Entergy

Entergy Nuclear Northeast
Entergy Nuclear Operations, Inc
Indian Point Energy Center
295 Broadway, Suite 1
P.O. Box 249
Buchanan, NY 10511-0249

December 18, 2002

Re: Indian Point Unit No. 2
Docket No. 50-247
NL-02-162

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Mail Stop O-P1-17
Washington, D.C. 20555-0001

SUBJECT: **Reactor Vessel Head Inspection Results;**
Indian Point 2, Fall 2002 Refueling Outage

References:
1. Consolidated Edison Letter to NRC, NL-01-106, "Thirty-Day Response to NRC Bulletin 2001-01," dated September 4, 2001.
2. ENO letter to NRC, NL-01-133, "Revised Vessel Head Penetration Inspection Plans; NRC Bulletin 2001-01, Circumferential Cracking of Reactor Pressure Vessel Head Penetration Nozzles," dated November 13, 2001.
3. ENO letter to NRC, NL-02-101, "NRC Bulletin 2001-01 - Reactor Pressure Vessel Head Penetration Nozzle Inspection Plan for 2002 Refueling Outage (2R15)," dated July 23, 2002.
4. ENO letter to NRC, NL-02-119, "30-Day Response to NRC Bulletin 2002-02," dated September 11, 2002.

Dear Sir:

On August 3, 2001, the Nuclear Regulatory Commission (NRC) issued Bulletin 2001-01, "Circumferential Cracking of Reactor Pressure Vessel Head Penetration Nozzles" requesting information regarding the structural integrity of the reactor pressure vessel head penetration nozzles. A 30-day response was provided for Indian Point Nuclear Generating Unit No. 2 (IP2) by the previous owner, Consolidated Edison Company of New York, in Reference 1. The response was supplemented by the current owner, Entergy Nuclear Operations, Inc. (ENO) in Reference 2. Additional details regarding the reactor vessel head inspection plans were provided in References 3 and 4, in response to other requests for information in related Bulletins 2002-01 and 2002-02.

ENO has performed the inspection of the IP2 reactor pressure vessel head and vessel head penetration nozzles during refueling outage 2R15 that was completed on November 27, 2002.

A088

The inspection consisted of a bare metal visual examination supplemented by ultrasonic and eddy current inspection techniques. Details of the inspection, as required by the three related Bulletins, are provided in Attachment I. The inspection demonstrated that there are no signs of reactor pressure vessel head degradation or primary water stress corrosion cracking of the Alloy 600 penetration nozzles.

No new commitments are being made in this letter. If you have any questions, please contact Mr. John McCann (914) 734-5074, Licensing Manager.

I declare under penalty of perjury that the foregoing is true and correct. Executed on 12-18-02.

Very truly yours,

Fred Dacimo
Vice President – Operations
Indian Point 2

cc: Mr. Hubert J. Miller
Regional Administrator, Region I
U.S. Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, PA 19406-1415

Mr. Patrick Milano, Senior Project Manager
Project Directorate I-1
Division of Licensing Project Management
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Mail Stop 0-8-C2
Washington, DC 20555-0001

Senior Resident Inspector
Indian Point 2 Nuclear Power Plant
U.S. Nuclear Regulatory Commission
P.O. Box 38
Buchanan, NY 10511

U.S. Nuclear Regulatory Commission
Resident Inspectors' Office
Indian Point 3 Nuclear Power Plant
P.O. Box 337
Buchanan, NY 10511

ATTACHMENT I TO NL-02-162

REACTOR VESSEL HEAD INSPECTION RESULTS; INDIAN POINT 2, FALL 2002 REFUELING OUTAGE

ENTERGY NUCLEAR OPERATIONS, INC
INDIAN POINT NUCLEAR GENERATING UNIT NO. 2
DOCKET NO. 50-247

NRC Required Information

- NRC Bulletin 2001-01, Item 5:

Addressees are requested to provide the following information within 30 days after plant restart following the next refueling outage:

a. *a description of the extent of VHP nozzle leakage and cracking detected at your plant, including the number, location, size, and nature of each crack detected;*

b. *if cracking is identified, a description of the inspections (type, scope, qualification requirements, and acceptance criteria), repairs, and other corrective actions you have taken to satisfy applicable regulatory requirements. This information is requested only if there are any changes from prior information submitted in accordance with this bulletin.*

- NRC Bulletin 2002-01, Item 2:

Within 30 days after plant restart following the next inspection of the reactor pressure vessel head to identify any degradation, all PWR addressees are required to submit to the NRC the following information:

a. *The inspection scope (if different than that provided in response to Item 1D.) and results, including the location, size, and nature of any degradation detected,*

b. *The corrective actions taken and the root cause of the degradation.*

- NRC Bulletin 2002-02, Item 2:

Within 30 days after plant restart following the next inspection of the RPV head and VHP nozzles to identify the presence of any degradation, all PWR addressees are requested to provide:

A. *the inspection scope and results, including the location, size, extent and nature of any degradation (e.g., cracking, leakage, and wastage) that was detected; details of the NDE used (i.e., method, number, type, and frequency of transducers or transducer packages, essential variables, equipment, procedure and personnel qualification requirements, including personnel pass/fail criteria); and criteria used to determine whether an indication, "shadow", or "back wall anomaly" is acceptable or rejectable.*

B. *the corrective actions taken and the root cause determinations for any degradation found.*

Entergy Response

ENO has performed the inspection of the IP2 reactor pressure vessel (RPV) head and vessel head penetration (VHP) nozzles during refueling outage 2R15 that was completed on November 27, 2002. The inspection plan was based on prior responses (References 1 through 4) to the three related Bulletins and consisted of a bare metal visual examination supplemented by ultrasonic and eddy current inspection techniques. Details of the inspection, as required by the Bulletins, are provided below. The inspection demonstrated that there are no signs of RPV head degradation or primary water stress corrosion cracking (PWSCC) of the Alloy 600 VHP nozzles.

A. Bare Metal Visual (BMV) Examinations

The remote BMV examination included the entire top surface of the vessel head inside the control rod drive mechanism (CRDM) cooling shroud and 360-degree around each of the individual penetrations in the vessel head, consistent with EPRI and MRP guidance provided in References 5 and 6. The BMV examination was conducted using a remote system equipped with:

1) A low profile robotic crawler with traction devices;
2) High-resolution cameras (front and side);
3) Debris scraping attachment; and
4) A video probe delivery system.

The remote examination system provided visual resolution equivalent to a direct VT-2 visual examination.

The original IP2 reactor vessel head insulation consisted of "Kaylo Block", covered with asbestos tape and asbestos cement. The "Kaylo Block" rested directly on and followed the contour of the vessel head surface. Since the insulation configuration prevented IP2 from performing an effective BMV, the original insulation was removed prior to performing the inspection.

Following removal of the original insulation, an effective BMV examination of the head surface was performed. There was some debris observed around most of the nozzles, but there were no boron deposits found in the nozzle areas which is indicative of through-wall nozzle leaks originating from within the RPV head base material. The debris found around the nozzles was the result of specific instructions given to the insulation removal crew to leave the CRDM/head junction cavity undisturbed to the extent possible during the insulation removal process. The purpose of these instructions was to prevent the inadvertent removal of any boron evidence around the nozzles prior to the BMV examination, which could indicate the presence of leakage initiated at the J-groove weld region. Upon completion of the BMV examinations, the remaining debris was subsequently removed to the extent possible and a newly designed reflective insulation system, which is offset from the head surface, was installed to allow for future BMV inspections of the head.

Three samples of debris were taken from the reactor head nozzle penetration locations (penetrations 58, 70, and 85) for chemical/isotopic analysis to determine the approximate age of the deposits. Analysis results of the debris samples indicated that the radioactive isotopes were at least several cycles old. It was estimated that they are probably more than 15 years old, due to the absence of Cs-134 from two of the samples and the low Cs-134 to Cs-137 ratio for the third sample. Similar results were obtained for four insulation samples taken from other locations on the head. These insulation samples were also examined microscopically and appeared to be mostly insulation material.

ENO concluded that the debris noted on the vessel head surface is most likely a mixture of insulation material, with some old boron deposits from earlier identified leaks which originated from above the reactor vessel head. A history of the leaks from the canopy seals above the reactor vessel head was previously submitted in a response to Bulletin 2001-01. The chemical/isotopic analysis of the age of boron deposits is consistent with the historical data.

Some isolated spots of light rust were noted. One penetration (11) was found to have a partially enlarged annulus, which was consistent with the vessel head as-built data (Reference 7). The BMV examinations confirmed that there are no indications of head degradation at IP2.

Personnel Qualification

Personnel who performed the remote examination were VT-2 Level II or Level III visual examiners, in accordance with the requirements of ASME Section XI, 1989 Edition or later approved code editions. The BMV examiners also received a familiarization training using photographs of industry examination results from References (5) and (6). An Entergy Level III visual examiner also reviewed the inspection results and findings summarized in the BMV inspection report (Reference 7).

B. Supplemental NDE Examinations

In addition to the BMV described above, Entergy also performed some supplemental NDE examinations of the VHP nozzles, as proposed in Reference 4.

The inside surface of the CRDM tube was inspected with a combination of volumetric (i.e., ultrasonic, UT) and surface (i.e., eddy current, ECT) examination techniques using a dual probe arrangement. The examination covered sufficient axial length of the tube to span the J-groove weld and the upper and lower weld heat affected zones. The supplemental NDE inspections were performed by qualified personnel from WesDyne, a division of the Westinghouse Corporation, under the supervision of ENO personnel.

Qualification (Demonstration) of Equipment, Personnel and Procedures:

A demonstration of the WesDyne inspection equipment and procedures was conducted at their Windsor, CT facility during the period of August 26 to September 11, 2002. Open-tube and blade-probe UT and ET equipment and the specific WesDyne procedures for the inspection of the VHP tube and weld-to-tube interface from the inside surface of the tube

were demonstrated. The demonstration was conducted using the Entergy / EPRI / MRP mock-up samples, as part of the readiness review process established by the MRP demonstration protocol (i.e., a blind demonstration testing for the relevant procedures and essential variables) (Reference 9). The essential variables relevant to the inspection procedures for UT and ECT data acquisition are as specified in the appropriate sections of the procedures (References 10 through 14). These essential variables were presented in the MRP demonstration, which was also witnessed by the NRC Staff. EPRI has reviewed these procedures for essential variables and no deficiencies were noted during their review.

Comments from WesDyne, EPRI, NRC and Entergy representatives who attended the demonstration were addressed during the demonstration process. Necessary changes and/or improvements were subsequently incorporated into applicable WesDyne NDE procedures for the IP2 VHP inspection.

WestDyne personnel associated with either data acquisition or analysis received additional specialized training for the appropriate skills. There are no specific pass/fail criteria at this time since there is no formalized qualification program beyond the MRP demonstrations.

Personnel performing data acquisition or data analysis were certified Level II or Level III, in accordance with ASNT, SNT-TC-1A, 1984 Edition requirements. Entergy personnel provided continuous oversight during the VHP inspection project and reviewed both the eddy current and ultrasonic data analysis results.

Ultrasonic examinations (UT) using time-of-flight diffraction (TOFD) techniques were used to interrogate the thickness of the CRDM VHPs and approximately 0.1 inches of the attachment J-weld thickness. The primary transducers were axially oriented, 5 or 6 MHz pairs, with a probe center spacing (PCS) of 24mm. A supplemental Eddy Current (ECT) coil accompanied the UT transducers to provide an examination of the inside surface for each of the open housings and a portion of the thermal sleeved CRDM VHPs that were inspected.

Probe delivery for CRDM VHPs with thermal sleeves was by a saber / blade probe - gap scanner designed to fit between the thermal sleeve and VHP inside surface. CRDM VHPs without a thermal sleeve were examined using a 7010 open housing scanner. Both scanners were mounted on a DERI 700 multi-purpose manipulator used to position the scanner directly below the VHP being examined.

<u>Exception criteria for determining if "shadowing" should be called a flaw</u>:

Typically when evaluating the NDE data, the loss of "backwall" coupled with "shadowing" of the background material noise shall be called an OD flaw > 0.5" deep (Reference 14). There was one exception in which the "backwall" and apparent "shadowing" occurred but was not considered a flaw. This condition occurs when the ultrasonic transducer loses coupling to the surface and the entire ultrasonic signal is lost. The analysts are trained to distinguish these two phenomena and both conditions are reported in accordance with the analysis procedure.

The UT/ET inspection coverage and results are summarized as follows:

92 of the total 97 nozzles (94.8% of all CRDM penetrations) were inspected using UT and 56 of these were further examined by ECT. The remaining 5 of 97 total nozzles were not scanned by either UT or ECT because of nozzle-to-thermal sleeve gap constraints and equipment malfunctions. Some of the nozzles were 100% inspected while others were only partially inspected due to geometric interferences. A further description of the inspection coverage is provided below. No cracking was detected in any of these 92 nozzles inspected.

- All open-housing nozzles (44 total) and 12 thermal-sleeved nozzles were 100% scanned with the combined UT / ECT probe.
- 33 of the thermal-sleeved nozzles were 100% scanned by UT only.
- Therefore 89 (44 + 12 + 33) of 97 total nozzles examined achieved 100% scanned coverage. This coverage included 27 of the 28 peripheral nozzles which are normally subjected to the highest weld residual stresses. This coverage also included the five nozzles fabricated from a high yield strength heat of material.
- 3 thermal-sleeved nozzles, scanned by UT, achieved only partial coverage: nozzle 42 (55%), nozzle 51 (80%) and nozzle 53 (78%).
- 5 nozzles (1, 6, 7, 9 and 77) were not scanned due geometry constrains and equipment malfunctions.
- Nozzle 86 was classified as a special interest nozzle due to weld/surface reflectors, which were consistent with the fabrication methods used to assemble the nozzles. To ensure that these reflectors were not a result of PWSCC, IP2 performed liquid penetrant testing (PT) of the J-weld to ensure that no leakage path existed up through the weld into the tube/head annulus. This surface examination confirmed the absence of cracking in the J-groove weld.

C. Corrective Actions and Root Cause Determination

Based on the results of the 100% BMV examinations there were no indications of degradation of the VHPs or wastage of the vessel head base metal surface. The supplemental NDE examinations of the VHP nozzles and the adjacent J-groove welds (i.e., 0.1 inches of the weld metal adjacent to the nozzle material) also confirmed there were no defects which would be indicative of PWSCC of the Alloy 600 material. The robustness of the inspection program (i.e., using three different inspection methods, with 100% BMV examination and 94.8% of the VHP nozzles inspected by some combinations of volumetric and surface examination methods) coupled with the low susceptibility ranking of the IP2 head confirms that PWSCC is currently not an active degradation mechanism in the IP2 reactor vessel head. Therefore, no corrective actions or root cause determinations were deemed necessary.

Upon completion of the BMV examinations, the remaining debris on the reactor vessel head was removed to the extent possible and a newly designed reflective insulation system, which is offset from the head surface, was installed to allow for future visual inspection of the head.

D. References

1. Consolidated Edison Letter to USNRC, NL-01-106, "Thirty-Day response to NRC Bulletin 2001-01," dated September 4, 2001.

2. ENO letter to NRC, NL-01-133, "Revised Vessel Head Penetration Inspection Plans; NRC Bulletin 2001-01, Circumferential Cracking of Reactor Pressure Vessel Head Penetration Nozzles," dated November 13, 2001.

3. ENO letter to NRC, NL-02-101, "NRC Bulletin 2001-01 - Reactor Pressure Vessel Head Penetration Nozzle Inspection Plan for 2002 Refueling Outage (2R15)," dated July 23, 2002.

4. ENO letter to NRC, NL-02-119, "30-Day Response to NRC Bulletin 2002-02," dated September 11, 2002.

5. EPRI Report 1006296, Rev. 1; "Visual Examination for Leakage of PWR Reactor Head Penetrations", January 2002.

6. EPRI Report 1007337, Rev. 1; "PWR Reactor Pressure Vessel (RPV) Upper Head Penetrations Inspection Plan, September 2002.

7. IP2 Report, "VT-2 Visual Examination of the Indian Point 2 Reactor Vessel Head Penetrations", and Addenda No. 1, November 19, 2002.

8. Calculation No. PGI-00566, Rev. 0, "IP2-Updated Finite Element Gap Analysis of CRDM Penetrations", October 31, 2002.

9. MRP Interim Status Report on PVHP Inspection Performance Demonstration Activities, November 1, 2002.

10. Procedure No. WDI-ET-003, Rev. 3, "IntraSpect Eddy Current Imaging Procedure for Inspection of Reactor Vessel Head Penetrations", and three "Procedure Field Change Requests", October/November, 2002.

11. Procedure No. WDI-ET-004, Rev. 1, "IntraSpect Eddy Current Analysis Guidelines Inspection of Reactor Vessel Head Penetrations", and two "Procedure Field Requests", October/November, 2002.

12. Procedure No. WDI-ET-008, Rev. 0, "IntraSpect Eddy Current Imaging Procedure for Inspection of Reactor Vessel Head Penetrations with Gap Scanner", October/November, 2002.

13. Procedure No. WDI-UT-010, Rev. 3, "IntraSpect Ultrasonic Procedure for Inspection of Reactor Vessel Head Penetrations, Time of Flight Ultrasonic, Longitudinal Wave & Shear Wave, and one "Procedure Field Change Request", October/November, 2002.

14. Procedure No. WDI-UT-013, Rev. 1, "CRDM/ICI UT Analysis Guidelines", and six "Procedure Field Change Requests", October/November , 2002.

Entergy

Entergy Nuclear Northeast
Entergy Nuclear Operations, Inc.
Indian Point Energy Center
295 Broadway, Suite 1
PO Box 249
Buchanan, NY 10511-0249

December 18, 2002

Re: Indian Point Unit No. 2
Docket No. 50-247
NL-02-162

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Mail Stop O-P1-17
Washington, D.C. 20555-0001

SUBJECT: **Reactor Vessel Head Inspection Results;**
Indian Point 2, Fall 2002 Refueling Outage

References:
1. Consolidated Edison Letter to NRC, NL-01-106, "Thirty-Day Response to NRC Bulletin 2001-01," dated September 4, 2001.
2. ENO letter to NRC, NL-01-133, "Revised Vessel Head Penetration Inspection Plans; NRC Bulletin 2001-01, Circumferential Cracking of Reactor Pressure Vessel Head Penetration Nozzles," dated November 13, 2001.
3. ENO letter to NRC, NL-02-101, "NRC Bulletin 2001-01 - Reactor Pressure Vessel Head Penetration Nozzle Inspection Plan for 2002 Refueling Outage (2R15)," dated July 23, 2002.
4. ENO letter to NRC, NL-02-119, "30-Day Response to NRC Bulletin 2002-02," dated September 11, 2002.

Dear Sir:

On August 3, 2001, the Nuclear Regulatory Commission (NRC) issued Bulletin 2001-01, "Circumferential Cracking of Reactor Pressure Vessel Head Penetration Nozzles" requesting information regarding the structural integrity of the reactor pressure vessel head penetration nozzles. A 30-day response was provided for Indian Point Nuclear Generating Unit No. 2 (IP2) by the previous owner, Consolidated Edison Company of New York, in Reference 1. The response was supplemented by the current owner, Entergy Nuclear Operations, Inc. (ENO) in Reference 2. Additional details regarding the reactor vessel head inspection plans were provided in References 3 and 4, in response to other requests for information in related Bulletins 2002-01 and 2002-02.

ENO has performed the inspection of the IP2 reactor pressure vessel head and vessel head penetration nozzles during refueling outage 2R15 that was completed on November 27, 2002.

The inspection consisted of a bare metal visual examination supplemented by ultrasonic and eddy current inspection techniques. Details of the inspection, as required by the three related Bulletins, are provided in Attachment I. The inspection demonstrated that there are no signs of reactor pressure vessel head degradation or primary water stress corrosion cracking of the Alloy 600 penetration nozzles.

No new commitments are being made in this letter. If you have any questions, please contact Mr. John McCann (914) 734-5074, Licensing Manager.

I declare under penalty of perjury that the foregoing is true and correct. Executed on 12-18-02

Very truly yours,

Fred Dacimo
Vice President – Operations
Indian Point 2

cc: Mr. Hubert J. Miller
Regional Administrator, Region I
U.S. Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, PA 19406-1415

Mr. Patrick Milano, Senior Project Manager
Project Directorate I-1
Division of Licensing Project Management
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Mail Stop 0-8-C2
Washington, DC 20555-0001

Senior Resident Inspector
Indian Point 2 Nuclear Power Plant
U.S. Nuclear Regulatory Commission
P.O. Box 38
Buchanan, NY 10511

U.S. Nuclear Regulatory Commission
Resident Inspectors' Office
Indian Point 3 Nuclear Power Plant
P.O. Box 337
Buchanan, NY 10511

ATTACHMENT I TO NL-02-162

REACTOR VESSEL HEAD INSPECTION RESULTS; INDIAN POINT 2, FALL 2002 REFUELING OUTAGE

ENTERGY NUCLEAR OPERATIONS, INC
INDIAN POINT NUCLEAR GENERATING UNIT NO. 2
DOCKET NO. 50-247

NRC Required Information

- NRC Bulletin 2001-01, Item 5:

Addressees are requested to provide the following information within 30 days after plant restart following the next refueling outage:

a. *a description of the extent of VHP nozzle leakage and cracking detected at your plant, including the number, location, size, and nature of each crack detected;*

b. *if cracking is identified, a description of the inspections (type, scope, qualification requirements, and acceptance criteria), repairs, and other corrective actions you have taken to satisfy applicable regulatory requirements. This information is requested only if there are any changes from prior information submitted in accordance with this bulletin.*

- NRC Bulletin 2002-01, Item 2:

Within 30 days after plant restart following the next inspection of the reactor pressure vessel head to identify any degradation, all PWR addressees are required to submit to the NRC the following information:

a. *The inspection scope (if different than that provided in response to Item 1D.) and results, including the location, size, and nature of any degradation detected,*

b. *The corrective actions taken and the root cause of the degradation.*

- NRC Bulletin 2002-02, Item 2:

Within 30 days after plant restart following the next inspection of the RPV head and VHP nozzles to identify the presence of any degradation, all PWR addressees are requested to provide:

A. *the inspection scope and results, including the location, size, extent and nature of any degradation (e.g., cracking, leakage, and wastage) that was detected; details of the NDE used (i.e., method, number, type, and frequency of transducers or transducer packages, essential variables, equipment, procedure and personnel qualification requirements, including personnel pass/fail criteria); and criteria used to determine whether an indication, "shadow", or "back wall anomaly" is acceptable or rejectable.*

B. *the corrective actions taken and the root cause determinations for any degradation found.*

Entergy Response

ENO has performed the inspection of the IP2 reactor pressure vessel (RPV) head and vessel head penetration (VHP) nozzles during refueling outage 2R15 that was completed on November 27, 2002. The inspection plan was based on prior responses (References 1 through 4) to the three related Bulletins and consisted of a bare metal visual examination supplemented by ultrasonic and eddy current inspection techniques. Details of the inspection, as required by the Bulletins, are provided below. The inspection demonstrated that there are no signs of RPV head degradation or primary water stress corrosion cracking (PWSCC) of the Alloy 600 VHP nozzles.

A. Bare Metal Visual (BMV) Examinations

The remote BMV examination included the entire top surface of the vessel head inside the control rod drive mechanism (CRDM) cooling shroud and 360-degree around each of the individual penetrations in the vessel head, consistent with EPRI and MRP guidance provided in References 5 and 6. The BMV examination was conducted using a remote system equipped with:

1) A low profile robotic crawler with traction devices;
2) High-resolution cameras (front and side);
3) Debris scraping attachment; and
4) A video probe delivery system.

The remote examination system provided visual resolution equivalent to a direct VT-2 visual examination.

The original IP2 reactor vessel head insulation consisted of "Kaylo Block", covered with asbestos tape and asbestos cement. The "Kaylo Block" rested directly on and followed the contour of the vessel head surface. Since the insulation configuration prevented IP2 from performing an effective BMV, the original insulation was removed prior to performing the inspection.

Following removal of the original insulation, an effective BMV examination of the head surface was performed. There was some debris observed around most of the nozzles, but there were no boron deposits found in the nozzle areas which is indicative of through-wall nozzle leaks originating from within the RPV head base material. The debris found around the nozzles was the result of specific instructions given to the insulation removal crew to leave the CRDM/head junction cavity undisturbed to the extent possible during the insulation removal process. The purpose of these instructions was to prevent the inadvertent removal of any boron evidence around the nozzles prior to the BMV examination, which could indicate the presence of leakage initiated at the J-groove weld region. Upon completion of the BMV examinations, the remaining debris was subsequently removed to the extent possible and a newly designed reflective insulation system, which is offset from the head surface, was installed to allow for future BMV inspections of the head.

Three samples of debris were taken from the reactor head nozzle penetration locations (penetrations 58, 70, and 85) for chemical/isotopic analysis to determine the approximate age of the deposits. Analysis results of the debris samples indicated that the radioactive isotopes were at least several cycles old. It was estimated that they are probably more than 15 years old, due to the absence of Cs-134 from two of the samples and the low Cs-134 to Cs-137 ratio for the third sample. Similar results were obtained for four insulation samples taken from other locations on the head. These insulation samples were also examined microscopically and appeared to be mostly insulation material.

ENO concluded that the debris noted on the vessel head surface is most likely a mixture of insulation material, with some old boron deposits from earlier identified leaks which originated from above the reactor vessel head. A history of the leaks from the canopy seals above the reactor vessel head was previously submitted in a response to Bulletin 2001-01. The chemical/isotopic analysis of the age of boron deposits is consistent with the historical data.

Some isolated spots of light rust were noted. One penetration (11) was found to have a partially enlarged annulus, which was consistent with the vessel head as-built data (Reference 7). The BMV examinations confirmed that there are no indications of head degradation at IP2.

Personnel Qualification

Personnel who performed the remote examination were VT-2 Level II or Level III visual examiners, in accordance with the requirements of ASME Section XI, 1989 Edition or later approved code editions. The BMV examiners also received a familiarization training using photographs of industry examination results from References (5) and (6). An Entergy Level III visual examiner also reviewed the inspection results and findings summarized in the BMV inspection report (Reference 7).

B. Supplemental NDE Examinations

In addition to the BMV described above, Entergy also performed some supplemental NDE examinations of the VHP nozzles, as proposed in Reference 4.

The inside surface of the CRDM tube was inspected with a combination of volumetric (i.e., ultrasonic, UT) and surface (i.e., eddy current, ECT) examination techniques using a dual probe arrangement. The examination covered sufficient axial length of the tube to span the J-groove weld and the upper and lower weld heat affected zones. The supplemental NDE inspections were performed by qualified personnel from WesDyne, a division of the Westinghouse Corporation, under the supervision of ENO personnel.

Qualification (Demonstration) of Equipment, Personnel and Procedures:

A demonstration of the WesDyne inspection equipment and procedures was conducted at their Windsor, CT facility during the period of August 26 to September 11, 2002. Open-tube and blade-probe UT and ET equipment and the specific WesDyne procedures for the inspection of the VHP tube and weld-to-tube interface from the inside surface of the tube

were demonstrated. The demonstration was conducted using the Entergy / EPRI / MRP mock-up samples, as part of the readiness review process established by the MRP demonstration protocol (i.e., a blind demonstration testing for the relevant procedures and essential variables) (Reference 9). The essential variables relevant to the inspection procedures for UT and ECT data acquisition are as specified in the appropriate sections of the procedures (References 10 through 14). These essential variables were presented in the MRP demonstration, which was also witnessed by the NRC Staff. EPRI has reviewed these procedures for essential variables and no deficiencies were noted during their review.

Comments from WesDyne, EPRI, NRC and Entergy representatives who attended the demonstration were addressed during the demonstration process. Necessary changes and/or improvements were subsequently incorporated into applicable WesDyne NDE procedures for the IP2 VHP inspection.

WestDyne personnel associated with either data acquisition or analysis received additional specialized training for the appropriate skills. There are no specific pass/fail criteria at this time since there is no formalized qualification program beyond the MRP demonstrations.

Personnel performing data acquisition or data analysis were certified Level II or Level III, in accordance with ASNT, SNT-TC-1A, 1984 Edition requirements. Entergy personnel provided continuous oversight during the VHP inspection project and reviewed both the eddy current and ultrasonic data analysis results.

Ultrasonic examinations (UT) using time-of-flight diffraction (TOFD) techniques were used to interrogate the thickness of the CRDM VHPs and approximately 0.1 inches of the attachment J-weld thickness. The primary transducers were axially oriented, 5 or 6 MHz pairs, with a probe center spacing (PCS) of 24mm. A supplemental Eddy Current (ECT) coil accompanied the UT transducers to provide an examination of the inside surface for each of the open housings and a portion of the thermal sleeved CRDM VHPs that were inspected.

Probe delivery for CRDM VHPs with thermal sleeves was by a saber / blade probe - gap scanner designed to fit between the thermal sleeve and VHP inside surface. CRDM VHPs without a thermal sleeve were examined using a 7010 open housing scanner. Both scanners were mounted on a DERI 700 multi-purpose manipulator used to position the scanner directly below the VHP being examined.

Exception criteria for determining if "shadowing" should be called a flaw:

Typically when evaluating the NDE data, the loss of "backwall" coupled with "shadowing" of the background material noise shall be called an OD flaw > 0.5" deep (Reference 14). There was one exception in which the "backwall" and apparent "shadowing" occurred but was not considered a flaw. This condition occurs when the ultrasonic transducer loses coupling to the surface and the entire ultrasonic signal is lost. The analysts are trained to distinguish these two phenomena and both conditions are reported in accordance with the analysis procedure.

The UT/ET inspection coverage and results are summarized as follows:

92 of the total 97 nozzles (94.8% of all CRDM penetrations) were inspected using UT and 56 of these were further examined by ECT. The remaining 5 of 97 total nozzles were not scanned by either UT or ECT because of nozzle-to-thermal sleeve gap constraints and equipment malfunctions. Some of the nozzles were 100% inspected while others were only partially inspected due to geometric interferences. A further description of the inspection coverage is provided below. No cracking was detected in any of these 92 nozzles inspected.

- All open-housing nozzles (44 total) and 12 thermal-sleeved nozzles were 100% scanned with the combined UT / ECT probe.
- 33 of the thermal-sleeved nozzles were 100% scanned by UT only.
- Therefore 89 (44 + 12 + 33) of 97 total nozzles examined achieved 100% scanned coverage. This coverage included 27 of the 28 peripheral nozzles which are normally subjected to the highest weld residual stresses. This coverage also included the five nozzles fabricated from a high yield strength heat of material.
- 3 thermal-sleeved nozzles, scanned by UT, achieved only partial coverage: nozzle 42 (55%), nozzle 51 (80%) and nozzle 53 (78%).
- 5 nozzles (1, 6, 7, 9 and 77) were not scanned due geometry constrains and equipment malfunctions.
- Nozzle 86 was classified as a special interest nozzle due to weld/surface reflectors, which were consistent with the fabrication methods used to assemble the nozzles. To ensure that these reflectors were not a result of PWSCC, IP2 performed liquid penetrant testing (PT) of the J-weld to ensure that no leakage path existed up through the weld into the tube/head annulus. This surface examination confirmed the absence of cracking in the J-groove weld.

C. Corrective Actions and Root Cause Determination

Based on the results of the 100% BMV examinations there were no indications of degradation of the VHPs or wastage of the vessel head base metal surface. The supplemental NDE examinations of the VHP nozzles and the adjacent J-groove welds (i.e., 0.1 inches of the weld metal adjacent to the nozzle material) also confirmed there were no defects which would be indicative of PWSCC of the Alloy 600 material. The robustness of the inspection program (i.e., using three different inspection methods, with 100% BMV examination and 94.8% of the VHP nozzles inspected by some combinations of volumetric and surface examination methods) coupled with the low susceptibility ranking of the IP2 head confirms that PWSCC is currently not an active degradation mechanism in the IP2 reactor vessel head. Therefore, no corrective actions or root cause determinations were deemed necessary.

Upon completion of the BMV examinations, the remaining debris on the reactor vessel head was removed to the extent possible and a newly designed reflective insulation system, which is offset from the head surface, was installed to allow for future visual inspection of the head.

D. References

1. Consolidated Edison Letter to USNRC, NL-01-106, "Thirty-Day response to NRC Bulletin 2001-01," dated September 4, 2001.

2. ENO letter to NRC, NL-01-133, "Revised Vessel Head Penetration Inspection Plans; NRC Bulletin 2001-01, Circumferential Cracking of Reactor Pressure Vessel Head Penetration Nozzles," dated November 13, 2001.

3. ENO letter to NRC, NL-02-101, "NRC Bulletin 2001-01 - Reactor Pressure Vessel Head Penetration Nozzle Inspection Plan for 2002 Refueling Outage (2R15)," dated July 23, 2002.

4. ENO letter to NRC, NL-02-119, "30-Day Response to NRC Bulletin 2002-02," dated September 11, 2002.

5. EPRI Report 1006296, Rev. 1; "Visual Examination for Leakage of PWR Reactor Head Penetrations", January 2002.

6. EPRI Report 1007337, Rev. 1; "PWR Reactor Pressure Vessel (RPV) Upper Head Penetrations Inspection Plan, September 2002.

7. IP2 Report, "VT-2 Visual Examination of the Indian Point 2 Reactor Vessel Head Penetrations", and Addenda No. 1, November 19, 2002.

8. Calculation No. PGI-00566, Rev. 0, "IP2-Updated Finite Element Gap Analysis of CRDM Penetrations", October 31, 2002.

9. MRP Interim Status Report on PVHP Inspection Performance Demonstration Activities, November 1, 2002.

10. Procedure No. WDI-ET-003, Rev. 3, "IntraSpect Eddy Current Imaging Procedure for Inspection of Reactor Vessel Head Penetrations", and three "Procedure Field Change Requests", October/November, 2002.

11. Procedure No. WDI-ET-004, Rev. 1, "IntraSpect Eddy Current Analysis Guidelines Inspection of Reactor Vessel Head Penetrations", and two "Procedure Field Requests", October/November, 2002.

12. Procedure No. WDI-ET-008, Rev. 0, "IntraSpect Eddy Current Imaging Procedure for Inspection of Reactor Vessel Head Penetrations with Gap Scanner", October/November, 2002.

13. Procedure No. WDI-UT-010, Rev. 3, "IntraSpect Ultrasonic Procedure for Inspection of Reactor Vessel Head Penetrations, Time of Flight Ultrasonic, Longitudinal Wave & Shear Wave, and one "Procedure Field Change Request", October/November, 2002.

14. Procedure No. WDI-UT-013, Rev. 1, "CRDM/ICI UT Analysis Guidelines", and six "Procedure Field Change Requests", October/November , 2002.