Georgia Power Company
333 Piedmont Avenue
Atlanta, Georgia 30308
Telephone 404 526-6526

Mailing Address:
Post Office Box 4545
Atlanta, Georgia 30302

Georgia Power
the southern electric system

L. T. Gucwa
Manager Nuclear Safety
and Licensing

SL-4343
0832m
X7GJ17-V310

March 31, 1988

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

PLANT VOGTLE - UNIT 1
NRC DOCKET 50-424
OPERATING LICENSE NPF-68
SPECIAL REPORT ON PRESSURE
LOCKING OF MOTOR OPERATED GATE VALVES

Gentlemen:

Georgia Power Company (GPC) is submitting a special report concerning pressure locking of two motor operated gate valves in the Residual Heat Removal System. This information is being submitted as a followup to the notification made by Emergency Notification System on February 3, 1988.

Sincerely,

William E. Burns /for

L. T. Gucwa

EMB/lm

Enclosure

c: Georgia Power Company
Mr. P. D. Rice
Mr. G. Bockhold, Jr.
GO-NORMS

U. S. Nuclear Regulatory Commission
Dr. J. N. Grace, Regional Administrator
Mr. J. B. Hopkins, Licensing Project Manager, NRR (2 copies)
Mr. J. F. Rogge, Senior Resident Inspector-Operations, Vogtle

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Georgia Power

ENCLOSURE

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SPECIAL REPORT ON PRESSURE LOCKING OF
MOTOR OPERATED GATE VALVES

SUMMARY

On January 28, 1988 Vogtle Unit 1 experienced failures of two motor operated gate valves within the Residual Heat Removal (RHR) System. These valves, 1HV-8716A and B, are the RHR crosstie valves and were being opened to perform surveillance procedure 14805-1, "Residual Heat Removal Pump and Checkvalve Test." Both valves failed to open due to overheating of their motor operators. Investigation revealed that the valves failed due to a "pressure locking" phenomenon similar to that described in INPO Significant Operating Experience Report 84-7, "Pressure Locking and Thermal Binding of Gate Valves."

In conjunction with Westinghouse, Georgia Power Company (GPC) conducted an evaluation of active valves at Plant Vogtle that could potentially be susceptible to pressure locking. This review identified only the two RHR crosstie valves (1HV-8716A and B) as susceptible. On February 3, 1988 GPC informed the NRC of these findings via the Emergency Notification System (ENS).

A design change for these valves (e.g., drilling a small drain hole in the higher pressure side of the valve disc) was then implemented to preclude pressure locking in the future. Following the modification, the valves were tested using Motor Operated Valve Acceptance Testing System (MOVATS) which indicated that the modification was successful in reducing the required opening thrust.

SEQUENCE OF EVENTS

On January 28, 1988 Plant Vogtle Unit 1 was operating in Mode 4 (hot shutdown), heating up in preparation for reactor startup. Surveillance procedure 14805-1, "Residual Heat Removal Pump and Check Valve Test", was in progress. At 2340 CST, the two RHR crosstie valves, which were in the closed position, were given open signals by a reactor operator. Neither valve responded and trouble alarms from the valve motor control centers were received. A plant equipment operator (PEO) was dispatched to investigate the cause of the alarms. At 2343 CST, fire alarms from both RHR pump rooms were received. The PEO dispatched to the pump rooms reported smoke in both rooms, prompting the dispatch of the Fire Brigade. It was determined that no fire existed, but that the smoke alarm actuation was caused by the failure of the motors for the RHR crosstie valves (1HV-8716A and B).

ENCLOSURE (Continued)

SPECIAL REPORT ON PRESSURE LOCKING OF
MOTOR OPERATED GATE VALVES

An event critique team was convened the next morning to investigate the failure of the motors. This team reviewed valve specification data, previous MOVATS test results, RHR system conditions, and surveillance procedures in use at the time of the event. A previous failure of valve 1HV-8716B (in October 1987) was also reevaluated.

Over the next several days, various failure mechanisms were identified and evaluated. Initially, the failures were considered to have been caused by high differential pressure across the valve discs. Dynamic MOVATS tests at increasing differential pressures were conducted. The test at high differential pressure (515 psid) indicated no binding, discounting the differential pressure failure mechanism. The investigation then centered on a pressure locking phenomenon.

On February 1, 1988 a test was conducted in which the valves were shut cold and then heated to approximately 220 degrees F (body temperature). This resulted in doubling of the thrust required to open the valves. The valves did open though, and on subsequent openings the measured thrust values were greatly reduced. These results indicated that pressure locking was occurring in the valves.

In conjunction with Westinghouse, GPC conducted an evaluation of active valves at Plant Vogtle that could potentially be susceptible to pressure locking. This review identified only the two RHR crosstie valves as susceptible. GPC informed the NRC of the results of this evaluation and the MOVATS testing on February 3, 1988 via the Emergency Notification System.

Both RHR crosstie valves were then modified by drilling a small drain hole into the disc facing the upstream (high pressure) side of each valve. This should preclude pressure locking by allowing any water trapped in the bonnet to drain back into the piping, thereby reducing the pressure buildup on the disc. Following modification, the valves were tested using MOVATS. These actions were complete and the plant resumed power operation on February 8, 1988.

PRESSURE LOCKING PHENOMENON

When a double disc gate valve is closed with the water system full, water can become trapped in the bonnet cavity and area between the discs. Usually, the trapped water leaks past the valve seat and does not significantly impact the operation of the valve. However, should the water remain trapped, the potential for pressure buildup between the discs occurs, causing increased drag between the discs and their seats.

Georgia Power

ENCLOSURE (Continued)

SPECIAL REPORT ON PRESSURE LOCKING OF
MOTOR OPERATED GATE VALVES

The RHR crosstie valves (1HV-8716A and B) were initially closed on January 24, 1988 during plant cooldown. During the outage, the valves were cycled open/closed for surveillance testing at approximately 110 degrees Fahrenheit (F). On January 28, 1988 in preparation for startup, the plant was heated to approximately 320 degrees F, and the attempt to open the valves was made. The valves failed at this time when the heating of the trapped water greatly increased the pressure on the valve discs and correspondingly increased the opening thrust required by the motor operators. Following replacement of the motor operators and prior to modification of the valve discs, dynamic MOVATS tests were conducted on the valves. The valves opened satisfactorily with up to 510 psid differential pressure at cold conditions (approximately 100 degrees F). However, shutting the valves cold and then heating to approximately 220 degrees F (valve body temperature) resulted in more than doubling the thrust required to open the valves. From this testing it was concluded that the pressure buildup at the RHR system temperature of 320 degrees F resulted in the valve failures.

IDENTIFICATION OF VALVES SUSCEPTIBLE TO PRESSURE LOCKING

In conjunction with Westinghouse, GPC conducted an evaluation of active valves at Plant Vogtle that could potentially be susceptible to pressure locking. While this phenomenon is generally associated with gate valves, all valves identified as having the potential for being closed in a cold condition, being heated, and then being required to open in order to perform a safety function were considered. Most of the valves identified were gate valves; however, a number of solenoid valves were also evaluated. Valves in the following systems were evaluated:

- Reactor Coolant System
- Chemical and Volume Control System
- Emergency Core Cooling System
- Residual Heat Removal System
- Containment Spray System
- Steam Generator Blowdown Processing System
- Liquid Waste Processing System

Piping isometric drawings were then reviewed to determine proximity to and intensity of heat sources and the spatial relationship of the valves to those sources (e.g., locations above or below). Heating due to elevated containment temperatures in a post accident environment was also considered. From this evaluation, it was concluded that the RHR crosstie valves (1HV-8716A and B) are unique with respect to the combination of interrelated factors such that common mode failure of safety related valves in other applications is not expected to occur as a result of pressure locking.

Each RHR crosstie valve is in close proximity to its respective RHR heat exchanger outlet pipe (approximately five feet) and almost directly above it. Thus, the potential for heating the valve by convection exists.

This hypothesis is supported by the tests which were performed at approximately 220 degrees F (valve body temperature) after heating from a cold condition. The tests indicated extremely high thrust for the first stroking. Repeated strokings measured normal thrust readings. It is postulated that the first stroking allowed pressure equalization between the valve discs and body such that seating forces during later stroking were reduced. It must be emphasized that the valve did open at 220 degrees F with no damage to the motor during the first stroking.

CONSEQUENCES ANALYSIS

Although the RHR crosstie valves have been subsequently modified to preclude pressure locking, the possibility was considered that similar pressure locking could have occurred during an accident situation (LOCA) before the modification was implemented.

These valves are normally open during the safety injection phase of system operation following a LOCA. Procedure 19013-1, "ES-1.3 Transfer to Cold Leg Recirculation," calls for both valves to be closed remotely from the control room during the switchover from cold leg injection to cold leg recirculation. Pressure locking for this phase of operation is not a concern since the valves are initially open. At least one of the valves must be closed during cold leg recirculation in order to prevent a passive failure from disabling both trains of low head safety injection (LHSI). Another important reason is that, with the crosstie header open, the stoppage of one LHSI pump could result in excessive runout of the remaining LHSI pump and possibly inadequate NPSH for the high head safety injection (HHSI) pumps and charging pumps. This concern exists because the remaining LHSI pump could be supplying four cold legs in addition to two HHSI pumps and two charging pumps. Cold leg recirculation can be initiated as early as 20 minutes into a major LOCA.

ENCLOSURE (Continued)

SPECIAL REPORT ON PRESSURE LOCKING OF
MOTOR OPERATED GATE VALVES

Due to the proximity of the crosstie valves to the RHR heat exchanger outlet lines, it appears that these valves could be heated from the cold condition to a hot condition during cold leg recirculation such that pressure locking could occur at 16 hours when a valve is re-opened for hot leg recirculation. However, the degree of heating is not a concern for the following reasons.

When cold leg recirculation is initiated, the sump water temperature could be as high as 250 degrees F. This temperature would be reduced to approximately 183 degrees F by cooling in the RHR heat exchanger. By 16 hours, the sump water temperature is reduced to approximately 150 degrees F. After cooling in the RHR heat exchanger, the fluid temperature would be further reduced to approximately 135 degrees F. Because of the long period between initiation of cold leg recirculation and hot leg recirculation (e.g., 15 hours or longer), the valve body temperatures would be in the range of 135 degrees F to 150 degrees F.

These valves were successfully operated, as part of a test conducted in the investigation of this event, with a body temperature of approximately 220 degrees F. Since this test temperature bounds the expected valve body temperature in the post LOCA environment described above, these test results support the postulation that the valves would not have failed to re-open as a result of pressure locking during the re-alignment for hot leg recirculation. This discussion notwithstanding, the necessity of this function is discussed below.

At 16 hours, procedure 19014-1, "ES-1.4 Transfer to Hot Leg Recirculation," calls for one of the crosstie valves to be opened in order to switch to hot leg recirculation. Ideally, one LHSI pump should be able to deliver flow directly to two hot legs via its respective crosstie valves and valve 1HV-8840 if reactor coolant system pressure permits.

The switchover from cold leg recirculation to hot leg injection is made in order to ensure that boron does not concentrate in the reactor vessel/core to unduly high levels and block passages in the fuel with precipitate. This could occur by boiling in the reactor vessel during cold leg recirculation for a cold leg break. Switching to hot leg recirculation will flush the high boron concentration liquid from the vessel/core via the ruptured cold leg.

Georgia Power

ENCLOSURE (Continued)

SPECIAL REPORT ON PRESSURE LOCKING OF
MOTOR OPERATED GATE VALVES

The requirements for core cooling (i.e., make up for core boiloff) and prevention of boron precipitation are satisfied by one HHSI pump delivering to two hot legs, in conjunction with flow from one charging pump delivering to four cold legs. Direct injection to the hot legs through valve 1HV-8840 from the LHSI pump is desired only to maximize the effectiveness of the emergency core cooling system for a large break LOCA.

Also considered has been the possibility of returning to cold leg recirculation approximately six hours after initiating hot leg recirculation. This requires closing either valve 1HV-8840 or the open crosstie valve. In either case, the pressure locking phenomenon is not postulated to occur when a valve is initially open because of the clearance between the wedge and the bonnet in the open position.

VALVE MODIFICATION

Both RHR crosstie valves have been modified to prerlude pressure locking. A small drain hole was drilled into the disc facing the upstream (high pressure) side of each valve. This hole allows any water trapped in the bonnet and between the discs to drain back into the piping, thereby reducing the pressure buildup on the discs.

Following modification, both valves were statically tested and one dynamically tested using MOVATS. Measurements taken following heating of the valves indicated that the modification was successful in reducing the required opening thrust.