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WATTS BAR NUCLEAR PLANT
RESPONSE TO NRC BULLETIN 88-08

Prepared by

Roy Uffer

Aptech Engineering Services, Inc.
Post Office Box 3440
Sunnyvale, California 94089-3440

Prepared for

Tennessee Valley Authority
Watts Bar Nuclear Plant
Route 60, Near Spring City
Watts Bar Dam, Tennessee 37395

Attention: Mr. Wayne Smathers

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APTECH ENGINEERING SERVICES, INC.
1282 REAMWOOD AVENUE ☐ SUNNYVALE ☐ CA 94089
POST OFFICE BOX 3440 ☐ SUNNYVALE ☐ CA 94088-3440 ☐ (408) 745-7000 ☐ FAX (408) 734-0445
OFFICES ☐ UPPER MARLBORO, MD ☐ (301) 599-2301 ☐ HOUSTON, TX ☐ (713) 558-3200
CHATTANOOGA, TN ☐ (615) 499-3777 ☐ GASTONIA, NC ☐ (704) 865-6318

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Prepared by	R. A. [signature] Preparer	2 MAR 94 Date
Approved by	[signature] Project Manager	3/2/94 Date
Verified by	[signature] for Clayton P Lee Verifier	3/2/94 Date
Quality Assurance	[signature] Quality Assurance Engineer	3/2/94 Date
Quality Assurance	[signature] Quality Assurance Manager	3/2/94 Date

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EXECUTIVE SUMMARY

This report presents the results of analyses and evaluations performed to develop the Watts Bar Nuclear Plant response to United States Nuclear Regulatory Commission (NRC) Bulletin 88-08 (1). Bulletin 88-08 requested that licensees address valve leakage caused thermal stratification or cycling in unisolable lines attached to the Reactor Coolant System (RCS).

The identification of susceptible lines was performed in three steps. First, the RCS flow diagram was reviewed to identify all lines that were attached to the RCS.

The operating conditions of each line attached to the RCS were reviewed, using information from system descriptions and flow diagrams, to determine if the unisolable portion of the line was generically susceptible to the scenarios identified in Bulletin 88-08. The review of operating conditions indicated that the lines listed below required further evaluation.

- Auxiliary Pressurizer (PZR) spray line
- Normal charging line
- Alternate charging line
- Four 1½-inch Safety Injection (SI) lines attached to the RCS loops

The geometry of each line identified as being generically susceptible to thermal stratification or cycling was reviewed to determine if the line was susceptible to valve leakage caused thermal stratification or cycling. Lines with a higher pressure source of inleakage were considered not to be susceptible to thermal stratification if their check valves were located more than 25 diameters from the RCS hot or cold legs in accordance with NRC evaluation criteria provided in Ref. (2).

Additionally, the 14-inch Residual Heat Removal (RHR) line was evaluated to determine if it was geometrically susceptible to the outleakage scenario addressed in Supplement 3 to NRC Bulletin 88-08.

The detailed geometric evaluation showed the following:

- Initially, the 1½-inch SI lines to Loops 1 and 2 of the Unit 1 RCS and to Loop 1 of the Unit 2 RCS required either additional analysis or modification.
- The auxiliary Pressurizer spray line check valve is located outside of the normal Pressurizer Spray Line turbulent penetration zone and is not susceptible to thermal stratification or cycling.
- The closest check valves of all other lines subject to inleakage were more than 25 diameters from the RCS and in accordance with the criteria provided by the NRC in Ref. (2) do not have to be evaluated for valve leakage caused thermal stratification.
- The RHR supply line isolation valves are within the RCS turbulent penetration zone and are, therefore, not subject to the valve outleakage caused thermal stratification scenario that was postulated in Supplement 3 to Bulletin 88-08.

Four options, discussed in Section 6, were considered to ensure that the 1½-inch SI lines were not susceptible to excessive thermal stresses caused by postulated valve leakage.

It was decided to move the Unit 1 SI check valves to locations more than 25 diameters from the RCS. This option was selected because it would ensure that the lines were in compliance with the NRC guidelines for evaluating conformance to Bulletin 88-08.

One of the four options discussed in Section 6 will be implemented for Unit 2 before the unit reaches initial criticality.

Section 1
INTRODUCTION

This report provides supporting documentation for the Watts Bar Nuclear Plant response to Nuclear Regulatory Commission (NRC) Bulletin 88-08 (1). The work reported herein was performed by Aptech Engineering Services, Inc. (APTECH) for the Tennessee Valley Authority (TVA) under TVA Contract TV84208V, Task T1062-3955581 (3).

Nuclear Regulatory Commission Bulletin 88-08 addresses thermal stratification related stresses caused by postulated valve leakage to or from unisolable segments of piping attached to the Reactor Coolant System (RCS). The development of a response to Bulletin 88-08 was performed in two phases.

The first phase of the response development identified all lines attached to the Watts Bar Nuclear Plant RCS and determined which of those lines might be susceptible to thermal stresses caused by valve leakage. The second phase provided a detailed evaluation of the lines that might be susceptible to stresses caused by thermal stratification or cycling and developed corrective actions to preclude the occurrence of the phenomena.

Section 2 provides the background for Bulletin 88-08. The supporting documents for the responses are identified in Section 3. The methodologies used in developing the responses are described in Section 4. The results of the screening evaluations are presented in Section 5. Various options considered are discussed in Section 6. Conclusions are provided in Section 7. References are provided in Section 8.

Section 2
BACKGROUND

In December of 1987, a leak, due to a through-wall crack, occurred at the Farley Plant, Unit 2, in an Emergency Core Cooling System (ECCS) pipe connected to the RCS. It was determined that the crack resulted from high-cycle thermal failure that was caused by relatively cold water leaking through a normally closed globe valve isolating high pressure Charging Pump discharge piping from the RCS. The leakage flow then caused a swing disk check valve in the 6-inch ECCS line to open and close in a cyclic manner. The resulting flow conditions caused large fluctuating radial thermal gradients in the piping just beyond the check valve in the unisolable 6-inch ECCS piping attached to the RCS (1).

As a result of this failure, the NRC requested (1) that a review of systems connected to the RCS be performed by all holders of operating licenses and construction permits for Light Water Reactors to determine whether unisolable sections of piping connected to the RCS can be subjected to excessive stresses from thermal stratification or oscillations that could be induced by leaking valves.

The initial issue of NRC Bulletin 88-08, and its first two supplements, addressed inleakage of cold water into the RCS from sources at a higher pressure than the RCS. On June 6, 1988, a leak was detected in a foreign reactor that was caused by intermittent outleakage of RCS water through a closed Residual Heat Removal (RHR) isolation valve. As a result of this event, the NRC issued Supplement 3 of Bulletin 88-08 which requested that licensees also address thermal stratification and cycling caused by outleakage through unisolable lines (1).

The NRC provided the following evaluation criteria (2) to identify piping with a high pressure source that is susceptible to cyclic thermal stratification.

"Sections of injection piping systems, regardless of pipe size, which are normally stagnant and have the following characteristics:

1. The pressure is higher than the RCS pressure during reactor power operation.

2. The piping sections contain long horizontal runs.

3. The piping systems are isolated by one or more check valves and a closed isolation valve in series.

4. For sections connected to the RCS:

   a. Water injection is top or side entry.

   b. The first upstream check valve is located less than 25 pipe diameters from the RCS nozzle."

The NRC provided the following evaluation criteria (2) to identify piping with a low pressure sink that is susceptible to cyclic thermal stratification caused by valve leakage.

"Sections of other piping systems connected to the RCS, regardless of pipe size, which are normally stagnant and have the following characteristics:

1. The downstream pressure is lower than RCS pressure during reactor power operation.

2. The piping systems are isolated by a closed isolation valve, or a check valve in series with a closed isolation valve.

3. There is potential for external leakage from the isolation valve."

Section 3
SUPPORTING DOCUMENTS

Key supporting documents for the analyses reported, herein, are identified as follows:

1. The scenarios to be evaluated are defined by NRC Bulletin 88-08, including Supplements 1 through 3 (1).

2. Additional criteria for evaluating the scenarios defined in Ref. (1) are provided by Refs. (2 and 4).

3. The lines attached to the RCS are defined by the Watts Bar Nuclear Plant flow diagrams (5).

4. The geometric configuration of lines are defined by Watts Bar Nuclear Plant isometric drawings (6a through 6o) and component drawings (7, 8, 9).

   4.1 Design Change Notice M-27585 including DCA's M-27585-39 (6d) and M-27585-41 (6e) which document the new locations of Check Valves 1-63-586 and 1-63-587 for the 1½-inch SI lines attached to Unit 1 RCS Loops 1 and 2.

   4.2 The locations of Check Valves 1-63-586 and 1-63-587 for the 1½-inch SI lines attached to Unit 1 RCS Loops 1 and 2 prior to modification are defined by Refs. (6p and 6q).

5. System operating parameters are defined by the Watts Bar Nuclear Plant system descriptions (10).

6. Residual heat removal valve operation is defined by Refs. (11 and 12).

Section 4
METHODOLOGY

4.1 PHASE I IDENTIFICATION OF SUSCEPTIBLE LINES

The identification of susceptible lines (13) was performed in three steps. First, the RCS flow diagram (5a) was reviewed to identify all lines that were attached to the RCS.

The operating conditions of each line attached to the RCS were reviewed, using information from system descriptions and flow diagrams, to determine if the unisolable portion of the line was generically susceptible to the scenarios identified in Ref. (1).

The geometry of each line identified as being generically susceptible to thermal stratification or cycling was reviewed to determine if it was geometrically susceptible to valve leakage caused thermal stratification or cycling. Lines with a higher pressure source of inleakage were considered not susceptible to thermal stratification if their check valves were located more than 25 pipe diameters from the RCS (2). Lines with a low pressure sink for outleakage were not considered susceptible to thermal stratification if their isolation valves were in locations that are essentially always at RCS temperature.

4.2 PHASE II EVALUATIONS

4.2.1 Fatigue Evaluations

Bounding fatigue evaluations were performed to determine whether modifications would be required for unisolable sections of piping connected to the RCS. The evaluations were limited to the 1½-inch SI lines determined to be potentially susceptible to valve leakage induced temperature stratification or oscillations.

Two types of analyses were performed. One analysis (14) provided a conservative bounding limit on the number of thermal cycles that could occur. The other analysis (15) determined the number of thermal cycles that would result in a usage factor of unity, based on the most conservative thermal conditions that could occur.

4.2.2 Maximum Possible Thermal Cycles

The maximum number of thermal cycles that could occur, based solely on hydraulic conditions, was calculated by determining the maximum number of times a check valve would open due to pressure build-up from a leaking block valve during an 18-month fuel cycle. The analysis considered the maximum flow rate under which stratification could exist and the change in pressure of a fixed volume of water due to inleakage of water.. Details of the analysis are provided in Ref. (14).

4.2.3 Allowable Number of Fatigue Cycles

A bounding calculation of the number of thermal cycles that would cause a usage factor of unity was performed and is documented in Ref. (15).

The analysis calculated thermal stress in a cylinder conservatively assumed the temperature gradient to be the difference between the incoming fluid, assumed to be 100°F and the RCS cold leg temperature of 559°F.

The allowable number of stress reversals (cycles) for the calculated stress was calculated from the ASME Design Fatigue Curve for austenitic steels (16), corrected for the elastic modulus of the piping material.

Section 5
SUSCEPTIBILITY DETERMINATION

5.1 LINES ATTACHED TO THE RCS

Table 5-1 provides a list of all lines attached to the RCS (13).

5.2 SUSCEPTIBILITY OF LINES

Additional details of these evaluations are contained in Ref. (13).

5.2.1 Vent and Drain Lines

Vent and drain lines contain normally closed, manually operated globe valves and are not susceptible to the outleakage scenario described in Supplement 3 to Bulletin 88-08.

5.2.2 Sampling Lines

Sampling lines are normally open lines. Therefore, they are not susceptible to either of the scenarios described in Bulletin 88-08.

5.2.3 Instrumentation Lines

Instrumentation lines are normally open lines with no external pressure source or sink other than the RCS. Therefore, they are not susceptible to either of the scenarios described in Bulletin 88-08.

5.2.4 Pressurizer Relief Valve Lines

The Pressurizer (PZR) safety relief valve supply lines exhaust to a lower pressure than the RCS and thus are not susceptible to the inleakage scenario of Bulletin 88-08. The lines are attached to the PZR vapor space and drain back to the PZR. Thus, these lines are not susceptible to the outleakage scenario of Supplement 3 to Bulletin 88-08, because the valves are not susceptible to the thermal cycling of the gate valve cited in Bulletin 88-08 and because there is no horizontal liquid filled line in which stratification can occur.

The lines supplying the power operated relief valves (PORV) may be isolated from the PZR by normally open Valves FCV 68-332 and FCV 68-333. Therefore, no unisolable portions of these lines can be subjected to the scenarios of Bulletin 88-08.

5.2.5 Pressurizer Spray Line

The normal PZR spray line has normally open bypass valves that allow a small continuous flow and is, therefore, not susceptible to either of the scenarios of Bulletin 88-08.

5.2.6 Auxiliary Pressurizer Spray Line

The auxiliary Pressurizer spray line is normally isolated from the pressurizer spray line by a check valve and isolation valve and has a source pressure higher than the RCS. Geometric specific evaluation determined that the auxiliary spray line is not susceptible to the inleakage scenario of Bulletin 88-08, because its check valve is located outside of the normal Pressurizer spray line turbulent penetration zone.

5.2.7 3-Inch Lines from RHX

Loop 1. This is the normal charging line and it normally supplies flow to the RCS. However, the use of the normal and alternate charging line will be alternated. Therefore, there will be extensive periods of time when the normal charging line is in the idle mode. Geometric specific evaluations determined that this line is not susceptible to valve leakage induced thermal stratification because its check valve is located more than 25 diameters from the RCS.

Loop 4. This is the alternate charging line. It is normally isolated from the RCS, and has a source pressure higher than the RCS. Geometric specific evaluation determined that the alternate charging line is not susceptible to valve leakage induced thermal stratification because its check valve is located more than 25 diameters from the RCS.

5.2.8 3-Inch Line to RHX

This is the normal letdown line and it normally removes flow from the RCS. Because the line is normally flowing, it is not susceptible to either of the scenarios of Bulletin 88-08.

5.2.9 1-Inch Line to Excess Letdown Heat Exchanger

This is the excess letdown line. The line is normally isolated from the RCS and discharges to the Excess Letdown Heat Exchanger. Because the line flows to a lower pressure source than the RCS, it is not susceptible to the inleakage scenario of Bulletin 88-08. The isolation valve closest to the RCS, Valve FCV 62-54 is an air operated globe valve. The air operator assembly always exerts a closing force on the valve disc when the valve is closed. Thus, the disc of the valve will not cyclically open and close in response to temperature changes and is not susceptible to the cyclic leakage scenario described in Supplement 3 of Bulletin 88-08.

5.2.10 10-Inch SI Lines from Accumulators

The 10-inch lines from the accumulators are supplied by a lower pressure source than the RCS and contain no normally closed valves other than check valves. Therefore, they are not susceptible to either of the scenarios of Bulletin 88-08.

5.2.11 6-Inch SI and RHR Pump Discharge Lines to 10-Inch Accumulator Lines

All portions of the SI and RHR lines to the 10-inch accumulator lines are isolable by the accumulator line check valves and are not susceptible to either of the scenarios of Bulletin 88-08. They are not connected to source pressures greater than the RCS. Their supply lines contain relief valves with set points lower than the RCS pressure. Therefore, these lines cannot cause the inleakage scenario of Bulletin 88-08 to occur in the accumulator lines.

5.2.12 1½-Inch Lines from BIT

These lines have a normally isolated source pressure higher than the RCS. Geometric specific evaluation has determined the following:

- The closest check valves in the SI lines to all RCS loops of Unit 1 and to RCS Loops 2, 3, and 4 of Unit 2 are located more than 25 pipe diameters from the RCS and are, thus, not susceptible to the inleakage scenarios of Bulletin 88-08.
- The check valves for the SI lines to RCS Loops 1 and 2 of Unit 1 were originally located less than 25 pipe diameters from the RCS (6p and 6q). These valves have been relocated to positions more than 25 pipe diameters from the RCS (6d and 6e) and thus are not susceptible to the inleakage scenario of Bulletin 88-08. Note that the calculations contained in Ref. (13) are based on the modified locations of these valves.
- The check valve for the SI line to SI Loop 1 of Unit 2 is located less than 25 pipe diameters from the RCS. This line might be susceptible to excessive thermal stresses caused by postulated valve inleakage. Options to address the concerns of Bulletin 88-08 are discussed in Section 6.

5.2.13 14-Inch RHR Supply Line

This line is normally isolated from the RCS and flows to a pressure sink lower than the RCS. Isolation Valves FCV 74-1 and 9 are closed by torque setting. Therefore, they will be closed whether the valve disc is cold or hot. Because the torque settings maintain the valves in closed positions, the discs of the valves will [illegible] cyclically open and close in response to temperature changes. Therefore, the RHR supply line is not susceptible to the scenario of cyclic leakage postulated in Supplement 3 of Bulletin 88-08. Additionally, the RHR valves are located within the

RCS turbulent penetration zone, which is essentially at RCS temperature. Thus, there are no pockets of cold water at the discs to be heated by postulated RCS leakage. Therefore, the RHR valves are not susceptible to the outleakage damage scenario due to their locations.

5.2.14 6-Inch RHR/SI Pump Discharge Lines to Hot Legs

(Note: The line to Loop 4 is connected to the 14-inch RHR line) The 6-inch RHR/SI pump discharge lines are normally stagnant. They have potential high pressure leak sources from ¾-inch lines containing Valve FCV 63-156, Valve FCV 63-167, and Valve FCV 63-21. A minimum of three normally closed valves in series (e.g., Valves FCV 63-156, 63-24, and 63-25) must leak to pressurize these lines. Therefore, the inleakage scenario of Bulletin 88-08 is not considered to be a credible scenario for these lines.

The lines are connected to the RHR system which is at a lower pressure than the RCS. Each line contains two check valves in series and are isolated by normally closed block valves. Outleakage requires that three valves in series must leak. Therefore, the outleakage scenario of Supplement 3 to Bulletin 88-08 is not considered to be credible for these lines.

5.3 THERMAL FATIGUE EVALUATIONS

Bounding cycling and fatigue evaluations (14 and 15) predict that should stratification occur in the SI BIT lines, their usage factor would exceed unity in less than one fuel cycle. Therefore, either more detailed analyses, modification, or monitoring are required to ensure that valve leakage caused thermal stratification or cycling could not result in unacceptable damage to unisolable piping attached to the RCS.

Table 5-1

LINES CONNECTED TO THE REACTOR COOLANT SYSTEM

Description	System	Quantity	Leak Path[1]	Disposition[2]
Vent and Drain Lines	RCS[3]	Several	Out	5.2.1
Sampling Lines	RCS[3]	Several	Out	5.2.2
Instrumentation Lines	RCS[3]	Several	None	5.2.3
6-Inch Pressurizer Relief Valve Lines	RCS[3]	3	Out	5.2.4
6-Inch and 4-Inch Pressurizer Spray Line	CVCS	1	In	5.2.5
3-Inch Auxiliary Pressurizer Spray Line (Unit 1)	CVCS	1	In	5.2.6
2-Inch Auxiliary Pressurizer Spray Line (Unit 2)	CVCS	1	In	5.2.6
3-Inch Charging Lines from Regenerative Heat Exchanger	CVCS	2	In	5.2.7
3-Inch Letdown Line to Regenerative Heat Exchanger	CVCS	1	Out	5.2.8
1-Inch Line to Excess Letdown Heat Exchanger	CVCS	1	Out	5.2.9
10-Inch Lines from Accumulators	SI	4	Out	5.2.10
6-Inch SI/RHR Pump Discharge Lines to Accumulator Lines	SI/RHR	4	Out	5.2.11
1½-Inch SI Lines from BIT	SI	4	In	5.2.12
14-Inch RHR Supply Line	RHR	1	Out	5.2.13
6-Inch SI Line to 14-Inch RHR Line	SI	1	In/Out	5.2.14
6-Inch SI/RHR Pump Discharge Lines to Hot Legs	SI/RHR	3	In/Out	5.2.14

[1]In denotes that the potential leakage path is into RCS. Out denotes that the potential leakage path is out of RCS.

[2]This column lists subsection providing a discussion of the results of the susceptibility evaluation.

[3]Although these lines are par the RCS they were included in the evaluation for completeness because they are attached to the Reactor olant L ps and/or a pressure sink different than the RCS.

Section 6
OPTIONS

During the development of the Watts Bar Response to Bulletin 88-08, the performance of several analyses and plant modifications were evaluated as potential responses.

A design modification to implement one of the potential responses, i.e., relocation of check valves (Subsection 6.2), has been prepared by TVA (6d, 6e) for the Unit 1, Loops 1 and 2, SI BIT lines.

This section discusses the options considered as responses to Bulletin 88-08 (1).

6.1 ADDITIONAL ANALYSIS

6.1.1 Perform Additional Fatigue Evaluations

The results of the bounding thermal fatigue evaluations (14, 15), discussed in Subsection 5.3, indicated that the maximum postulable thermal cycles (14) are in excess of the maximum allowable thermal cycles (15). Based on engineering judgement, it is believed that a dynamic analysis of the check valves could reduce the maximum postulable cycles. Also based on engineering judgement, it is believed that more sophisticated fatigue analyses, which included calculations of the piping thermal transient, could significantly increase the allowable thermal cycles.

However, it is highly unlikely that performing more sophisticated fatigue analyses would result in a thermal fatigue usage factor less than unity for a single refueling cycle. Therefore, the performance of additional fatigue analyses is not recommended, because of the low likelihood of its success.

6.1.2 Fluid Mixing Analyses

The Watts Bar Nuclear Plant SI BIT check valves are Kerotest 1½-inch Y-type check valves as shown in Figure 6-1 (17). The check valve at the Farley Plant, that initiated the issuance of Bulletin 88-08, is a swing check valve (18) similar to that shown in Figure 6-2. The flow patterns through these valves are very different from each other.

In a slightly open swing check valve, the flow travels over the disk seat on the bottom of the valve and flows along the bottom of the valve. Because the colder leaking fluid is more dense than the existing hot fluid, stratification can occur.

In a partially open Y-type check valve, leak flow will travel in an upward direction in the small annular gap between the disk and the seat. Most of the flow will enter the downstream section of the valve above its center line. The heavier leak flow will have to pass through the warmer existing flow to settle at the bottom. It is expected that considerable mixing and heat transfer will occur during this settling process. It is possible that it can be shown that no significant thermal stratification will occur due to flow leakage.

6.2 RELOCATE VALVES

Reference (2) requires consideration of thermal stratification or cycling for lines with a high pressure source only if "the first upstream check valve is located less than 25 diameters from the RCS nozzle." Relocating the check valves to locations more than 25 diameters (33.5 inches) from the RCS lines will remove the 1½-inch SI BIT lines from consideration of thermal stratification or cycling.

6.3 CHANGE VALVE SPRINGS

The check valves on the existing BIT lines to Unit 1, RCS Loops 1 and 2 (as originally located), and Unit 2, Loop 1, are less than 25 diameters from the RCS loop. Therefore, it is desirable to eliminate the potential for leak flow in the Unit 1, Loops 1 and 2, and the Unit 2, Loop 1, BIT line check valves. The check valves in the BIT lines to Unit 1, RCS Loops 3 and 4, and Unit 2, Loops 2, 3, and 4, are located more than 25 diameters from the RCS loop and do not have to be evaluated for valve leakage induced thermal stratification and cycling. All four check valves are connected in parallel to the same leak source and are at the same elevation. Thus, the pressure at the disk of each valve will be identical. The opening pressures of the check valves are 2.0 to 2.5 psid and are controlled by springs (19), shown as Item 6 in Figure 6-1.

A potential solution for Unit 1 is to replace the valve springs (Item 6 on Figure 6-1) so that Loops 1 and 2 valves have cracking pressures at least 2.0 psi greater than, but no more than 4.0 psi greater than the cracking pressures of the Loops 3 and 4 valves. The cracking pressure differential must account for tolerances in the valves and the springs and calculational inaccuracies. Springs of different stiffnesses can be readily installed in the valves. If the springs in the valves in the lines supplying Unit 1, Loops 1 and 2, were replaced with stiffer springs, leakage caused pressure increases would always be relieved through Loops 3 and 4 and not through Loops 1 and 2. A small difference in valve cracking pressure, such as 2 to 4 psi would preclude leakage flow through the check valves to Loops 1 and 2 and still permit normal operation of the valves when the SI system was activated. A similar solution for Unit 2 would only involve replacing the valve spring in the Loop 1 valve. The Loops 1 and 2 valves will be operating at 559°F environment. The Loops 3 and 4 valves will be operating in a 100°F environment.

Calculations (14) have shown that the effects of forward leakage through the closed check valves will be insignificant.

6.4 SAFETY INJECTION RECIRCULATION LINE

The flow of cold water into unisolable portions of the SI BIT lines cannot occur unless the lines upstream of the check valves are pressurized above the RCS operating pressure (2250 psia). The modification, discussed below, would prevent pressurization of these lines.

A small recirculation line could be added to connect a point downstream of the BIT isolation valves, FCV 63-25 and 63-26, to the Charging Pump suction header. Thus, any leak flow through the BIT isolation valves would be returned to the Charging Pump suction header. This design would prevent leak flow from pressurizing the SI lines upstream of the isolation check valves. Two options of this modification are discussed below.

The first option, shown in Figure 6-3a, is totally passive and is the least expensive one to implement. The recirculation line would be sized to be large enough to accommodate the maximum postulated leak flow rate, but would still limit recirculation flow rate sufficiently to permit the SI to perform its function, when required. Analyses will be required to appropriately size the line.

The second option, shown in Figure 6-3b, would include two normally open, fail closed solenoid valves in the recirculation line. The valves would close on a Safety Injection Actuation Signal (SIAS). Each valve would be powered and actuated by a different safety train. This option would be more expensive than the passive option, but would allow the recirculation line to accommodate a larger leak flow rate and would have no impact on the SI system operation or capacity.

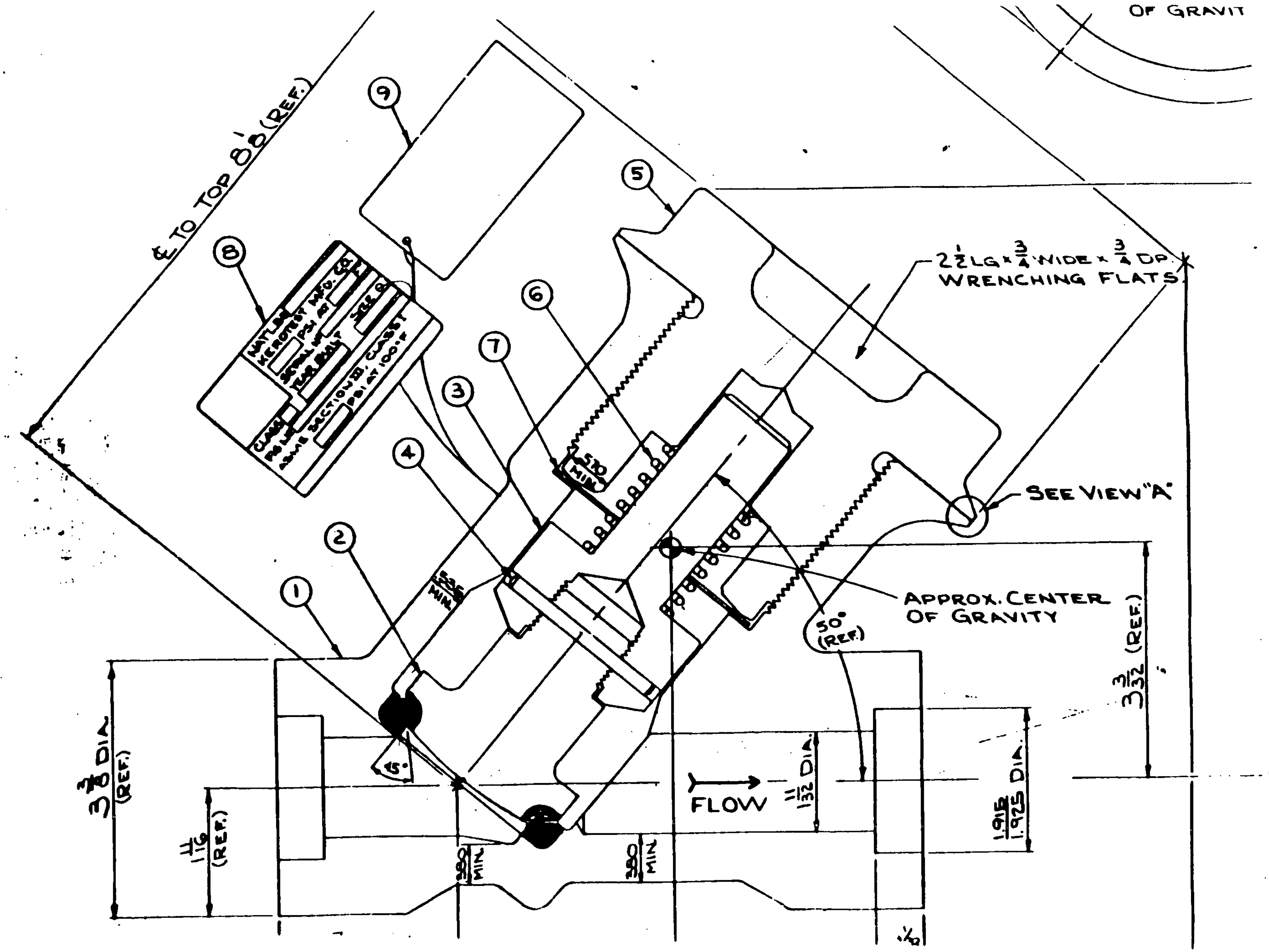

Figure 6-1 — Boron Injection Tank Line Check Valve.

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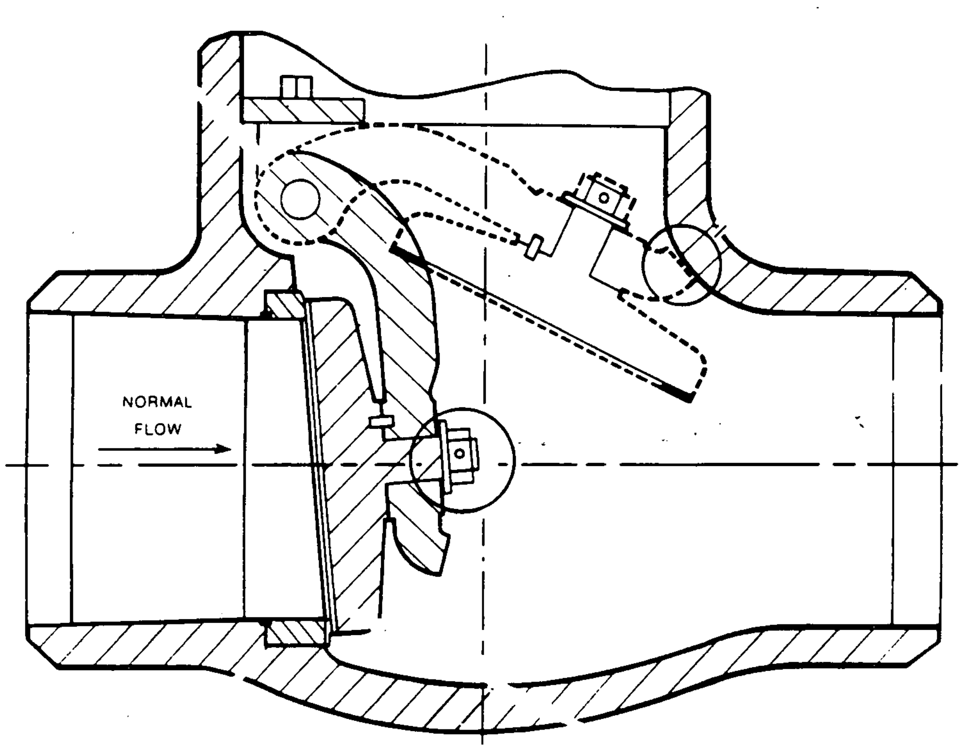
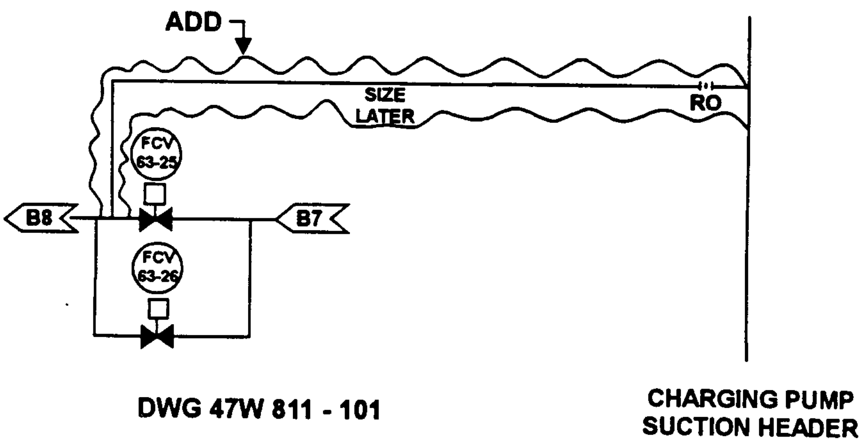


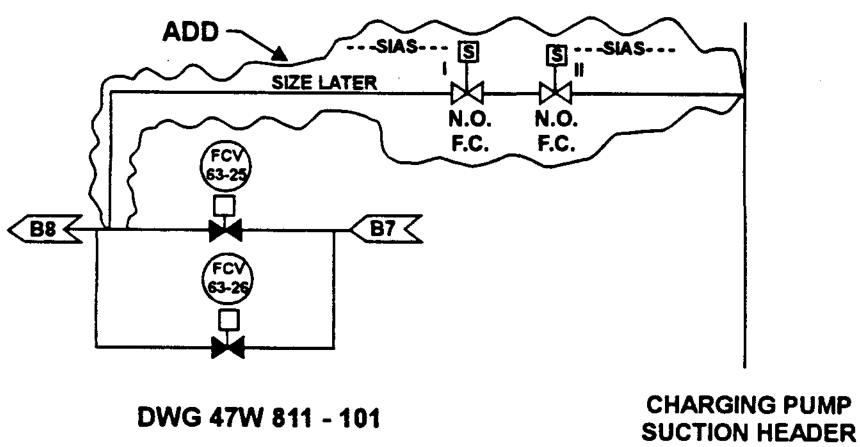
Figure 6-2 — Typical Swing Check Valve.

A



a) PASSIVE OPTION

B



b) ACTIVE OPTION (SOLENOIDS CLOSE ON SIAS.)

Figure 6-3 — Proposed Safety Injection Recirculation Line.

Section 7
CONCLUSIONS

- Watts Bar, Unit 1 is in conformance with all requirements of NRC Bulletin 88-08, including Supplements 1 through 3.
- The design and operation of Watts Bar Unit 1 preclude all potential for unacceptable stress levels in unisolable lines attached to the Reactor Coolant System (RCS) caused by postulated valve inleakage.
- The check valves in all four 1½-inch Safety Injection (SI) lines to the Watts Bar Unit 1 RCS are located more than 25 pipe diameter from the RCS loops to ensure that these lines are not subject to excessive thermal stresses caused by postulated valve inleakage.
- The design and operation of Watts Bar Unit 2 precludes all potential for unacceptable stress levels in unisolable lines attached to the RCS caused by postulated valve inleakage, except for the 1½-inch SI line to the Loop 1 RCS. Consequently, one of the options discussed in Section 6 will be implemented for Unit 2 to address the potential for unacceptable stress levels caused by postulated valve inleakage into the SI line to the Loop 1 RCS.
- The design and operation of both Watts Bar Units 1 and 2 preclude all potential for unacceptable stress levels in unisolable lines attached to the RCS caused by postulated valve outleakage addressed by Supplement 3 to NRC Bulletin 88-08.

Section 8
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4. Roarty, D.H. and P.L. Strauch, "Westinghouse Owners Group Thermal Stratification, Cycling, and Striping Program (MUHP-1092) Summary Report," Westinghouse Electric Corporation, WCAP-12708 (Proprietary), Pittsburgh, Pennsylvania (January 1991) (E-45).

5. Watts Bar Nuclear Plant Flow Diagrams, Tennessee Valley Authority

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   b. Chemical and Volume Control System, Drawing 47W809-101, Revision 0 (E-5)

   c. Safety Injection System, Drawing 47W811-101, Revision 0 (E-3)

   d. Residual Heat Removal System, Drawing 47W810-101, Revision 0 (E-4)

6. Watts Bar Nuclear Plant Isometric Piping Drawings, Tennessee Valley Authority

   a. "Problem 0600200-13-02 Analysis Isometric of 4" PZR Spray Line from RCS to PZR," Drawing 47W465-206D (R*), DCA-K06263-60 (E-81)

   b. "Problem 0600200-08-11 Analysis Isometric of CVCS Piping," Drawing 47W406-321B (R*), Revision 2 (E-12)

   c. "Problem 0600200-08-11 Analysis Isometric of CVCS Piping," Drawing 47W406-321 (RC), Revision 2 (E-10)

d. "Problem 0600200-09-05 Analysis Isometric of SIS Piping," Drawing 47W435-217B, DCA-M27585-39 (E-77)

e. "Problem 0600200-09-06 Analysis Isometric of SIS Piping," Drawing 47W435-216A, DCA-M27585-41 (E-79)

f. "Problem 0600200-09-06 Analysis Isometric of SIS Piping," Drawing 47W435-216 (RB), Revision 1 (E-19), including DCN M-14818-A (DCA-M14818-02) (E-89)

g. "Problem 0600200-09-05 Analysis Isometric of SIS Piping," Drawing 47W435-217A (R*) (E-14)

h. "Problem 0600200-03-01 Analysis Isometric of RHR Piping," Drawing 47W432-215 (RE), Revision 1 (E-9)

i. "Problem 0600200-13-02, Isometric-Static, Thermal, and Dynamic Analysis, 4" Diameter PZR Spray Line from PZR to RCS Cold Leg Loop 1 and RCS Cold Leg Loop 2 and Brk Point," Drawing 47W465-206, Revision 8 (E-50)

j. "Problem 0600200-08-11, Isometric-Static, Thermal, and Dynamic Analysis of 3" Nor., Altn. Chgrg, and Aux. Pressurizer Spray Lines from Regen Heat Exchanger," Drawing 47W406-321, Revision 9 (E-21)

k. "Problem 0600250-09-05, Isometric-Static, Thermal, and Dynamic Analysis of SIS, Boron Injection from Pen. X-22 to RCL Cold Legs 1 and 4," Drawing 47W435-264, Revision 2 (E-61)

l. "Isometric-Static and Dynamic Analyses of Boron Injection Piping to Reactor Coolant Loop 2 and 3 Cold Leg, Problem 0600250-09-06," Drawing 47W435-218, Revision 5 (E-24)

m. "Problem 0600250-03-01, Isometric-14", 6", 2" RHR," Drawing 47W432-216, Revision 5 (E-22)

n. "Problem 0600200-09-05 Analysis Isometric of SIS Piping," Drawing 47W435-217 (RB), Revision 1 (E-13)

o. "Problem N2-62-30A Analysis Isometric of CVCS Piping," Drawing 47W406-0207 (RA), including DCA P-04625-01-1 (E-59)

p. "Problem 0600200-09-05 Analysis Isometric of SIS Piping," Drawing 47W435-217B (R*) (E-15)

q. "Problem 0600200-09-06 Analysis Isometric of SIS Piping," Drawing 47W435-216A (R*), Revision 1 (E-20)

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   a. Drawing 2-68-042, Sheet 1/2, Revision 903 (E-94)

   b. Drawing 2-68-055, Sheet 1/2, Revision 903 (E-95)

8. "2" Series 1500# Y-Type Check Valve, Drawing TVD-D-9911-(1), Kerotest, Pittsburgh, Pennsylvania (E-62).

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   b. Motor Op Gate Valve Mod 14000GM885EH01B 14-1500 ASME Cl.1, GPO Assy," Drawing 115E622, Revision 902 (E-31)

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    b. Chemical and Volume Control System, Document N3-62-4001, Revision R3 (February 5, 1993) (E-38)

    c. Safety Injection System, Document N3-63-4001, Revision R5 (February 18, 1993) (E-41)

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