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October 31, 2001
L-01-136

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

Subject: Beaver Valley Power Station, Unit No. 1
Docket No. 50-334, License No. DPR-66
Bulletin 2000-01 Circumferential Cracking of Reactor Pressure Vessel Head Penetration Nozzles

On August 31, 2001, the FirstEnergy Nuclear Operating Company (FENOC) provided a response to NRC Bulletin 2001-01 for Beaver Valley Power Station (BVPS) Units 1 and 2. The Bulletin pertains to the structural integrity of the reactor pressure vessel head penetration (VHP) nozzles. The BVPS response to Question 5.a. of the Bulletin stated, in part, that following the 1R14 Refueling Outage, Beaver Valley Unit 1 would provide a description of the visual inspection performed and provide the results.

Attached is a report of the 1R14 visual examinations performed on the Unit 1 Control Rod Drive Mechanism (CRDM) penetrations. This report includes the evaluation of the visual examinations performed for Bulletin 2001-01 and all indications identified as a result of these examinations.

If there are any questions concerning this matter, please contact Mr. Thomas S. Cosgrove, Manager, Regulatory Affairs at 724-682-5203.

Sincerely,

Lew Myers
Lew W. Myers

Attachment

c: Mr. L. J. Burkhart, 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

A088

Evaluation Report for 1R14 Visual Inspection of Beaver Valley Unit 1 CRDM Penetrations

Evaluation Performed by Dennis Weakland

October 2001

Introduction

The inspection of the CRDM penetrations at Beaver Valley Unit 1 during the 1R14 Refueling outage was performed as part of the commitment made by Beaver Valley in response to IEB 2001-01 issued by the NRC. NRC Bulletin 2001-01 was issued as a result of leakage and subsequent identification of circumferential through wall cracking in the CRDM penetrations at the Oconee Units 1, 2,and 3 and Arkansas Nuclear One power plants. The Industry has investigated the issue and is continuing to perform work to address the Regulatory and Industry concerns under the direction of the EPRI Materials Reliability Project (MRP).

The Beaver Valley commitment in the response to NRC Bulletin 2001-01 is to perform a bare metal visual examination of the area on the Reactor Vessel head where the CRDM penetrations meet the outside surface of the Reactor Vessel Head. This examination is performed under the Reactor Vessel Head insulation on the exterior surface of the Reactor Vessel Head. The inspection is for the identification of boric acid accumulations that may indicate a CRDM penetration is cracked through wall and leaking.

Purpose and Scope

The purpose of the inspection was to identify any evidence of leakage from the CRDM penetration area and Reactor Vessel Head Vent piping penetration. The scope of the Beaver Valley Unit 1 inspection during 1R14 was 100% of the CRDM penetrations and the Reactor Vessel Vent Line penetration.

The identification of visual evidence of leakage in the form of an accumulation of boric acid crystal residue extruding from the penetration area where the CRDM tubing and Reactor Vessel Head Vent tubing penetrated the outside surface of the Reactor Vessel Head is the area of focus for the visual inspection. This inspection was performed by Framatome ANP personnel using high resolution remote visual examination equipment and video probes. The inspection was recorded on Super-VHS tape for review and evaluation by the Beaver Valley Site Level III Visual Examiner and the Site Materials Engineer.

As noted in the attached visual examination summary report (Attachment 1) from Framatone ANP, all examinations were performed by qualified visual examination personnel. The personnel and equipment were qualified using the performance demonstration method. All personnel documentation and certifications are included in the Inspection package maintained by the NDE Department for such examinations.

Inspection Results

The bare metal inspection of the sixty-five (65) CRDM penetrations and one (1) Reactor Head Vent Line from under the insulation found no indication of Boric Acid leakage extruding from any penetration in the Reactor Vessel Head. The configuration and visual presentation of the type of boric acid accumulation that would be of concern is

shown in Figure 1 (shown below). This picture illustrates the configuration of boric acid accumulation that is associated with through wall leakage from a CRDM Tubing. None of the penetrations on the Beaver Valley Unit 1 displayed boric acid accumulations of a similar configuration. Additionally all indications of boric acid accumulations were associated with previously identified Conoseal leakage, as a result it is concluded that no penetrations at Beaver Valley Unit 1 contain a leaking through wall flaw.

Figure 1 – Typical Boric Acid Accumulation Around a Failed CRDM

The inspection found loose boric acid pebbles scattered across the surface of the Reactor Vessel Head with some accumulation of these loose pebbles on the up hill side of several penetrations. Additionally the inspection identified boric acid spray patterns on several CRDMs, the two (2) most significant indications of external leakage onto the Reactor Vessel Head are discussed in this engineering evaluation in the Evaluation of Results Section of this report.

The two (2) locations, CRDM penetration numbers 59 and 65, identified as having boric acid deposits on and around the CRDM tubing are shown on the next page.

C01

Figure 2 – Penetration #59

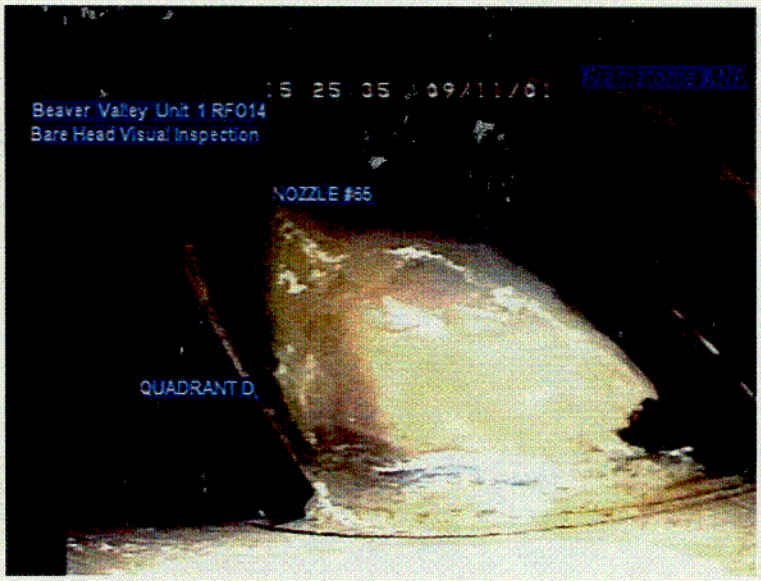

Figure 3 – Penetration #65

C02

Evaluation of Results

The boric acid accumulations around and on Penetrations #59 and #65 are discussed in this section. Pictures of the penetrations and the surrounding area are identified as Figures 4 thru 9. These figures will be used to illustrate the conclusions and evaluations described. Figure 10 describes the location of the Conoseals relative to the Penetrations #59 and #65. This sketch on Figure 10 shows that Penetration #59 is located near Conoseal #1 and Penetration #65 is located near Conoseal #2.

Evaluation of Penetration #59:

Figures 4(a) and 4(b) show the area around the base of Penetration #59 where it meets the Reactor Vessel Head. As can be observed, very little accumulation of boric acid residue can be seen at the base of the penetrations. The accumulation around the base of the penetration is light dry boric acid no more than 1/16 inch in thickness in the form of a film or coating rather than distinct accumulations of boric acid "puff balls". These film like accumulations of this type are not similar in any way to that shown in Figure 1.

The residue pattern that can be observed on the sides of the penetration are consistent with leakage from above (like that of a Conoseal leak). The distinct spray pattern (shown in Figures 5 and 6) across the CRDM tubing is well above the intersection of the CRDM tube and the Reactor Vessel Head and is also displayed on the surrounding insulation panels. A review of the Unit 1 Refueling Logs indicates that leakage from a conoseal occurred during 1R04 (October of 1984). The Log noted that boric acid residue was removed from the head, there was no indication that the area around the CRDM was cleaned. Penetration #59 is located near Conoseal #1 and leakage from this Conoseal would spray onto and run down around the insulation opening at Penetration #59. The appearance of the spray pattern on CRDMs #53 and #59 is one of liquid being dropped into a high velocity air flow and then splattered on the surrounding surfaces.

Figure 7 shows that there is a gap of nearly 1/8 inch or more at the base of the insulation package where it meets the Reactor Vessel Head near Penetration #59. During plant operations the CRDM Cooling Fans pull approximately 440 CFM of air through the Reactor Vessel Head area. Figures 5, 6 and 7 show the accumulation of the boric acid spray on the surrounding areas consistent with leakage from above being carried by high velocity air on to the CRDM tubing. This fact coupled with the lack of boric acid accumulation around the base of Penetration #59, as displayed in Figures 4(a) and (b), provides sufficient evidence that the boric acid residue is a result of Conoseal leakage and not from a through wall leak of the CRDM tubing.

Evaluation of Penetration #65

Figure 8(a) and 8(b) show the base of Penetration #65 where is meets the Reactor Vessel Head. As can be observed there is some slight accumulation of boric acid residue around the penetration. None of the accumulation has the fluffy appearance like that displayed in Figure 1. There is some small amount of gradual residue that has accumulated on the up hill side of this penetration as can be observed in Figure 8(a). It should also be noted that the staining on the sides of the penetration indicate that leakage from above has occurred in the past (see Figures 8(a) and 8(b).

A similar investigation of the Conoseal leakage history of the #2 Conoseal was performed. Since Conoseal #2 is located above Penetration #65 the leakage history of this conoseal is relevant. The investigation found a significant history of leakage from the #2 Conoseal was documented during the 1R07 Refueling outage. A photocopy of the Polaroid photographs taken during 1R07 are attached as Figure 11. It can be seen from the amount of accumulation at the conoseal there was significant leakage over a period of time.

A closer inspection of the area around the base of Penetration #65, as shown in Figure 9, indicates that some corrosion wastage of the Reactor Vessel Head has occurred. The depth of this corrosion is between 1/16 inch and 1/8 inch in depth and approximately 1/2 inch in width. Wastage of this type is consistent with the damage one would expect from a borated fluid coming in contact with a hot carbon steel surface. It is concluded from the photographs of the extent of boric acid accumulations (Figure 11) found around the #2 Conoseal upon shutdown for 1R07 Refueling Outage that a significant amount of reactor coolant came in contact with the surface of the Reactor Vessel Head during the end of the power operation cycle and during shutdown prior to depressurization. It is further concluded that the corrosion wastage occurred during the shutdown process, when there was insufficient heat to boil off the water in the leaking reactor coolant prior to it coming in contact with the carbon steel Reactor Vessel Head. During this period the wastage occurred to the wetted Reactor Vessel Head surface. A review of the design analysis for the Reactor Vessel Head indicates that a minimum wall thickness for the head is 6.188 inches. During ISI inspections the actual head thickness was determined to be 6.78 inches using a straight beam Ultrasonic probe. This minor localized corrosion (0.125 to 0.200 inches) does not infringe upon the specified minimum wall thickness use for design, which includes the design margins; therefore it is concluded that this area of localized corrosion wastage does not present a structural concern.

Summary

The bare metal inspection of the Beaver Valley Unit 1 Head indicates that none of sixty-five (65) CRDM penetrations have indications similar to those of interest, as shown in Figure 1. The inspection did reveal that previous conoseal leakage did occur and some minor corrosion damage around Penetration #65 did occur as a result of the conoseal leakage. It was found that the corrosion was minor in nature and well within the acceptance limits for the Reactor Vessel Head design.

It was recommended that following the inspection of the CRDM penetrations no cleaning of the as found condition be performed. This recommendation is based upon the following rational; first the as found condition was recorded and can be used as a baseline for inspections to be performed during the next refueling outage; secondly, to remove the boric acid residue would result in unnecessary man-rem exposure and finally the dried boric acid residue presents no corrosion concerns and will not affect the function of the components adversely.

Figure 4 (a) – Penetration #59

Figure 4 (b) – Penetration #59

C03

Figure 5 – CRDM #59

Figure 6 – Penetrations #59 and #35

C04

Figure 7 – Insulation Gap at Penetration #59

C05

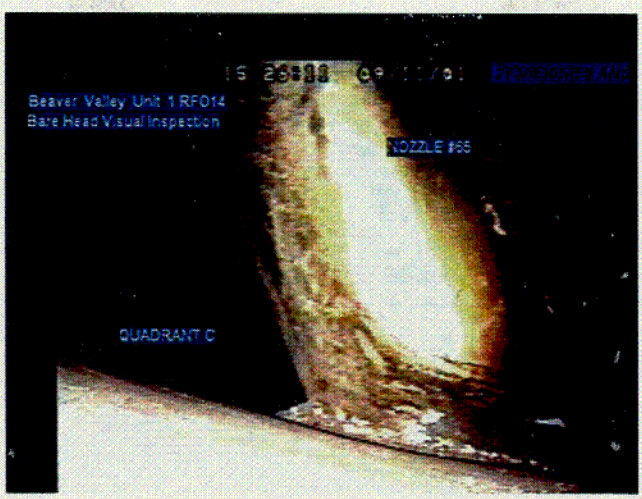

Figure 8 (a) – Penetration #65

Figure 8 (b) – Penetration #65

C06

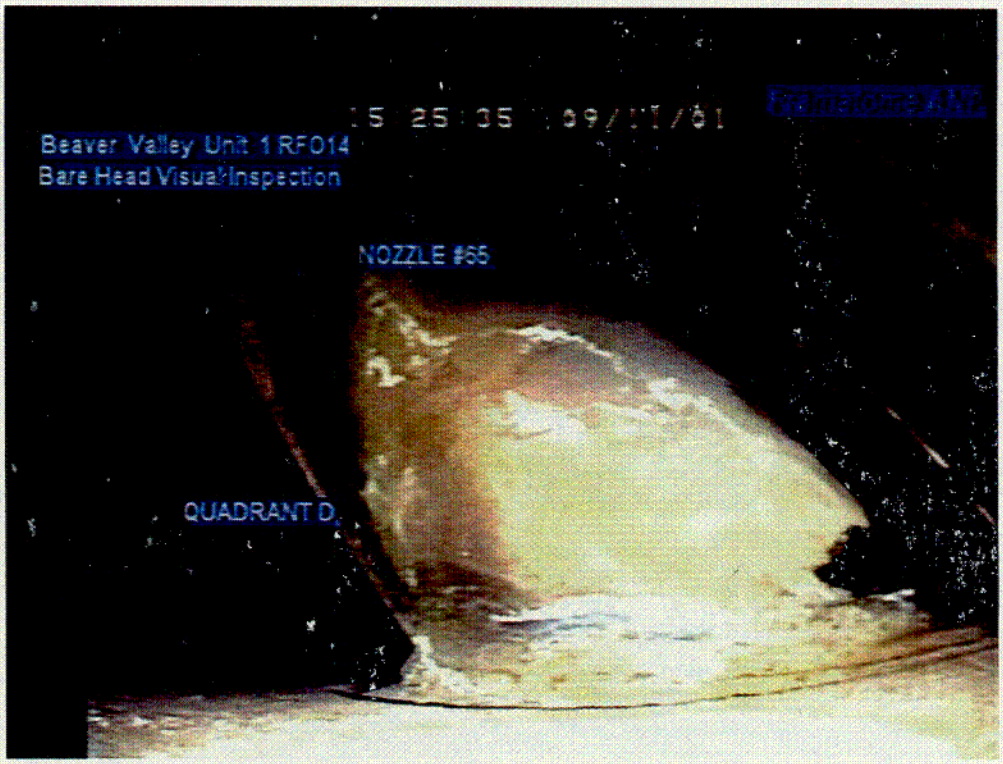

Figure 9 – Penetration #65

Corrosion at Base of Penetration

C07

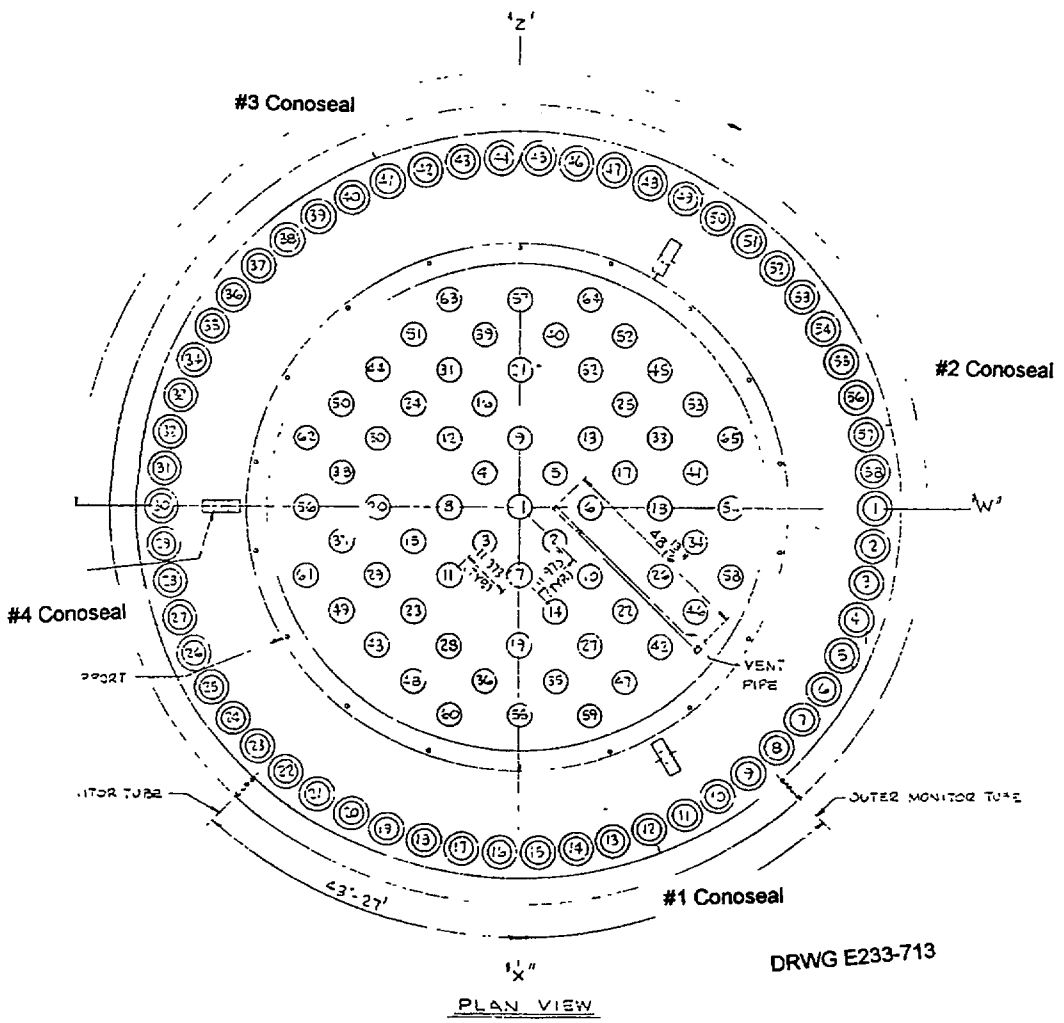
'Z'
#3 Conoseal
#2 Conoseal
'W'
#4 Conoseal
VENT PIPE
OUTER MONITOR TUBE
#1 Conoseal
43'-27'
'X'
DRWG E233-713
PLAN VIEW

Figure 10

TR

BV-1 (CONDOSEAL #2) 9.6.89

TR

BV-1 [illegible] 9/6/89

[redacted]

TR

[illegible] 9/6/89

BV-1 [illegible]

[redacted]

TR
CONDOSEAL #2
(9.6.89)

Figure 11

Summary Report for Beaver Valley Unit 1
RVH CRDM Penetration Visual Inspection

September 2001

Framatome ANP Task Lead George Kevin Slade
GK Slade

Beaver Valley Site Project Coordinator Timothy C Harrod

This document is a summary of the visual inspection of the RVH penetrations at the Beaver Valley Unit 1 plant. Inspections were performed during the 1RFO-14 outage.

Purpose and Scope

The purpose of this visual examination was to look for evidence of discharge or leakage around the 65 RPV penetrations and one (1) Reactor Head Vent piping penetration in the form of the build-up of boric acid crystal residue. The experiences and results of the Oconee and ANO inspections, as performed by Framatome-ANP and reviewed by EPRI MRP, provided guidance for performing effective VT-2 exams and evaluations.

Method

Due to the dose considerations involved with removing the head's insulation package each of the 65 RPV nozzle penetrations and the head's vent line was remotely inspected for a full 360°utilizing high resolution cameras and video probes delivered through guidetubes and crawlers. These cameras have been qualified through performance demonstrations in a mock up as well as passing resolution and lighting checks throughout the inspection process in accordance with the FRA-ANP procedure governing this In Service Inspection. VT Level II personnel ensured that complete inspections were performed and documented in real time. Additionally the Beaver Valley Level III visual inspectors were directly involved throughout the data collection process All inspections were recorded to Super-VHS tape and reviewed by site Level III's and Material Engineering responsible for this inspection.

Inspection Results

Refer to the accompanying video tape of the inspections at nozzle penetration #65 and #59.

In general, there were no nozzle penetrations identified to have evidence of leakage as defined by the experiences at Oconee and ANO. Specifically, the deposits at BV 1 fall into two categories, loose boric acid pebbles and boric acid spray patterns. None of the boric acid deposits observed originated from the intersection of the nozzle and the head, and furthermore, the deposits can be directly correlated to past events with conoseal leakage

Documented leakage has occurred at the conoseals located near RPV stud location #57 and stud location #12. In both cases, the nozzles nearest to these studs (nozzles #65 and #59 respectively) showed evidence of a significant boric acid event. Refer to the attached map for stud and nozzle location data.

In the case of nozzle penetration #59, the visual inspection shows a distinct spray pattern across the nozzle above the intersection of the CRDM and reactor vessel head onto the surrounding insulation and onto nozzle #35. The boric acid was deposited in a rooster tail pattern that seems to reflect a bottom-up direction. However, the conoseal leakage would have yielded a top-down flow of boric acid. The spray effect resulted from the high upward air flow of the CRD cooling ventilation, which will form air jets in gaps between the insulation and the head around the periphery locations The high flow air picks up and atomizes the boric acid running down the shroud and throws it across the face of the nearest nozzle and insulation. This conclusion is bolstered by the fact that no streaming stains or deposits are present anywhere on the head surface. If the boric acid at nozzle 59 were from a penetration leak, it should have run down to the shroud as was seen at the Oconee and ANO leaks.

The second conoseal leak occurred near the reactor vessel stud location #57. As a result, the #65 nozzle was affected by a flow of boric acid. Refer to the attached map for stud and nozzle location data. In this case, the boric acid seems to flow directly down the nozzle on the uphill side. As the acid flowed around the nozzle, at operating temperatures, the carbon steel of the head was affected. Erosion to a depth of less than .125 inches for about ½ inch around the base of the

nozzle was noted and present only at the #65 nozzle location. This does not appear to be an active mechamsm.

In both cases, deposits and accumulations were identified near the conoseal locations where previous leakage has been documented. The insulation and the nozzles within a 2-foot radius are discolored and/or coated with a thin layer of boric acid.

In addition to spraying the nozzles near the conoseal leaks with boric acid residue, some of the debris (boric acid crystals/pebbles) was scattered to other areas of the head. These small pebbles (typically around .125 " diameter) were scattered randomly at the top of the head and many were mixed with the debris piles that were found at the topsides of the nozzles where loose material gathers. Their small size and the fact that they are typically found to be mixed in with loose surface corrosion product at the debris piles separates these pebbles from any penetration leakage event which would result in a deposit bloom. Again, no running deposits or stains were noted anywhere on the BV 1 head.

Conclusions

The interpretation of the visual inspection data was a collaborative effort between the site Level III inspectors, the site Materials Engineer and the Framatome ANP inspectors There were no boric acid events that remotely resemble the Oconee and ANO experience. No boric acid blooms and/or flowing deposits are present on the Beaver Valley 1 head.

FRAMATOME ANP will prepare a full report including images at each nozzle per the customer's direction. This will aid resolution of locations during future inspections.

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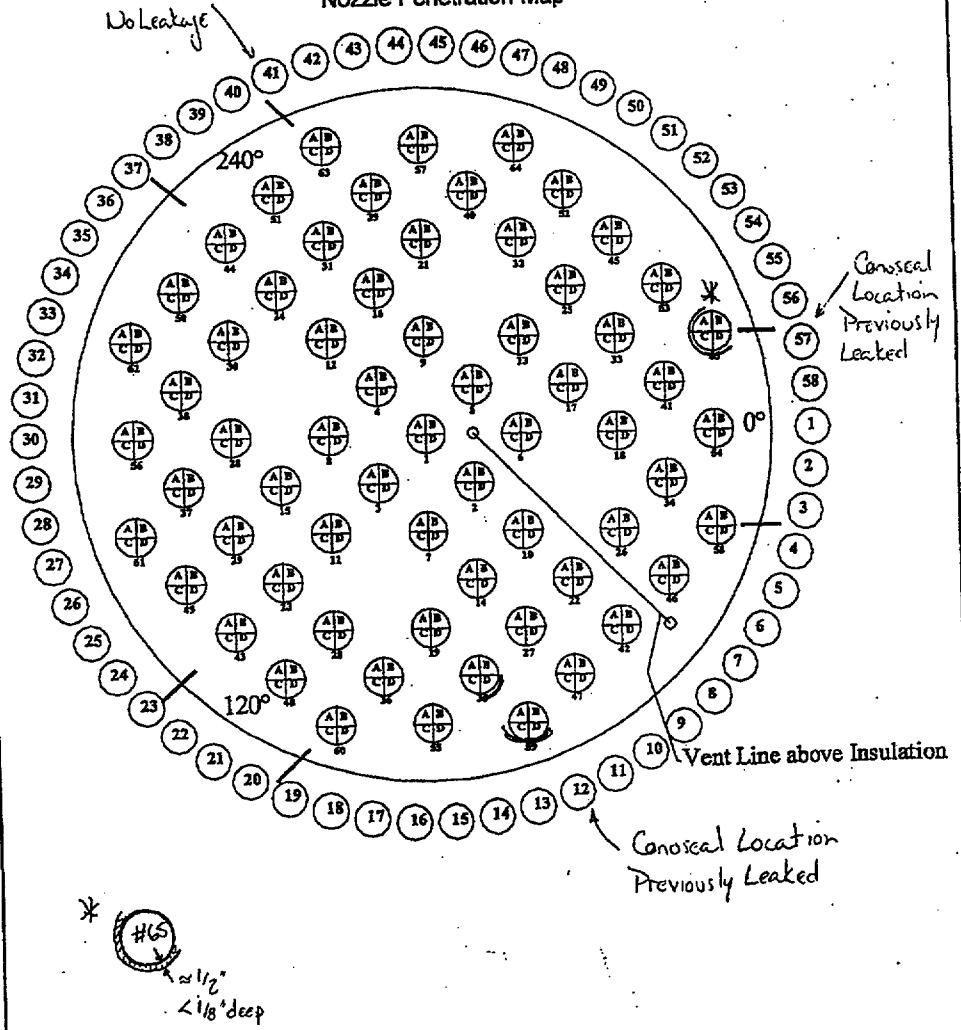
Attachment A
Beaver Valley Unit 1
RFO-14
Nozzle Penetration Map



August 29, 2001	Reactor Head Nozzle Penetration Remote Visual Inspection Plan For Beaver Valley Unit 1 RFO-14	6010653A rev.00 Page 31 of 30