U. S. NUCLEAR REGULATORY COMMISSION
Region I

Docket Nos.: 50-317, 50-318 License Nos.: DPR-53, DPR-69

Report Nos.: 50-317/89-31
50-318/89-32

Licensee: Baltimore Gas and Electric Company
Post Office Box 1475
Baltimore, Maryland 21203

Facility: Calvert Cliffs Nuclear Power Plant, Units 1 and 2

Inspection at: Lusby, Maryland

Inspection Conducted: October 1 - November 30, 1989

Inspectors: J. Beall, Senior Resident Inspector
S. McNeil, Project Manager, NRR

Approved by: _____ 1/3/90
David F. Limroth, Acting Chief Date
Reactor Projects Section No. 1A

Summary:

Areas Inspected: This was an unannounced special inspection of the licensee's actions to assure adequate low temperature overpressure protection for the reactor vessel.

Results: An overall programmatic weakness was identified in the licensee's tracking of corrective actions. Examples were identified in which commitments were overlooked and not completed. Failure to fulfill commitments and implement timely corrective action may have resulted in a reduction in plant safety in the area of reactor vessel low temperature overpressure protection. Apparent violations of 10 CFR 50.60, 10 CFR 50.9, and 10 CFR 50 Appendix B and Technical Specification 3.4.9.3 were identified.

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DETAILS

1. Persons Contacted

During the course of this inspection, interviews and discussions were conducted with various licensee personnel, including control room operators, design engineers, and site managers. A partial list of individuals contacted is presented in Attachment A.

2. Background

The fracture toughness requirements for reactor coolant pressure boundary materials are embodied in 10 CFR 50.60 and 10 CFR 50, Appendix G. These fracture toughness requirements include pressure-temperature (P-T) limits which are established to provide an adequate margin of safety to protect ferritic materials in the reactor coolant pressure boundary, including the reactor vessel, from brittle fracture. Overpressure protection measures are provided to ensure that these limits are not exceeded during normal operation or anticipated operational occurrences.

As reactor coolant system temperature decreases, the reactor vessel's susceptibility to brittle fracture markedly increases, thus, in low temperature ranges, the adequacy of overpressure protection is particularly important. To protect against reactor vessel brittle fracture in the susceptible low temperature range, licensees were required to provide additional Low Temperature Overpressure Protection (LTOP) measures to prevent anticipated operational occurrences, such as an inadvertent safety injection pump start, from causing pressure transients that would result in conditions exceeding the associated P-T limits.

3. Inspection Scope

During this inspection period, licensee actions taken to resolve deficiencies and concerns pertaining to plant P-T limits and low temperature, overpressure protection (LTOP) systems, previously identified in NRC Inspection Report Nos. 50-317/88-05; 50-318/88-06 and 50-317/88-12; 50-318/88-12, were examined. The items initially examined included the June 28, 1988 inadvertent lifting of a power operated relief valve (PORV) on Unit 1, while heating up the reactor coolant system, and necessary modifications to the P-T limits contained in Technical Specification 3/4.4.9, "Pressure-Temperature Limits."

4. Chronology of LTOP Issue

The Unit 2 Operating License (DPR-69) was issued on November 30, 1976 and contained a license condition requiring a permanent, NRC-approved LTOP system prior to startup from the first refueling outage. In July 1977, the licensee submitted the LTOP plan, applicable to both Units 1 and 2. In August 1978, that plan was approved and incorporated into the Technical Specifications of both units. Both units operated for several fuel cycles, which necessitated P-T curve revisions due to reactor vessel radiation embrittlement. During the last three years, the licensee developed the revised P-T curves, the NRC issued new guidelines and requirements based on industry experience (Generic Letter 88-11), and the licensee took measures to respond to Generic Letter (GL) 83-11.

During this inspection, several deficiencies and omissions were identified in the licensee's actions to assure adequate LTOP. This led to a meeting with the NRC staff on November 27, 1989. Additional deficiencies were identified in the licensee's approach on the following day. A more detailed chronology is presented in Attachment B.

5. Deficiencies in Meeting Original Commitments

The original LTOP measures, as evaluated by the NRC, utilized a combination of administrative controls, hardware improvements, Technical Specifications (TS) and operator training to ensure that the P-T limits established to provide protection against reactor vessel brittle fracture would not be exceeded. The licensee's approach was intended to apply to the period of operation from 0-10 Effective Full Power Years (EFPY), and was not designed to provide protection after 10 EFPY of operation.

The licensee established the administrative controls based upon the results of the analyses for the most limiting pressure transient-producing incidents at low RCS temperature conditions. The two transients of concern were: 1) an inadvertent high pressure safety injection (HPSI) pump actuation (Limiting Mass Addition Transient (LMA)) and 2) the reactor coolant pump start transient during plant conditions where steam generator water temperature is higher than reactor vessel water temperature (Limiting Energy Addition Transient (LEA)). The principal LTOP administrative controls to which the licensee committed in its July 21, 1977 submittal, are described in Table 1 for the design LMA and in Table 2 for the design LEA. Similarly, the results of the design LMA events analyses are provided in Table 3.

The July 21, 1977, licensee submittal stated that most of the administrative controls were in place, including those involving the HPSI system. As documented in a later NRC inspection report (IR 50-317/88-05; 50-317/88-06), certain LTOP-based administrative controls were found not to be in place. Specifically, the licensee had not prohibited either the testing of the emergency core cooling system (ECCS) with the plant solid or the startup of the shutdown cooling system when steam generator temperature was above 220° F. The licensee modified plant procedures to prohibit ECCS testing while in a solid condition following NRC identification of the deficiency in the above inspection report. However, during the current inspection, the inspector identified that certain of the original 1977 commitments had still not been met. Sustained operation without the committed controls indicates that adequate LTOP may not have existed during the period and constitutes an apparent violation of 10 CFR 50.60, "Acceptance Criteria for Fracture Prevention Measures for Light Water Nuclear Power Reactors for Normal Operation." (Details are provided in the attached Tables referenced above.) Further, these actions constituted the basis for the August 7, 1978 NRC SER authorizing deletion of the LTOP license condition (that is, the outage startup hold), this is an apparent violation of 10 CFR 50.9(a), "Completeness and Accuracy of Information."

6. Reanalyses Indicating Potentially Inadequate LTOP Not Addressed

On January 21, 1987, the licensee staff submitted new P-T curves (reflecting reanalysis) to the Plant Operations and Safety Review Committee (POSRC) for approval. The curves were developed to cover up to 12 EFPY since Unit 1 was felt to be approaching 10 EFPY and would transition to the more restrictive TS curves for 10-40 EFPY. During the current inspection, licensee representatives stated that the 10-12 EFPY curves were approved for use by engineering personnel for activities such as determining relief valve setpoints. The 10-12 EFPY curves were not submitted for NRC review and approval as were the TS curves. The in situ setpoints did not prevent transient pressures above the TS 10-40 EFPY curves but were intended to meet the less restrictive 10-12 EFPY curves not reviewed by the NRC.

Another concern involved the memo to the POSRC that accompanied the proposed 10-12 EFPY curves in that certain TS controlled parameters needed to change. Specifically, the maximum PORV setpoint that would provide adequate protection for the 12 EFPY cooldown curve was 400 psia (TS 3.4.3.a allows the PORV setpoint to go up to 450 psig). Also, the maximum differential temperature between the steam generator water and the reactor vessel water for an RCP start, when RCS temperature is below 275° F, to ensure adequate LTOP for the LEA is less than 30° F (TS 3.4.1.3 allows a maximum differential temperature limit of less than 46° F). These changes were made but no TS change was submitted.

Subsequently, on March 26, 1987, the licensee completed a thermal-hydraulic reanalysis to model RCS response to various LTOP transients. In this reanalysis, it was determined that significantly higher RCS pressures would occur as a result of various mass addition transients. These pressures would exceed the P-T limits for both the 0-10 EFPY P-T curves and the 10 - 40 EFPY P-T curves for significant portions of the RCS temperature range over which LTOP is required. These mass addition transient results are included in Table 3.

The licensee took no mitigating or corrective actions at the time of the reanalysis to address the potential inadequacy of in place LTOP measures. These concerns were raised in a later NRC inspection (IR 50-317/88-05; 50-318/88-06) which identified that reanalyzed LMA peak pressures were significantly higher than the design basis LTOP limits. The licensee again took no mitigating or corrective actions. Failure to implement corrective action in response to the reanalysis is a violation of 10 CFR 50 Appendix B Criterion XVI, "Corrective Action."

7. Precursor Event Not Addressed

During a Reactor Coolant System (RCS) heatup on June 25, 1988, an inadvertent RCS relief valve lift occurred. System pressure was about 390 psia (setpoint 400 psia +/- 16 psi) and temperature was about 303° F. This event was documented in Inspection Report 50-317/88-12; 50-318/88-12 which identified the cause of the event as licensed operator error. Operators were too focused on maintaining pressure above the minimum required to operate reactor coolant pumps and inadvertently allowed RCS pressure to rise to the relief setpoint.

The inspection report noted that the licensee had ongoing efforts to remove excessive P-T conservatisms to improve ease of plant maneuvering and to reduce the temperature at which the RCS relief valve setpoint is increased to its normal operating value (about 2400 psia) to below 330° F. At 300° F, the P-T limit for LTOP is about 900 psia during a heatup. At 330° F, which is the temperature where the relief valve setpoint was permitted to be changed, the P-T limit is 1200 psia during a heatup. In neither case would a setpoint of 2400 psia have afforded adequate over-pressure protection. The event, then, was a precursor reemphasizing the need for adequate LTOP. Followup inspection during the current period, however, was unable to identify any evidence that licensee corrective actions were responsive to this precursor event.

This event was a challenge to the LTOP system, which actuated automatically, as designed. No report was made to NRC regarding this event. Failure to submit a Special Report concerning this event within thirty days is an apparent violation of TS 3.4.9.3 action statement c.

8. NRC Holds Meeting With Licensee Due to LTOP Safety Concerns

Generic Letter (GL) 88-11, "NRC Position on Radiation Embrittlement of Reactor Vessel Materials and Its Impact on Plant Operations," was issued on July 12, 1988. The licensee conducted reanalysis of P-T limits and submitted a TS change request on October 26, 1989 in response to GL 88-11. The inspector reviewed the analyses and noted that the results were similar to the March 26, 1987 analysis results. That is, certain transients could result in unacceptably high RCS pressures (see Section 6).

Discussions with the licensee indicated that the 10-12 EFPY curves of P-T limits were being used for RCS relief valve setpoints. The inspector also noted that not all administrative controls were in place. At that time, the Unit 1 pressurizer manway was not installed, providing a large RCS vent such that no overpressure transient was possible. Unit 2 was defueled. The licensee stated that Unit 1 pressurizer manway reinstallation was imminent but agreed to first meet with the NRC to discuss LTOP concerns prior to its installation.

The licensee met with the NRC staff at the NRC:NRR offices on November 27, 1989. At that meeting, the licensee indicated an investigation was underway to determine why the originally committed administrative controls were not currently in place. This investigation was not expected to be completed until February, at the earliest. The licensee stated that two additional actions were being taken to ensure adequate Unit 1 brittle fracture protection. These actions were the lowering of the PORV lift pressure setpoint to 384.4 psia and the throttling of HPSI pump flow to a maximum of 350 gpm. One of the original LTOP administrative control requirements was for the HPSI header isolation valves to be physically locked shut. The licensee stated that the valves were administratively locked shut and that no single failure could cause the valves to open and defeat the HPSI flow throttle requirement.

Based upon the licensee's commitments and reevaluation of Unit 1 LTOP, the NRC staff agreed to the reinstallation of the Unit 1 pressurizer manway and the subsequent pressurization of the Unit 1 RCS. The licensee also committed to submit the documentation of LTOP adequacy prior to heating the Unit 1 RCS above 325° F, the PORV enable temperature. The Unit 1 pressurizer manway was installed on November 27, 1989.

9. Errors Identified in Licensee's Justification for Pressurizer Manway Installation

The inspector conducted an on-site verification of interim LTOP measures on November 28, 1989 and identified two additional deficiencies. The first deficiency, identified concurrently by the licensee, was that no such provision as "administratively locked shut" applied to the HPSI header isolation valves. Neither physical controls (such as locks), nor administrative controls (such as tags), were in place to prevent or restrain valve motion.

The second deficiency involved the identification, by the inspector, of a single failure scenario involving an unthrottled HPSI pump (LMA transient). The alternate boration path available to the operator involved using the HPSI pump which had its power supply breaker racked in and throttling HPSI flow to 350 gpm. The eight HPSI header isolation valves receive automatic full open signals during certain accident situations. Of the two possible initiating signals (low pressurizer pressure and high containment pressure), only one was blocked (low pressurizer pressure). The other signal (high containment pressure) was not blocked. An inadvertent or spurious high containment pressure signal initiated during HPSI use for boration would have caused all HPSI valves to leave the shut or throttled position and go full open. The same signal would also have started the HPSI pump which had the power supply breaker racked in if the pump was inadvertently removed from the "pull to lock" position.

The licensee acknowledged the inspector's concerns and placed the hand switches for the HPSI header isolation valves in the "pull to override" position. This position prevents any electronic signal from initiating automatic valve motion while allowing the operator to reposition the valve from the control board.

The errors identified in the licensee's justification for the reinstallation of the pressurizer manway are additional examples of weakness in the licensee's resolution of the LTOP issue.

10. Conclusion

The failure to meet original operating license LTOP commitments, to address reanalysis results showing LTOP deficiencies, and to address an LTOP precursor event, reduced the level of protection for a low temperature overpressure event. These failures represent apparent violations; details are found in the individual report sections.

11. Exit Meeting

An exit meeting was held on November 22, 1989. Attendees are listed in Attachment A.

ATTACHMENT A

Individuals Contacted During Inspection

Baltimore Gas and Electric Company

A. B. Anuje, Supervisor, Quality Audit Unit
*# T. L. Cook, Senior Engineer, Nuclear Engineering Unit
G. C. Creel, Vice President, Nuclear Energy
* P. T. Crinigan, General Supervisor, Chemistry
* C. H. Cruse, Manager, Nuclear Engineering Services Department
* R. E. Denton, Manager, Quality Assurance Department
*# D. S. Elkins, Senior Engineer, Nuclear Engineering Unit
* R. P. Heibel, General Supervisor, Quality Assurance
* J. R. Lemons, Manager, Nuclear Outage Management
*# W. J. Lippold, General Supervisor, Technical Services Engineering
*# B. S. Montgomery, Principal Engineer, Licensing
P. A. Pieringer, Supervisor, Independent Safety Evaluation Unit
* R. B. Pocha, Contract Employee Licensing
* L. B. Russell, Plant Manager
# J. E. Thorp, Senior Engineer
* J. O. Wood, Senior Auditor, Quality Assurance

Nuclear Regulatory Commission

*# J. E. Beall, Senior Resident Inspector
R. A. Capra, Director, Project Directorate I-1, NRR
C. Y. Cheng, Chief, EMTB, NRR
T. E. Collins, Section Chief, SRXB, NRR
B. J. Elliot, Senior Engineer, EMTB, NRR
M. A. Hunemuller, Operations Engineer, LPEB, NRR
R. C. Jones, Jr., Acting Chief, SRXB, NRR
C. Y. Liang, Senior Engineer, SRXB, NRR
E. Throm, Engineer, RES
P. N. Randall, Engineer, EMTB, NRR
D. F. Limroth, Project Engineer, Region I
*# S. A. McNeil, NRR Project Manager, Calvert Cliffs
V. L. Pritchett, Resident Inspector, Calvert Cliffs
J. T. Wiggins, Chief, Reactor Prohects Branch No. 1, Region I

* Denotes those present at the exit meeting on November 22, 1989.
# Denotes those present at the public meeting on November 27, 1989.

ATTACHMENT B

LTOP Chronology

November 30, 1976	Unit 2 OL (DPR-69) issued, contains license condition requiring permanent, NRC-approved LTOP system prior to startup from first refueling outage.
July 21, 1977	Licensee submits LTOP plan, containing a combination of administrative controls, hardware improvements, TS revisions and operator training.
August 7, 1978	NRC issues SER documenting completion of staff review of licensee submittal and removing LTOP Unit 2 license condition.
January 21, 1987	Licensee staff submits new P-T curves to site Plant Operations and Safety Review Committee (POSRC) for review and approval. The curves are for the Unit 1 reactor vessel for the period of up to 12 EFPY. The POSRC did not take issue with the proposed approach. No TS submittal is made and the curves are not NRC reviewed.
March 26, 1987	Licensee completes a reanalysis indicating that P-T limits could be substantially exceeded despite existing LTOP measures in certain mass addition transients.
May 11, 1988	NRC issues inspection report (50-317/88-05; 50-318/88-06) which identifies that the transition to the more restrictive 10-40 EFPY curves poses problems needing licensee resolution with respect to LTOP. The report also documents that some of the analysis results (see March 26, 1987 above) need to be addressed by the licensee.
June 28, 1988	Unit 1 PORV lifts at about 390 psia during an RCS heatup due to operator error which allowed pressure to drift high. The PORV setpoint was 400 psia (+/- 16 psi) as required for LTOP. This was a precursor event demonstrating the need for adequate LTOP.
July 12, 1988	NRC issues Generic Letter (GL) 88-11, "NRC Position on Radiation Embrittlement of Reactor Vessel Materials and Its Impact on Plant Operations." The GL provides new guidelines and requires reanalysis of P-T limits.
September 29, 1989	Licensee reanalysis in response to GL 88-11 again shows that P-T limits can be exceeded during certain mass addition transients. The results are similar to the March 26, 1987 reanalysis results.

October 26, 1989	Licensee submits TS amendment in response to GL 88-11.
November 27, 1989	The licensee meets with NRC staff to discuss status of LTOP corrective measures in response to the findings of the ongoing NRC inspection (50-317/89-31; 50-318/89-32). On the basis of the licensee's actions and commitments, the staff agrees to the reinstallation of the Unit 1 pressurizer manway.
November 28, 1989	Inspector identifies deficiencies in the licensee's corrective measures; namely, the valves to be used for manual throttling still have the capability to fully open automatically. HPSI pump use with full open valves is the major LTOP risk scenario. The licensee then placed the affected valves in "pull to override" to resolve the concern.

TABLE 1

Limiting Mass Addition Transient Administrative Controls

LTOP Controls	Design (7-21-87)	In Place (3-31-88)	In Place (11-22-89)
HPSI Pumps	≤320F: 1 Disabled* ≤220F: 2 Disabled ≤160F: All Disabled	<275F: 2 Disabled Third caution tagged with switch in pull-to-lock. Pump use permitted at all temperatures.	<300F: 2 Disabled Third caution tagged with switch in pull-to-lock. Pump use permitted at all temperatures.
HPSI Header Isolation Valves	RCS solid and <200F: valves locked shut	(Not Determined)	Valve position uncontrolled
Charging Pumps	RCS solid: Those not required are disabled. Only one normally required.	(Not Determined)	RCS solid and <200F: Two caution-tagged with switches in pull-to-lock.
ECCS Testing (RCS Solid)	Prohibited	Not Prohibited	Prohibited
Pressurizer Steam Volume	≥ 60% steam volume: precaution to minimize time with RCS solid	Same as design	Same as design

*Disabled by racking out master breaker, caution tagging and placing handswitch in pull-to-lock.

TABLE 2

Limiting Energy Addition Action Transient Administrative Controls

	Design (7-21-77)	In Place (3-31-88)	In Place (11-22-89)
Shutdown Cooling Initiation with steam generator temp >220 F.	Prohibited	Allowed	Allowed - limits on initiation if RCS pressure <270 psia or RCS temperature <300 F.
Reactor Coolant pump start with secondary to primary temp differential > 5° F (RCS Solid).	Prohibited	Not Determined	Prohibited - RCP start not allowed with RCS solid.
Pressurizer Heaters (RCS Solid)	Disabled and Tagged	Not Determined	Disabled and Tagged

TABLE 3

Limiting Mass Addition Transient Events Analyses

Transient	Design (7-21-77)	Reanalysis (3-26-87)	Reanalysis (9-29-89)	P-T Limit 0-10 EFPY	P-T Limit 10-40 EFPY
PORV Setpoint	460 psia	424 psia	390 psia	--	--
1 HPSI & 3 CCG Pumps (T = 160F) (RCS Solid)	540 psia	N/A	N/A	540 psia	300 psia
1 HPSI & 3 CCG Pumps (T = 100F) (RCS Solid)	N/A	740 psia	770 psia	380 psia	300 psia
1 HPSI & 3 CCG Pumps (T = 180F) (RCS Solid)	N/A	740 psia	770 psia	610 psia	300 psia
2 HPSI & 3 CCG Pumps (T = 220F) (RCS Solid)	870 psia	N/A	N/A	860 psia (7-21-77 submittal stated 870)	300 psia
2 HPSI & 3 CCG (T = 280F) (RCS bubble)	N/A	850 psia	N/A	1230 psia	360 psia