U. S. NUCLEAR REGULATORY COMMISSION

REGION III

Report No. 50-237/88013(DRP)

Docket No. 50-237 License No. DPR-19

Licensee: Commonwealth Edison Company
P. O. Box 767
Chicago, IL 60690

Facility Name: Dresden Nuclear Power Station, Unit 2

Inspection At: Dresden Site, Morris, IL

Inspection Conducted: May 17 thru 24, 1988

Inspectors: S. G. Du Pont
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Approved By: M. A. Ring, Chief
Reactor Projects Section 1B

6/29/88
Date

Inspection Summary

Inspection during the period of May 17 thru 24, 1988 (Report No. 50-237/88013(DRP))
Areas Inspected: Augmented Inspection Team (AIT) inspection of the May 16 and 17, 1988, Unit 2 Main Steam Isolation Valves' failure to close during loss of air testing.
Results: No violations or deviations were identified.

- The routine Technical Specification required surveillance does not identify Main Steam Isolation Valve (MSIV) degradation due to excessive stem packing friction.

- The Automatic Valve Company (AVCo) 4-Way solenoid valves will hangup in an intermediate position during gradual loss of system air pressure, rendering the MSIV accumulators inoperable.

- The root cause of the eight Unit 2 MSIVs' failure to achieve full closure during the special loss of air test on May 16 and 17, 1988, was due to excessive MSIV stem packing friction.

- Unit 3 MSIVs did not experience excessive MSIV stem packing friction and were operable.

Augmented Inspection Team Report
50-237/88013

Attachments

Attachment No.	Description
1	Confirmatory Action Letter (CAL-RIII-88-12)
2	AIT Charter
3	Main Steam Isolation Valve - Control Diagram
4	Main Steam Isolation Valve
5	Pneumatic Manifold - Closed Configuration
6	Pneumatic Manifold - Open Configuration
7	Pump Back System
7A	Primary Containment Atmospheric Control System
8	Instrument Air System
8A	Service Air System

I. Introduction

A. Synopsis of Event

On Thursday, December 24, 1987, at 2:30 a.m., with Dresden Unit 2 at 93% power, the 1B inboard Main Steam Isolation Valve (MSIV) was observed to have a dual position indication in the control room. Steam flow through the B steam line was observed to be approximately 75% of the flow through each of the A, C, and D steam lines. The licensee decreased power and attempted to cycle the 1B MSIV with no success (the MSIV would neither open or close). The licensee's investigation into the event determined that the air supply line had pulled out of the pneumatic manifold on the valve operator. The air supply line was repaired, tested, and subsequently declared operable. Because the valve had failed to fully close in response to the loss of air, the licensee scheduled further inspection and testing to be performed at the next outage.

On Monday, May 16, 1988, at approximately 8:00 a.m., with Dresden Unit 2 shutdown, the licensee was performing the special testing (SP 88-3-15) in response to the December 24, 1987, event. The test being performed involved using the exercise control solenoid (MSIVs spring force alone without air assistance) to slowly close the MSIVs. This test was performed for all four inboard and four outboard MSIVs and none of them fully closed.

On Tuesday, May 17, 1988, at approximately 8:00 a.m., the licensee was continuing the special testing of the MSIVs. The testing consisted of isolating the pneumatic air supply to the inboard MSIVs and the instrument air supply to the outboard MSIVs and monitoring the MSIVs to see if they would fully close on loss of air. The test results revealed that all eight MSIVs failed to fully close. Based on this, the licensee declared all of the MSIVs inoperable and made the required Emergency Notification System (ENS) phone call to notify the NRC.

B. AIT Formation

In response to the May 16 and 17 events, Region III formed a special inspection team on May 18, 1988, comprised of S. G. Du Pont, Dresden Senior Resident Inspector (SRI) and Team Leader, P. D. Kaufman, Dresden Resident Inspector (RI), R. D. Lanksbury, LaSalle SRI, and J. F. Schapker, Region III Reactor Safety Inspector. All four members were on site by the morning of May 18. Based upon information gathered on May 18 and upon further evaluation, the decision was made to form an Augmented Inspection Team (AIT). The AIT was comprised of the above four individuals plus the addition of M. P. Huber, Region III Reactor Safety Inspector, and H. L. Ornstein, Senior Reactor Systems Engineer, Office of Analysis and Evaluation of Operational Data (AEOD). All of the AIT members had arrived on site by the morning of May 21, 1988. Concurrent with the AIT activities, Region III issued a Confirmatory Action Letter

(CAL-RIII-88-12) which was received by the licensee on May 18, 1988, and is included as Attachment 1 to this report. The CAL confirmed certain actions to be taken by the licensee in support of the AIT and established that the restart of Unit 2 could only occur upon concurrence of the Region III Regional Administrator, or his designee.

C. AIT Charter

On May 19, 1988, the AIT formulated and provided to Region III a draft charter for concurrence. On May 20, 1988, Region III transmitted the approved AIT charter (Attachment 2) to the AIT on site. The general areas to be investigated were:

- Root cause of the MSIVs' failure to fully close on loss of air.
- Safety significance.
- Interaction of prior maintenance activities to the event.
- Broader implications.
- Event reporting.

D. Persons Contacted

Commonwealth Edison Company (CECo)

*N. J. Kalivianakis, General Manager, CECo BWR Operations
*E. D. Eenigenburg, Station Manager, Dresden
*J. W. Wujciga, Production Superintendent, Dresden
J. A. Silady, Nuclear Licensing Administrator, CECo
*E. R. Zebus, Engineering Superintendent, CECo BWRE
*R. Meadows, Maintenance Staff Supervisor, Dresden
D. Van Pelt, Assistant Superintendent - Maintenance, Dresden
W. R. Betourne, Quality Assurance Engineer, Dresden
*J. Achteberg, Technical Staff Supervisor, Dresden
*E. Armstrong, Regulatory Assurance Supervisor, Dresden
M. Strait, Master Mechanic, Dresden
J. Kotowski, Assistant Superintendent - Operations, Dresden

General Electric Company (GE)

*C. T. Nieh, Design Engineer, GE - Valve Design
*J. Nash, Resident Engineer, GE

*Denotes those attending the exit meeting on May 24, 1988.

In addition, other members of the Dresden staff were contacted by the AIT.

II. Description - MSIVs Failure to Fully Close on Loss of Air Event of May 16 and 17, 1988.

A. Narrative Description

With Dresden Unit 2 in cold shutdown for a short maintenance outage and Unit 3 in a refueling outage, all eight Unit 2 Main Steam

Isolation Valves (MSIVs) failed to fully close during a special loss of air test which was being conducted to further investigate a December 24, 1987, failure of Unit 2 inboard MSIV 203-1B to fully close when its pneumatic supply air line pulled out of the manifold block. To conduct this test, the drywell pneumatic supply and instrument air supply headers were isolated, permitting the headers to bleed down slowly, while monitoring the MSIVs to verify if full closure was achieved on a loss of air. Test results revealed that all eight MSIVs failed to fully close, thus the licensee declared all the MSIVs inoperable.

B. Sequence of Events

On December 24, 1987, Unit 2 inboard MSIV 203-1B failed to fully close when its pneumatic supply line separated from the manifold block on the valve operator. In response to this event, a special loss of air test procedure was developed (SP 88-3-15) to be performed during an upcoming short maintenance outage on Unit 2 to determine if incomplete MSIV closure was related to loss of main supply air to the valve while maintaining pilot air.

On April 14, 1988, while Unit 2 was operating at about 30% power, a drywell inspection revealed an air leak on the coupling connecting the supply air to the inboard MSIV 203-1B pneumatic manifold. There had not been any MSIV motion as a result of the air leak. Review of the leak was unable to determine if the significance was large enough to cause the valve to close.

On April 27, 1988, while Unit 2 was operating at about 80% power, inboard MSIV 203-1B partially closed. The cause of the partial closure was determined to be due to the air supply connection separating from the manifold block similar to the December 24, 1987 event. The air supply line was reconnected after corrective maintenance to the manifold increased the thread distance for the connection. As previously noted, testing was scheduled during the May 1988 outage to determine the cause of the failure of the MSIV to fully close during loss of air conditions.

On May 16, 1988, with Unit 2 in cold shutdown, the special loss of air test commenced at 8:00 a.m. The first section of the test involved installing a jumper to maintain the AC exercise control solenoid (Number 6 on Attachment 3) energized to allow full stroke testing of each MSIV when the test pushbutton was depressed in the control room. This test configuration enables the over-piston area to be vented and the air from under-piston area to bleed off. The valves should then drift closed on MSIV spring force only. None of the eight valves fully closed.

On May 17, 1988, another section of the special test was performed on the inboard MSIVs. This section required complete isolation of the air supplied by the drywell pneumatic supply header, permitting a slow bleed down rate. None of the valves fully closed. The same test was performed on the outboard MSIVs by isolating the instrument air supply header and the same results occurred. Thus, at 12:55 p.m., all eight MSIVs were declared inoperable.

The licensee contacted the NRC Duty Officer via ENS at 3:26 p.m., on May 17, 1988, and informed him that all 8 Unit 2 MSIVs were declared inoperable since they failed to fully close on loss of air. The Resident Inspector was in the control room when the ENS call was made.

The NRC Region III, Reactor Projects Branch 1, Branch and Section Chiefs held a conference call with the Dresden Station Manager at approximately 5:30 p.m., on May 17, 1988, during which it was agreed that the MSIV problem had to be investigated and fully understood prior to restart of Dresden Units 2 and 3. During this call, it was also agreed that two of the eight MISVs could be released for further testing while six valves would be quarantined in an as found condition.

On May 18, 1988, a telephone conversation between the NRC Region III Director, Division of Reactor Projects and the Dresden Station Manager was held to discuss the MSIVs' failure to close during a loss of air test on Unit 2. Additionally, a Confirmatory Action Letter (CAL-RIII-88-12) was issued following the conversation which prohibited the startup of Dresden Units 2 and 3 until a determination had been made that equipment performance (MSIVs) was satisfactory and concurrence of the Regional Administrator or designee had been obtained.

A special inspection into the MSIV event commenced on May 18, 1988, by a team comprised of the Dresden Resident Inspector staff, the Senior Resident Inspector - La Salle, and a Regional Specialist.

The special inspection progressed into an Augmented Inspection Team (AIT) on May 19, 1988. The AIT was headed by the Dresden Senior Resident Inspector.

III. System Descriptions

A. Main Steam Isolation Valves (MSIVs)

The Main Steam Isolation Valves (MSIVs) are 20 inch air/spring operated, balanced "T" type, globe valves. A typical MSIV is shown in Attachment 4. The MSIV combines full port design with straight line flow to provide a good flow pattern. The MSIV utilizes upstream pressure to aid in valve closure by tilting the actuator toward the upstream side of the valve. The balancing feature of the MSIV makes it possible to take advantage of the upstream pressure to aid in holding it closed and to have the advantage of requiring a smaller actuator cylinder to open it. This is accomplished by allowing the full upstream line pressure to bleed into the chamber above the plug through the balancing port to exert a force on the plug internals in a direction to hold it against the seat. When the actuator starts to open the MSIV, the steam lifts the pilot off its seat to vent the steam inside the plug into the downsteam line. As the stem travel continues, the plug is lifted off the main valve seat to open the valve port. The actuator is supported by four spring guide shafts designed to support the actuator without any outside support. Eight coil springs located

around the spring guide shafts are used for closing the MSIV in case of air failure. The MSIVs are opened, and held open, by compressed air but will close with either air or spring action. The valve closure time is controlled between 3 and 5 seconds by a hydraulic (oil) dash pot which is mounted below the main air cylinder and is equipped with an external bypass pipe and flow control valve. The air for the MSIV actuator is supplied and controlled by a pneumatic manifold that is located on one side of the actuator. The inboard MSIVs receive their air supply from the drywell pneumatic pumpback system and the outboard MSIVs receive their air supply from the instrument air system.

Attachment 3 shows a schematic diagram of the MSIV pneumatic manifold. The MSIV pneumatic manifold directs air to one side of the piston, located inside the actuator, and vents the other side to atmosphere, to control which direction the MSIV will move. The pneumatic actuator consists of three 3-Way solenoid operated valves (SOVs) (2 AC and 1 DC) and two 4-Way valves. The three 3-Way SOVs act as pilot valves and control the positions of the 4-Way valves by directing air to, or venting air from, them. These SOVs are shown on Attachments 5 and 6 as #1, #2, and #3. SOVs #1 and #2 are utilized for normal opening and fast closure of the MSIVs. SOV #3 is only utilized to allow exercising the MSIV (i.e., slow closure) when it is already open. The two 4-Way valves are shown on Attachments 5 and 6 as Valve #1 and Valve #2. Valve #1 is controlled by SOV #1 or #2 (only one SOV is required to open the MSIV) and Valve #2 is controlled by SOV #3. Since, as discussed earlier, SOV #3 is only used for exercising the MSIV, Valve #2 normally does not change position from that shown.

Attachment 5 shows the configuration of the MSIV pneumatic manifold to close the MSIV. Pilot air cannot pass through the 3-Way SOVs since they are de-energized. Without pilot air, the two pistons in Valve #1 are located to their normal positions by their respective springs. The left piston is forced up to seal exhaust port #1 and allows air to pass from the inlet to the over piston area of the actuator. The right piston is forced down, thus blocking the inlet air and allowing exhaust port #2 to be open to Valve #2. Valve #2 does not have pilot air directed to it so it's internal spring forces the piston up, sealing exhaust port #3 and allowing the under piston area to be vented through Valve #1 and exhaust port #2. With the MSIV actuator over piston area pressurized, the under piston area vented to atmosphere, and the MSIV springs pushing down, the MSIV is forced closed.

Attachment 6 shows the configuration of the MSIV pneumatic manifold to open the MSIV. SOVs #1 and #2 are shown energized, thus allowing the passage of pilot air to Valve #1. The pilot air forces the left piston down against spring pressure, allowing the MSIV actuator over piston area to be vented to atmosphere and blocking the inlet air. This also allows the over piston area of the right piston of Valve #1 to be vented to atmosphere. With the above piston area of Valve #1 vented, inlet air can force the right piston up against spring

pressure and thus allow the inlet air to then pass through Valve #2 to the under piston area of the MSIV actuator. With the MSIV actuator under piston area pressurized and the over piston area vented to atmosphere sufficient force is provided to open the MSIV against the spring force that is tending to hold it closed.

B. Drywell Pneumatic System

The drywell pneumatic (DP) system supplies "instrument air" to components in the drywell. However, unlike the instrument air system described below, the DP system takes its suction from the drywell rather than outside air. Since during normal operation, the drywell is inerted with nitrogen, the DP system supplies nitrogen, rather than oxygenated air, to the drywell components. This reduces the need for venting of the drywell due to continuous bleeding of air from pneumatic components, which would otherwise lead to an internal pressure rise in the containment and excessive oxygen concentration in the inerted atmosphere. The motive force for the DP system normally comes from the pump back system (Attachment 7). The pump back system includes two air compressors, after coolers, and an air receiver tank. Other than supplying DP, the purpose of the pump back system is to maintain the drywell to torus differential pressure. This is done in order to decrease the amount of hydro shocking of the torus support structure during drywell pressurization. As a backup to the pump back system, nitrogen can also be supplied to the drywell components from the nitrogen makeup system.

C. Instrument Air System

The purpose of the instrument air (IA) system is to supply clean, dry, compressed air for air-operated control devices and instruments. This includes the outboard MSIVs. The system (Attachment 8) consists of compressors, after coolers, air receiver tanks, dryers, oil filters, and the necessary control and support equipment. The pressure control valve provides backup instrument air supplied from the Unit 1 instrument air system. This supply is normally valved out. The IA also has a service air crosstie. This crosstie provides IA backup from the service air header. The crosstie valve will automatically operate if the IA header pressure falls below 85 psig.

D. Integrated Operation of Pneumatic and Instrument Air Systems

1. Pneumatic Pumpback System

The pumpback compressors, which supply nitrogen to the drywell pneumatic system, are backed up by the nitrogen makeup system. A "pneumatic supply trouble" alarms in the control room when system pressure decreases below 70 psig and a "drywell pneumatic supply low pressure" also annunciates when system pressure decreases below 60 psig. An emergency nitrogen makeup supply valve automatically opens at 60 psig to provide backup

supply from the nitrogen makeup system. Since several of the air operated valves for the pumpback system are located outside of the drywell and are actuated by instrument air, the AIT reviewed the actuator supply to the emergency nitrogen makeup supply valve, the associated valves in the makeup system and the integrated valves between the makeup and pumpback systems. The review revealed that upon a loss or degradation of the instrument air system, the inboard MSIVs would be sufficiently supplied nitrogen for actuation from the makeup system through the emergency nitrogen makeup supply valve prior to the system pressure decreasing to the pneumatic phenomenon setpoint of 48 psig (as noted in Paragraph IV.B.).

2. Instrument Air System

As stated above, the instrument air system receives backup supply from the service air system at 85 psig through a automatically operating valve. In addition, the Unit 2 instrument air system receives backup from the Unit 1 instrument air system (Unit 1's instrument air system is maintained per Technical Specifications). Several annunciators alarm in the control room to alert the operator of degrading instrument air system pressure. "Low Pressure in Instrument Air Receiver" alarms for both units at 85 psig. Additionally, the instrument air dryers are automatically bypassed at 60 psig to maintain downstream air pressure and the Service Air to Instrument Air cross-connects also automatically open at 85 psig. Additional redundancy is provided by three available Unit 1 instrument air compressors, two Unit 2 instrument air compressors and three Unit 3 instrument air compressors.

Based upon these reviews, the AIT concluded that the nitrogen pneumatic and instrument air systems are adequately separated and supported by backup systems.

IV. Investigative Efforts

A. Synopsis of AIT Activities

The AIT initially reviewed the special test procedure (SP 88-3-15) and results of the May 16 and 17 testing. From this review the team determined that five possible root causes existed in two general areas. The May 16 test results indicated that a possible physical restriction may have prevented the MSIVs from closing on springs only. The team identified MSIV spring tension degradation and excessive valve packing friction as possible causes. The review of the May 17 testing revealed that three additional causes associated with the motive force (instrument air for the outboards and pneumatic air for the inboards) may have prevented the MSIVs from fully closing; excessive leakage of stored accumulator air (check valve failure), failure of the MSIV solenoid manifold pilot valves, or air purity.

On May 19, the licensee began a series of troubleshooting tests to determine the root cause. Listed below is a summary of these areas of possible root cause and reasons why they were chosen.

1. MSIV Actuator Springs:

The springs were chosen because of the generic failure of all eight MSIVs during the Spring Only Closure Test on May 16.

2. MSIV Stem Packing:

The packing was chosen by the AIT because of prior experience of some of the Team's members with steam valves and packing. The team determined that, for packing to be the generic cause of all eight failures, the maintenance practices and procedures would also be investigated.

3. Automatic Valve Co. (AVCo) Air/Pneumatic Manifold:

The manifold, including solenoids, pilots and 4-Way valves, was selected based upon similar failures documented in NUREG 1275, Volume 2.

4. Loss of Accumulator Volume:

During the May 17, 1988 testing, the accumulator volume bled down to 0 psig without positioning the MSIVs fully closed. Based upon the understanding of the function of accumulator, the team selected the accumulator check valves and the integrity of the air system as likely suspects.

5. Air Supply Purity:

The team selected the quality of the air motive system because of similar problems noted in NUREG 1275.

The team also established a quarantine of the MSIVs and their associated systems to assure that the initial "as found" conditions would be maintained. The licensee conducted an extensive "as found" documentation to assist in the root cause determination. Based upon these efforts and the May 16 test results the following "as failed" conditions were determined for the inboard and outboard MSIVs:

	Valve No.	Position
(inboards)	203-1A	2 1/4" from full open
	203-1B	1/8" " " "
	203-1C	2 5/8" " " "
	203-1D	8 1/4" " " "
(outboards)	203-2A	3/4" " " "
	203-2B	1 5/8" " " "
	203-2C	5 5/8" " " "
	203-2D	2 1/2" " " "

It should be noted that valves 203-1B and 203-2A traveled less than 10% from the full open position while all others traveled beyond the 90% of full open scram setpoint.

On May 18, the licensee conducted an initial troubleshooting test on the inboard 203-1A valve. The objective of the test was to determine the effect that valve packing had on preventing the MSIV from closing on spring force only. The licensee loosened the valve packing and conducted the May 16 testing using the exercise control solenoid (venting the above and below MSIV actuator piston cavities) and allowing closure on spring force only. Additionally, the Technical Specification surveillance test DOS 250-2, "Quarterly MSIV Closure Timing," was conducted. DOS 250-2 tests the ability of the MSIVs to close between 3 to 5 seconds with instrument/pneumatic air and spring assistance. The results of both tests revealed that the MSIV would fully close on spring force only within 30 seconds and within 3 to 5 seconds (as required by Technical Specifications) on pneumatic air with spring assistance. The licensee additionally applied lubricant to the valve stem and the valve guides. The lubrication improved the valve's response to spring only closure to less than 20 seconds but did not have any noticeable affect on the pneumatic air with spring assistance closure (DOS 250-2). The team reviewed these results and determined that further testing would still be required to identify the root cause.

On May 19, the licensee commenced a formal troubleshooting program.

B. Licensee Actions

On May 17, 1988, the licensee formed a task force to investigate the event and determine the root cause. The root cause analysis determined possible causes in agreement with the AIT determination as listed previously.

The following is a summary of troubleshooting tests conducted by the licensee with brief descriptions of test objectives, results and methods:

1. Special Test SP 88-5-56, "Leak Rate Test of the MSIV Accumulator Check Valves"

   * Test Objectives: To verify that the accumulator check valves will maintain the stored volume during a slow loss of air.

   * Results: inboards 1A 2.86 SCFH, 1C 2.32 SCFH, 1B 4.42 SCFH, 1D 8.55 SCFH
     outboards 2A 12.13 SCFH, 2C 33.19 SCFH, 2B 8.29 SCFH, 2D 7.02 SCFH

* Conclusion: Although the leakage from 2C was excessive and 1D, 2A, 2B and 2D were high, the team concluded that check valve leakage was not the root cause of the 8 MSIV failures or the associated losses of accumulator volume because several of the valves did not exhibit leakage.

2. Special Test SP 88-5-57, "MSIV Manifold Assembly Testing"

   * Test Objective:

     Simulate Rapid and Slow Loss of Air (SLOA) to determine response of AVCo 4-Way valve and Pilot valve.

   * Test Method:

     The manifold was removed from the 1C inboard MSIV and tested with a bench assembly that included a 90 psi air supply, simulated above and below MSIV piston cavities, and an installed accumulator.

   * Results:

     During Rapid Loss of Air, the pilot and 4-Way valve responded as required and per design. However, during the SLOA test, the pilot intermediately positioned allowing the accumulator and below (opening) piston to vent to the atmosphere. This phenomenon started at a reduced system pressure of 48 psi and maintained the 4-Way in an intermediate position until system pressure reduced to 6 psi. At 6 psi, the pilot would position (due to internal spring tension) to allow pressurizing the above (closing) and complete venting of the below (opening) piston and close the valve.

   * Conclusions:

     The team could not determine that the failure of the 4-Way to position was the root cause.

3. Special Test SP 88-5-57 (Second Test), "MSIV Manifold Assembly Testing."

   (a) Test Objective:

   Simulate the phenomenon on a newly rebuilt AVCo 4-Way valve.

   (b) Test Method was the same as SP 88-5-57 on the 1C manifold.

   (c) Results:

   The same as the 1C tests.

4. Special Test SP 88-5-60, "Determination of Force to Compress MSIV Springs"

   * Test Objective:

     Demonstrate that MSIV closure springs have not degraded from original tension values.

   * Test Method:

     The 1C MSIV springs were compressed on a bench test assembly.

   * Results:

	1968 Data	1988 Test Data
a. Total Spring Constant	650 lbs/in	643 lbs/in
b. Closed Preload	4300 lbs	4335 lbs
c. Open Force	10280 lbs	10121 lbs

   * Conclusion:

     No significant degradation of the springs.

5. Special Test, "Unit 2 Outboard MSIV Air Isolation Testing Following Packing Adjustment"

   * Test Objective:

     To demonstrate the effect that packing adjustments have on the MSIV ability to go full closed during SLOA or spring-only.

   * Test Method:

     a. SP 88-3-15 testing for spring force only by isolating instrument air from the MSIV with the exercise control solenoid. b. DOS 250-2, "Quarterly MSIV Closure Timing," using air with spring to assist in closure of the valves. c. DOS 250-3, "Loss of Air," using the SLOA testing (accumulator plus spring as motive force) to achieve the phenomenon. d. The packing in valves 203-2A and 2C was adjusted per the results of the May 18 testing of valve 203-1A to allow operation with spring force only while valves 203-2B and 2D remained in the May 16 and 17 as failed packing condition.

* Results:

  Valves 203-2A and 2C passed all testing; fully closing on spring force only per SP 88-3-15 and closing within 3 to 5 seconds per DOS 250-2 with instrument air and spring force.

  Valves 203-2A and 2C achieved full-closed on spring force only even during the SLOA test designed to achieve the phenomenon.

  Valves 203-2B and 2D did not go full closed during either SP 88-3-15 (Spring-Only) or DOS 250-3, SLOA Phenomenon. However, both 2B and 2D did go full closed within 3 to 5 seconds during the air plus spring to close (DOS 250-2) test.

* Conclusion:

  The Phenomenon is only effective on preventing the valve from going full closed if the resistance due to tight packing is excessive.

  Valves 2A and 2C achieved full closure with springs-only and correctly adjusted packing with the accumulator clearly venting to the atmosphere. Also, the excessively tight packing did not prevent any of the MSIVs from going closed within the Technical Specification requirement of 3 to 5 seconds with normal system air available.

6. Special Test, "Packing Variable with MSIV Air Isolation Testing"

   * Test Objective:

     To determine if valve stem lubrication or valve stroking per the May 18 testing would free up valves 203-2B and 2D without loosening valve packing.

   * Test Method:

     The 2B valve's stem and guide posts were lubricated and stroked per DOS 250-2. Valve 2D was not lubricated but stroked per DOS 250-2 as initial conditions to performing the special air isolation testing.

   * Results:

     Both valves failed to go fully closed on spring only.

C. Details of Testing and Inspection Activities

1. Pneumatic Manifold Inspection and Testing

Results of bench testing the 1C-Inboard MSIV solenoid manifold assembly (valve pack 3-Way and 4-Way pilot valves) revealed that the Automatic Valve Company (AVCo) 4-Way pilot valve functioned as designed during a rapid loss of air. However, under a slow loss of supply air condition, the AVCo pilot valve positioned in a manner which enabled the stored air in the accumulator to bleed off at the same rate as the supply air header. The phenomenon, locking the 4-Way pilot valve in a mid-position, allowed both the below piston capacity and the stored accumulator capacity to vent off through the same manifold exhaust port. The phenomenon began, as repeated through subsequent testing, at about 48 psig supply air header pressure and persisted until both the accumulator and below piston pressure had reduced to about 7 psig. At about 7 psig, the 4-Way pilot valve's internal springs would overcome the phenomenon condition and complete the positioning of the pilot valve, allowing the remaining 7 psig stored air to be directed to the above piston cavity for assisting in MSIV closure. Thus, for the MSIVs to go full closed under this slow loss of air condition, little stored air would be available to assist in valve closure, requiring the springs to close the MSIVs unassisted.

On May 21, 1988, members of the AIT witnessed disassembly of the 1C MSIV 4-Way AVCo pilot valve. All of the viton o-rings were intact with no visible degradation. Patches of Dow-Corning Selecone lubricant were observed on several of the o-rings. Small black particles were observed adhering to the plungers. It could not be determined if the particles were from plant instrument air, or from bench testing, which had been conducted with service air in the hot shop subsequent to the May 17th event. Nonetheless, the internal parts of the AVCo pilot valve are so large it appeared unlikely that the small particles could have been a factor in the 4-Way pilot valve's performance.

Additionally, the AIT reviewed the maintenance procedure used in disassembly and assembly of the manifold solenoid valves and found the procedure adequate in instruction. The procedure also contained good clear diagrams that were of assistance to maintenance technicians during the disassembly and assembly evolutions.

2. Drywell Pneumatic System and Instrument Air System Inspection/ Testing

The AIT witnessed and reviewed the results of the licensee's inspection and leak testing of the pneumatic and instrument

air systems. The results revealed that most of the piping connections associated with the pneumatic/air systems had leaks. However, none of the leaks were significant individually or cumulatively to explain the loss of accumulator stored air during the slow loss of air condition.

Additionally, the licensee conducted leak rate testing of the eight accumulator check valves. Several of the check valves had high leakage rates and one had significant leakage (accumulator check valve associated with outboard MSIV 203-2C) requiring corrective maintenance, however; the leakage rate of all eight check valves was not at a sufficient rate to explain the loss of accumulator stored air during the duration of the slow loss of air test.

3. MSIV Closure Spring Inspection/Testing

The eight closure springs from the 1C inboard MSIV were tested to determine the force required to compress the MSIV springs. All springs performed as anticipated.

4. MSIV Stem Packing Assessment

The Team reviewed maintenance procedures, vendor manual and maintenance history to assess the type of packing installed in the Unit 2 MSIVs. The initial type of packing that was installed prior to 1986 was Q-P Self-setting packing (Q-P). Q-P packing is made from heavy woven asbestos in a general chevron shape. Asbestos packing has a natural moisture content and when used to seal steam, has a tendency to dry out. Because of the packing drying out, shrinkage of the packing will exist resulting in the need to insert additional packing to maintain adequate sealing and contact against the gland. The instructions contained within the Q-P manufacturer's manual listed several important notes for installation and use of Q-P Self-setting packing. The manual noted that additional packing rings may be added to maintain the necessary contact with the gland and that the number of additional rings should be equal to approximately 10% of the number of rings required to initially fill the stuffing box. Based upon this instruction, one or two additional rings would be sufficient to maintain gland contact and adequate steam sealing. Additionally, the manual cautioned that Q-P packing must not be jammed or forced into the stuffing box (as is the practice with square and other types of packing) because the packing friction would clamp the stem and prevent free movement.

The review of maintenance history revealed that in 1986, the Unit 2 MSIV Q-P packing was replaced with John Crane Model 287 chevron packing. Model 287-I is a non-asbestos replacement packing for John Crane Model 187-I packing (equivalent packing to Q-P Self-setting). The review also revealed that Unit 3 still has Q-P installed.

The AIT determined that additional packing rings were installed or adjusted at an infrequent basis over three years (noted in Paragraph V) with no occurrences of adjustment on the Unit 2 MSIVs since 1986.

Subsequent to the review and testing, the licensee replaced the John Crane 287-I packing on the four inboard MSIVs (203-1A, 1B, 1C and 1D) with Chesterton Live Loaded packing. During the replacement, extreme difficulty was experienced in removing the installed John Crane 287-I packing.

One noticeable advantage with the Chesterton packing is vendor supplied torque values for the gland to prevent over tightening that could result in stem binding. Additionally, the new packing is squared graphoil type GIPI 5300 with an upper and lower carbon wiper to prevent excessive packing wear and provide consistent stem friction.

Additional review of the packing installation instructions and maintenance procedures revealed that the John Crane 287-I did not have specific instructions or cautions, applicable to chevron type packing, supplied by the vendor or addressed in the maintenance procedure. The AIT was not able to determine if the lack of specific instructions was the root cause of the stem binding, but did determine that because of the lack of instructions there was nothing to prevent recurrence of stem packing binding with future installation of John Crane 287-I chevron packing.

5. Unit 2 Outboard MSIV Air Isolation Testing Following Packing Adjustments

This test was the integrated Slow Loss of Air Test (SLOA) following the cycling of MSIVs 2A and 2C. Dresden Operating Surveillance DOS-250-3 was performed on May 21, 1988, to determine conclusively that valve packing was the major contributor preventing the MSIVs from fully closing. This was accomplished by simulating the same test conditions that existed during the original failure, the only difference being that the packing was adjusted on only 2 MSIVs (2A and 2C). The 2B and 2D MSIVs were maintained in their as-found condition with no packing adjustments, lubrication or any other maintenance. Packing on the 2A and 2C outboard MSIVs was adjusted as identified in the previous test. This adjustment actually "loosened up" the packing, that is, the force applied to the valve stem by the packing was decreased. The integrated test was performed by isolating the air supply to the outboard MSIVs, starting the valve timing at that time and observing the control room MSIV position indicating lights.

As pressure in the air supply to the MSIVs was decreasing, operations personnel were observing the pressure at the MSIVs.

At about 48 psig air header pressure, the pneumatic phenomenon initiated as expected from the manifold testing results. After approximately 5 minutes, MSIV 2C began to drift closed as indicated by lights in the control room and by confirmation of actual valve movement, when the MSIV air pressure reached 30 psi. Subsequently, MSIV 2A began to drift closed when the air pressure reached approximately 25 psi, which was also verified by both control room and local indications.

The 2A and 2C MSIVs reached the full closed position in 9 minutes 44 seconds and 9 minutes 15 seconds from the start of the test and about 15 seconds from start of stem movement, respectively. The 2B and 2D MSIVs did not reach the full closed position and only moved 3.75 and 4.75 inches out of approximately 17 inches total travel.

The test demonstrated that with properly adjusted packing (MSIVs 2A and 2C), the MSIVs would achieve full fail safe closure on spring force only. Additionally, the test demonstrated that the pneumatic phenomenon, as experienced during the bench testing, would not prevent closure of the MSIVs unless aided by excessive packing friction.

6. Testing/Cycling of MSIVs 2A and 2C

On May 21, 1988, members of the AIT witnessed closure tests of the 2A and 2C MSIVs. The tests were run to determine the effects that packing tightness and lubrication have upon MSIV closure timing. The procedure was to loosen the valve packing and then observe the time for closure in the spring only "fail-safe" mode as well as with an "air assist" (instrument accumulator air).

In order to obtain motion of MSIV 2C with only spring forces it was necessary to loosen up the packing nuts four flats. Full closure in the fail-safe/spring-only mode was achieved in 29.7 seconds. Next the packing nuts were tightened to the original position. Closure of the MSIV was then obtained with only spring forces in about 35 seconds. Following this the stem was greased with Felpro N5000 lubricant. The MSIV was then tested two times with instrument air. The valve closed during the air test in 5.2 and 4.7 seconds respectively. Subsequently, another fail-safe/spring-only test was performed. The closure time for this fail-safe/spring-only test was 19.7 seconds. Next the valve guide posts were lubricated and two more air assist tests were performed. Closure times for these two air assist tests were 4.8 and 4.5 seconds respectively. Another fail-safe/spring-only test was then run. Closure was achieved in 16.5 seconds.

MSIV 2A was tested in a manner similar to that which had been performed on 2C. The packing nuts were loosened 3 flats but the valve would not close in the spring-only mode. The packing nuts were then tightened flat and the valve was cycled and closed using air assists in 4.2 and 3.8 seconds, respectively. The valve was then tested in the spring-only mode in 30.4 seconds. The valve stem was then greased and 2 more air assist tests were run. The valve closed in 4.0 and 3.6 seconds respectively. Next, a spring-only test was run and the valve closed in 23.1 seconds. The guide posts were then greased with Felpro N-5000. Two air assist tests were run, resulting in closure times of 3.9 and 3.5 seconds respectively. One spring-only test was then run resulting in a closure time of 21.1 seconds.

D. Lessons Learned and Corrective Actions

Based upon the testing results and reviews of procedures, maintenance history and information associated with the failure of the MSIV to achieve full closure, several corrective actions and lessons learned were implemented by the licensee both prior to and subsequent to the May 24, 1988, AIT exit.

Provided below are summaries of some of the lessons learned and corrective actions:

1. The reviews revealed that, although several alarms would annunciate during degrading conditions of the pneumatic and instrument air systems, the operator actions required per the various Dresden Operating and Abnormal procedures were directed at finding the problem with the air system and correcting the condition instead of addressing the affected equipment.

   Based upon this lesson learned, the licensee revised the following annunciator procedures on May 24, 1988, to address operator actions required to mitigate adverse affects upon equipment. Abnormal operations procedure DOA 4700-1, "Instrument Air System Failure," was revised to require a manual scram at 55 psig instrument air header pressure and to manually close the affected outboard MSIVs. Annunciator Procedures DOA 923-1 (F6), "Instrument Air Dryer Trouble," and DOA 923-1 (F4), "Low Pressure in Instrument Air Receiver," were also revised to require a manual scram and closure of the affected MSIVs upon a decrease in instrument air system pressure below 55 psig.

2. The testing and vendor manual reviews revealed that inadvertent over tightness of chevron type packing could result in MSIV stem binding.

   Based upon this lesson learned, the licensee replaced the inboard MSIV chevron packing with Chesterton Live Load

square type packing. The square type packing was recommended as a replacement because of its relatively good steam sealing properties without exerting additional stem friction and because it allows control of stem friction by use of gland torque values. The chevron type packing was not supplied with applicable torque values by the manufacturer. The Chesterton packing was installed in the Unit 2 inboards subsequent to the May 24, 1988 AIT exit.

Additionally, the licensee initiated an evaluation of the maintenance procedure to ensure that adequate instructions and cautions are included for the applicable type of packing.

3. The testing revealed that the pneumatic phenomenon associated with the AVCo solenoid valves would render the MSIV accumulators inoperable during a gradual loss of pneumatic/air condition. The licensee committed to evaluate the possibility of eliminating the phenomenon as a requirement for satisfying the CAL. This evaluation is expected to be completed within six months after the May 24, 1988 AIT exit.

4. The FSAR description and the licensee's determination of fail safe closure of the MSIVs does not appear to be in agreement with the demonstrated spring only closure testing. The FSAR is not clear on the fail-safe closure, whether the closure is to be achieved by the MSIV external springs only or by the stored accumulator air with spring assistance. The licensee, GE and the Office of Nuclear Reactor Regulation (NRR) were continuing to evaluate the design basis of the MSIVs subsequent to the May 24, 1988 AIT exit.

V. Historical Reviews

A. MSIV Maintenance

1. Inservice Testing of MSIVs

The development of the current fail-safe test (FST) procedures by the licensee was a result of IE Information Notice No. 85-84: "Inadequate Inservice Testing of Main Steam Isolation Valves," and a previous failure identified in DVR No. 12-2-87-166. The FST was developed to verify MSIV closure upon a loss of actuator power, in this case, air.

ASME Code Section XI Paragraph IWV-34/5 states, in part "Valves with fail-safe actuators shall be tested by observing the operation of the valves upon loss of actuator power."

Upon review of the licensee's past and current IST programs, it was found that the FST was neither required nor performed prior to May 17, 1988, which appears to be contrary to the ASME Section XI Code.

However, it is not certain that MSIV closure on spring force only is within the design basis, and therefore, may not be required by the ASME Code Section XI.

In the interim, the licensee has committed to testing the MSIVs to verify closure on spring force alone on a cold-shutdown frequency by performing the SLOA test.

Again, the design basis of the MSIVs needs review in order to determine what would be the correct fail-safe mechanism of the valve and that the IST program adequately addresses fail-safe testing for the MSIVs.

2. Valve Maintenance History

The team reviewed the maintenance history listing for the Unit 2 inboard and outboard MSIVs. The review revealed that the Unit 2 MSIV packing (Q-P self-setting asbestos packing) was replaced with John Crane Model 287 in December 1986. The review also revealed that on only two occasions since 1984 was packing added during non-overhaul maintenance activities (valves 203-2A on January 14, 1985, and 203-2B on June 28, 1984), and that packing was adjusted on only three occasions (valves 203-1A and 203-1D on October 26, 1985, and valve 203-2B on April 6, 1986). A similar review of Unit 3 maintenance history also indicated that packing was added on only two occasions (valves 203-1C and 203-1D on July 12, 1986) and no adjustments during other than overhaul activities.

In general, the team found that both types of packing, QP and John Crane, has required little maintenance during operating cycles (seven occasions within three years for 16 valves with Q-P self setting and no occasions between December 20, 1986, and May 16, 1988, for 8 valves with John Crane #287 installed.)

B. Industry Events

A review of NUREG-1275, Volume 2, "Operating Experience Feedback Report - Air System Problems" and related NRC and industry information pertaining to MSIV failure to close was conducted. Listed below are the various documents reviewed:

1. NRC

IEC 81-14, "Main Steam Isolation Valve Failure to Close"

IEN 81-28, "Failure of Rockwell-Edwards MSIVs"

IEN 82-25, "Failure of Hiller Actuators Upon Gradual Loss of Air Pressure"

IN 85-17, "Possible Sticking of ASCo Solenoid Valves"

IN 85-35, "Failure of Air Check Valves to Seat"

IN 86-51, "Excessive Pneumatic Leakage in ADS"

IN 86-57, "Operating Problems with Solenoid Valves"

IN 86-81, "Broken Closure Springs on A&M MSIVs"

IN 87-28, "Air System Problems at Light Water Reactors"

2. INPO

O&MR-35, "MSIV Solenoid Actuator Lubricant Degradation"

O&MR-36, "MSIV Pilot Valve Adjustment/Testing"

SER 26-84, "Failure of MSIV to Fully Close During Surveillance"

SER 8-82, "MSIV Closure and Inadvertent Primary Safety Valve Actuation"

OPEX 4563518503800, "Failure of MSIVs to Close"

3. General Electric (GE)

SIL 309, "Lubrication of MSIV Guide Rods"

SIL 442, "Inspection of Atwood & Morrill MSIV External Springs"

4. Dresden Deviation (DVRs) and Event Reports (LERs)

DVR 12-2-73, "Reactor Scram, Drywell Pneumatic Isolated, MSIV Drift Close"

DVR 12-2-87-166, "MSIV Drifts Partially Closed"

DVR 12-3-81-16, "MSIV Closure During Scram Without Group I Signal"

DVR 12-3-81-56, "MSIV Closure During Testing"

DNR 12-2-87-166, "MSIV Partial Closure Due to Loose Air Line"

LER 86-017, "MSIV Full Closure During Surveillance"

The review of NRC Circular IEC 81-14, revealed that, in 1980, six failures of MSIVs to close were due to stem binding related to over

tightening of packing glands or inappropriate lubricants on the guide posts. The majority of the above NRC and industry information pertains to air system related problems with a few addressing broken closure springs (IN 86-81 and GE SIL 442) or lubrication of guide posts (GESIL 309 and INPO O&MR-35). Circular IEC 81-14 also recommended that maintenance procedures should be reviewed to ensure that they include precautions against detrimental affects such as over tightening of packing glands and that testing should demonstrate that the valves will perform under operating conditions before being placed in service. However, the IEC 81-14 was vague on what type of testing or operating conditions would be required to demonstrate operability of the MSIVs. It has been demonstrated that the Technical Specification required surveillance testing does not demonstrate the fail safe condition of the MSIVs with a loss of pneumatic/air supply. The licensee's response to IEC 81-14, dated January 8, 1982, also did not address the potential failure of the MSIVs to close upon a loss of pneumatic/air. The response addressed the Dresden specific problems of MSIV closure times being outside the Technical Specification required 3 to 5 seconds due to hydraulic dash pot adjustments.

The review of licensee's DVRs and LERs revealed that on July 12, 1986, MSIV 203-1C (Unit 2) went full closed during the surveillance test DOS 500-8, "MSIV Not Full Open Scram." The test normally allows the MSIV to go only 10% closed to test the MSIV-not-full-open-scram-setpoint by venting the above and below piston capacity and slowly closing on springs only. However, because of a limit switch failure, the MSIV went fully closed on spring only. This event, LER 86-017, demonstrated the ability of the MSIV to close on spring only.

C. Procedure Reviews

The AIT reviewed the Dresden Operating Annunciator (DOA) procedures to determine the required operator actions during a loss of pneumatic or instrument air header pressure. The review revealed that the majority of operator actions were focused upon finding the cause of the loss of air pressure rather than alerting the operator to significant actions to be taken with regard to specific equipment. The exception was DOA 902(3)-5 A-1, "Scram Valve Air Supply Low Pressure." The procedure stated that, "if the air header pressure is decreasing rapidly, or if the cause of the low air pressure cannot be determined in a timely manner, then immediately scram the reactor." The setpoint for the annunciator is 55 psig (decreasing), which would be also an indicator of instrument air supply header decreasing.

The AIT also reviewed various maintenance procedures, including those pertaining to overhauling and testing of the MSIV pneumatic manifold and installation of MSIV stem packing.

VI. Safety Significance

A. Immediate

This event had no immediate safety significance since the special loss of air test to Unit 2 MSIVs was conducted while Unit 2 was in cold shutdown and Unit 3 was in a refueling outage.

B. Under Operational Conditions

If this event were to occur while operating, it would be of minimal safety significance since the MSIVs would start to drift closed with either a loss of instrument air to the outboard MSIVs or a loss of the drywell pneumatic supply to the inboard MSIVs resulting in an automatic reactor scram due to an MSIV not full open (§90% open) scram setpoint. Also, the inboard and outboard MSIVs have two separate and independent air supply systems. The outboards MSIVs are supplied by the Instrument Air System and the inboard MSIVs are supplied with nitrogen from the Pump Back System. Thus, there is little safety significance if this slow loss of air condition developed while operating. If either the inboard or outboard MSIVs failed to go full closed due to a slow loss of supply air, the capability to isolate the main steam lines by closing the other MSIV, since it's air supply is independent of the first one, would still assure isolation.

VII. AIT Conclusion

Based upon the testing results, the AIT concluded that the root cause of all eight Unit 2 MSIVs failure to close was due to the restriction force supplied by the John Crane manufactured 287-I chevron packing. The integrated slow loss of air test demonstrated that with properly adjusted packing, the stored tension of the MSIV springs would close the MSIVs independent of air motive force, even during the pneumatic phenomenon. Additionally, the integrated test demonstrated that the MSIVs would close during the routine Technical Specification surveillance for MSIV timing using the normal pneumatic/air supplies. The AIT found that the routine surveillance would not reveal that packing restriction or the pneumatic/air phenomenon existed because of the significant force supplied by the normal pneumatic/air supply.

The ratio of normal closing forces verses resistance forces is about 8 to 1 with actuator (air supply) force available. Normal closing forces include the mass of moving parts (2%), inertia force of the valve mass (1%), spring force (27%) and the actuator force associated with the pneumatic or air supply (70%). The resistance force includes the packing friction (39%) and the stem unbalanced force (61%). During spring only closure, the ratio is normally only about 2 to 1 which is more than sufficient to fully close the MSIVs. However, if the packing resistance is increased to reduce the ratio to nearly 1 to 1, the MSIVs would not travel to full closure on spring only forces. Since the surveillance procedure uses normal actuator forces (pneumatic/air) to stroke the

MSIVs, an increase of packing resistance to twice its normal force would still produce a closing force ratio of about 6 to 1, sufficient to achieve full closure.

VIII. Concerns

Based upon the AIT reviews, the following concerns address the various maintenance, inspection and testing programs at Dresden.

The AIT reviewed the Inservice Testing (IST) Plan and determined that prior to the May 16 and 17 MSIV failure, fail safe testing with MSIV closure on spring only or slow loss of air testing, Instrument Air/ Pneumatic system leak tightness testing or MSIV accumulator check valve leak rate testing had not been periodically performed.

The accumulator check valve leak rate testing performed as part of the root cause determination associated with the MSIVs failure demonstrated leakage ranging from 2.3 to 8.6 SCFH for the inboard MSIVs and 7.0 to 33.2 SCFH for the outboards. Since the accumulator volumes are less than 24 SCF, the outboard 203-2C leakage of 33.2 SCFH would render the accumulator inoperable in less than one hour. Additionally, two others only had the ability of maintaining their stored volume for under three hours. Section XI of the ASME code requires testing of accumulator check valves. The licensee has committed to performing periodic leak rate testing of MSIV accumulator check valves. Subsequent to the May 24, 1988, exit, the licensee tested the Unit 3 accumulator check valves and replaced one outboard check valve because of excessive leakage. Additionally, the Unit 2 outboard MSIV (203-2C) accumulator check valve was replaced prior to returning the unit to service.

The slow loss of air testing is a method recommended by both the industry and the NRC based upon the failures experienced with the Automatic Switch Company (ASCo) solenoid valves. Dresden has Automatic Valve Company (AVCo) solenoid valves installed, as noted in NRC Information Notice IN 85-17 and IN 86-57. The slow loss of air testing will detect solenoid valve pilots sticking or locking in intermediate positions, where as testing the solenoids by only de-energizing the electrical solenoids and repositioning the solenoid valve pilots with motive air (pilot or system air), will not usually detect the pneumatic phenomenon. The licensee agreed that slow loss of air testing would be performed and conducted the Unit 2 integrated slow loss of air test on Unit 3 MSIVs subsequent to the May 24, 1988, AIT exit.

Pneumatic/air system leakage has been discussed in NRC Information Notice IN 86-51, "Excessive Pneumatic Leakage in the Automatic Depressurization System." The licensee is re-evaluating the type of testing and frequency for system testing. Currently, the Maintenance Work Analyst instructions verify the quality of pneumatic and instrument air but do not appear to contain periodic system leak tightness inspections.

The licensee's MSIV closure testing does not appear to meet ASME Code XI Paragraph IWV-3415, which requires that valves with fail-safe actuators

be tested by observing the operation of the valves upon loss of actuator power. Since the MSIVs are actuated by air (pneumatic for inboards and instrument air for the outboards) with spring assist for closure, and maintained open by compressed air below the actuator piston, the AIT ascertained that fail-safe operation would be without air and with spring only for closure. The licensee responded to NRC Information Notice IN 87-28 and Supplement 1, "Air Systems Problems at U.S. Light Water Reactors," on May 9, 1988. The response addressed the NRC Recommendation #5, "all operating plants should be required to perform gradual loss of instrument air system pressure tests," by providing a description of the current testing procedures. In addition, a new surveillance procedure, DOS 250-3, "Main Steam Isolation Valve Fail-Safe Test During Cold Shutdown," (dated July 1987) was developed. DOS 250-3 was the basis for the special test performed on May 16 and 17, 1988, that discovered the failure of MSIVs to close on loss of air. Because the MSIVs would not close on spring only, the licensee declared the MSIVs inoperable. However, a review of DOS 250-3 revealed that the intended fail-safe operation is springs assisting stored accumulator air to actuate the MSIV closure. The test method contained within DOS 250-3 isolated the main pneumatic/air supplies from the accumulators and allowed gradual decrease of pneumatic/air system pressure until the pressure stored under the MSIV actuator piston had vented, when the stored air within the accumulators would be directed through the pneumatic manifold solenoid valves (repositioned by internal springs to closing ports because of loss of pilot air) to the actuator above piston cavity. Because of the pneumatic phenomenon (demonstrated during bench testing of the manifold valves) the accumulators would not be available during a gradual loss of air and, as a result, the true fail-safe operation is the MSIV external springs only. Once the pneumatic phenomenon was understood, DOS 250-3 became the basis of the special integrated slow loss of air test. This test clearly demonstrated that fail-safe operation (per DOS 250-3) can be achieved if packing friction does not exceed the spring tension force.

The AIT also reviewed the slow loss of air test performed at Dresden's sister facility, Quad Cities. The Quad Cities test clearly demonstrated that fail-safe operation was achieved on MSIV external springs only but did not verify whether the pneumatic phenomenon did or did not exist. The difference between the Dresden and Quad Cities tests was Quad Cities ability to isolate and vent the MSIV accumulators prior to isolating the pneumatic/instrument air system. The licensee has agreed to perform the integrated slow loss of air test periodically and after significant maintenance involving MSIV stem packing. The licensee is evaluating a criteria in determining when testing will be required for less significant maintenance, such as adjusting the packing on one or two MSIVs only.

IX. AIT Recommendations

The AIT recommends that MSIV fail safe testing should be conducted with spring only forces to close and that this testing should also be conducted prior to unit startup after significant maintenance activities involving stem packing; such as, replacement of packing, modification of packing type, addition to and adjustment of installed packing, to ensure that closing resistance has not increased to prevent fail safe closure of MSIVs during a loss of actuator pneumatic/air supply.

Additionally, the AIT recommends the following testing, inspection and evaluation activities.

A. IST Activities

1. Criteria and testing should be established for MSIV pneumatic/air accumulators, accumulator check valve and system piping for air leakage to ensure that system and component degradation does not result in loss of air conditions. The leak rate testing performed as part of the root cause determination revealed that the capacity of the accumulators was only 24 SCF and that measured check valve leakage ranged from 2.3 to 8.6 SCFH for the inboards (the licensee repaired the 203-2C accumulator check valve because of leakage greater than 24 SCFH). Since a leakage rate of 12 SCFH would render an accumulator inoperable with insufficient capacity in less than two hours, it is recommended that the basis for the criteria of less than 24 SCFH be determined and that the criteria address the length of time that the stored air is required to be available to meet the design basis of the MSIVs.

2. Fail-Safe Testing of MSIV as Required by ASME Code Section XI (The Code) Paragraph IWV-3415 (IWV-3415).

   The code requires "valves with fail-safe actuators shall be tested by observing the operation of the valves upon loss of actuator power." Prior to the test performed on May 17, 1988, no fail-safe test (FST) was performed on the MSIVs.

   The team observed this situation and contends that the proper FST is conducted with loss of air to the MSIV, requiring closure solely by spring pressure.

   The licensee contends that closure by spring force alone is not within the design basis, and therefore does not fall into the scope of IWV-3415. To properly resolve this issue, the team has requested NRR to include fail-safe testing methodology of the MSIVs along with the design basis review.

B. Procedures

1. Procedures pertaining to installation and adjustment of MSIV stem packing should contain adequate instructions and criteria to ensure that packing friction forces do not restrict closure of MSIVs during fail safe conditions.

2. Operating procedures should provide for operator actions prior to pneumatic/air system pressure decreasing to about 48 psig. Testing demonstrated that the pneumatic phenomenon exists during slow loss of air conditions at about 48 psig to 7 psig. Operator action prior to the phenomenon initiation pressure region would ensure isolation availability.

3. Maintenance procedures should provide adequate instruction for installation of applicable packing types used in the MSIVs. Since Unit 3 has Q-P Self-setting installed while Unit 2 has Chesterton Live Load type installed in the four inboard valves and John Crane 287-I in the outboards, procedures should address the different practices associated with each type of packing. The Review of Vendor instructions demonstrated that chevron type packing cannot be installed in the same method, jamming into the stuffing box, as with square and other types without causing stem binding.

C. Evaluations

1. The licensee should conduct an evaluation to determine the adequacy of the pneumatic/air phenomenon and the possibility of eliminating its existence.

   Since the AVCo pneumatic phenomenon contributed to the failures experienced on May 16 and 17, it is recommended that in order to assure successful MSIV closure upon gradual loss of air, the licensee should evaluate modifications to eliminate the phenomena. The licensee has committed to complete an evaluation within six months as long term corrective actions to the CAL.

2. An additional evaluation should be conducted to determine the possibility of the phenomenon existing with other pneumatic control valves in systems requiring a fail safe condition.

3. An evaluation should be conducted to determine the adequacy of fail safe testing on other systems to ensure that proper testing methodology is being used to verify compliance of system designs.

4. An evaluation of maintenance procedures should be conducted to ensure that adequate instructions and cautions are included to address the appropriate type of packing being used for different applications.

5. IE Circular IEC 81-14 should be re-evaluated for applicability to stem binding and post maintenance testing associated with packing installation, repacking, addition of rings and adjustments. The testing should demonstrate operability of the valves during operating and, as reasonable as possible, accident conditions including fail-safe conditions with and without stored accumulator air.

6. An evaluation of Quad Cities Units 1 and 2 should be conducted to determine the applicability of MSIV fail-safe testing, MSIV stem packing practices and the existence of the pneumatic phenomenon.

D. Testing

The AIT recommends that periodic fail-safe MSIV closure on springs only testing be performed. In addition, fail-safe testing should also be performed as post maintenance requirements associated with significant maintenance to MSIV stem packing.

E. Information Notice

1. The AIT recommends that the NRC issue an Information Notice addressing the Dresden Unit 2 MSIV failure, including the importance of fail-safe testing, post packing maintenance testing and the pneumatic phenomenon.

2. The AIT recommends that CECo communicate to the industry the lessons learned from the MSIV failure to close event, including the pneumatic phenomenon and post maintenance testing associated with stem packing.

F. Inspection

The AIT recommends that Hope Creek's MSIV fail-safe testing be evaluated by the NRC. Hope Creek has a similar air manifold (although different MSIVs) and may experience similar pneumatic phenomena. The AIT reviewed, subsequent to the May 24, 1988 exit, the Hope Creek slow loss of air test data (performed in December 1985). Examination of the test data revealed that the MSIVs closed on springs only (between 15 and 30 seconds). However, it was not apparent from the review of the test procedure that the MSIV closure was expected to be on spring only and not to be assisted by the stored accumulator air. The testing conducted at Dresden demonstrated that during the pneumatic phenomenon condition, MSIV closure will occur within about 20 seconds on spring only instead of between 3 to 5 seconds via stored accumulator air.

10. Exit Interview (30703)

The inspectors met with licensee representatives (denoted in Paragraph 1) on May 24, 1988, and informally throughout the inspection period, and summarized the scope and findings of the inspection activities.

The inspectors also discussed the likely informational content of the inspection report with regard to documents or processes reviewed by the inspector during the inspection. The licensee did not identify any such documents/processes as proprietary. The licensee acknowledged the findings of the inspection.