October 31, 2002

Mr. M. Bezilla
Vice President
FirstEnergy Nuclear Operating Company
Beaver Valley Power Station
Post Office Box 4
Shippingport, Pennsylvania 15077

SUBJECT: BEAVER VALLEY POWER STATION - NRC SPECIAL INSPECTION REPORT NO. 50-334/02-012; 50-412/02-012

Dear Mr. Bezilla:

On September 19, 2002, the NRC completed a special inspection at the FirstEnergy Nuclear Operating Company's Beaver Valley Power Station Unit 2 to evaluate the circumstances related to the August 24, 2002, gas void condition identified in the high head safety injection (HHSI) system. The results of the NRC team's inspection were discussed on September 19, 2002, with Messrs. J. Lash, F. von Ahn, M. Pearson, and other members of your staff. The enclosed report (Enclosure 1) presents the results of the inspection.

The NRC team examined activities related to reactor safety and compliance with the Commission's rules and regulations, and with the conditions of your operating license. The inspection consisted of selected examination of procedures, representative records and equipment, interviews with personnel, and observations of activities per the NRC team's charter (Enclosure 2).

This report discusses two findings that have been evaluated under the risk significance determination process (SDP) as having very low safety significance (Green). These findings were determined to be violations of NRC requirements. However, because of their very low safety significance and because they have been entered into your corrective action program, the NRC is treating these findings as Non-Cited Violations, consistent with Section VI.A.1 of the NRC's Enforcement Policy. If you deny the non-cited violations, you should provide a response with the basis of your denial, within 30 days of the date of this inspection report to the U.S. Nuclear Regulatory Commission, ATTN: Document Control Desk, Region I, the Director of Enforcement, United States Nuclear Regulatory Commission, Washington, DC 20555-001, and the NRC Resident Inspector at the Beaver Valley Power Station.

In addition, this report discusses the NRC team's assessment of your staff's evaluation of the causal factors, corrective actions, equipment operability and associated risk significance of the pipe void condition. In these areas, the team concluded that your staff's immediate actions to identify the root cause of the gas accumulation in the suction piping of the HHSI charging pumps to be acceptable.

Upon the discovery and event notification to the NRC of the gas void on August 24, 2002, we conservatively determined that the increased risk of this condition to be on the order of 1.0E-5 (in terms of incremental conditional core damage probability). However, subsequent to your initial discovery and event notification, your staff performed a detailed assessment, which determined that the operability of neither of the two aligned HHSI charging pumps would have been challenged based upon actual size, location, and transport of the gas void. Accordingly, there was no increase in risk as a result of this issue, and the mitigating function of the HHSI charging pumps was not compromised.

In accordance with 10 CFR 2.790 of the NRC's "Rules of Practice," a copy of this letter and its enclosures will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's document system (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room).

Sincerely,

/RA/

Wayne D. Lanning, Director
Division of Reactor Safety

Docket Nos: 50-334, 50-412
License Nos: DPR-66, NPF-73

Enclosures:
1) NRC Inspection Report 50-334/02-012, 50-412/02-012
2) NRC Special Inspection Team Charter

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REGION I

Docket No:	50-334; 50-412
License No:	DPR-66; NPF-73
Report No:	50-334/02-012; 50-412/02-012
Licensee:	FirstEnergy Nuclear Operating Company
Facility:	Beaver Valley Power Station, Units 1 and 2
Dates:	September 16 - 19, 2002
Inspectors:	S. Pindale, Senior Reactor Engineer, DRS, Team Leader K. Mangan, Reactor Engineer, DRS E. Cobey, Senior Reactor Analyst, DRS (in-office)
Approved by:	Lawrence T. Doerflein, Chief Systems Branch Division of Reactor Safety

SUMMARY OF FINDINGS

IR 05000334/02-012, IR 05000412/02-012; on September 16 - 19, 2002; Beaver Valley Power Station, Units 1 and 2; Special Inspection of the August 24, 2002, identification of a gas void in the high head safety injection charging pump suction piping. Two violations were identified in the area of design control.

The inspection was conducted by two regional inspectors with support from a regional senior reactor analyst. Two green findings of very low significance were identified during this inspection and were classified as non-cited violations. The significance of issues is indicated by their color (green, white, yellow, red) using IMC 0609 "Significance Determination Process" (SDP). Findings for which the SDP does not apply may be "green" or be assigned a severity level after NRC management review. The NRC's program for overseeing the safe operation of commercial nuclear power reactors is described in NUREG-1649, "Reactor Oversight Process," Revision 3, dated July 2000.

Inspector Identified Findings

Cornerstone: Mitigating Systems

- **GREEN**. The licensee failed to assure that appropriate quality standards were specified for the high head safety injection (HHSI) system. Engineers assumed an upper limit of 30% void fraction in their 1997 design calculation for gas entrained fluid entering the suction of the HHSI charging pumps, and this limit was based on the point at which gas entrained in liquid transitions from homogeneous to slug flow. However, this limit was non-conservative and exceeded the pump service vendor limits.

  This issue was considered to be of very low significance (Green) based on a Phase 1 evaluation of the At-Power Reactor Safety Significance Determination Process (SDP) because the gas void found in the piping would not have resulted in a void fraction at the pump suction exceeding the limits recommended by the pump service vendor. Therefore, there was not a loss of the safety system function. The finding was determined to be a non-cited violation (NCV) of 10 CFR Part 50, Appendix B, Criterion III, Design Control. (Section 40A3.b)

- **GREEN**. The licensee failed to use drawings that reflected the as-installed piping elevations while implementing a design change to install a high point vent in the recirculation spray/low head safety injection to HHSI cross-over piping. As a result, the vent was installed at an elevation that was not the high point. The modification package also failed to adequately test the installed vent and, therefore, did not identify the ineffective venting configuration.

  This issue was considered to be of very low safety significance (Green) based on a Phase 1 evaluation of the At-Power Reactor Safety Significance Determination Process (SDP) because the design deficiency did not result in a loss of safety system function. The finding was determined to be a non-cited violation (NCV) of 10 CFR Part 50, Appendix B, Criterion III, Design Control. (Section 40A3.b)

Report Details

Summary of Plant Status

On August 19, 2002, Beaver Valley Units 1 and 2 were operating at 100% power. Workers conducted a scheduled monthly test to monitor for the presence of gas voids in several sections of emergency core cooling system (ECCS) piping. Due to performance problems encountered during the measurement, communication and assessment of the data, several days passed until the licensee determined that the results indicated that both Unit 2 high head safety injection charging pumps may have been inoperable due to the presence of a gas void in a specific piping section. Both Beaver Valley units remained at 100% during the test and subsequent follow-up.

Background

In response to industry events and industry communications during the early 1990s, several licensees conducted reviews of safety-related piping systems that were vulnerable to gas voiding issues, and made procedure and hardware modifications, as appropriate. In October 2000, Beaver Valley Unit 2 installed several vent valves in ECCS piping via modification DCP 2360, "Vent Valve Addition on Suction Piping for Unit 2 ECCS Pumps." Included in this modification was ECCS vent valve 2SIS-904 (low head safety injection 'B' header to high head safety injection vent isolation). The purpose of the modification was to install high point vent manual valves to remove potentially trapped gas so that the gas could not enter the suction of the high head safety injection (HHSI) charging pumps.

Beaver Valley had previously experienced gas accumulation concerns in the Unit 2 HHSI system piping in late 1997. Periodic pump testing led the licensee to identify that the 'C' HHSI charging pump shaft had cracked due to abnormal impact loading attributed to the ingestion of gas voids during pump starts. Following this failure, in December 1997, the licensee developed gas void fraction limits for the Unit 1 and Unit 2 HHSI charging pump suction piping.

Beaver Valley implemented a monthly test (3BVT 2.11.1) in June 1998 to measure and monitor the development or growth of gas voids in the HHSI suction piping. This was done to ensure that the ECCS piping was free of gas that could challenge the HHSI system availability. This procedure was instituted as a corrective action following an event in March 1998, where gas voids were discovered in the low head safety injection (LHSI) discharge piping to the suction of the high head safety injection charging pumps (at Unit 1). The procedure determines whether voiding exists in several Unit 1 and Unit 2 susceptible system high points by utilizing ultrasonic testing (UT) methodology. If the technician identifies voiding, then data is communicated to the appropriate system engineer, who calculates an associated void volume from the UT results. These results are then compared against void limits established by the licensee and specified in 3BVT 2.11.1.

Chronology and Details

As described in the testing chronology (attached), the licensee identified a gas void during a routine performance of 3BVT 2.11.1 that commenced on August 19, 2002. The piping section that was affected was located in the 'B' train piping, which would be used to support the transfer to recirculation phase following a postulated accident. Specifically, following receipt of a low RWST level condition and containment isolation phase B signal, two of the four recirculation spray system (RSS) pumps are automatically realigned to provide flow to the reactor via recirculation spray/LHSI cross-over piping to the suction of the HHSI charging pumps. This recirculation flow is provided to the suction of the HHSI charging pumps via two supply lines ('A'

and 'B' headers, with isolation valves 2SIS-MOV863A and B, respectively). These lines combine into a common header to the two HHSI charging pumps (there is a third swing, or spare, HHSI pump not normally aligned). The void was found in a horizontal pipe section of the 'B' header that was located about 200 feet from the HHSI charging pump suction header.

On August 19, 2002, the licensee believed the results of the test to show that the void volume was acceptable. However, after taking additional UT measurements on a daily basis, the licensee identified several problems that caused them to re-evaluate the test results and their associated operability conclusions on August 24. These problems included:

- Pipe areas previously thought to be inaccessible near the UT test point in question (point No. 12) were actually accessible (with some physical space challenges). Consequently, the length of the gas void was not accurately determined due to verbal communication problems between personnel obtaining the UT measurements and the engineers evaluating the data.

- After additional UT measurements were taken in areas previously thought to be inaccessible, the licensee identified that the pipe was actually slightly sloped upward (about 1 7/16 inch) upstream of both the UT test point and the installed vent valve (2SIS-904).

- The technical justification for the void limit in the procedure was inadequate. Previously, on January 15, 2001, the licensee performed an evaluation to assess a specific void that they had identified in HHSI piping. This value, 0.872 ft^3, was incorrectly used as the acceptance criterion for all pipe locations in 3BVT 2.11.1. In August 2002, the licensee re-evaluated the acceptance criteria, and the previously calculated value of 0.319 ft^3 was used to assess operability.

On August 24, 2002, the licensee's void measurement and associated calculation yielded a total void volume of 1.994 ft^3, in an affected horizontal piping section of about 51 linear feet. After this discovery, at 4:25 a.m. on August 24, operators entered Technical Specification (TS) 3.5.2.a and 3.5.2.d for 'B' ECCS train being inoperable. Subsequently, operators de-energized the closed 'B' header isolation valve 2SIS-MOV863B, which would prevent the void from traveling to the common HHSI suction header in the event of a design basis accident (recirculation phase of accident mitigation). After the licensee recognized that 0.319 ft^3 was the proper acceptance criterion on August 24, they concluded that both HHSI pumps had been vulnerable to degraded operation due to the single gas void. Upon this discovery, the licensee made an associated 10 CFR 50.72 notification (EN No. 39152) to the NRC Operations Center.

On August 25, 2002, the gas void was evacuated from the pipe using a vacuum pump, controlled via a temporary operating procedure (2TOP-02-09, "Train B Safety Injection Void Removal Using Vacuum Fill"). The licensee analyzed the gas that was collected, and it was found to be air. The licensee's evaluation determined that the void was introduced when the safety injection system was filled and vented (that piping section had been drained for maintenance) during the most recent refueling outage (February 2002). During that activity, the licensee used a safety injection pump to fill the piping, however, the pipe slope and vent configuration apparently prevented the activity from adequately filling the associated 'B' header piping.

After the piping was vacuum filled, additional UT readings were obtained in the area of the previous void and additional areas along horizontal recirculation/LHSI cross-over piping to HHSI section (about 64 linear feet) to redefine the void size. The void size was calculated to be about 0.1 ft^3, and that void size has remained constant following additional daily readings. This smaller void remained in the pipe section largely due to the small area of piping located upstream of vent valve 2SIS-904 that contains the slight upward slope. Following the performance of 2TOP-02-09 and verification of void size, the licensee re-energized the 'B' header isolation valve 2SIS-MOV863B (valve remained closed), exited the associated TS Action Requirements, and declared both HHSI charging trains operable at 9:04 p.m. on August 25.

On September 19, 2002, the licensee performed a final calculation of the void size that had been present on August 19, and determined that the void was 1.8 ft^3 in a section of piping that was approximately 200 feet from the suction of the HHSI charging pumps. The licensee employed a technical vendor (Westinghouse) to analyze the as-found condition. For the analysis, the vendor assumed the size of the gas void was 3 ft^3. The vendor utilized existing scale model data from a 1997 evaluation to support their analysis. This analysis determined that a void fraction of 17% (which equates to the assumed 3 ft^3 gas void at system pressure) at its identified location correlates to a void fraction at the pump suction of approximately 5%. Westinghouse also contacted the pump service vendor to establish the gas entrainment limits specific to the installed HHSI charging pumps. The resulting analysis determined that the pump could withstand a 5% continuous (homogeneous) void fraction, and a 15% transient (slug) void fraction for several seconds. Therefore, the licensee concluded that the pumps would have remained operable during an assumed design basis accident.

Following the completion of the Westinghouse analysis, the licensee retracted event notification No. 39152 on September 18, 2002, because it was concluded that the operability of the HHSI charging pumps had been maintained. In reviewing both the 1997 technical analysis (test and calculation), as well as the recently completed Westinghouse analysis, the team found that the 1997 scale test and associated data provided appropriate and realistic information that could be used for detailed analysis.

4. OTHER ACTIVITIES [OA]

4OA3 Event Follow-up

.1 Gas Void Found in Emergency Core Cooling System Piping

a. Inspection Scope

This inspection was conducted in accordance with NRC IP 93812, "Special Inspection," to assess the licensee's actions associated with the August 24, 2002, discovery of a gas void in the Unit 2 'B' recirculation spray/LHSI cross-over piping to the HHSI system. The licensee conducted a root cause investigation which, in part, requested Westinghouse Electric Company to evaluate whether the gas void would have caused one or both of the aligned HHSI charging pumps to become inoperable due to gas binding. The team reviewed the associated design basis documents, Westinghouse evaluation, test data

and other related documents for accuracy and reasonableness. A list of the documents reviewed by the team is provided as Attachment 1 to this report.

The team reviewed aspects of the gas monitoring history of the ECCS to determine if there were previous instances of voiding at either Unit 1 or Unit 2. The team also walked down the system and interviewed licensee personnel.

The team reviewed the results of testing that was conducted in 1997 following a discovery of gas accumulation in the suction of the HHSI charging pumps (due to gas stripping at the minimum flow line restricting orifice). Scale models had been developed by contractor personnel based on the actual Unit 1 and Unit 2 HHSI system suction piping configuration. The purpose of the testing was to measure and correlate the void fraction at the pump suction based on varied size air voids at various locations in the suction piping. The team also reviewed associated calculations performed in conjunction with the 1997 testing activities.

b. Findings

Design Control - Failure to Establish Suitable Acceptance Limits for Gas Voids

(1) Introduction

The licensee failed to specify an acceptable limit for gas void fraction for liquid entering the HHSI charging pumps. This finding was considered to be of very low safety significance (Green) because the void found in the piping would not have resulted in a void fraction at the pump suction exceeding the limits established by the pump service vendor. The finding was determined to be a non-cited violation of 10 CFR Part 50, Appendix B, Criterion III (Design Control).

(2) Description

In 1997, the licensee commissioned a study to determine the relationship between voids in suction piping and the resulting void fraction that would exist at the suction of the HHSI charging pumps. The study, which included scale model flow tests and engineering calculations, was initiated following the 1997 discovery of gas accumulation in the suction of the HHSI charging pumps. The results determined that the largest void fraction at the pump suction would occur from a given gas void in the first section of horizontal piping (closest to the pump suction). In calculating an acceptable void size in the suction piping, licensee engineering established a 30% void limit at the pump suction. This limit was based on published data which determined that gas-liquid mixture flow characteristics transfer from a mixed (homogenous) flow to slug flow at that point. The licensee deduced that if a slug of gas entered the pump, then it would gas bind the pump. However, they did not establish that the pumps were able to operate with homogenous void fractions of less than 30%.

In establishing the void acceptance limits, the licensee analyzed the section of horizontal piping closest to the pump suction and established that a void fraction of approximately 12% in the piping would equate to less than a 30% void fraction entering the pump

suction. This relationship was based upon scale model and test results, which determined that the 12% void fraction would be compressed and transported to the pump suction, resulting in a higher void fraction at the pump. This was a conservative model in that it utilized relatively short pipe lengths, and assumed the entire void would be compressed and transported. Further, subsequent testing and analysis demonstrated that voids existing in piping farther from the pump suction would tend to break up and result in lower (vs. higher) void fractions at the pump suction. Therefore, the piping section closest to the pump suction was a bounding condition. The licensee applied the 12% void fraction limit to all horizontal pipe sections, which was translated to a void volume acceptance criterion of 0.319 ft^3. This criterion was then incorporated in the monthly UT test procedure (3BVT 2.11.1).

Additionally, revision 3 of procedure 3BVT 2.11.1 stated that the operability maximum void limit for Unit 2 was 0.872 ft^3 (Step VI.E.2). The prior version (Rev. 2) had correctly stated that the Unit 2 limit was 0.319 ft^3. The licensee's investigation team found that the procedure was incorrectly modified on January 15, 2001, when Rev. 3 became effective. Specifically, after evaluating a specific void size in January 2001, the licensee mis-interpreted the results in that engineering evaluation to apply to all data points measured in 3BVT 2.11.1. Accordingly, the operability maximum limit was changed in the BVT to apply to all Unit 2 voids. As a result of this non-conservative criterion, the BVT failed to demonstrate that the HHSI system would perform satisfactorily in service and in accordance with design basis acceptance limits. The testing chronology (Attachment 2) illustrates how the incorrect void limit in the test procedure (as well as communication deficiencies) contributed to the delay in recognizing that the identified gas void exceeded the design basis limit of 0.319 ft^3. Specifically, the licensee had sufficient information on August 21 to know that even the non-conservative acceptance limit of 0.872 ft^3 had been exceeded, but was not recognized until August 24.

Recent correspondence with the pump service vendor indicated that the pump could withstand a 5% continuous (homogeneous) void fraction, and a 15% transient (slug) void fraction for several seconds. While this information was used to demonstrate that the as-found condition on August 19 - 24, 2002, did not render the HHSI system incapable of performing its intended function, it represented noteworthy insights regarding the licensee's 1997 void volume acceptance criterion (which was based upon 30% void fraction) and subsequent void limit evaluations. In particular, it revealed that the licensee's previously selected 30% void fraction at the pump was non-conservative when compared to those prescribed by the pump service vendor.

The team determined that the recent Westinghouse analysis provided a reasonable basis for concluding that the void fraction at the HHSI charging pump suction would have been less than the limits established by the pump manufacturer and, therefore, the HHSI system would have been able to perform its intended safety function. However, the team found that the licensee's 1997 evaluation that established the gas void acceptance limit was non-conservative because it failed to recognize that homogenous flow (less than 30% void fraction) could gas bind the pump. The licensee intends to re-calculate the void limits for the suction piping based on the limits established by the pump service vendor (15% - transient; 5% - continuous). It appears that only the pipe locations closest to the HHSI pump suction may require more conservative acceptance

limits. For the interim, the licensee has established more restrictive criteria for these pipe locations.

(3) Analysis

This was a performance issue since this oversight could have been reasonably within the licensee's ability to foresee and correct, and which should have been prevented. This issue was more than minor because applying a non-conservative acceptance design limit for void fraction (30%) at the pump suction did not assure the availability of the HHSI system. Specifically, the licensee did not establish an appropriate void fraction limit from the vendor when establishing void volume acceptance criteria. This issue was applicable to the mitigating system cornerstone because the HHSI system is a risk-significant, safety-related system and is required during design basis accidents. The finding was determined to be of very low safety significance (Green) because the licensee's subsequent evaluation determined that the void found in the piping on August 19 would not have resulted in a void fraction at the pump suction exceeding the limits established by the manufacturer. The issue screened to Green in SDP Phase I because mitigating system equipment remained available, there was no loss of safety function, and no technical specification limiting conditions for operation were exceeded.

(4) Enforcement

10 CFR Part 50, Appendix B, Criterion III (Design Control), requires, in part, that measures to assure that appropriate quality standards are specified and included in design documents. Contrary to this requirement, the licensee used a non-conservative design limit in their 1997 calculation to establish void acceptance limits in ECCS piping. However, because of the very low safety significance and because the issue was entered into the licensee's corrective action program (Condition Report Nos. 02-06831 and 02-06992), it was treated as a non-cited violation, consistent with Section VI.A.1 of the NRC Enforcement Policy. **(NCV 50-412/02-12-01)**

Design Control - Failure to Properly Implement and Test a Plant Modification

(1) Introduction

The licensee failed to install the high point vent valve at the physical high point of the recirculation spray/LHSI cross-over piping to the HHSI system. This was determined to be of very low significance (Green) because the actual size of the void found in the piping would not have prevented the HHSI charging pumps from performing their intended safety function. This finding was determined to be a non-cited violation of 10 CFR Part 50, Appendix B, Criterion III (Design Control).

(2) Description

During the Unit 2 refueling outage 2R08 (October 2000), the licensee installed several high point vents in ECCS piping via modification DCP 2360, "Vent Valve Addition on Suction Piping for Unit 2 ECCS Pumps." Included in this modification was ECCS vent valve 2SIS-904, "low head safety injection 'B' header to high head safety injection vent

isolation." The purpose of the modification was to install high point vent manual valves to remove potentially trapped gas so that the gas does not enter the suction of the high head safety injection (HHSI) charging pumps.

After the licensee's discovery on August 24, 2002, that the piping on which the vent was installed contained an upward slope (beginning upstream of the vent), the licensee conducted a detailed review of this modification. They identified that engineers used Inservice Inspection (ISI) isometric drawings instead of the design isometric drawings. Design isometric drawing 111103-1DAC, "Safety Injection System Safeguard Tunnel 725'-0" Elevation," contained a reference that showed an as-built field elevation measurement for the piping section in question (upstream of 2SIS-904). It showed that although the piping was designed to be at elevation 732 ft., 4 5/16 in., it was actually at 732 ft., 5 3/4 in. (1 7/16 in. higher than designed). The team determined that this discrepancy was identified on the drawing, and the drawing referenced an associated non-conformance and disposition report (N&D No. 25296), which evaluated the discrepancy.

In addition to failing to use 1) the proper type drawing and 2) the correct design isometric drawing in the design phase of the modification, independent design reviews of the package failed to identify the problem.

Finally, the DCP failed to include an appropriate post-modification test of the installed vent. The only testing prescribed and implemented in the package was a mechanical proof test, which subjected the valve to a leak test at normal operating pressure. There was no test to verify the ability of the vent valve to effectively remove gas from the line on which it was installed.

(3) Analysis

This was a performance issue since this oversight could have been reasonably within the licensee's ability to foresee and correct, and which should have been prevented. The finding is more than minor because it affects a design control attribute related to plant modifications. The error could have affected the availability of the HHSI system, which is a system designed to mitigate the consequences of postulated accidents. However, this finding was determined to be of very low safety significance (Green) because the licensee subsequently determined that the system would have been able to accomplish its design safety function. The issue screened to Green in SDP Phase I because the affected mitigating system equipment remained operable, there was no loss of safety function, and no technical specification limiting conditions for operation were exceeded.

(4) Enforcement

10 CFR Part 50, Appendix B, Criterion III (Design Control) requires, in part, that measures shall be established to assure that the design basis are translated into drawings, procedures, and instructions; and that design control measures shall provide for checking the adequacy of design, such as by the performance of a suitable testing program. Contrary to this requirement, during the implementation of a design change, the licensee failed to use drawings that reflected the as-installed piping elevations and installed a vent at an elevation that was not the high point. In addition, the modification package failed to adequately test the installed vent and, therefore, did not identify the ineffective venting configuration. However, because of the very low safety significance and because the issue was entered into the licensee's corrective action program (Condition Report 02-06831) it was treated as a non-cited violation, consistent with Section VI.A.1 of the NRC Enforcement Policy. **(NCV 50-412/02-12-02)**

.2 Event Causal Factors, Root Causes and Corrective Actions

a. Inspection Scope

The team reviewed the licensee's activities to determine the root cause of the gas void formation in the recirculation spray/LHSI cross-over piping to the HHSI system. The team also independently assessed the causal factors for the event and the appropriateness of the licensee's initial corrective actions. The team reviewed data, procedures, conducted plant tours, and interviewed personnel, including station management. The team also assessed the licensee's overall response to the identification of the gas void.

b. Findings

No findings of significance were identified. However, the team identified several observations, which are discussed in this report because these observations relate to the quality of the licensee's root cause investigation and associated corrective actions.

The team found that the licensee applied conservatism and implemented appropriate response actions after the gas void was correctly quantified on August 24, 2002. The conservative assumptions led to the licensee's determination that potentially both aligned HHSI charging pumps could have been adversely affected by the single gas void, and they notified the NRC of this issue via event notification 39152. The licensee formed a large event response team composed of technically diverse individuals, and provided the team with significant management involvement/oversight.

The licensee determined that the root cause of the gas void formation was the vent for the affected piping section was in the incorrect location to provide adequate high point venting. The appropriate portion of the design isometric drawing was not consulted or reviewed to determine the location of the valve. The mis-location of the vent valve and the subsequent monitoring for voids in that area allowed the gas void to remain undetected at the actual high point of the line.

Overall, the team concluded that the licensee's Event and Root Cause Analysis Review was an acceptable effort that provided proper focus and detail on investigation details. The team found that the licensee identified the appropriate root and contributing causes, and implemented appropriate immediate corrective actions. The investigation also assessed the extent of condition at both Units 1 and 2. Notwithstanding, the team identified some weaknesses associated with the licensees efforts:

- In some areas, the root cause investigation did not probe to a sufficient level of detail to gain a complete understanding of all potential contributing causes. For example, the licensee identified that during the most recent refueling outage (February 2002), operators ran an LHSI pump to supplement the existing proceduralized gravity fill of the safety injection system (procedure 2OM-11.4.H). However, the team found that the licensee did not thoroughly pursue this activity to determine whether running the LHSI pump may have contributed substantially to the gas void formation.

- The team identified that the root cause evaluation presented an opportunity to question the 30% void fraction assumption associated with the 1997 void limit evaluation. This could have identified that the 30% value resulted in establishing non-conservative void size limits in some piping locations. A specific corrective action item of the root cause investigation was to review the calculation for correctness. However, this action was completed and closed on August 25, 2002, and the associated work description stated that engineering had confirmed that applicable inputs and assumptions, proper methodology, accurate calculation and analysis in the calculation presented a reasonable and appropriate conclusion. The team noted that after information was provided to the licensee by Westinghouse related to the pump service vendor's acceptable void limit, the issue was assigned to be re-evaluated under a separate corrective action.

- Some of the corrective actions were too broadly stated such that it was unclear that some of the specific and expected corrective actions were planned. For example, in the extent of condition review section, system engineering planned to review 3BVT 2.11.1 data for last three years for both units; however, this action was not specified as a corrective action in the evaluation report. The team determined this was an important activity since it would bound the extent of the historical void configuration. The team conducted an independent review of selected test results, and did not identify any additional or unevaluated gas voids.

- The team independently evaluated this event and confirmed the licensee's root cause determination. However, the team concluded that the licensee did not aggressively determine the reason why the proper isometric drawings were not used. Further, the licensee's review did not identify why the independent review of DCP 2360 failed to identify the design deficiency. This was important because the corrective actions should address the root of the problem to prevent future similar occurrences.

- Finally, the monthly tests showed the piping to be filled for several months following restart from the February 2002, refueling outage before the gas void was identified in August 2002. The team found that the licensee did not identify the reason for this "delayed appearance" of the void. Specifically, the void length "ended" about 10 feet beyond the inspection point where the void was ultimately identified. The licensee subsequently performed a void sensitivity study to explain that the void length was very responsive to minor system pressure changes (which would result as a consequence of volume control tank pressure changes). However, this study was not done until questioned by the team.

The team presented these observations to the licensee at the exit meeting on September 19, 2002. The licensee noted that their Event and Root Cause Analysis Review had not been yet finalized, and that the observations presented would be factored into their continuing evaluation and associated report.

.3 Risk Significance of Event

a. Inspection Scope

The team evaluated the risk significance of the gas void that was discovered in the recirculation spray/LHSI cross-over to HHSI piping based on incremental conditional core damage probability (CCDP).

b. Findings

Following the August 24, 2002, event discovery, the licensee completed a detailed technical evaluation and determined that the availability of the HHSI charging pumps would not have been affected (based upon the size and location of the discovered gas void). The team reviewed this evaluation and found it to be acceptable. Therefore, the team concluded that, because the ECCS remained capable of performing its intended safety function, there was no increased risk as a result of this issue.

4OA6 Meetings, Including Exit

.1 Exit Meeting Summary

On September 19, 2002, the NRC team presented the inspection results to Messrs. J. Lash, F. von Ahn, M. Pearson and other members of the FirstEnergy Nuclear Operating Company. The team reviewed some proprietary documents during the inspection, and these documents were identified and discussed by the NRC at the exit meeting. Based upon subsequent discussions with the licensee, none of the information presented at the exit meeting and included in this report was considered proprietary.

Attachment 1

SUPPLEMENTAL INFORMATION

KEY POINTS OF CONTACT

FirstEnergy Nuclear Operating Company (Licensee)

M. Adams	System Engineer
A. Brunner	System Engineer
K. Deberry	System Engineer
K. Frederick	Design Engineer
L. Freeland	Manager, Nuclear Regulatory Affairs & Corrective Actions
K. Halliday	Manager, Security
D. Price	Nuclear Engineer
P. Sena	Manager, Nuclear Operations
B. Sepelak	Regulatory Affairs
F. von Ahn	Director, Plant Engineering

Other

Thomas Gerlowski, Senior Engineer, Westinghouse Electric Company

NRC Personnel

L. Doerflein, Chief, Systems Branch, DRS
D. Kern, Senior Resident Inspector, Beaver Valley
J. Rogge, Chief, Projects Branch 7, DRP
G. Smith, Resident Inspector, Beaver Valley

ITEMS OPENED, CLOSED, AND DISCUSSED

Opened and Closed

NCV	50-412/02-12-01	Failure to assure that appropriate quality standards were specified for the high head safety injection (HHSI) system in that the licensee established limits for gas void fraction for liquid entering the HHSI charging pumps that were non-conservative in some instances. [Section 4OA3]
NCV	50-412/02-12-02	Failure to assure that the design basis was translated into drawings, procedures, and instructions; and for the failure to properly check the adequacy of a modification (high point vent modification installed vent at an elevation that was not at the actual piping section high point). [Section 4OA3]

LIST OF ACRONYMS

BVPS	Beaver Valley Power Station
BVT	Beaver Valley Test
CCDP	Conditional Core Damage Probability
CDF	Core Damage Frequency
CFR	Code of Federal Regulations
CR	Condition Report
DRP	Division of Reactor Projects
DRS	Division of Reactor Safety
ECCS	Emergency Core Cooling System
EN	Event Notification
ft^3	Cubic Feet
HHSI	High Head Safety Injection
LER	Licensee Event Report
LHSI	Low Head Safety Injection
LCO	Limiting Condition for Operation
NCV	Non-Cited Violation
NRC	Nuclear Regulatory Commission
RSS	Recirculation Spray System
SDP	Significance Determination Process
SIS	Safety Injection System
SIT	Special Inspection Team
TS	Technical Specifications
UFSAR	Updated Final Safety Analysis Report
UT	Ultrasonic Testing

DOCUMENTS REVIEWED

Procedures

2OM-7.4.E	Hydrogen Concentration Control of the Reactor Coolant System, Rev. 4
2OM-7.4.F	Degassing the Reactor Coolant System From the Volume Control Tank, Rev. 13
2OM-11.4.H	Filling and Venting the Safety Injection System, Rev. 10
2OM-11.3.B.1	Valve List - 2SIS, Rev. 9

Engineering Documents

FAI/97-125	Scoping experiments to Assess the Two-Phase Flow Patterns Entering the Beaver Valley Unit 2 Charging Pumps, Fauske & Associates, Inc.
FAI/97-134	Scoping experiments to Assess the Two-Phase Flow Patterns Entering the Beaver Valley Unit 1 Charging Pumps, Fauske & Associates, Inc.
CN-SEE-02-82	Evaluation of Beaver Valley Unit 2 Gas Void, Westinghouse (Westinghouse Proprietary Class 2)
EM-201055	Voids Identified in SIS piping from RSS to LHSI/HHSI System

Flowserve Corporation Letter to Westinghouse Electric Company - Dated September 6, 2002
Calculation 8700-DMC-342-1, BVPS Unit 1 Void Fraction At Charging Pump Inlet
Calculation 10080-N-757-0, BVPS Unit 2 Void Fraction At Charging Pump Inlet

Drawings

111103-1DAC	Safety Injection System Safeguard Tunnel El. 725'-0" (1/29/87)
109926-1EAC	Safety Injection System Main Steam and Cable Vault Area El. 718'-6" (12-1-86)
10080-RM087A	Flow Diagram - Safety Injection Piping - Sheet 1, Rev. 26
10080-RM079D	Flow Diagram - Chemical and Volume Control Piping - Sheet 4, Rev. 29
OM Figure 11-1	VOND - Low/High Head Safety Injection, Rev. 10
OM Figure 7-1A	VOND - Chemical and Volume Control - Sheet 1, Rev. 10
OM Figure 13-1	VOND - Recirculation Spray System, Rev. 10
10080-2806.263-997-001-SH.1	Safety Injection System Vent Line Details Main Steam Valve Room and Safeguards El. 718'-6" (1-6-00)

Condition Reports

CR 02-06831
CR 02-06976
CR 02-06992
CR 02-07188

Other

Draft Event and Root Cause Analysis Report (Gas Void Detected During 3BVT 2.22.1 Performance)
BVPS LER 1-98-021, Gas Voids Discovered in the Low Head Safety Injection Discharge Piping to the Suction Piping of the Charging/High Head Safety Injection Pumps
BVPS LER 1-97-039, Gas Accumulation in Charging/High Head Safety Injection Pump Piping
NUREG 0897, Rev. 1, Containment Emergency Sump Performance
NRC Information Notice 88-23, "Potential for Gas Binding of High-pressure Safety Injection Pumps During a Loss-of- Coolant Accident," (Including Supplements 1 through 5)

Attachment 2

CHRONOLOGY OF ULTRASONIC TESTING

Date	Void Size, ft^3 (Note 1)	Void Size, ft^3 (Note 2)	Comments
8/19/02	0.376	0.376	Void size calculated based on depth at measurement (point 12) and assumed to be constant entire length of horizontal pipe section (64 feet).
8/20/02	0.376	0.376	
8/21/02	0.459	0.998	UT measurement taken beyond point 12. Incorrect void length communicated to system engineer. Review of UT report on 8/27/02 revealed wrong void length was reported.
8/22/02	0.459	1.253	Additional verbal communication deficiencies resulted in system engineer concluding same results from 8/21/02 measurements.
8/23/02	0.459	1.253	Verbal report from field indicated “same results as yesterday” and, therefore, void size did not change.
8/24/02	1.994	1.994	Identified 1) void measurements had not previously been complete and bounded; 2) BVT acceptance criterion was incorrect; 3) pipe was slightly sloped.

Note 1: This column lists void sizes calculated by the licensee based upon information believed to be complete and accurate on date listed in left column.

Note 2: This column lists void sizes that were calculated subsequent to the date listed, and reflect information recognized only after August 24. See comments column for specific details.

ENCLOSURE 2

September 13, 2002

MEMORANDUM TO: Lawrence T. Doerflein, Manager
Special Inspection

Stephen M. Pindale, Leader
Special Inspection

FROM: Wayne D. Lanning, Director **/RA/**
Division of Reactor Safety

SUBJECT: SPECIAL INSPECTION CHARTER - BEAVER VALLEY POWER STATION UNIT NO. 2

A special inspection has been established to inspect and assess the discovery of gas voiding in the emergency core cooling system (ECCS) piping at Beaver Valley Power Station Unit No. 2 on August 24, 2002. The special inspection will be conducted onsite during the week of September 16, 2002, and will include:

Manager:	Lawrence T. Doerflein, Systems Branch Chief, DRS
Leader:	Stephen M. Pindale, Senior Reactor Inspector, DRS
Members:	Kevin A. Mangan, Reactor Inspector, DRS Eugene W. Cobey, Senior Reactor Analyst, DRS (In-office)

This special inspection is in response to the event report made by the licensee on August 25, 2002, describing the identification of a gas void in the “B” train ECCS piping that had the potential of disabling the high head safety injection pumps. The basis for this inspection is to assess the licensee’s root cause evaluation and corrective actions, independently evaluate the risk significance of the event, and determine possible generic implications.

The special inspection was initiated in accordance with NRC Management Directive 8.3, “NRC Incident Investigation Program.” The inspection will be performed in accordance with the guidance of NRC Inspection Procedure 93812, “Special Inspection,” and the inspection report will be issued within 45 days following the exit meeting for the inspection. If you have any questions regarding the objectives of the attached charter, please contact Larry Doerflein at 610-337-5378.

Attachment: Special Inspection Charter

Special Inspection Charter
Beaver Valley Power Station Unit No. 2
Gas Voiding in Emergency Core Cooling System Piping

The objectives of the inspection are to determine the facts surrounding the discovery on August 24, 2002, of gas voiding in the Beaver Valley Unit No. 2 emergency core cooling system (ECCS) piping. Specifically, the inspection should:

1. Assess the adequacy of the licensee's investigation and root cause evaluation of the existence of a gas void in the section of ECCS piping used in the transfer-to-recirculation phase of a loss of coolant accident and that could potentially disable a high head safety injection pump if ingested.

2. Assess the adequacy of the licensee's corrective actions and extent of condition review for the specific void discovered and for potential voids in other safety-related systems.

3. Independently evaluate the risk significance of the gas void in the ECCS piping and confirm the adequacy of the licensee's risk evaluation.

4. Determine the possible generic implications associated with gas voiding in ECCS piping, specifically considering the impact of gas void ingestion on centrifugal pumps.

5. Document the inspection findings and conclusion in an inspection report within 45 days of the exit meeting for the inspection.