March 17, 2003

MEMORANDUM TO: Mark S. Lesser, Chief Engineering Branch 2
Division of Reactor Safety
Region II

FROM: John A. Nakoski, Chief, Section 1 ***/RA/***
Project Directorate II
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

SUBJECT: NORTH ANNA, UNIT 2, REACTOR PRESSURE VESSEL HEAD REPLACEMENT RECONCILIATION INSPECTION

The purpose of this memorandum is to provide you with the input from the Office of Nuclear Reactor Regulation on activities related to the oversight of the replacement of the North Anna, Unit 2, reactor pressure vessel head. The attachment documents the efforts of the team that reviewed the design and reconciliation activities conducted by Virginia Electric Power Company and should be used in the preparation of inspection report 50/339/2003-09. The review of design and reconciliation activities was conducted between January 27 and 30, 2003.

The team consisted of:

| | | |
|---|---|---|
| Team Leader: | John A. Nakoski | Chief, Section 1, Project Directorate II (PDII-1), Division of Licensing Project Management (DLPM) |
| Team Members: | Keith Wichman | NRC Special Consultant, Materials & Chemical Engineering Branch (EMCB), Division of Engineering (DE) |
| | Richard McIntyre | Senior Reactor Engineer, Equipment & Human Performance Branch, Division of Inspection Program Management |
| | Billy Crowley | NRC Special Consultant, Engineering Branch 2, Division of Reactor Safety, Region II |
| | Kenneth Chang | Mechanical Engineer, Mechanical and Civil Engineering Branch, DE |
| | Stephen R. Monarque | Project Manager, PDII-1, DLPM |
| | Thomas McLellan | Materials Engineer, EMCB, DE |
| | Edward Andruszkiewicz | Materials Engineer, EMCB, DE |

Please contact me at 301-415-1068 if you have any questions regarding the input provided in the attachment.

Attachment: As stated

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Reactor Pressure Vessel Head Replacement
Design and Reconciliation Activities
North Anna, Unit 2

Background:

Virginia Electric Power Company (VEPCO, Dominion, the licensee) performed inspections of the North Anna, Unit 2, reactor pressure vessel head (RPVH) in the fall of 2002 in accordance with the provisions of Bulletin 2002-02, "Reactor Pressure Vessel Head and Vessel Head Penetration Nozzle Inspection Programs." VEPCO identified numerous indications in 64 of the 65 vessel head penetration (VHP) nozzle J-groove welds. Most of these indications required repair in accordance with the American Society of Mechanical Engineers *Boiler and Pressure Vessel Code* (ASME Code). In addition, several of the VHP nozzles had through-wall leakage. None of the indications were of a size or location to cause concern regarding the structural integrity of the welds. Therefore, adequate safety margins were maintained during plant operation. Originally, the North Anna, Unit 2, RPVH was to be replaced in the spring of 2004. However, to address these indications, VEPCO determined that the appropriate course of action was to accelerate its plans to replace the RPVH rather than repair the existing head. VEPCO's decision was, in large part, made knowing that a replacement RPVH was available from Electricite de France (EdF) through Framatome, ANP (EdF RV Head No. 28R). The replacement RPVH was manufactured by Framatome, ANP in 1998 to the 1993 Edition, through the 1996 Addenda, of the French Nuclear Construction Code (RCC-M Code) as part of the French program of replacing RPVHs at pressurized water reactors (PWRs) to address concerns with primary water stress corrosion cracking.

The original North Anna, Unit 2, RPVH was procured to owner specifications that incorporated the technical requirements of ASME Section III, 1968 Edition, and Westinghouse design specifications, but was not "N" stamped. The replacement RPVH was similarly procured to owner specifications that incorporated appropriate technical requirements. As such, VEPCO could proceed with procuring the replacement RPVH manufactured to the RCC-M Code within the current licensing basis of the unit. This allowed VEPCO to proceed with the replacement without prior staff approval using the reconciliation process of ASME Section XI (Article IWA-4000), provided there were no design changes introduced that required a license amendment per the requirements of Title of 10 of the *Code of Federal Regulations* (10 CFR) Section 50.59. This approach is also applicable to North Anna, Unit 1, and Surry, Unit 1, for which VEPCO plans a similar head replacement strategy.

The replacement of the North Anna, Unit 2, RPVH in January 2003 represented the first time a major reactor component fabricated to the French RCC-M Code was used in a commercial U.S. PWR. To assess whether the design, fabrication, examination, and testing of the replacement RPVH provided reasonable confidence that safety was maintained, the staff performed reviews and inspections of the activities conducted by, or for, the licensee in the U.S. and in France. This included meeting with the French regulatory authority and Framatome, ANP; inspections of replacement activities onsite; and an inspection of the design engineering and reconciliation effort the licensee performed following the requirements of Article IWA-4000 of the 1995 Edition, with Addenda through 1996, of Section XI to the ASME Code. In addition, the staff met with Belgian regulatory organizations to discuss their experience with reconciling the RCC-M Code to the ASME Code for the replacement of the Tihange, Unit 1, RPVH. An overview of the staff's interactions with French and Belgian organizations is provided in a Commission Paper

that can be found in ADAMS at Accession No. ML030580391. The staff's inspection of the design and reconciliation efforts for replacing the North Anna, Unit 2, RPVH are provided below.

Discussion:

## 1. Quality Assurance (QA) Programs and Records

1.1 Overview of Framatome, ANP Chalon Quality Assurance Program

a. Inspection Scope

The inspectors reviewed documentation and oversight actions performed by VEPCO to support the conclusion that the replacement RPVH for North Anna, Unit 2, manufactured in Chalon/ Saint Marcel, France by Framatome, ANP was done so implementing a QA program that met the provisions of 10 CFR Part 50, Appendix B, QA requirements.

b. Findings

On November 20, 2002, the inspectors met with VEPCO personnel in Glen Allen, VA to discuss VEPCO's recent vendor audit at Framatome, ANP in Chalon/Saint Marcel, France and also to discuss its understanding of the French QA process used during manufacture of the North Anna, Unit 2, replacement RPVH. VEPCO conducted a 5 person audit (including 2 technical specialists) at the Framatome, ANP Chalon facility during the period October 22-31, 2002, using the NUPIC performance based audit checklist. The audit included the review of activities associated with the implementation of the current Framatome, ANP Chalon/Saint Marcel Quality Management Manual (QMM). Additionally, the QMMs that were applicable during the manufacture of the replacement RPVH (EdF RV Head No. 28R) were evaluated against the current revision to ensure no major changes to the QA program had occurred during the time of the manufacture of the replacement head.

The VEPCO audit encompassed a review of all the applicable areas of the QMM and the supporting implementing procedures that related directly to the 18, 10 CFR Part 50, Appendix B criteria, including all the areas of fabrication. The review included the documentation associated with the activities that had been performed for the replacement head, as well as observations and discussions of actual work and inspection activities.

Based on the positive results of the program elements that were audited by VEPCO (no audit findings identified), VEPCO concluded that Framatome, ANP Chalon was effectively implementing a QA program for supplying the replacement RPVH that meets the requirements of 10 CFR Part 50, Appendix B. In the concluding paragraph of the audit report, VEPCO stated, "Overall, it is apparent that Framatome has established appropriate and effective means to control design, documentation and special processes (welding, heat treatment, examination, testing, and inspection) related to fabrication of reactor vessel heads and other nuclear components. Additionally, it is clear that Framatome personnel involved in special processes are well trained and highly skilled."

Based on the review of the Framatome, ANP QMM and the discussions with VEPCO and Framatome, ANP Chalon personnel, it appears that the ANP Chalon QMM is similar to the Framatome, ANP Lynchburg, VA, QA program and is structured to satisfy 10 CFR Part 50, Appendix B requirements. Additionally, the ANP Chalon QMM as written, states, that it satisfies the codes, standards, and regulations listed below:

- ISO 9001 - 2000, International Organization for Standardization, Quality Management Systems - Requirements
- IAEA 50-C-QA - 1996 International Atomic Energy Agency Code on the Safety of Nuclear Power Plants: Quality Assurance
- KTA 140, - June 1996, German quality standard
- ASME NQA-1 - 1983, Quality Assurance Program Requirements for Nuclear Facilities, and
- French Regulation Ministerial Order of August 10, 1984, Relative to the Quality of the Design, Construction, and Operation of Nuclear Facilities.

The inspectors also learned that a NUPIC utility had performed a performance based joint utility audit of the Framatome, ANP Paris and the Chalon/Saint Marcel facilities on June 10-14, 2002. This 5-day audit (4 days at Chalon) consisted of a team of 6 auditors and 3 technical specialists that was led by Exelon Nuclear to review the Framatome ASME NQA-1/ NCA 4000/ANS N45.2 quality program as it applies to the supply of replacement RPVHs and steam generators under its ASME nuclear certificates of authorization for U.S. utilities. This audit also had positive results and stated that the "audit team concluded that the Framatome, ANP facilities located in Paris and Saint Marcel had established and implemented a satisfactory 10 CFR Part 50 Appendix B, quality assurance program for the supply of replacement reactor pressure vessel heads, steam generators, and pressurizers." One programmatic audit finding in the area of corrective actions was identified, however, it did not affect the quality of supplied products.

Finally, the team learned that Framatome, ANP had an ASME Nuclear Survey performed at the Chalon/Saint Marcel plant in November 2002. The survey was performed by an ASME survey team for renewal of its N and NPT Certificates of Authorization and its NS Certificate of Accreditation, that were due to expire in January 2003. The survey team included as team members, the Chalon authorized nuclear inspector (ANI) and the authorized nuclear inspection supervisor. This review, included a review of the QMM as well as manufacturing activities, including welding and nondestructive examination (NDE), and procedure and personnel qualification, with successful results.

One final positive note concerning the Framatome, ANP Chalon QMM, is that in a letter dated May 15, 1998, the NRR Quality Assurance, Vendor Inspection, and Maintenance Branch documented that it had reviewed the Framatome Quality Assurance Program topical report (for United States applications) and found it continued to meet the requirements of Appendix B to 10 CFR Part 50.

Based on the reviews performed by the inspectors and oversight activities of the QA program conducted by VEPCO, as well as other groups, it appears the Framatome, ANP Chalon Saint Marcel facility has the capability and is effectively implementing a quality program that meets the requirements of Appendix B to 10 CFR Part 50, as well as several other regulatory and quality program requirements, for the supply of replacement RPVHs.

1.2 Review of VEPCO's ASME QA Data Package Documentation

a. Inspection Scope

The inspectors reviewed a sample of the documentation assembled in the two data packages: (1) Reconciliation Data Package that included all the Framatome, ANP Chalon Reconciliation Reports with the justifications for differences between the French RCC-M and ASME codes and (2) RCC-M Manufacturing and Fabrication Data Package that included all manufacturing records provided by Framatome, ANP Chalon such as forging, machining, welding, NDE and hydrostatic test. The review included technical reviews of several of the Reconciliation Reports, as well as an overall quality review of the records contained within the data packages against required documentation per Framatome, ANP 51-5021491-01, "EDF to Dominion Replacement Closure Head Plan," dated January 27, 2003, and Framatome, ANP 51-5023183-00, "North Anna II RV Closure Head Report of Reconciliation," dated January 24, 2003.

b. Findings

Based on the review of the documentation assembled in the Reconciliation Data Package and the RCC-M Manufacturing and Fabrication Data Package, it appears that the North Anna, Unit 2, replacement RPVH manufactured by Framatome, ANP using the 1993 Edition, through the 1996 addenda, of the French RCC-M code is essentially equivalent to a head manufactured by Framatome, ANP using the ASME Section III design code.

Finally, the inspectors noted with significance that the ANI assigned to Framatome, ANP Chalon facility, attested, by signature on the Code Data Report on January 24, 2003, that "to the best of my knowledge and belief, the contents of this report are accurate and as far as possible are equivalent to the requirements of Section III, Division 1 of the ASME code and the scope of work order."

## 2. Review of Design and Design Changes

2.1 Review of Reconciliation Plan and Report

a. Inspection Scope

Framatome, ANP 51-5021491-01 (reconciliation plan) and Framatome, ANP 51-5023183-00, (reconciliation report) were reviewed together to assess the consistency between the two documents. Further, the team evaluated the impact of the RPVH replacement on reactor coolant system (RCS) pressure and temperature limits as specified in Section 3.4.3 of the plant's Technical Specifications (TS).

b. Findings

Minor comments were made by the team on the reconciliation plan that were appropriately incorporated. The reconciliation report addressed all elements of plan and, therefore, the reconciliation plan and report were found to be consistent.

The reconciliation report indicated that the low alloy steel of the replacement RPVH had impact toughness equal to or exceeding the Owner's requirements of the original RPVH. The low alloy steels were found to have a reference temperature of less than 10 °F and were consistent with the values for the original head. The team found that the pressure and temperature curves did not need to be modified. The Team concluded that reconciliation report provided reasonable assurance that the use of the replacement RPVH will not result in changes to the RCS pressure, temperature, and heatup and cooldown rates shown in TS Section 3.4.3.

2.2 Review of Design Specification

a. Inspection Scope

The team reviewed the design specification for certification to the applicable ASME Section III requirements and that it contained the applicable Owner's Requirements from the original design.

b. Findings

The team found that revision 1 of the Design Specification was certified to the 1995 Edition of the ASME Section III Code with 1996 Addenda. The Design Specification also covered all of the applicable portions of the Owner's requirements associated with the original design. The Design Specification provides the design requirements to which the reconciliation of the replacement RPVH must be analyzed. To the extent possible, the team verified that the Design Specification was complete and contained the necessary information for assessing the design and reconciliation of the replacement RPVH components. Minor enhancements in the Design Specification were identified and were appropriately addressed by the licensee.

During review of design calculation BUCRNP/NCC 1957, Rev. E, "Stress and Fatigue Analysis Report of Closure Head," the team noted that RPVH studs and reactor vessel flange threads showed the highest cumulative usage factor, values of 0.92 and 0.77, respectively. These values were based on increasing the RPVH opening and closing cycles from 57 to 200 times. Based on current plant operation, the team determined that this assumption is extremely conservative and thereby, presents adequate margins for safety. The team also reviewed additional supporting analysis, modeling, interfacing/load data, and fatigue calculation details. The methods of analyses and conclusions were consistent with the Design Specification and the ASME Code requirements.

In the review of design calculation BUCRNP/NCC 1958, Rev. C, "Stress and Fatigue Analysis Report of Adapter Tube," the team noted that a 2-dimensional axi-symmetric model was generated to analyze the 3-dimensional adapter tube. In addition to the standard Code analysis method, the licensee produced a comparison between 2-D (approximate) and 3-D (exact) models. To obtain proper stress intensities, a coefficient was developed to multiply stresses obtained from the 2-D model. A stress concentration factor of 4.0, consistent with the Code requirement, was applied at the weld. The team found that the approaches used by the licensee were appropriate or conservative, and were acceptable from the Code standpoint. The team determined that the adapters meet the applicable ASME Code requirements for safe plant operation. In addition, the team found that in the conclusion section of this design calculation there were discussions on the conservatism used in the calculation and what conservatism remained.

As noted in Framatome, ANP 51-5023671-00, “North Anna II Tensioning Procedure,” there was a 3.5-inch increase in the thickness of the flange for the replacement RPVH from the original head. This difference in the distance between the washer bearing areas was required to be accounted for in O-MCM-1106-04, “Installation and Tensioning of RV Studs.” The team reviewed O-MCM-1106-04, Rev. 19 and found that it had not accounted for the increased head thickness. Subsequent review of O-MCM-1106-04, Rev. 20, found that the licensee had appropriately accounted for the increased head thickness and the team had no remaining issues.

The team found that the replacement RPVH Design Specification contained all information, including Owner’s requirements, applicable to the design and reconciliation for the replacement RPVH, and was certified by a professional engineer knowledgeable in the area of ASME III Code design and analysis. The Design Reports for various RPVH components were also certified by PEs familiar with the ASME Code, the Framatome design analyses, and North Anna, Unit 2, plant specific requirements. The inputs to calculations and analyses provided by VEPCO were appropriate and conservative. The documents reviewed were technically correct, generally of good quality, and contained adequate details in accordance with the Code and Design Specification requirements. The documents provided the reviewer adequate information to conclude, with reasonable confidence, that the replacement RPVH manufactured by Framatome, ANP is of high quality and adequate to maintain RCS pressure boundary integrity and supports the safe operation of North Anna, Unit 2.

2.3 Review of the Reactor Vessel Level Instrumentation System (RVLIS) Stress Report

a. Inspection Scope

The team reviewed the RVLIS Stress Reports (Framatome, ANP 32-5022931-01, "RVLIS Supports," dated January 17,2003, and Framatome, ANP 32-5022963, "RVLIS Piping," Rev. 1, dated January 17, 2003, and Rev. 2, dated January 29, 2003), to ensure that the modifications resulting from the replacement of the RPVH were appropriately addressed and that the RVLIS penetration, piping, and supports remained capable of performing their safety functions.

b. Findings

RVLIS piping and supports were re-analyzed and re-qualified due to the replacement of the cooling shroud, modification of the radiation shield, the addition of an intermediate lift ring, supports bolted to the intermediate lift ring, and RVLIS piping modifications to account for locational differences in the routing of the RVLIS line.

Minor clarifications were identified by the team to Framatome, ANP 32-5022931-01 that did not impact the overall results of the RVLIS supports stress report. The piping stress report (Framatome, ANP 32-5022963), was completely revised based on the team's comments, in part, for the following reasons:

- Pages 1 and 5 indicated 3/4-inch pipe while design drawings showed the piping as 1-inch.

- There was an overstress condition on page 14 of the stress report based on a conservative method. To address the overstress condition, the equation $Z = \pi r_m^2 T$ was used in the calculation as an exact method of calculating the section modulus. However, the ASME

Code defined that equation as the approximate section modulus. This equation is not appropriate to use for resolving overstress conditions. For 1 inch Schedule 160 pipe, the average through-wall stress for a thick wall cylinder should be used.

Revision 2 of the RVLIS piping stress report (Framatome, ANP 32-5022963), was issued on January 29, 2003, before the team completed its inspection. Revision 2 completely superceded all previous revisions. All of the team's observations were appropriately addressed in Revision 2 and there were no changes to any conclusions in the RVLIS piping stress report.

2.4 Control Rod Drive Mechanism (CRDM) Cooling Air Shroud and Support

a. Inspection Scope

The team reviewed ADVENT 02052SP-02, "Design and Analysis Specification," Rev. 2, dated January 11, 2003, and ADVENT 02052.1.1, "Structural Evaluation" Rev. 1, dated January 11, 2003, to ensure the structural analyses for the CRDM cooling air shroud and support appropriately considered the modifications and design changes resulting from the replacement of the RPVH.

b. Findings

The team found that ADVENT 02052SP-02, and ADVENT 02052.1.1 both made reference to NRC Regulatory Guide (RG) 1.61, "Damping Values for Seismic Design of Nuclear Power Plants," to justify the damping value used for the structural analysis of shrouds. RG 1.61 can be used only with the ground spectra listed in RG 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants." Neither RG 1.60, nor RG 1.61 are approved for North Anna and, therefore, are not part of the Plant's Design Bases. Therefore, the team concluded that referencing these RGs was inappropriate. However, the team found that the response spectra provided by VEPCO for the analyses were based on a damping value lower than that specified in Section 3.7 of the North Anna, Unit 2, Updated Final Safety Analysis Report and, therefore, the team concluded that a conservative response spectra was used in the structural analyses. In addition, the team found that the documents contained detailed descriptions on state of the art seismic design that may not be consistent with the licensing basis for North Anna, Unit 2. The inclusion of this information does not affect the overall conclusion of the analyses and the team identified this issue to the licensee for appropriate action. The licensee has entered this condition into its corrective action program.

2.5 Review of Reactor Pressure Vessel O-Ring Seal Design Change

a. Inspection Scope

The replacement RPVH O-ring surface is dimensionally different than the original RPVH. To ensure the difference was incorporated into the design of the replacement O-ring, the team reviewed the associated design change.

b. Findings

In a letter from the Advanced Products Company (APC) to VEPCO dated November 19, 2002, it was recommended that a seal larger than 0.5 inches be used. APC recommended the use of 0.550-inch nominal cross-section seal with a 0.004 - 0.005-inch thickness of silver plating. This recommendation was implemented by VEPCO as documented in the associated design change package.

## 3. Materials and Fabrication of RPVH

3.1 Base Materials Requirements

a. Inspection Scope

The team reviewed Equivalency Report EFFNM DT 1500, "RCC-M/ASME Equivalency Report," Revision D. This report evaluated the material requirements of the as ordered material to the ASME Section III NB 2000 requirements. A requirement of ASME Section III NB 2000, is to procure material in accordance with ASME Section II. Therefore, the equivalency report also addressed the specific requirements of ASME Section II. Where differences were noted in actual manufacturing and the ASME Codes, the EFFNM Report justified the equivalency of the requirements. The report documented justifications for eleven differences that were principally in destructive testing and coupon sampling and concluded that although differences existed, all chemistry, impact and strength requirements were satisfied.

b. Findings

The team concluded that Equivalency Report EFFNM DT 1500 provided reasonable confidence that the base materials used for the North Anna, Unit 2, replacement RPVH were equivalent to materials meeting the requirements of the ASME Code.

3.2 Examination at Procurement of Materials

a. Inspection Scope

The team reviewed Equivalency Report EFFQM 02/17295, "RCC-M/ASME Equivalency Report," Revision B, including EFFQM 02/17296 Revision B," APPENDIX A: Justifications." This report evaluated the NDE performed on the base materials versus the ASME Section III NB-2500 requirements. The evaluation included not only the actual NDE performed, but also the techniques used versus the applicable ASME Section II and ASME Section V requirements. Where differences were identified in the actual NDE performed and the NDE required by the ASME Code, the EFFQM Report justified the equivalency of the requirements. The report documented justifications for seventeen differences that varied from transducer size, to extent of coverage, to calibration method, to acceptance criteria, and concluded that although these differences existed, the type of and the acceptance standards of the examinations performed were equivalent to the ASME Section III NB-2500 requirements.

b. Findings

The team concluded that Equivalency Report EFFQM 02/17295 and APPENDIX A: Justifications to EFFQM 02/17296 provided reasonable confidence that the NDE performed at procurement of materials for the North Anna, Unit 2, replacement RPVH was equivalent to that required by the ASME Code.

3.3 Filler Materials

a. Inspection Scope

The team reviewed Equivalency Report EFFNM DT 1501, "RCC-M/ASME Equivalency Report Filler Materials," Revision D. This report compared welding materials used on the replacement RPVH to the requirements of ASME Code Section III, Subjection NB, 1995 Edition with Addenda through 1996. Where differences were noted in requirements between the two Codes, the EFFNM Report justified the equivalency of the requirements. The report concluded that although differences existed, the requirements under the RCC-M Code were equivalent to ASME Code requirements.

b. Findings

The team concluded that Equivalency Report EFFNM DT 1501 provided reasonable confidence that the welding materials used on the North Anna, Unit 2, replacement RPVH were equivalent to material requirements of the ASME Code.

3.4 Post Weld Heat Treatment (PWHT)

a. Inspection Scope

The team reviewed Equivalency Report EFFNM DT 1505, "RCC-M/ASME Equivalency Report Post Weld Heat Treatment," Revision C. This report compared PWHT used on the replacement RPVH to the requirements of ASME Code Section III, Subjection NB, 1995 Edition with Addenda through 1996. No differences were noted in the PWHT received and the requirements of the ASME Code requirements.

b. Findings

The team concluded that Equivalency Report EFFNM DT 1505 provided reasonable confidence that the PWHT received by the North Anna, Unit 2, replacement RPVH was equivalent to that required by the ASME Code.

3.5 Fabrication Records

a. Inspection Scope

The team reviewed the fabrication welding and NDE records listed below and verified that the records documented evidence that welding and NDE activities for the North Anna, Unit 2, replacement RPVH were performed in accordance with requirements.

- Weld S/C 205 (Flange to Dome Girth Weld)

  Production Weld Data Sheet, including QC signoffs for surface examinations
  Ultrasonic Examination Report
  Radiographic Examination Report, including film evaluation sheets

- Weld R/D 336 (Flange Cladding)

  Production Weld Data Sheet, including QC signoffs for surface examinations Liquid Penetrant Examination Report, identifying rejectable indications Weld Repair Records

- Welds R/D 337 (Key-Way Cladding), R/D 338 (Dome Cladding), and R/D 339 (Flange/Dome Butt Weld Cladding)

  Production Weld Data Sheets, including QC signoffs for surface examinations Ultrasonic Examination Reports

- Welds B/D 325 (Buttering for Vent Pipe) and B/D 326 (Buttering for J-Groove CRDM Welds)

  Production Weld Data Sheets, including root pass, intermediate, and final surface examination QC signoffs
  Ultrasonic Examination Report
  Liquid Penetrant Examination Report

- Welds S/P 325 (Vent Pipe J-Groove) and S/P 326 (CRDM J-Groove)

  Production Weld Data Sheets, including root pass, intermediate, and final surface examination QC signoffs
  Ultrasonic Examination Report

b. Findings

The records reviewed were good quality, provided detailed documentation of fabrication and inspection activities in accordance with Code requirements, and provided reasonable confidence the replacement RPVH is of acceptable quality to maintain safety.

In addition, although the team did not review them, the team verified that Welding Procedure Specifications, supporting Procedure Qualification Records, welding material records, and NDE procedures were available as part of the quality records obtained to support the RPVH replacement.

## 4. Welding

4.1 Welding Procedure Specifications and Welding Procedure Qualification Records

a. Inspection Scope

The team reviewed Equivalency Report EFFNM DT 1503, "RCC-M/ASME Equivalency Report for Welding Procedure Specification and Welding Procedure Qualification Records," Revision F. This report compared Welding Procedure Specifications and Welding Procedure Qualification Records used on the replacement RPVH to the requirements of ASME Code Section IX and ASME Code Section III, Subsection NB, 1995 Edition with Addenda through 1996. Where differences were noted in requirements between RCC-M and ASME, the EFFNM Report justified the equivalency of the requirements. The report concluded that although differences existed, the requirements under the RCC-M Code were equivalent to ASME Code requirements.

b. Findings

The team concluded that Equivalency Report EFFNM DT 1503 provided reasonable confidence that the Welding Procedure Specifications and Welding Procedure Qualification Records used on the North Anna, Unit 2, replacement RPVH were equivalent to the Welding Procedure Specification and Welding Procedure Qualification Record requirements of the ASME Code.

4.2 Welders Performance Qualifications

a. Inspection Scope

The team reviewed Equivalency Report EFFNM DT 1504, "RCC-M/ASME Equivalency Report for Welders Performance Qualifications," Revision C. This report compared Welders Performance Qualification Specifications used on the replacement RPVH to the requirements of ASME Code Section IX and ASME Code Section III, Subsection NB, 1995 Edition with Addenda through 1996. Where differences were noted in requirements between RCC-M and ASME, the EFFNM Report justified the equivalency of the requirements. The report concluded that although differences existed, the requirements under the RCC-M Code were equivalent to ASME Code requirements.

b. Findings

The team concluded that Equivalency Report EFFNM DT 1504 provided reasonable confidence that the Welders Performance Qualifications used on the North Anna, Unit 2, replacement RPVH were equivalent to the Welders Performance Qualification requirements of the ASME Code.

4.3 Friction Welding of the CRDM Housing Flanges-to Tubes

a. Inspection Scope

The team reviewed EFFNM DT 1506, "Friction Welding of the CRDM Housing Flanges-to Tubes," Revision E. This document evaluated the qualification of the friction welding process utilized in the joining of the stainless steel CRDM housing flanges to the NiCrFe (Alloy 690) CRDM nozzles. The document describes the essential variables and the procedure qualification process compared to ASME Section IX. The document includes documentation of the production test welds that are performed to support the weld qualification and also includes production history of the same weld process used for the other RPVHs manufactured in France.

b. Findings

ASME Section III does not allow friction welding for vessel fabrication or piping fabrication. ASME Section IX, which is for welding procedure and performance qualifications, does have requirements for friction welding procedures and qualifications, but these do not include all of the testing required by the French RCC-M Code. In addition to the tensile and bend tests required by ASME Section IX, the French Code requires metallographic examination of the test coupon. This metallographic examination includes a macroscopic examination and a microscopic examination that is performed at a magnification of 200X. All production and qualification parts are subject to a visual examination, a dimensional check, liquid penetrant examination and an ultrasonic examination. In addition, production welds are tested as follows: one test coupon for a campaign of less than 80 welds or two coupons for a campaign of 80 to 300 welds are subject to the same non-destructive and destructive testing required for the procedure qualification welds. A campaign is a continuous manufacturing sequence in which no tooling and no setting is changed. Based on the information provided in EFFNM DT 1506, of the 4320 CRDM assemblies friction welded between Alloy 690 and 304 stainless steel only five were rejected in the production process. Of the remaining 4315 CRDM assemblies made between Alloy 690 and 304 stainless steel, some of which have been in service since 1994, there have been no reportable service indications.

With these data, which were included in Report EFFNM DT 1506, the team concluded that Report EFFNM DT 1506 provided reasonable confidence that the friction welding process used to weld the stainless steel CRDM housing flanges to the NiCrFe CRDM nozzles provided acceptable welds in the CRDM adapters for the North Anna, Unit 2, replacement RPVH.

4.4 Welding Fabrication Procedures and Qualifications

a. Inspection Scope

The team reviewed the welding fabrication procedures and qualifications listed below and verified that the records documented evidence that welding activities for the North Anna, Unit 2, replacement RPVH were performed in accordance with requirements:

- Electroslag welding procedure, FMO SOFSZP/CR1252, Rev. F
- Friction Welding Procedure Establishment, FRA/QCT/CP 028R

- Friction Welding Data Package, FRA/CDS/CP
- Friction Welding Qualifications, FRA QMO/NC320

b. Findings

The records reviewed were good quality, provided documentation of welding activities in accordance with Code requirements, and provided reasonable confidence the replacement RPVH is of acceptable quality to maintain safety.

**5. Nondestructive Examination**

5.1 Examination During Manufacturing

a. Inspection Scope

The team reviewed Equivalency Report EFFQM 02/17296. This report compared NDE performed during fabrication under the RCC-M Code to the NDE examinations required by the ASME Code, Section III, 1995 Edition with Addenda through 1996. Where differences were noted in actual inspections and the ASME Codes, the EFFQM Report justified the equivalency of the requirements. The report documented justifications for 27 differences and concluded that although differences existed, the actual NDE performed was equivalent or better than that required by the ASME Code.

b. Findings

The team's review of the EFFQM Report determined that a number of the justifications for equivalency of differences were weak. Further discussions with the licensee revealed that, for the questionable justifications, additional data was available that had not been included in the written justifications. When coupled with the written justifications, this additional data provided adequate justification for equivalency. In most cases the additional justification was the additional NDE examinations (repeat of fabrication examinations) performed in accordance with the ASME Code by the licensee's contractor in December 2002. Examples of the justifications that needed additional information are as follows:

The ASME Code requires performing surface NDE examinations after post weld heat treatment (PWHT) whereas the RCC-M Code allows performing surface NDE examinations prior to PWHT. The written justification for this difference was based on the manufacturer's experience, and did not refer to the fact that the surface examinations were repeated to the ASME Code in December 2002 after PWHT.

In a number of cases, the RCC-M allowed slightly larger NDE indications than allowed by the ASME Code. Again, the justifications did not refer to the fact that the examinations were repeated to the ASME Code in December 2002.

For ultrasonic (UT) examination, the ASME Code specifies minimum transducer overlap and maximum scanning speed. These variables are not addressed in the RCC-M Code. These differences were justified based on the observation of UT of welds on other contracts where

the variables were within ASME requirements and the assertion that these variables would be controlled based on examiner's training. Again, the justification did not refer to the fact that the head welds received another UT examination to the ASME Code in December 2002.

When questioned by the team, the licensee revised the Reconciliation documentation to strengthen the justifications as appropriate. The team concluded that Equivalency Report EFFQM 02/17296, with the revised justifications documented during the inspection, provided reasonable confidence that the fabrication NDE for the replacement RPVH was equivalent to that required by the ASME Code and provided adequate quality inspections to maintain safety.

5.2 NDE Personnel Qualification and Certification

a. Inspection Scope

The team reviewed Equivalency Report EFFQM 02/17292, "SNT-TC-1A /NF-EN-473 Equivalency Report," Revision B. This report compared NDE personnel qualification and certification requirements of Standard NF-EN-473, used for inspections under the RCC-M Code, to the requirements of SNT-TC-1A as invoked and modified by ASME Code Section III, 1995 Edition with Addenda through 1996. Where differences were noted in requirements between the two Codes, the EFFQM Report justified the equivalency of the requirements. The report documented justifications for seven differences and concluded that although differences existed, the requirements under the RCC-M Code were equivalent or better than that required by the ASME Code and SNT-TC-1A.

b. Findings

The most significant difference was in the maximum re-certification intervals for Level I and II examiners. SNT-TC-1A requires re-certification every 3 years whereas Standard NF-EN-473 requires re-certification every 5 years. The documented justification for equivalency was based on the difference in the re-certification process in the 2 Codes. The ASME re-certification can be by continued satisfactory performance, resulting in potentially never being subjected to re-examination. Standard NF-EN-473 requires re-certification every 5 years with re-examination every 10 years. The justification contends that this is equivalent to the 3-year re-certification of ASME since the Level I and II examiners are closely monitored by the Level III examiner, which would be effectively the same as re-certification by continued satisfactory performance. Further discussions revealed that the majority or the examiners used on the replacement RPVH were dual certified (certified to both ASME and Standard NF-EN-473) and thus were re-certified every three years. In addition, as detailed above relative to EFFQM 02/17296, most of the final examinations were repeated to ASME requirements in December 2002. After questioning by the team, the licensee supplemented the equivalency report to document this additional justification.

The team concluded that Equivalency Report EFFQM 02/17292, with the supplements to the justifications documented during the inspection, provided reasonable confidence that the qualification and certification of NDE personnel for fabrication of the replacement RPVH was equivalent to that required by the ASME Code and provided adequate quality inspections to maintain safety.

## 6. Preservice Examinations and Hydrostatic Testing During Manufacturing

6.1 Preservice Examinations

a. Inspection Scope

The NRC Team reviewed the ASME Code, Section XI Preservice examination report to assess compliance with ASME Code requirements.

b. Findings

For the RPVH dome to flange weld the team reviewed the North Anna, Unit 2, replacement RPVH NDE report and summary dated January 6, 2003, for the inservice inspection preservice UT examination of the RPVH dome to flange weld. The team found that the licensee had obtained 66 percent volumetric coverage and 99.2 percent magnetic particle surface coverage. All examinations resulted in no recordable indications. To address having less than essentially 100 percent volumetric coverage during the dome to flange weld examination as required by the ASME Code, the licensee submitted a request for relief to the NRC in its letter dated January 28, 2003 (ADAMS Accession No. ML030380333). NRC review of the licensee's request for relief will be documented under separate correspondence.

For the RPVH lifting lugs the team found that the licensee performed a magnetic particle surface examination on the lifting lug welds and obtained essentially 100 percent surface coverage, meeting ASME Code requirements.

Although there is no ASME Section XI Code requirement to examine the CRDM nozzle penetrations or the J-grove welds, the licensee performed UT of the VHP housing and liquid dye penetrant (PT) examinations of the J-groove welds to establish a base line for future examinations. All UT and PT examinations resulted in no recordable indications or any associated welding process indications.

For the vent line nozzle inspections the team found that the licensee examined the vent line nozzle penetrations by remote UT and PT examinations. The examinations resulted in no recordable indications.

The team found that for the bi-metallic friction welds the licensee performed UT examinations of the bi-metallic friction weld or fusion line that joined the Alloy 690 CRDM adapter tube to the stainless steel CRDM flange. Since this type of weld configuration is not specifically addressed in Section XI of the ASME Code, the weld was treated by the licensee as a Category B-O, Item No. B14.10 component and examined accordingly. In addition to the UT examinations, the licensee performed PT examinations of the 65 friction welds from the outer surface. All examinations resulted in no recordable indications.

The team concluded that there were no items of concern in the area of preservice examinations and that the documentation reviewed was of high quality.

6.2 RPVH Hydrostatic Test

a. Inspection Scope

The team reviewed the reconciliation report regarding the hydrostatic testing of the replacement RPVH for compliance with ASME Code requirements.

b. Findings

The team reviewed Section 2.2.6 of Framatome, ANP 51-5023183-00 regarding the hydrostatic test of the RPVH. Section III of the ASME Code requires that the hydrostatic test be conducted at the pressure of 1.25 times the design pressure (design pressure is 2485 psi). The RPVH was shop hydrostatically tested at a pressure of 3335.9 psi or 1.34 times the design pressure. The test was performed to the RCC-M requirements that require a higher test pressure than the ASME Code, Section III requirements. The team concluded that there were no concerns with the hydrostatic testing of the RPVH and that the documentation reviewed was of high quality.

## 7. **Documents Reviewed**

a. Framatome, ANP 08-5021888-01, "Design Specification for Reactor Vessel Closure Head Replacement North Anna Unit-2," dated January 17, 2003

b. Framatome, ANP 51-5021491-01, "EDF to Dominion Replacement Closure Head Plan," dated January 27, 2003

c. Framatome, ANP 51-5023183-00, “North Anna II RV Closure Head Report Reconciliation,” dated January 24, 2003

d. Framatome, ANP 51-5023417-00, "North Anna 2 Replacement RVH NDE Report and Summary," dated January 6, 2003

e. North Anna, Unit 2 Replacement Reactor Vessel Head Pre-Service Inspection Report dated January 23, 2003

f. Framatome, ANP Chalon/Saint-Marcel Data Report for Nuclear Part, North Anna 2 Nuclear Power Station Reactor Vessel Replacement Closure Head, dated January 23, 2003

g. Dominion Nuclear Oversight Audit Report and NUPIC Checklist for Framatome, ANP Chalon/Saint Marcel, dated November 21, 2002

h. Dominion Nuclear Oversight Audit Report and NUPIC Checklist for Framatome, ANP Chalon/Saint Marcel, dated January 13, 2003

i. Exelon Nuclear NUPIC Joint Quality Assurance Program Audit Report and NUPIC Checklist for Framatome, ANP Chalon/Saint Marcel, dated July 2, 2002

j. Special Report - "Dominion Nuclear Oversight - Quality Process Review"

k. Equivalency Report EFFQM 02/17292, “SNT-TC-1A / NF EN 473 Equivalency Report,” Revision B

l. Equivalency Report EFFQM 02/17295, “RCC-M/ASME Equivalency Report,” Revision B

m. Equivalency Report EFFQM 02/17296, “APPENDIX A: Justifications,” Revision B

n. Equivalency Report EFFNM DT 1500, “RCC-M/ASME Equivalency Report - Base Materials,” Revision D

o. Equivalency Report EFFNM DT 1501, “RCC-M/ASME Equivalency Report Filler Materials,” Revision D

p. Equivalency Report EFFNM DT 1502, “List of Welds,” Revision B

q. Equivalency Report EFFNM DT 1503, “RCC-M/ASME Equivalency Report for Welding Procedure Specification and Welding Procedure Qualification Records,” Revision F

r. Equivalency Report EFFNM DT 1504, “RCC-M/ASME Equivalency Report for Welders Performance Qualifications,” Revision C

s. Equivalency Report EFFNM DT 1505, “RCC-M/ASME Equivalency Report Post Weld Heat Treatment,” Revision C

t. Equivalency Report EFFNM DT 1506, Friction Welding of the CRDM Housing Flanges-to Tubes,” Revision E

u. Equivalency Report EFFNM DT 1530, “Additional Supporting Documents not Included in the CC/CP28R Data Package,” Revision A

v. Equivalency Report EFFNE DT 3007, "Hydrostatic Test"

w. Equivalency Report EFFQM 03/17007, "List of Non Destructive Examination Procedures Used During Manufacturing of the Closure Head CC/CP28R"

x. RCC-M Manufacturing and Fabrication Report Data Package, specifically:
   1. End of Fabrication Certificate
   2. Certificate of Conformance
   3. Quality Release
   4. Test Coupon Schedule
   5. Welding and NDE records for various manufacturing activities
   6. Pre-Service Inspection Plan
   7. Pre-Service Inspection (PSI) Final Report and Summary for RPVH NDE Inspections (includes Welding and NDE Data as well as NDE procedures and personnel certifications)

y. Framatome, ANP BUCRNP/NCC 1977, Rev. B, “RV Closure Head Design Reports (Certified)”

z. Design Calculation BUCRNP/NCC 1956, Rev. C, “Introduction and General Requirements”

aa. Design Calculation BUCRNP/NCC 1957, Rev. E, “Stress and Fatigue Analysis Report of Closure Head”

ab. Design Calculation BUCRNP/NCC 1958, Rev. C, “Stress and Fatigue Analysis Report of Adapter Tube”

ac. Design Calculation BUCRNP/NCC 1959, Rev. C, “Stress and Fatigue Analysis Report of Vent Pipe”

ad. Design Calculation BUCRNP/NCC 0003, Rev. D, “Stress Analysis Report of Lifting Lugs”

ae. O-MCM-1106-04, Rev. 19 and 20, “Installation and Tensioning of RV Studs”

af. O-MCM-1106-01, Rev. 18, “De-tensioning and Removal of RV Head Studs and Installation of RV Head Guide Studs”

ag. Closure Head of the Vessel Design Drawings, BUEPNA/NCC-2001, Rev. E; BUEPNA/NCC-2012, Rev. C; and BUEPNA/NCC-2014, Rev. B

ah. Framatome, ANP 32-5022931-01, "RVLIS Supports," dated January 17, 2003

ai. Framatome, ANP 32-5022963, "RVLIS Piping," Rev. 1, dated January 17, 2003, and Rev.2, dated January 28, 2003

aj. Stress Report for Intermediate Lift Ring:
1. Design Specification, Framatome, ANP 08-50213471-02
2. Design Report, Framatome, ANP 33-5024060-00
3. Stress Analysis Report, Framatome, ANP 32-1011012-01 (NFEMR DC 58, Rev. D)

ak. Stress Report for CRDM Nozzle Plugs:

1. Design Specification, Framatome, ANP 08-5022207-01
2. Design Report, Framatome, ANP 33-5023305-01

al. Stress Report for Modified Radiation Shield:

1. ADVENT 02052SP-03 Rev. 1, “Design and Analysis Specification,” dated January 11, 2003
2. ADVENT 02052.1.2 Rev. 1, “Structural Evaluation,” dated January 11, 2003

am. Stress Report for CRDM Cooling Air Shroud (CAS) lower Chamber and Shroud Support Modifications:
1. ADVENT 02052SP-02 Rev. 2, “Design and Analysis Specification,” dated January 11, 2003
2. ADVENT 02052.1.1 Rev. 1, “Structural Evaluation,” dated January 11, 2003

an. RPVH O-Ring Seals, Letter from Peter Amos of the Advanced Products Company to David Harris of VEPCO, 11/19/02

ao. Letters from Westinghouse to Dominion:
1. January 9, 2003, letter from M.P. Osborne to R. Lee, CETNA Interface and Design Loads
2. January 16, 2003, letter from M.P. Osborne to Dominion, Head Adapter Loads at Bimetallic Weld
3. January 17, 2003, letter from M.P. Osborne to Dan Madden, CRDM Seismic Support Seismic Evaluation, Rev. 1
4. January 17, 2003, letter from M.P. Osborne to Dan Madden, CRDM Support Loss of Coolant Accident Evaluation