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Docket Nos. 50-317
and 50-318

Mr. A. E. Lundvall, Jr.
Vice President - Supply
Baltimore Gas & Electric Company
P. O. Box 1475
Baltimore, Maryland 21203

Dear Mr. Lundvall:

The enclosed report which is forwarded for your information resulted from an on-site NRC audit of the procedures and training relative to pressurized thermal shock (PTS). This audit was conducted at Calvert Cliffs during the period from July 6 to July 8, 1982.

This report is presently under review by the staff and will eventually be integrated into the overall study of pressurized thermal shock.

Sincerely,

Original signed by:

Robert A. Clark, Chief
Operating Reactors Branch #3
Division of Licensing

Enclosure:
As stated

cc: See next page

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Baltimore Gas and Electric Company

cc:
James A. Biddison, Jr.
General Counsel
Baltimore Gas and Electric Company
P. O. Box 1475
Baltimore, MD 21203

George F. Trowbridge, Esquire
Shaw, Pittman, Potts and Trowbridge
1800 M Street, N. W.
Washington, D. C. 20036

Mr. R. C. L. Olson, Principal Engineer
Nuclear Licensing Analysis Unit
Baltimore Gas and Electric Company
Room 922 - G&E Building
P. O. Box 1475
Baltimore, MD 21203

Mr. Leon B. Russell
Plant Superintendent
Calvert Cliffs Nuclear Power Plant
Maryland Routes 2 & 4
Lusby, MD 20657

Bechtel Power Corporation
Attn: Mr. J. C. Ventura
Calvert Cliffs Project Engineer
15740 Shady Grove Road
Gaithersburg, MD 20760

Combustion Engineering, Inc.
Attn: Mr. P. W. Kruse, Manager
Engineering Services
P. O. Box 500
Windsor, CT 06095

Public Document Room
Calvert County Library
Prince Frederick, MD 20678

Director, Department of State Planning
301 West Preston Street
Baltimore, MD 21201

Mr. R. M. Douglass, Manager
Quality Assurance Department
Fort Smallwood Road Complex
P. O. Box 1475
Baltimore, MD 21203

Mr. S. M. Davis, General Supervisor
Operations Quality Assurance
Calvert Cliffs Nuclear Power Plant
Maryland Routes 2 & 4
Lusby, MD 20657

Ms. Mary Harrison, President
Calvert County Board of County Commissioners
Prince Frederick, MD 20768

U. S. Environmental Protection Agency
Region III Office
Attn: Regional Radiation Representative
Curtis Building (Sixth Floor)
Sixth and Walnut Streets
Philadelphia, PA 19106

Mr. Ralph E. Architzel
Resident Reactor Inspector
NRC Inspection and Enforcement
P. O. Bos 437
Lusby, MD 20657

Mr. Charles B. Brinkman
Manager - Washington Nuclear Operations
Combustion Engineering, Inc.
4853 Cordell Avenue, Suite A-1
Bethesda, MD 20014

Mr. J. A. Tiernan, Manager
Nuclear Power Department
Calvert Cliffs Nuclear Power Plant
Maryland Routes 2 & 4
Lusby, MD 20657

Mr. W. J. Lippold, Supervisor
Nuclear Fuel Management
Baltimore Gas and Electric Company
Calvert Cliffs Nuclear Power Plant
P. O. Box 1475
Baltimore, Maryland 21203

Mr. R. E. Denton, General Supervisor
Training & Technical Services
Calvert Cliffs Nuclear Power Plant
Maryland Routes 2 & 4
Lusby, MD 20657

Administrator, Power Plant Siting Program
Energy and Coastal Zone Administration
Department of Natural Resources
Tawes State Office Building
Annapolis, MD 21204

Regional Administrator
Nuclear Regulatory Commission, Region I
Office of Executive Director for Operations
631 Park Avenue
King of Prussia, Pennsylvania 19406

# NRC STAFF AUDIT OF PROCEDURES AND TRAINING FOR PRESSURIZED THERMAL SHOCK - CALVERT CLIFFS NUCLEAR POWER PLANT UNIT 1

Conducted by: D. Morisseau, J. Buzy, B. Clayton

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## 1. INTRODUCTION

The NRC staff conducted an onsite audit July 6-8, 1982, of the procedures and training relative to pressurized thermal shock (PTS) at Calvert Cliffs Nuclear Power Plant Unit 1. Resolution of the pressurized thermal shock issue (Unresolved Safety Issue A-49) is now scheduled to be completed in 1983. Because of the potential consequences of PTS events and the uncertainty of the effects of operator action on PTS, the staff elected to audit procedures and training relative to PTS at seven key plants. The selected plants include pressurized water reactors from each vendor with relatively high reactor vessel RTNDT. The purpose of the audits is to evaluate the operating procedures, operator knowledge, and training on PTS and determine if improvements are necessary in the short-term prior to resolution of USI A-49. Calvert Cliffs 1 is a 2700 MW(t) PWR designed by Combustion Engineering, Inc. (CE).

Preparation for the Calvert Cliffs audit included a review of operator training developed prior to the emphasis on PTS and training that has been presented since the issue was raised. In addition, normal and emergency operating procedures, technical specifications, and correspondence between the licensee and the Commission were reviewed.

## 2. AUDIT METHODS AND CRITERIA

The audit methods and criteria used in assessing the Calvert Cliffs procedures and training are described in this section. These audit methods and criteria were developed for use during the PTS audit conducted April 5-7, 1982, at H. B. Robinson 2.

The criteria used in evaluating the procedures follows:

(1) Procedures should not instruct operators to take actions that would violate NDT limits.

(2) Procedures should provide guidance on recovering from transient or accident conditions without violating NDT or saturation limits.

(3) Procedures should provide guidance on recovering from PTS conditions.

(4) PTS procedural guidance should have a supporting technical basis.

(5) High pressure injection and charging system operating instructions should reflect a consideration for PTS.

(6) Feedwater and/or auxiliary feedwater operating instructions should reflect PTS concerns.

(7) An NDT curve and saturation curve should be provided in the control room. (Appendix G limits for cooldowns not exceeding 100°F/hr.)

The criteria used to evaluate training fell into three general areas:

(1) Training should include specific instruction on NDT vessel limits for normal modes of operation.

(2) Training should include specific instruction on NDT vessel limits for transients and accidents.

(3) Training should particularly emphasize those events known to require operator response to mitigate PTS.

The audit team reviewed procedures for normal, abnormal and emergency operation that cover situations in which operator action might cause, prevent, or mitigate PTS. Procedures reviewed include those for heatup and cooldown of the reactor coolant system, loss of main feedwater, loss of both main and auxiliary feedwater, steam line break, loss of coolant, steam generator tube rupture, natural circulation, long-term cooling following a small-break loss of coolant, and core flush following a loss of coolant. Procedural information that could impact PTS was discussed with licensee representatives.

Several interview outlines were developed for the interviews of licensed personnel. The outlines included material presented as part of the classroom training and revised procedures that would be used to mitigate PTS challenges. All outlines included an uncontrolled cooldown of the reactor coolant system by means of a large steam line break. The postulated break occurred with the plant at full power, "0" power, and after a complete loss of A.C. power. All interviewees were required to use EOP-4-Steam Line Rupture Procedure. Figures containing reactor coolant system pressure and vessel downcomer temperature were provided as a time reference. These figures were included in a report to the Commission and had been part of the required reading for all operators. Members of the operating staff who were interviewed were selected by the licensee. They included two licensed operators, two senior operators classified as senior control operator and shift technical advisor, and two senior operators who were designated shift supervisors. The interviews were conducted on July 9 and 10, 1982.

## 3. FINDINGS

### 3.1 Findings on Procedures

The procedures that were audited and the criteria used in their evaluation are stated in Section 2. The audit was limited to information and instructions relative to pressurized thermal shock. The audit did not include a technical review of other aspects of the procedures or a human factors review of the procedures.

- o The procedures audited generally did not appear to contain instructions that would cause operators to violate Technical Specification limits for heatup or cooldown. The procedures generally include cautions that violation of the Technical Specification curves may compromise vessel integrity. It should be noted that some accidents (e.g., steam line break) may violate the cooldown curve regardless of operator action.

- o The procedures instruct the operators, if the curves are violated, to depressurize until they are within limits. The instructions are not explicit on the method(s) to be used to perform this depressurization. The procedures generally contain instructions to maintain at least 50°F subcooling margin, thus assuring adequate core cooling. The 50°F margin is to be indicated by the subcooling margin monitor. If the monitor is not available, the operators must read a computer point or calculate the subcooling margin using pressure and temperature indications available in the control room.

- The procedures are generally supported by technical basis. The referenced heatup and cooldown limit curves are based on the requirements of the ASME Boiler and Pressure Vessel Code, Section III, Appendix G. The sequence of required actions is generally consistent with the draft emergency operating procedure guidelines being developed by CE and the CE Owners' Group in response to TMI Action Plan Item I.C.1. CE and the CE Owners' Group are reviewing their emergency operating procedure guidelines to determine if additional guidance relative to PTS should be provided. Licensee representatives stated that the Calvert Cliffs emergency operating procedures would be revised as necessary following that review.

- Cautions to prevent violation of the Technical Specification heatup and cooldown curves implied that high pressure safety injection and charging must be controlled or terminated to prevent repressurization of the reactor coolant system. However, the procedures lacked explicit instruction in this area.

- Instructions are provided to maintain steam generator levels following transients. There are instructions in the steam generator tube rupture procedure to locally close a valve to stop auxiliary feedwater flow to the steam generator with the ruptured tube following depressurization of the reactor coolant system to less than the setpoint of the secondary safety valves. In addition, the steam line rupture procedure provides instructions to verify isolation of main feedwater and to feed only the unaffected steam generator with auxiliary feedwater.

- The Technical Specification heatup and cooldown curves are available in the control room and are referenced in the applicable procedures. The saturation curve and 50°F subcooling curve are provided in the procedure for loss of coolant. In addition, licensee representatives stated that a single graph was being prepared that will display all these curves and that it will be placed in the control room for use by the operators.

In summary, the procedures reviewed provide guidance on unacceptable pressure-temperature conditions and maximum acceptable cooldown rates. The procedures often do not explicitly state the values of pressure and temperature the operator should try to maintain following accidents or transients or what trends he should try to establish. Likewise, the procedures do not include explicit instructions for the operation of plant equipment and systems needed to maintain or establish the preferred pressure-temperature conditions or trends.

## 3.2 Findings on Training

All interviews with the operating staff were conducted in the control room. Each interviewee was required to use a saturation curve and provide limits for the reactor vessel and core cooling. One individual selected the wrong value for vessel limits but later corrected himself. All were aware that the vessel limits would be more restrictive during the lifetime of the plant and those questioned knew the heatup and cooldown limits imposed by the Technical Specifications. Most of those interviewed knew how PTS developed and stated that a large steam line break (EOP-4) would be the greatest PTS challenge. Almost all who were asked knew the indications and immediate actions of EOP-4; however, several omitted manual initiation of emergency boration. All stated that the reactor coolant pumps must be tripped within 5 seconds after initiation of a safety injection actuation signal (SIAS) and that the steam and feedwater lines would be isolated when the steam generator isolation signal (SGIS) was actuated. In the blackout sequence, those interviewed correctly indicated they would have stopped auxiliary feedwater to the steam generators.

The sequence of events following the initial transient was conducted by review of the supplemental actions in EOP-4. The following is a summary of the interviews.

- With the exception of calculated value XC913 all interviewees were very familiar with instruments and control.

- Most concluded that a large steam line break would empty the pressurizer; however, few could plot the resulting T-hot and T-cold values as the system approached saturation nor did they consider steam bubble formation in the loops or reactor vessel head.

- All those requested could demonstrate use of the subcooled margin monitor to obtain a T-hot reading.

- Estimates of emergency boration for the steam line break event varied from 10 to 70 minutes.

- Most would use high pressure safety injection to control pressure but two stated that the pressurizer PORV could be used.

- Although subcooling margin value, XC913, is used in many emergency procedures, few know core thermocouples are used as an input to XC913.

- Few could state what specific temperature would be used to control atmospheric steam dumps during EOP-4 recovery or how use of steam dumps would influence RCS pressure.

- There was no consensus of which temperature should be used to plot the P/T values for vessel limits.

Many of the operators' responses during the interviews can be traced to lack of detail or specificity in the emergency operating procedures (EOPs). Because these revised EOPs had been available to the operating staff for review and comment more than six weeks before this audit, comments on the content and direction provided by the procedures should have been resolved prior to the audit. Apparently, the operating staff's review of the procedures was not performed in sufficient detail and depth to produce comments of this nature.

One person received requalification training at the C.E. simulator during April of this year. He stated that the exercises performed during the training did not include challenges to vessel limits but when questioned further stated that the simulator model was not reliable when reactor coolant pressure approached saturation conditions. Other members interviewed did not have recent simulator training nor could they recall specific exercises related to PTS.

During the exit interview members of the training staff confirmed that PTS exercises had not been scheduled partially because of heavy demands on simulator control manipulations and the reactor coolant system model could not respond when the system reached saturation conditions. Further conversations with the licensee's staff indicated that the lack of simulator capability had required additional classroom training including specific parameter response. This additional training was performed for hot license candidates; however, no additional training has been scheduled for requalification sessions or recent PTS training.

The following is a summary of findings on each of the audit criteria stated in Section 2.

(1) Training should include specific instruction on NDT limits for normal modes of operation.

Our discussions of vessel limits for heatup and cooldown included the reason for the limits and how the operating staff ensures that limits are not exceeded. Use of procedures and low pressure protection to prevent over-pressurization at lower operating temperature was adequately demonstrated by a number of the people interviewed.

(2) Training should include specific instruction on NDT vessel limits for transients and accidents.

Training was developed and conducted in the past six months that demonstrated how PTS could occur and how vessel limits could be challenged during this event. In addition to a review of vessel properties including metals under stress, defects and impurities in base metals and welds, effects of radiation and introduction to fracture mechanics and crack propagation, PTS history and analyzed transients were introduced. Methods to identify PTS events were also included in the classroom training.

(3) Training should particularly emphasize those events known to require operator response to mitigate PTS.

Classroom training included a series of analyzed transients and specific steps to mitigate PTS events. Also, included was plant design that would automatically stop uncontrolled cooldown, thereby reducing the challenges on vessel limits. In addition, main steam line break and atmospheric dump valve malfunction and other events were reviewed in the classroom. Although emergency procedures were revised to reflect PTS events and method(s) to mitigate the challenges, no discussion of the integrated plant response leading to and after the mitigating steps was conducted as part of the PTS training. In addition, steam bubble formation and means to control the plant in natural circulation were presented in the classroom phase of the PTS training program.

At the conclusion of classroom training, a quiz was administered covering the material presented during the training period. At present, 42 of the 46 licensed operators achieved a grade equal to or greater than 80%. The remaining operators will receive additional training in the near future.

4. RECOMMENDATIONS

Based on the findings in Section 3, we conclude that additional action should be taken by the licensee prior to the long-term resolution of the pressurized thermal shock issue. As discussed in Section 3.1, the licensee presently intends to make some revisions to improve its procedures. We concur with these revisions.

1. Provide additional guidance in the procedures for loss of coolant and steam line rupture on preferred values and trends of pressure and temperature during recovery.

2. Provide additional guidance in the procedures for loss of coolant, steam line rupture, and steam generator tube rupture on use of the high pressure safety injection and charging systems to control pressure and use of the auxiliary feedwater system and steam release paths to control cooldown. Use of the PORV's to control pressure when brittle fracture limits are approached should be included.

3. Review the use of and need for cross-referencing among procedures. Of particular concern is the referencing of the loss of coolant procedure to verify natural circulation instead of the natural circulation procedure.

4. Evaluate the need for additional guidance following a steam line rupture to ensure sufficient boron addition for reactivity control while trying to limit cooldown.

5. In conjunction with procedure revisions recommended by this audit, the training department should develop training sessions using available analysis to demonstrate how major parameters

respond during postulated PTS events. These parameters include effects on core cooling and shutdown margin. Procedures requiring integrated response by operating personnel should be reviewed in classroom lectures as well as the control room. Training should include recovery from PTS challenges with and without steam bubbles in the reactor coolant system and also with and without forced flow. Strategies or options for use of the pressurizer PORV should also be included in these training sessions.

6. All licensed personnel should review shutdown margin calculations for all events that include use of emergency boration with and without use of safety injection.

7. Reference of inputs to all instruments or computer points contained in normal and emergency operating procedures should be readily available to control room personnel.

8. Review the exercises conducted at the CE simulator that include depressurization events until saturation conditions develop in the reactor coolant system. If the simulator model does not respond as predicted provide the method(s) that have been used to complete transient training.