameter associated with this event is departure from nucleate boiling (DNB). There were two plant operating parameters that were notably affected by this event, reactor coolant cold leg temperature (T_c) and reactor power. Per Technical Specification 3.2.5, T_c is limited to $\leq$ 549F and is normally controlled at about 548.9F. As a result of the dilution, T_c increased to a peak value of 549.7F (per ERDADS). Graphical data showed T_c above 549F for approximately 50 minutes. Reactor power is normally maintained at $\leq$ 100 percent. From a review of ERDADS (Q power) and calorimetric power data, it can be inferred that calorimetric power did not exceed 101.13 percent. Interpolation of the data shows that reactor power was above 101 percent for approximately four minutes and above 100 percent for approximately 50 minutes.

UFSAR section 15.2.4 provides an analysis of the design basis boron dilution events. These events assume the injection of unborated demineralized water into the RCS at a rate of 132 gpm (3 charging pumps x 44 gpm/pump). The analysis notes that boron dilution events are relatively slow events and that there are numerous indications and alarms available to operators (e.g., boronometer, VCT level, makeup flow, VCT isolation). However, should dilution proceed without operator intervention, the event would be terminated by the TM/LP or variable high power trip. DNB ratio (DNBR) limits would not be exceeded in such a case. The subject dilution occurred at a rate of 38 gpm. Thus, the event is clearly enveloped by the existing UFSAR analysis for a boron dilution at power event. Additionally, a core flux map generated from DDPS data polled at 0300 (after the event) and compared to the data from 0200 (before the event) indicated a normal flux distribution.

In conclusion, the boron dilution event of January 22, 1996 was within the design basis and analysis of the plant and did not present a challenge to plant safety systems or pose a risk to the health and safety of the public. The event was terminated by operators prior to the onset of the alarms and automatic protective actions provided for such an event. The license condition of maximum steady-state thermal power was not violated.

VI. CORRECTIVE ACTIONS

Personnel

1. The BRCO was removed from licensed operator duties. Complete

2. Human Resources and Training are developing an assessment and remediation plan for possible return of the BRCO to licensed operator duties. Complete

3. Lessons learned from this event were reinforced via supervisory expectations communicated to Shift Technical Advisors in the areas of: Sensitivity to plant events, In-House Event summary accuracy and completeness of supporting data, and 10 CFR 50.59 reviews. Complete

4. The Operations Supervisor has discussed with each NPS the purpose and thresholds of Appendix E, Conduct of Operations, and the necessary notifications. Complete

Procedures/Documents/Policies

5. The Conduct of Operations Procedure was revised to include the following:

   - Board walk down is now included as part of the "Short Term Turnover" process,

   - Direct supervision of reactivity changes is required by a Senior Reactor Operator,

   - Reactor Control Operator is to remain at the controls during all reactivity changes while in progress,

   - Reactivity changes shall not be turned over while in progress.

   Complete

6. Operations will revise the "Conduct of Operations" to clarify "short term turnover". Examples of when "short term turnover" is required will be included in the revision. This revision should be communicated to Operation's personnel by Night Order and discussed with operating crews. Training should reinforce these expectations during training sessions and Management should monitor its effectiveness. Complete

7. Engineering has performed a 50.59 evaluation to reflect Operation's practice of using the "manual" mode of dilution and boration. (This 50.59 will be included in the next annual update to the UFSAR.) Complete

8. Engineering has reconvened the UFSAR review team to complete the review of the UFSAR versus plant procedures. Sampling completed 2/29/96. Full scope and schedule due by 3/31/96. Dan Denver

9. Operations will revise the "Conduct of Operations" procedure to require a sufficient level of detail in DS 7 reports so management will have adequate information for assessment of the problem. Jeff West - Due 3/31/96

10. System and Component Engineering is developing an Event Response procedure. The procedure will include or reference: Root Cause Analysis techniques, event severity classifications and resources required for analysis. This procedure will also include expectations for the team to include cross functional membership from: SCE, Operations, Engineering, Maintenance and QA. Turkey Point's Event Response Procedure is under review for incorporation at St. Lucie. Chuck Wood - Due 3/15/96

11. The procedure upgrade process will include UFSAR review to identify inconsistencies for correction. Complete

12. For the balance of plant procedure not captured in the upgrade process, Information Services will ensure that the UFSAR is examined during the three year procedure review process and that inconsistencies are noted and corrected. Jim Holt - Due 3/15/96

Equipment Performance

13. The Plant General Manager has reemphasized the reduction of nuisance alarms to all line organizations to support the "blackboard" concept for operations. Complete

14. Engineering is evaluating the current control room annunciation for possible improvements to help focus awareness of reactivity changes. Dan Denver - Due 3/31/96

15. OST will survey the industry on the use of automatic and manual boration and dilution controls to benchmark St. Lucie and determine best means of reactivity changes by chemical control. Complete

Training & Quality Assurance

16. All DS 7s, Operational Events, will be transmitted to the Training Department for lessons learned to be included in the training program. Complete

17. QA should evaluate performing a performance based audit on the adequacy and

effectiveness of the corporate program for transferring lessons learned between Turkey Point and St. Lucie for events which occur at the other site, and for events which occur in the industry. Wes Bladow - Due 3/15/96

Supervision and Management

18. Operations will review the current watchstanders for Historical Poor Performance, and assess need for action. Complete

19. A Training and Performance Review Board will be instituted to conduct a consolidated review of all performance indicators for licensed operations personnel who are identified as Historical Poor Performers. The review will assess the need for additional remedial measures and/or the removal of the Historical Poor Performer from licensed duties. Complete

20. Plant management has developed a mechanism for providing feedback on the understanding and implementation of all policies and expectations for all plant organizations. (Standards Assessment Guideline by Management) Complete

21. A review was undertaken to evaluate the adequacy of the existing policy and guidance involving reactivity control. Plant management will now reinforce expectations and the importance of reactivity control in a personal letter from the Plant General Manager and Site Vice President to each RCO and SRO. Complete

22. Operating crew briefings by Operations Supervision were held discussing the dilution event, Zach Pate's "The Control Room" and management's expectations with respect to conservative plant operation. Operations Supervision also reinforced expectations in "Conduct of Operations" with respect to notification of Operations Management, log keeping, focus on reactivity changes, and the short term turnover process. Complete

23. Operations Management reviewed its expectations for command and control using information obtained from other sites including Turkey Point. The implications of this event will also be reviewed by a team for applicability to other operation's activities both inside and outside the control room. J. A. West - STAR 960146B & C - Schedules due 3/31/96

24. Nuclear Plant Supervisors have been directed to review all new In-House Events at the 0740 meeting with Plant Management to help prioritize activities. Complete

25. In addition to specific corrective actions, plant management will self-assess the operation of St. Lucie plant. This self-assessment will include, but is not limited, to Conduct of Operations, alarm setpoint policy, operating experience feedback, training, procedures, corrective actions, and management policies. This review will be performed by plant personnel augmented by experienced individuals from off-site. Recommended actions will

be reviewed and statused in the monthly indicator book. Independent oversight of this self-assessment will be provided via the Company Nuclear Review Board. Jim Scarola - Report due 7/31/96