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April 19, 2002
L-02-040

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555-0001

Subject: **Beaver Valley Power Station, Unit No. 1**
BV-1 Docket No. 50-334, License No. DPR-66
Supplemental Response to Bulletin 2002-01, Reactor Pressure Vessel Head Degradation and Reactor Coolant Pressure Boundary Integrity

Reference: 1) FENOC letter L-02-032, dated April 1, 2001, BVPS 15-day Response to NRC Bulletin 2002-01

2) FENOC letter L-01-136, dated October 31, 2001, BV-1 1R14 Response to NRC Bulletin 2001-01

This letter provides a FirstEnergy Nuclear Operating Company (FENOC) supplemental response for Beaver Valley Power Station (BVPS) Unit 1 to NRC Bulletin 2002-01 dated March 18, 2002. As required by the Bulletin, a 15-day response was provided for BVPS Units 1 and 2 on April 1, 2002 (Reference 1) to address reactor pressure vessel head degradation.

In a conference call on March 28, 2002, the NRC requested that supplemental information be provided regarding the condition of the Unit 1 reactor pressure vessel head. Specifically, the following information was requested:

- Additional photographs that show the boric acid accumulations on the Unit 1 reactor pressure vessel head, as was noted in our previous submittal (Reference 2).
- Mapping of the entire head area based on the recent visual inspections captured on video.
- Discussion of the clean-up/evaluation efforts, specifically under the insulation on the head area, associated with previous external conoseal leaks from above the head insulation.

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The requested supplemental information is provided in Attachment A. Note that this submittal also supplements the information provided by FENOC on October 31, 2001 (Reference 2), which documented the results of the visual examinations performed on the Unit 1 reactor pressure vessel head during the most recent Unit 1 refueling outage.

In summary, a 100% bare head inspection of the Unit 1 reactor pressure vessel was conducted; and the inspection confirmed no indication of active boric acid leakage as evidenced by the absence of any rust-colored staining or streaking on the head.

Since the information being provided is supported by photos/video images, we believe that it would be beneficial if NRC reviewers met with cognizant BVPS personnel in order to obtain a more complete understanding of this matter. We suggest that a meeting be scheduled in the near future to aid in the review of this issue.

If there are any questions concerning this matter, please contact Mr. Larry R. Freeland, Manager, Regulatory Affairs/Corrective Action at 724-682-5284.

I declare under penalty of perjury that the following is true and correct. Executed on April 19, 2002.

Sincerely,

Lew W. Myers

Attachment

c: Mr. D. S. Collins, Project Manager
Mr. D. M. Kern, Sr. Resident Inspector
Mr. H. J. Miller, NRC Region I Administrator
Mr. D. A. Allard, Director BRP/DEP
Mr. L. E. Ryan (BRP/DEP)
Ms. C. O'Clair, Ohio Emergency Management Agency

Attachment A
BVPS Supplemental Response to NRC Bulletin 2002-01

The following is supplemental information regarding the condition of the Beaver Valley Power Station (BVPS) Unit 1 reactor pressure vessel head

In a conference call on March 28, 2002, the NRC requested that supplemental information be provided regarding the condition of the Unit 1 reactor pressure vessel head. Specifically, the following information was requested:

- Additional photographs that show the boric acid accumulations on the Unit 1 reactor pressure vessel head, as was noted in our previous submittal.
- Mapping of the entire head area based on the recent visual inspections captured on video.
- Discussion of the clean-up/evaluation efforts, specifically under the insulation on the head area, associated with previous external conoseal leaks from above the head insulation.

In order to address these issues, the following topics are presented in this supplemental response:

- Introduction
- Mapping of the BVPS Unit 1 Reactor Vessel Head
- BVPS Unit 1 Review of Boric Acid Leakage and Corrective Actions
- Boric Acid Corrosion Control Program at Beaver Valley
- Comparison of Design Features (BVPS Westinghouse design to the B&W plants)
- Visual Examination Results - BVPS Unit 1
- Summary

Introduction

The Materials Reliability Program (MRP) survey conducted for PWRs grouped the plants based on their response to reactor closure head degradation. The survey results identified Beaver Valley Unit 1 in the "other" category. The NRC questioned the categorization of Beaver Valley Unit 1 as "other" and requested additional information to better understand the condition of the Unit 1 Reactor Pressure Vessel (RPV) head.

The MRP categorizations were based on the following acceptance criteria relative to the amount of bare head inspection performed and the degree to which above the head leakage has been managed:

> _Category 1_: *The plant performed a 100% bare metal inspection of their RPV head and the region above the head at their most recent outage. The inspection indicates no boric acid was present on the head and none present above the head.*
>
> BVPS Unit 1 conducted a 100% bare head inspection of the RPV head, and was not placed into this category because the visual examinations indicated some boric acid accumulations on the head area.
>
> _Category 2_: *During the Category 1 inspections, boric acid accumulations were detected, removed by the plant, and the affected areas of the RPV head inspected. The source of the boric acid was determined and corrected.*
>
> BVPS Unit 1 could not specifically be classified as a Category 2 plant because, even though a 100% bare head inspection of the RPV head was conducted, some accumulations of boric acid were detected and have not been completely removed. Slight boric acid accumulations from previous Conoseal leaks were evident from the visual examinations recently conducted. The results of our visual examinations were provided in our submittal dated October 31, 2001, which noted accumulations in the vicinity of penetrations #59 and #65, which are near Conoseals #1 and #2, respectively.

Therefore, since BVPS Unit 1 did not strictly fit into the categories defined by the MRP acceptance criteria, it was designated as "other."

Mapping of the BVPS Unit 1 Reactor Vessel Head

Based on the visual examinations performed in September 2001 on the Unit 1 reactor vessel head area captured on video, a mapping of the entire head has been performed. The map (Figure 1) includes a legend to denote the various degrees of boric acid residue on the head surface, ranging from a light dusting to larger flakes and debris, as well as photos (Figures 2 through 6) to depict examples of the various conditions present. Figure 7 is provided to illustrate the mirror insulation configuration (plan view). The four conoseal joints identified in Figure 1 as penetrations #47, #53, #51, and #49 are located above the insulation and shroud.

BVPS Unit 1 Review of Boric Acid Leakage and Corrective Actions

There have been four recorded instances of external flanged connection leaks from above the head insulation at BVPS Unit 1. These were associated with the #1 and #2 conoseals (See Figure 1 for Conoseals #1 and #2 identified as penetrations #47 and #53, respectively). A review of available records and interviews with personnel involved with the previous conoseal leaks identified that the affected areas were cleaned and inspected. The following summarizes the results of our review:

- The first identified leakage was in 1984 during refueling outage 1R04. The leakage was from Conoseal #1 and the refueling logs indicate that the insulation in the vicinity of the leak was removed and the boric acid was cleaned following repair of the conoseal, however the extent of cleaning is not documented.

- Leakage from Conoseal #2 was noted in 1987 during refueling outage 1R06. This resulted in a very thin layer of boric acid residue in the vicinity of the leak. Refueling logs note boric acid cleanup efforts following repair of the #2 Conoseal. Follow-up inspection and evaluation of the head in the vicinity of the leak concluded no evidence of vessel head degradation.

- Leakage from Conoseal #2 was again detected in 1989 during refueling outage 1R07. The area was cleaned following repairs however the extent of cleaning is not documented. A visual inspection recorded only a slight dusting of boric acid on the reactor head insulation. There is no record of an inspection or evaluation of the head area. During plant startup from 1R07 at operating temperature and pressure, visual inspections reported no boric acid leakage around the conoseals and head area.

- In 1991, during plant startup from refueling outage 1R08, a leak at Conoseal #1 was discovered. A visual inspection noted boric acid accumulation around the conoseal area. The area was cleaned and inspected following the repair of the conoseal leak, however the extent of cleaning is not documented. Upon startup, the area was reinspected for leakage and no leaks were found.

As early as 1984, the records indicate that the boron accumulation from conoseal leakage was removed from the head area, which demonstrates the sensitivity to boric acid leakage at Beaver Valley.

During the visual examinations performed in September 2001, the two noted locations that showed evidence of previous external leakage on the surface of the reactor vessel head were in the area of CRDM penetrations #59 and #65, which are located adjacent to conoseals #1 and #2, respectively. Minor boric acid staining and slight traces of leakage running down the CRDM nozzles located adjacent to and near the four conoseals is also evident on the inspection video. The video shows evidence that the boric acid leakage from the conoseal flanged connections located above the head area, leaked through the mirror insulation seams and collected on the underside of the insulation, and in some cases ran down the penetration nozzles as shown on the attached photos (Figures 2 through 6).

The original style Marman Clamp Conoseal design, which was installed prior to initial power operations (1976), was replaced with the newer style Articulating Clamp Conoseal design during refueling outage 1R07 in the fall of 1989. The newer style clamp is stainless steel and eliminated the need to use a special hydraulic tool to install the old style Marman clamp. The improved conoseal design and the formal boric acid walkdowns that are conducted during the refueling outages following a cycle of operation and also during startup from a refueling outage have improved performance and minimized the effects of boric acid leakage from conoseals.

Beaver Valley was involved in the early development of the information and technical bases for the evaluation of boric acid leakage. In the early 1990s, following the release of Generic Letter 88-05, a Beaver Valley representative was one the three principles involved in the development of the Boric Acid Corrosion Evaluation Program managed by Electric Power Research Institute (EPRI). Phase 1 of this project, TR-101108, was issued in December of 1993. This publication was the first compilation of the available literature and testing that was performed concerning boric acid corrosion and provided the industry with an improved source of references that could be used in evaluations when necessary. The data presented in the references lacked the depth of understanding and much of the testing was of limited value, so continued efforts were funded. The program development continued with testing and further research and resulted in the Boric Acid Corrosion Handbook, TR-102748, which was published in 1995.

Boric Acid Corrosion Control Program at Beaver Valley

Beaver Valley developed the Boric Acid Corrosion Control Program as required by NRC Generic Letter 88-05 "Boric Acid Corrosion of Carbon Steel Reactor Pressure Boundary Components in PWR Plants". The program requirements included the following:

- The determination of principle locations where coolant leaks smaller than allowable specification limits could cause degradation of the pressure boundary by boric acid corrosion,
- Methods for conducting examinations that are integrated into VT-2 exams conducted during system pressure tests, and
- Corrective actions to prevent recurrences of this type of leakage.

Beaver Valley initiated formal boric acid walkdown inspections in July 1990. These inspections were performed during refueling outages to identify evidence of leakage following a cycle of power operation. The inspections provide for the identification of the need for corrective maintenance at the onset of an outage. Additionally, ASME Code required system leakage examinations at nominal RCS operating temperature and pressure are performed at the end of refueling outages prior to power operation. System leakage examinations have been performed since initial power operation at Unit 1.

In September 1999, Beaver Valley performed a self-assessment of the Bolted Connection Examination Program and identified areas for improvements. The Boric Acid Corrosion Control Program now has a single point of contact for ownership of the program. Inspection personnel are sensitive to the locations that contain carbon steel bolting when performing walkdowns. The boric acid leakage inspection practices at Beaver Valley currently include the following attributes:

- Inspection personnel are sensitive to the locations that contain carbon steel bolting when performing walkdowns.
- The low point of any insulated borated piping system is carefully examined for evidence of leakage since leakage would accumulate at this point.
- The underside, insulation joints and low points of insulated vessels and tanks containing borated water are also examined for evidence of leakage.
- Evidence of leakage is identified and evaluated.
- Boric acid leaks identified during the boric acid walkdown inspection are entered into the site corrective action program and are resolved through the mode hold resolution process prior to plant startup.

Comparison of Design Features (BVPS Westinghouse design to the B&W plants)

When assessing the status for the potential boric acid accumulations on the RPV Head that may go undetected for an extended period of time, the plant design and insulation type must be taken into account.

- The Westinghouse designed 3-loop plants, like Beaver Valley, are significantly different in design from the B&W designed plants. The major difference is in the number of mechanical joints above the reactor vessel head. The B&W design uses a flanged and gasketed connection for all 65 CRDM penetrations. The Westinghouse design uses threaded and seal welded connections for the CRDM housings which are less susceptible to leakage.

- The low number of mechanical joints in the Westinghouse design provides significantly fewer opportunities for external leakage to occur from above the head. While leaks from the flanged connection conoseals can occur, they are promptly detected and corrected prior to restoring the unit to operation following a refueling outage.

- The Westinghouse designs (like Beaver Valley) have a tiered, mirror type insulation on the RPV head that allows for reasonable access to the RPV head for inspection without major design changes to the ventilation shroud.

- The Westinghouse design allows for access to the top of the head by lifting or removing a few pieces of the insulation. Although not designed as inspection access points, it does provide access for both direct visual inspection of the general condition of large portions of the head, and for the use of remote visual inspection equipment. The B&W original design does not provide easy access for direct visual inspection of the top of the head.

Visual Examination Results - BVPS Unit 1

As documented in Reference 2, the bare head inspection performed during the 1R14 refueling outage found no indications of recent boric acid leakage from any penetrations in the Reactor Vessel Head at BVPS Unit 1. As can be seen from the BVPS Unit 1 photos provided in this submittal, none of the penetrations displayed boric acid accumulations (popcorn or string-like in nature) similar to a failed CRDM penetration experienced at other plants as noted in the recent EPRI Report, TR-1006296 Rev.1, "Visual Examinations for Leakage of PWR Reactor Head Penetrations on Top of RPV Head," dated March 2002. The results of the recent visual examination of BVPS Unit 1 reactor vessel head are also included in this EPRI report.

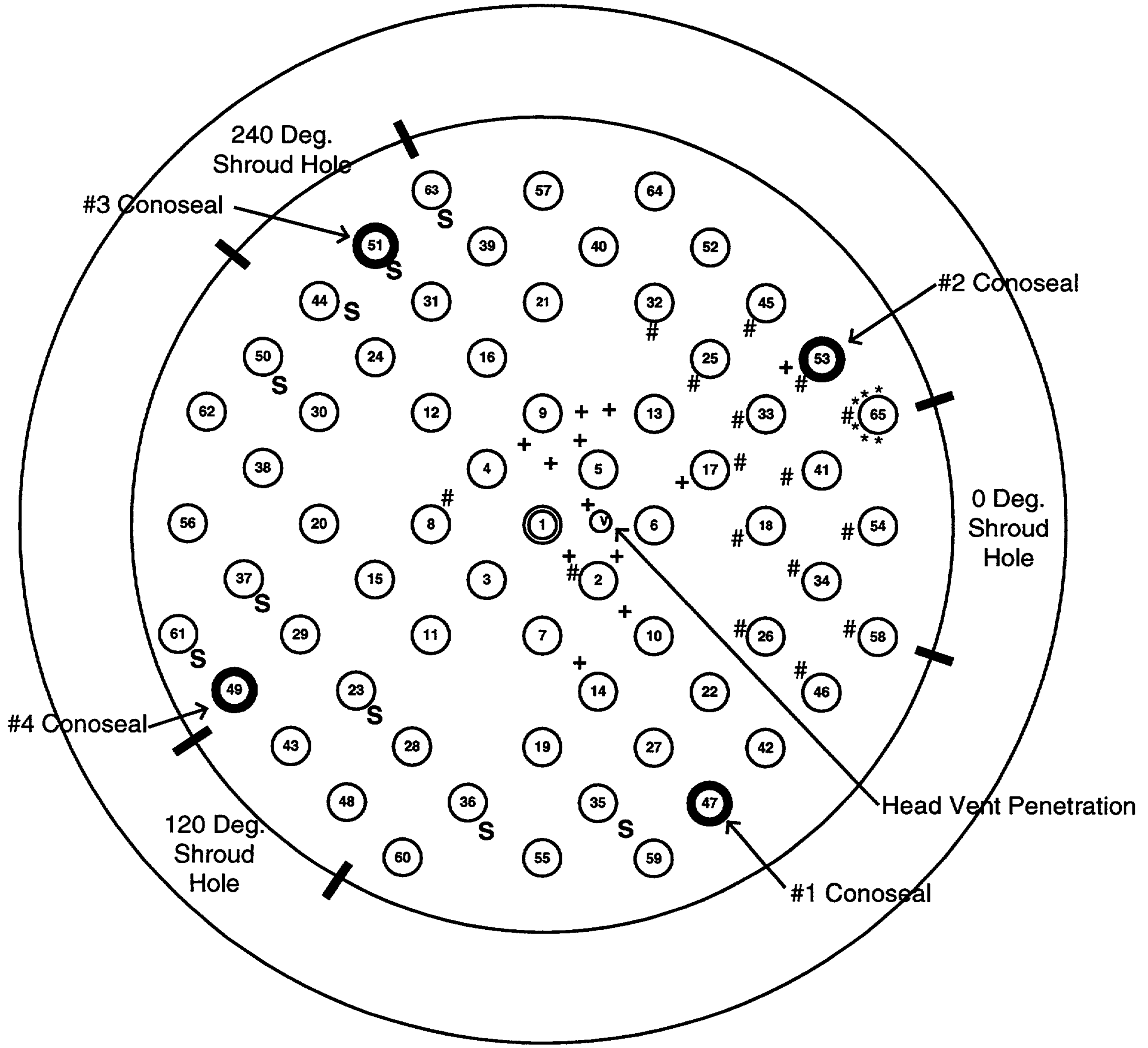
The BVPS Unit 1 report noted that some debris and small amounts of loose accumulations where found, primarily on the uphill side of several penetrations. These granular accumulations are such that a popcorn size or string-like deposit could not be missed, and since the accumulations were not adherent to the head surface (like those found at other plants that experienced leaking penetrations), they were evaluated as acceptable. These types of accumulations (dry crystalline boric acid residue mixed with insulation debris, rust flakes and dirt) are consistent with previous conoseal leaks from above the head. The inspection did identify a small area of corrosion around Penetration #65. (See Figure 6 for photos of the area) This corrosion was evaluated as being from a conoseal leak that was repaired several outages ago (1R06). Since the area around the CRDM #65 showed neither signs of active corrosion nor any significant accumulation of corrosion product around the CRDM or the area below the CRDM nozzles, the evaluation concluded that no active degradation or leakage was occurring. The report also noted some boric acid residue on Penetrations #35 and #59. The residue on these penetrations was white in color and lacked any depth; an inspection of the underside of the insulation in the area also identified boric acid residue on the insulation. The pattern of the residue was consistent with a leak from above that was carried by the ventilation air flow and deposited against the insulation material and the CRDMs 'down wind' from the leak. Past leakage from this conoseal was verified and no corrosion products were observed. It should be noted that the residue on Penetrations #35 and #59 does not extend to the base of the CRDM nozzles.

Summary

It was concluded that no penetrations at BVPS Unit 1 contain a leaking through-wall flaw, and that the indications of boric acid accumulations noted during the visual examinations were associated with previously identified external conoseal leaks from above the head insulation area.

It is important to note that no significant rust-colored corrosion products were identified on the head and the residue noted during the recent visual examinations was generally white in color, indicating that corrosion was not occurring. For all areas where either boric acid residue and/or evidence of corrosion was evident, these areas were evaluated to determine the most likely source of leakage and ensure that active leakage was not occurring. The lack of a quantifiable amount of corrosion products on the head and the absence of rust-colored staining or streaking provide evidence that there is no indication of active leakage at the head penetrations.

Figure 1
BV- 1 Reactor Vessel Head Map



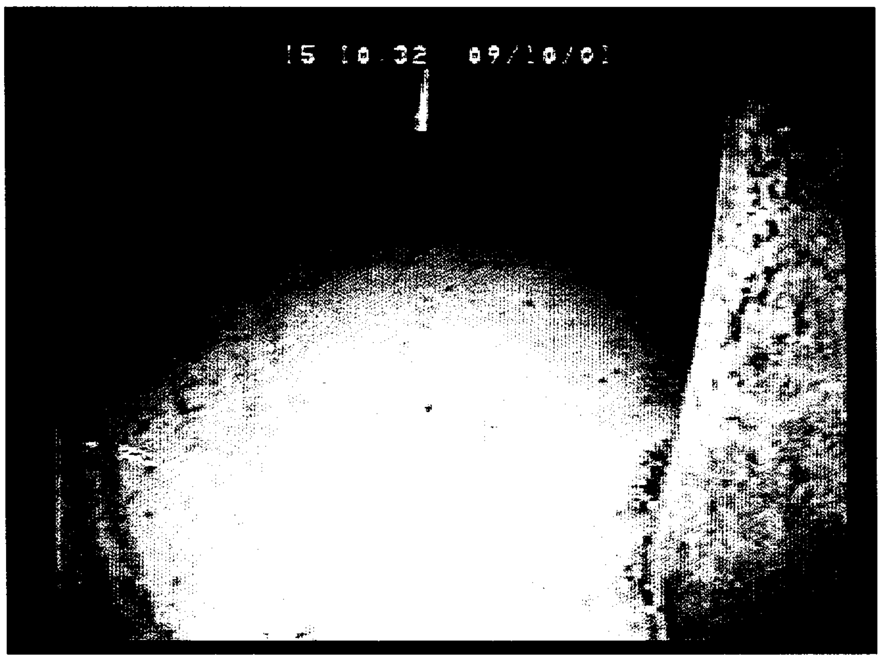
Greater than 90% of the reactor vessel head surface within the shroud periphery has a light dusting of boric acid residue. This dusting is primarily white in color and is generally less than 1/32" in thickness, and is illustrated in Figure (2)

- **+ = Head surface areas with larger, loose flakes and other debris present. (Figure 3)**
- **# = Penetrations with loose debris in vicinity of penetration (usually "uphill"). (Figure 4)**
- **S = Head surface areas with pronounced white stains (Figure 5)**
- *** = Corrosion adjacent to Penetration # 65 (Figure 6)**

Figure 2

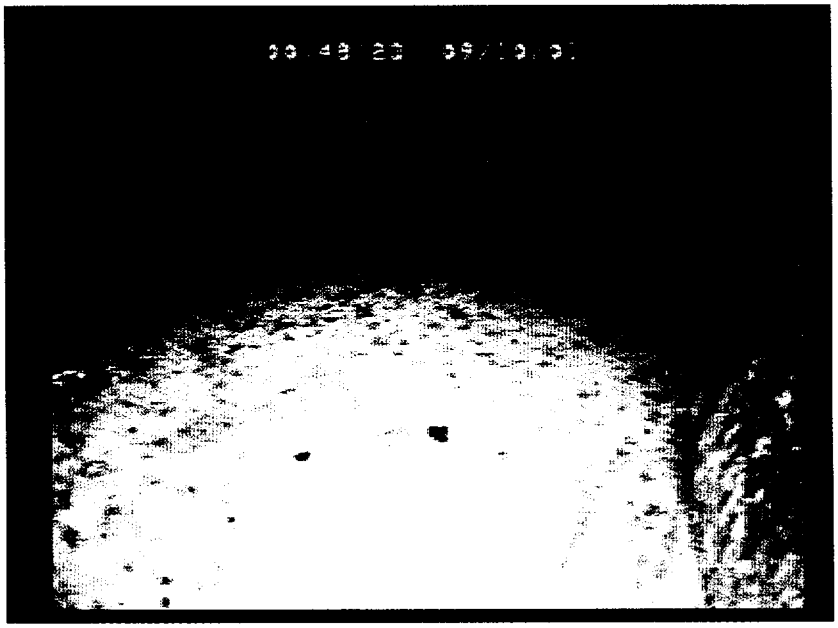
Typical Examples of “Light Dusting” on Head Surface & Penetrations

General note applicable to still images supplied in this submittal – The images shown are illustrative to provide images and examples of the conditions described within the text. The images are 320 x 240 pixel resolution captured from the Super VHS videotape used to document the examination. As such, some detail, latitude and contrast that is clearly visible in the videotape when viewed on appropriate monitors is lost in these images. Additionally, some images may exhibit reflection and saturation (as shown in the photo below) from the lighting source. In the examination record videotapes, the video probe rheostat was adjusted when this condition occurred while recording the penetration/head interface.



This image was captured from one of the videotapes made during the Unit 1 bare head examination in September 2001. The very light white dusting of boric acid as shown here (adjacent to penetration #16) is typical of the overall dusting of the head under the insulation. In this view, the tracks from the magnetic wheels of the crawler can be clearly seen. The dusting did not interfere with the crawler's ability to grip the head surface with the magnetic wheels. The overall coating of the head and many of the Alloy 600 penetrations & mirror insulation is due to previous conoseal leakage that was picked up and scattered over much of the head surface within the shroud periphery by the head ventilation system airflow.

Figure 2 continued
Typical Examples of “Light Dusting” on Head Surface & Penetrations



Another view of overall dusting and coating of the head and a penetration on the right – with some small debris also visible. Note image foreground is saturated by light reflection.

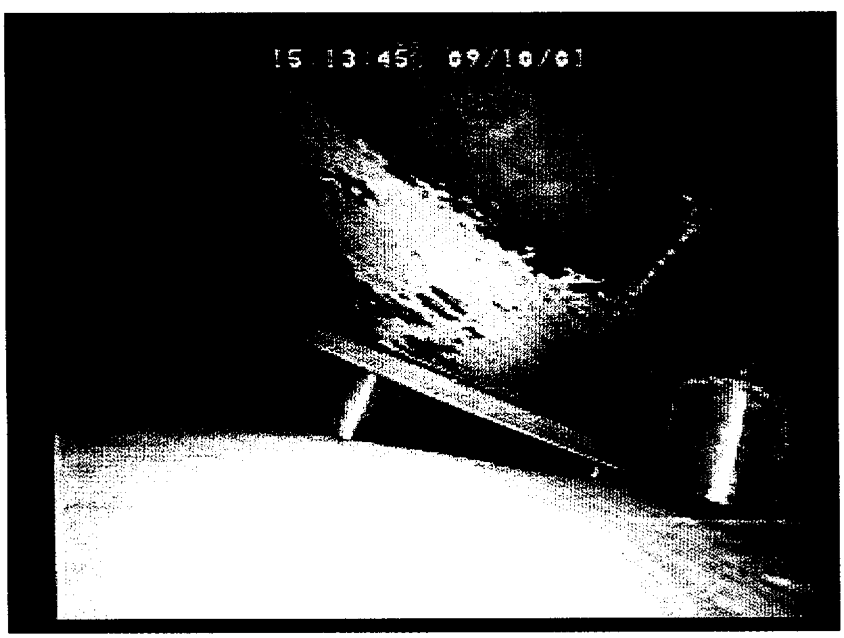
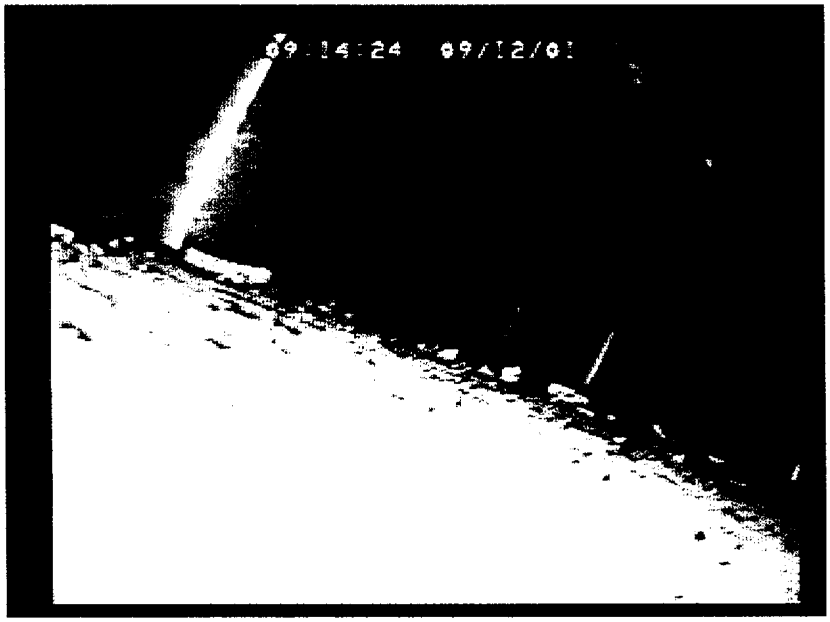


Image from the crawler camera looking uphill toward penetration #9. This illustrates some of the boric acid coating on the overhead mirror insulation as well as the general overall condition of the head surface. In many cases the crawler camera was used to navigate and confirm penetration locations and to assess the overall head condition. The crawler was also used to deliver the video probe to selected locations for specific examinations. The image foreground is saturated by the crawler light reflection.

Figure 3

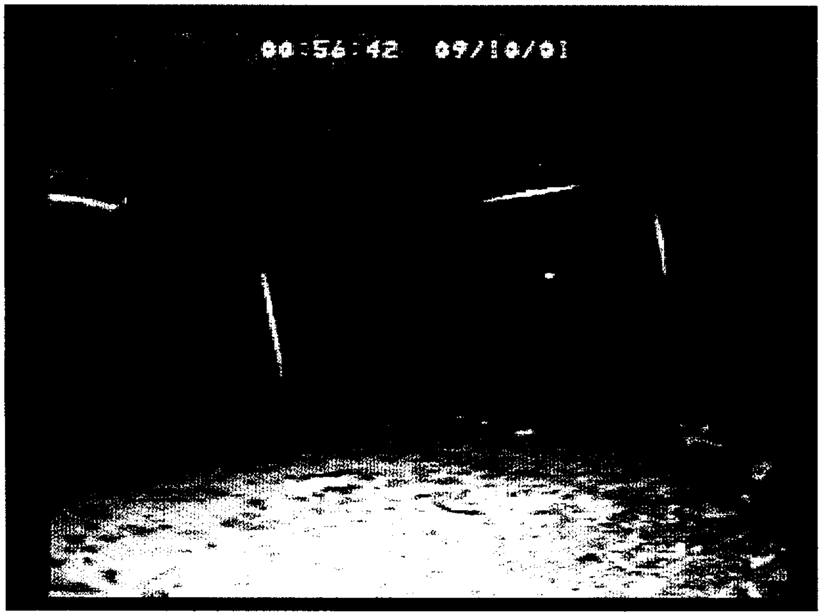
Typical Examples of Loose flakes and Debris (+ symbol on map)



Loose debris near top of head, looking slightly downhill between penetrations #9 and #13. White boric acid pieces that dropped from the mirror insulation seams above are also visible. The image foreground is saturated by light reflection.

View showing a magnified image of a piece of wire, with white stain and small boric acid flakes in the area near penetration #5. Image foreground in this view is also saturated by light reflection.

Figure 3 (continued)
Typical Examples of Loose flakes and Debris (+ symbol on map)

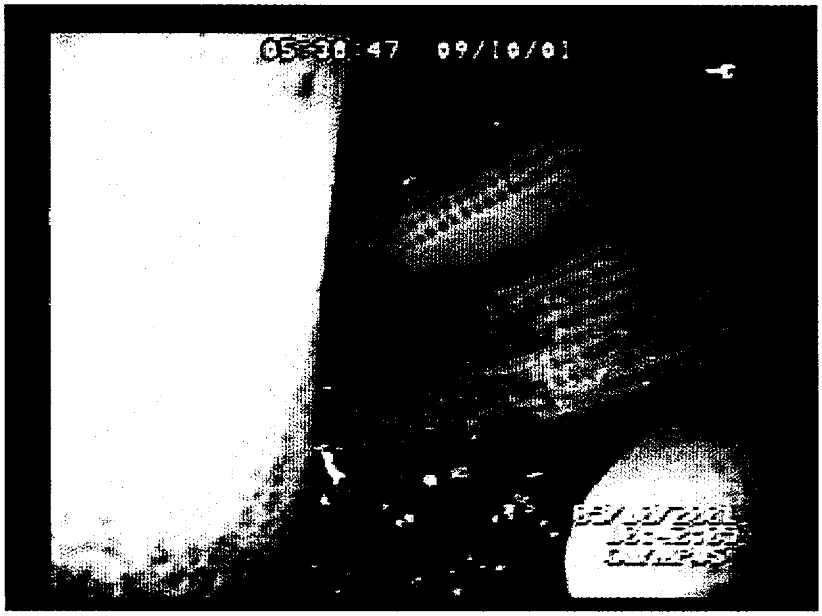


View adjacent to penetration #13 showing light dusting with some loose debris in the area of the penetration.

Image of a nail and debris on the uphill side of penetration #17. This is an example of how small items are magnified when viewed up close with the video probe system.

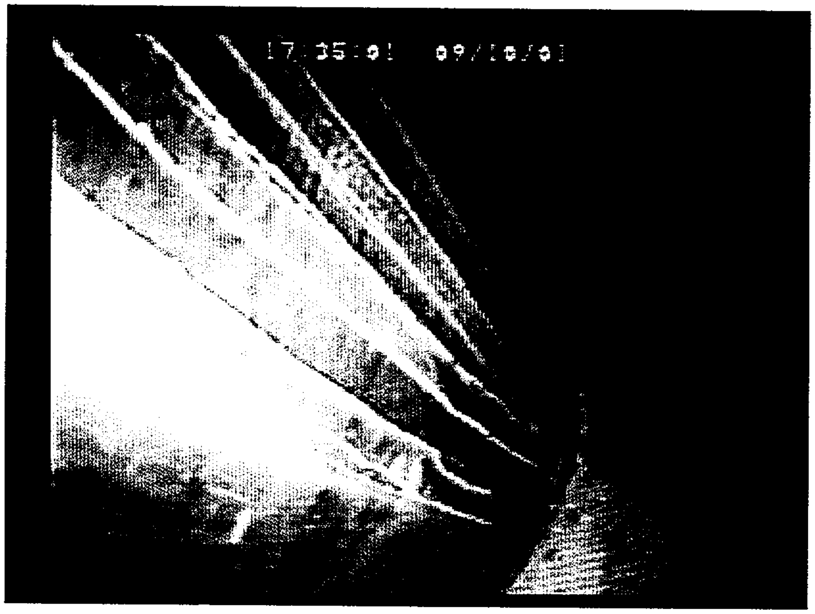
Figure 4

Typical Examples of Loose Debris near penetrations (# symbol on map)



View shows the scale of magnification as evidenced by the apparent size of the technician's gloved fingertips as they brushed away the loose debris. Image also shows example of loose debris on the uphill side of penetration 34. This was accessible from the lifted insulation panel and was brushed aside by the video technician. The debris appeared to have the consistency of coarse sand, and was easily brushed aside.

Figure 5
Typical Areas with distinct stains (**S** symbol on map)



View looking down from penetration 44 clearly shows boric acid residue from previous leakage above the insulation running down the penetration, resulting in a white stain on the penetration and at the head surface. This indicates the leakage was minor, which is borne out by the lack of rust, discoloration or other evidence of damage in this head quadrant.

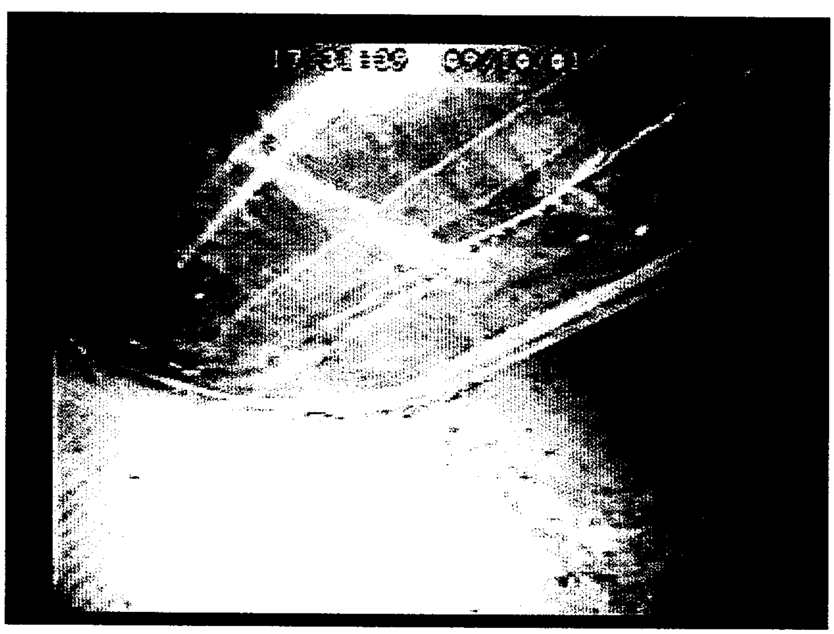
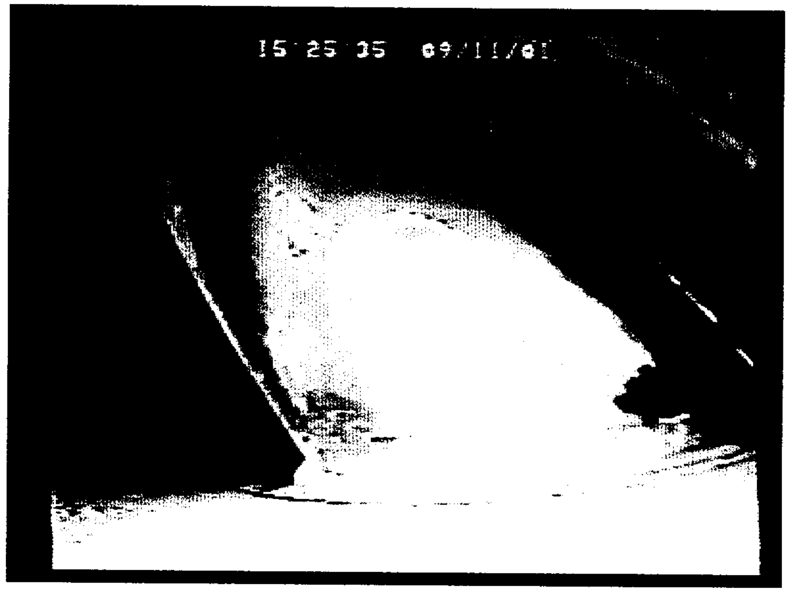


Image of the head at the base of penetration #51 showing white stains on the penetration and head area. Note the head machining marks are clearly visible in both views. Image foreground is saturated with lighting reflection

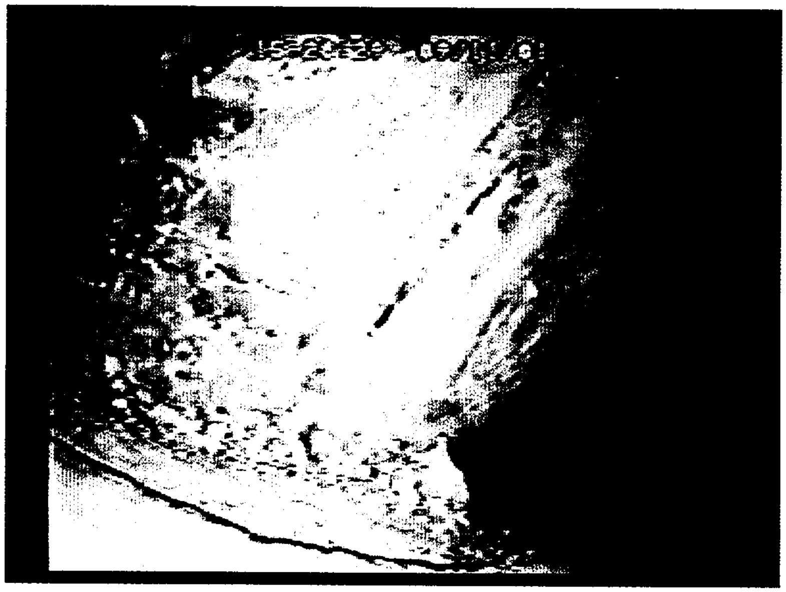
Figure 6
Corrosion near Penetration 65 (* symbol on map)



Side view of penetration 65 shows side-illuminated evidence of corrosion as viewed from the adjacent penetration 54 side. There is no indication of through-wall leakage from the penetration, no significant accumulation of corrosion product and no active degradation in the area Image is saturated by light reflection.

This view shows penetration 65 lower side viewed from the adjacent penetration 53 side. There is little or no corrosion damage on the lower 90 degrees of the penetration periphery. Dry boric acid coating is visible on the CRDM nozzle and surrounding insulation surfaces. The outer ring of insulation is shown on the left, against the shroud inside surface. Camera is tilted slightly in this view.

Figure 6 (continued)
Corrosion at Penetration 65 (* symbol on map)



This is another magnified view of the upper quadrant of penetration 65 using the zoom feature to get a better view of the extent of the corrosion. This area was previously described in our October 31, 2001 submittal as a depth of 1/16" to 1/8" in depth and approximately ½ " in width. This minor localized corrosion was evaluated and concluded that it does not present a structural concern. Also note the loose debris against the uphill side of the penetration. The debris was similar in appearance to other areas that were physically brushed away or dislodged as the video probe brushed past the accumulations.

The video probe was panned up to show the penetration 65 insulation interface. This shows the proximity of the insulation seam and evidence of previous leakage running down from the insulation seam and periphery around the penetration. It appears that most of the leakage was channeled down the junction of the two abutting insulation sections where they meet the upper side of the penetration, which is where the heaviest corrosion was observed.

Figure 7

BV-1 Basic Insulation
Panel Orientation