March 11, 2005

Mr. George Vanderheyden, Vice President
Calvert Cliffs Nuclear Power Plant, Inc.
Calvert Cliffs Nuclear Power Plant
1650 Calvert Cliffs Parkway
Lusby, MD 20657-4702

SUBJECT: CALVERT CLIFFS NUCLEAR POWER PLANT, UNIT NO. 2 - RELAXATION OF THE REQUIREMENTS OF FIRST REVISED ORDER MODIFYING LICENSE (EA-03-009), REGARDING REACTOR PRESSURE VESSEL HEAD INSPECTIONS (TAC NO. MC5705)

Dear Mr. Vanderheyden:

By letter dated January 14, 2005 (ADAMS Accession No. ML050260665), Calvert Cliffs Nuclear Power Plant, Inc. (CCNPPI) requested relaxation from certain inspection requirements in the Nuclear Regulatory Commission (NRC) Order Modifying License EA-03-009 (Order) for Reactor Pressure Vessel (RPV) Head Penetration Nozzles for CCNPP, Unit No. 2 (CCNPP 2). Additional information supporting your request was provided in letters dated March 4 (ADAMS Accession No. ML050680518) and March 8, 2005.

The NRC staff concludes that your proposed alternative UT examination of 50 control element drive mechanism (CEDM) penetration nozzles to a minimum of 1.2 inches above the highest point of the root of the J-groove weld and of 59 CEDM penetration nozzles below the J-groove weld to the maximum extent possible, provides reasonable assurance of the structural integrity of the RPV head, RPV penetration nozzles, and welds.

Further inspections of these RPV penetration nozzles in accordance with Section IV, paragraph C.(5)(b)(i), of the First Revised NRC Order EA-03-009 dated February 20, 2004, would result in hardship without a compensating increase in the level of quality and safety. Therefore, pursuant to Section IV, paragraph F, of the First Revised NRC Order EA-03-009 dated February 20, 2004, for good cause shown, the staff authorizes the proposed alternative inspections for the 50 RPV CEDM penetration nozzles above the highest point of the root of the J-groove weld and the 59 RPV penetration nozzles below the J-groove weld at CCNPP 2, subject to the following condition:

> If the NRC staff finds that the crack-growth formula in industry report MRP-55 is unacceptable, CCNPP [the licensee] shall revise its analysis that justifies relaxation of the First Revised Order dated February 20, 2004, within 30 days after the NRC informs the licensee of an NRC-approved crack growth formula. If our [the licensee's] revised analysis shows that the crack growth acceptance criteria are exceeded prior to the end of the current operating cycle, this relaxation can be rescinded and CCNPP shall, within 72 hours, submit to the NRC written justification for continued operation. If the revised analysis shows that the crack growth acceptance criteria are exceeded during the subsequent operating cycle, CCNPP shall, within 30 days, submit the revised analysis for NRC review. If the revised analysis shows that the crack growth acceptance criteria are not exceeded during either the current operating cycle or the subsequent operating

cycle, the licensee shall, within 30 days submit a letter to the NRC confirming that its analysis has been revised. Any future crack growth analyses performed for this and future cycles for reactor pressure vessel head penetrations must be based on an acceptable crack growth rate formula.

The details of the staff's review are contained in the enclosed safety evaluation. If you have questions regarding this matter, please contact Rich Guzman at 301-415-1030.

Sincerely,

/RA/

Cornelius F. Holden, Jr, Director
Project Directorate I
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-318

Enclosure: As stated

cc w/encl: See next page

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cc w/encl: See next page

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Accession No.: ML050700300 *Provided SE input by memo. No substantive changes made.

OFFICE	PDI-1/PM	PDI-1/LA	EMCB/SC	OGC	PDI-1/SC	DLPM/PDI
NAME	RGuzman	SLittle	TChan*	GLongo	PTam for RLaufer	CHolden
DATE	3/11/05	3/11/05	3/11/05 SE DTD	3/11/05	3/11/05	3/11/05

OFFICIAL RECORD

Calvert Cliffs Nuclear Power Plant, Unit Nos. 1 and 2

cc:

President
Calvert County Board of
Commissioners
175 Main Street
Prince Frederick, MD 20678

Carey Fleming, Esquire
Counsel
Constellation Energy
750 East Pratt Street, 17th floor
Baltimore, MD 21202

Jay E. Silberg, Esquire
Shaw, Pittman, Potts, and Trowbridge
2300 N Street, NW
Washington, DC 20037

Lou Larragoite
Calvert Cliffs Nuclear Power Plant
1650 Calvert Cliffs Parkway
Lusby, MD 20657-4702

Resident Inspector
U.S. Nuclear Regulatory
Commission
P.O. Box 287
St. Leonard, MD 20685

Mr. R. I. McLean, Administrator
Radioecology Environ Impact Prog
Department of Natural Resources
Nuclear Evaluations
580 Taylor Avenue
Tawes State Office Building
Annapolis, MD 21401

Regional Administrator, Region I
U.S. Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, PA 19406

Kristen A. Burger, Esquire
Maryland People's Counsel
6 St. Paul Centre
Suite 2102
Baltimore, MD 21202-1631

Patricia T. Birnie, Esquire
Co-Director
Maryland Safe Energy Coalition
P.O. Box 33111
Baltimore, MD 21218

Mr. Loren F. Donatell
NRC Technical Training Center
5700 Brainerd Road
Chattanooga, TN 37411-4017

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

FIRST REVISED ORDER MODIFYING LICENSE (EA-03-009) RELAXATION REQUEST,

EXAMINATION COVERAGE

FOR REACTOR PRESSURE VESSEL HEAD PENETRATION NOZZLES

CALVERT CLIFFS NUCLEAR POWER PLANT, UNIT NO. 2

CALVERT CLIFFS NUCLEAR POWER PLANT, INC.

DOCKET NUMBER 50-318

1.0 INTRODUCTION

The First Revised NRC Order EA-03-009 (Order), issued on February 20, 2004, requires specific examinations of the reactor pressure vessel (RPV) head and vessel head penetration (VHP) nozzles of all pressurized-water reactor (PWR) plants. Section IV, paragraph F, of the Order states that requests for relaxation of the Order associated with specific penetration nozzles will be evaluated by the NRC staff using the procedure for evaluating proposed alternatives to the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) in accordance with 10 CFR 50.55a(a)(3). Section IV, paragraph F, of the Order states that a request for relaxation regarding inspection of specific nozzles shall address the following criteria: (1) the proposed alternative(s) for inspection of specific nozzles will provide an acceptable level of quality and safety, or (2) compliance with this Order for specific nozzles would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

For Calvert Cliffs Nuclear Power Plant Unit 2 (CCNPP 2), and similar plants determined to have a high susceptibility to primary water stress-corrosion cracking (PWSCC) in accordance with Section IV, paragraph A and B, of the Order, the following inspections are required to be performed every refueling outage in accordance with Section IV, paragraph C.(5)(a) and paragraph C.(5)(b) of the Order:

(a) Bare metal visual [BMV] examination of 100 percent of the RPV head surface (including 360E around each RPV head penetration nozzle). For RPV heads with the surface obscured by support structure interferences which are located at RPV head elevations downslope from the outermost RPV head penetration, a bare metal visual inspection of no less than 95 percent of the RPV head surface may be performed provided that the examination shall include those areas of the RPV head upslope and downslope from the support structure interference to

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identify any evidence of boron or corrosive product. Should any evidence of boron or corrosive product be identified, the licensee shall examine the RPV head surface under the support structure to ensure that the RPV head is not degraded.

(b) For each penetration, perform a nonvisual NDE [nondestructive examination] in accordance with either (i), (ii), or (iii):

(i) Ultrasonic testing of the RPV head penetration nozzle volume (i.e., nozzle base material) from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 2 inches below the lowest point at the toe of the J-groove weld on a horizontal plane perpendicular to the nozzle axis (or bottom of the nozzle if less than 2 inches [See Figure IV-1]); OR from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 1.0-inch below the lowest point at the toe of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) and including all RPV head penetration nozzle surfaces below the J-groove weld that have an operating stress level (including all residual and normal operation stresses) of 20 ksi tension and greater (see Figure IV-2). In addition, an assessment shall be made to determine if leakage has occurred into the annulus between the RPV head penetration nozzle and the RPV head low-alloy steel.

(ii) Eddy current testing or dye penetrant testing of the entire wetted surface of the J-groove weld and the wetted surface of the RPV head penetration nozzle base material from at least 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 2 inches below the lowest point at the toe of the J-groove weld on a horizontal plane perpendicular to the nozzle axis (or the bottom of the nozzle if less than 2 inches [See Figure IV-3]); OR from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) to 1.0-inch below the lowest point at the toe of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) and including all RPV head penetration nozzle surfaces below the J-groove weld that have an operating stress level (including all residual and normal operation stresses) of 20 ksi tension and greater (see Figure IV-4).

(iii) A combination of (i) and (ii) to cover equivalent volumes, surfaces and leak paths of the RPV head penetration nozzle base material and J-groove weld as described in (i) and (ii). Substitution of a portion of a volumetric exam on a nozzle with a surface examination may be performed with the following requirements:

1. On nozzle material below the J-groove weld, both the outside diameter and inside diameter surfaces of the nozzle must be examined.

2. On nozzle material above the J-groove weld, surface examination of the inside diameter surface of the nozzle is permitted provided a surface examination of the J-groove weld is also performed.

Footnote 3 of the Order provides specific criteria for examination of repaired VHP nozzles.

By letter dated January 14, 2005, as supplemented by letters dated March 4 and 8, 2005, Calvert Cliffs Nuclear Power Plant, Inc. (the licensee), requested relaxation to implement an alternative to the requirements of Section IV, paragraph C.(5)(b)(i), of the First Revised NRC Order for RPV head penetration nozzles at CCNPP 2.

2.0 FIRST REVISED NRC ORDER EA-03-009 RELAXATION REQUEST FOR EXAMINATION COVERAGE FOR REACTOR PRESSURE VESSEL HEAD PENETRATION NOZZLES ABOVE THE J-GROOVE WELDS

2.1 First Revised NRC Order Requirements for Which Relaxation is Requested

The licensee has requested relaxation from Section IV, paragraph C.(5)(b)(i) of the First Revised NRC Order. The specific relaxation requested is identified below:

2.2 Licensee's Proposed Alternative

The licensee seeks relaxation from the Order where inspection coverage is limited by inaccessible areas of 50 control element drive mechanism (CEDM) penetration nozzles for CCNPP, Unit No. 2, with respect to NDE, specifically ultrasonic testing (UT). The licensee stated that relaxation is requested from Section IV, paragraph IV.C.(5)(b)(i) of the Order from 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis).

The licensee proposes to meet the Order requirements, or to examine each CEDM nozzle above the J-groove weld to the maximum extent possible. The licensee stated the minimum UT examination coverage expected will be approximately 1.2 inches above the highest point of the J-groove weld.

2.3 Licensee's Basis for Proposed Alternative

The licensee stated that the Unit 2 CEDM penetrations have guide/thermal sleeves with a funneled-end installed inside the CEDM penetration to position the CEDM shaft. The licensee stated that above the J-groove weld there is a counterbore step on the inside diameter of the nozzle which reduces the annular gap of approximately 0.175 inch to 0.123 inch. Because of this, the thin "gap scanning" UT blade probe does not fit into the region where the gap width decreases.

The licensee stated that Units 1 and 2 have identical geometries for reactor vessel head nozzle design and fabrication. The analysis and evaluation performed in support of the 2004 Unit 1 refueling outage relaxation request remain valid and are applicable to the 2005 Unit 2 refueling outage relaxation request.

The licensee stated that the residual plus operating stresses are all below 20 ksi, both in the hoop and axial directions at an elevation 1.2 inches above the highest point of the J-groove weld on every CEDM penetration on the Calvert Cliffs reactor vessel head. Therefore, primary water stress-corrosion cracking (PWSCC) is not expected to initiate in the small region that is the subject of this relaxation request.

The licensee stated that it is possible to permanently remove the guide/thermal sleeves, allowing the insertion of a rotating ultrasonic probe, instead of a blade probe to achieve full coverage. However, the licensee stated that during the refueling outage, the effort to remove and re-install thermal sleeves (based on Unit 1 experience) is estimated to result in additional radiation exposure of approximately 31 person-rems and would cost approximately 7.5 million dollars.

The licensee stated that the in-core instrumentation nozzles and the RPV head vent nozzle will be ultrasonically tested 2 inches above the J-groove weld in accordance with the requirements of the Order. The licensee stated that where limitations exist that preclude the full examination coverage, the limitations will be noted and reported as required by Section IV.E of the Order.

The licensee stated that experience with the inspection of the CCNPP, Units 1 head, which is similar to the RPV head on Unit 2, confirms the inability to examine a full 2 inches above the J-groove weld for all scans of the CEDM nozzles using a blade probe. Therefore, based upon the information provided above, the licensee concluded that compliance with the requirements specified in the First Revised NRC Order would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

2.4 Evaluation

The NRC staff's review of this request was based on criterion (2) of paragraph F of Section IV of the Order, which states:

> [C]ompliance with this Order for specific nozzles would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Regarding the required examination of the RPV head penetration nozzles, the licensee has demonstrated that hardship or unusual difficulty would result from implementing examinations to 2 inches above the highest point of the root of the J-groove weld of these nozzles, without a compensating increase in the level of quality and safety. The NRC staff reviewed the licensee's hardship or unusual difficulty based upon dose implications on the workers subjected to performing examinations to the bottom of the nozzle without a compensating increase in the level of quality or safety.

The phenomenon of concern is PWSCC, which typically initiates in the areas of highest stress. The area of CEDM penetrations that has the highest residual stress is the area adjacent to the J-groove attachment weld. Therefore, it is most likely that PWSCC will initiate in an area adjacent to the J-groove attachment weld.

The licensee proposed to examine the CEDM penetration nozzles to a minimum of 1.2 inches above the highest point of the root of the J-groove weld for those nozzles that could not achieve full coverage. The licensee's proposed minimum inspection distance of the nozzle base material above the J-groove weld is supported by the licensee's residual stress analysis of the CEDM nozzles at 0E, 11E, 29E, and 43E.

The licensee concluded that for all penetrations, the highest bounding, residual stress on the inside diameter (ID) surfaces at 1.2 inches above the highest point of the root of the J-groove weld is 19.9 ksi and occurs on the uphill side of the 11 degree nozzle. On the outside diameter (OD), the licensee stated that both hoop and axial stresses at 0.75 inch above the highest point of the root of the J-groove weld are below 7 ksi in all cases.

The licensee also had crack growth calculations performed for two different locations. The crack growth calculations were performed in accordance with the crack growth formula in Electric Power Research Institute (EPRI) Report Material Reliability Program (MRP) Report, MRP-55, "Material Reliability Program (MRP Crack Growth Rates for Evaluation Primary Water Stress Corrosion Cracking (PWSCC) of Thick Wall Alloy 600 Material (MRP-55), Revision 1."

The NRC staff has made a preliminary assessment of the crack growth formula, but has not yet made a final determination on the acceptability of the subject industry report. Should the NRC staff determine the crack growth formula used by the licensee to be unacceptable, the licensee will be required to revise its analysis to incorporate an acceptable crack growth formula as described below.

> If the NRC staff finds that the crack-growth formula in industry report MRP-55 is unacceptable, CCNPP [the licensee] shall revise its analysis that justifies relaxation of the First Revised Order dated February 20, 2004, within 30 days after the NRC informs the licensee of an NRC-approved crack growth formula. If our [the licensee's] revised analysis shows that the crack growth acceptance criteria are exceeded prior to the end of the current operating cycle, this relaxation can be rescinded and CCNPP shall, within 72 hours, submit to the NRC written justification for continued operation. If the revised analysis shows that the crack growth acceptance criteria are exceeded during the subsequent operating cycle, CCNPP shall, within 30 days, submit the revised analysis for NRC review. If the revised analysis shows that the crack growth acceptance criteria are not exceeded during either the current operating cycle or the subsequent operating cycle, the licensee shall, within 30 days submit a letter to the NRC confirming that its analysis has been revised. Any future crack growth analyses performed for this and future cycles for reactor pressure vessel head penetrations must be based on an acceptable crack growth rate formula.

The licensee concurred with the above statement in a letter dated March 8, 2005.

For the first calculation, the lower end of the crack was located 1.2 inches above the root of the J-groove weld. For the second calculation, the lower end of the flaw was placed at an elevation 2 inches above the root of the J-groove weld. The licensee concluded the results indicated there is little difference in the crack growths for flaws located at 1.18 inches above the weld or at 2 inches above the weld. A table of results is provided below:

Location	Initial Flaw Depth	Flaw Depth After 2 Years
1.18" Above the Weld	24.15%	24.24%
2.00" Above the Weld	24.15%	24.15%

Flaw depths are in terms of wall thickness.

The licensee stated that for circumferential flaws, the axial residual stresses decline very quickly with distances above the J-groove weld. The licensee stated that in the region above 1.2 inches above the highest point of the root of the J-groove weld, residual stresses are very low or are negative, so initiation and growth of circumferential flaws are not predicted for this region.

The licensee provided inspection data results of the 65 CEDM nozzle penetrations, 8 in-core instrumentation (ICI) nozzles and 1 vent-line penetration nozzle. Based on the inspection results, 15 of the CEDM nozzles were UT inspected at least 2 inches above the highest point of the root of the J-groove weld in accordance with the requirements of the First Revised NRC Order. All 8 ICI penetration nozzles and 1 vent-line penetration nozzle were UT examined in accordance with the requirements of the First Revised NRC Order. Fifty CEDM penetration nozzles which were UT examined did not meet the requirements of 2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) as required by the First Revised NRC Order EA-03-009, dated February 20, 2004. CEDM nozzle penetration #8 received the most limiting coverage of 1.2 inches above the root of the J-groove weld. A table of results is provided below.

Extent of UT Coverage in RVHP Nozzle Material

Pen #	Nozzle Angle	Coverage Above Weld Root on Uphill (in)	Coverage Below Weld Toe on the Downhill Side (in)	Circumferential Coverage Achieved (Degrees)	Scan Type (Blade Probe / Rotating) Axial Blade: A Circ Blade: C	Examined to End of Nozzle	Leak Path Assessment Possible? (Yes / No)
CEDM 1	0.0	1.70	1.00	360	C	No	Yes
CEDM 2	11.1	>2	0.51	360	C	No	Yes
CEDM 3	11.1	1.91	N/A	360	A/C	Yes	Yes
CEDM 4	11.1	1.50	0.65	360	C	No	Yes
CEDM 5	11.1	>2	0.85	360	C	No	Yes
CEDM 6	12.0	>2	0.70	360	C	No	Yes
CEDM 7	12.0	1.71	0.75	360	C	No	Yes
CEDM 8	12.0	1.20	0.85	360	C	No	Yes
CEDM 9	12.0	>2	0.80	360	C	No	Yes
CEDM 10	22.6	1.92	0.45	360	C	No	Yes
CEDM 11	22.6	1.90	0.60	360	C	No	Yes
CEDM 12	22.6	>2	0.40	360	C	No	Yes
CEDM 13	22.6	>2	0.80	360	C	No	Yes
CEDM 14	24.1	>2	N/A	360	A	Yes	Yes
CEDM 15	24.1	1.90	0.50	360	C	No	Yes

CEDM 16	24.1	>2	0.40	360	C	No	Yes
CEDM 17	24.1	>2	0.45	360	C	No	Yes
CEDM 18	25.5	1.61	N/A	360	A	Yes	Yes
CEDM 19	25.5	1.50	0.70	360	C	No	Yes
CEDM 20	25.5	1.61	0.50	360	C	No	Yes
CEDM 21	25.5	1.80	0.60	360	C	No	Yes
CEDM 22	25.5	1.55	0.40	360	C	No	Yes
CEDM 23	25.5	1.61	0.40	360	C	No	Yes
CEDM 24	25.5	>2	0.40	360	C	No	Yes
CEDM 25	25.5	>2	0.74	360	C	No	Yes
CEDM 26	29.3	1.81	N/A	360	A	Yes	Yes
CEDM 27	29.3	1.75	0.60	360	C	No	Yes
CEDM 28	29.3	>2	0.40	360	C	No	Yes
CEDM 29	29.3	1.80	0.75	360	C	No	Yes
CEDM 30	29.3	>2	0.45	360	C	No	Yes
CEDM 31	29.3	>2	0.35	360	C	No	Yes
CEDM 32	29.3	1.84	0.50	360	C	No	Yes
CEDM 33	29.3	>2	0.75	360	C	No	Yes
CEDM 34	34.9	1.66	0.80	360	C	No	Yes
CEDM 35	34.9	1.48	0.40	360	C	No	Yes
CEDM 36	34.9	1.61	0.85	360	A/C	No	Yes
CEDM 37	34.9	1.79	0.85	360	C	No	Yes
CEDM 38	38.5	1.63	N/A	360	A	Yes	Yes
CEDM 39	38.5	1.30	0.45	360	C	No	Yes
CEDM 40	38.5	1.30	0.40	360	C	No	Yes
CEDM 41	38.5	1.55	0.50	360	C	No	Yes
CEDM 42	38.5	1.75	0.45	360	C	No	Yes
CEDM 43	38.5	1.77	0.70	360	C	No	Yes
CEDM 44	38.5	1.27	0.65	360	C	No	Yes
CEDM 45	38.5	1.40	0.80	360	C	No	Yes
CEDM 46	41.8	1.56	N/A	360	A	Yes	Yes
CEDM 47	41.8	1.21	0.40	360	C	No	Yes
CEDM 48	41.8	1.50	0.45	360	C	No	Yes
CEDM 49	41.8	1.44	0.64	360	C	No	Yes
CEDM 50	41.8	1.58	0.60	360	C	No	Yes
CEDM 51	41.8	1.30	0.51	360	C	No	Yes
CEDM 52	41.8	1.60	0.63	360	C	No	Yes
CEDM 53	41.8	1.47	0.60	360	C	No	Yes
CEDM 54	42.5	1.60	0.55	360	C	No	Yes
CEDM 55	42.5	1.67	0.45	360	A/C	No	Yes
CEDM 56	42.5	1.75	0.90	360	C	No	Yes
CEDM 57	42.5	1.60	0.40	360	C	No	Yes
CEDM 58	42.5	1.55	0.55	360	C	No	Yes
CEDM 59	42.5	1.47	0.65	360	C	No	Yes
CEDM 60	42.5	1.25	1.51	360	A	No	Yes
CEDM 61	42.5	1.60	0.50	360	C	No	Yes

CEDM 62	42.5	1.66	0.50	360	C	No	Yes
CEDM 63	42.5	1.36	0.50	360	C	No	Yes
CEDM 64	42.5	1.35	0.50	360	C	No	Yes
CEDM 65	42.5	1.37	0.50	360	C	No	Yes
ICI 66	54.8	>2	N/A	360	Rotating	Yes	Yes
ICI 67	54.8	>2	N/A	360	Rotating	Yes	Yes
ICI 68	54.8	>2	N/A	360	Rotating	Yes	Yes
ICI 69	54.8	>2	N/A	360	Rotating	Yes	Yes
ICI 70	54.8	>2	N/A	360	Rotating	Yes	Yes
ICI 71	54.8	>2	N/A	360	Rotating	Yes	Yes
ICI 72	54.8	>2	N/A	360	Rotating	Yes	Yes
ICI 73	54.8	>2	N/A	360	Rotating	Yes	Yes
Vent-Line	0-11	>2	N/A	360	Rotating/ECT	Yes	N/A

The licensee also provided a table identifying the stress levels for the 50 CEDM nozzles which did not meet the requirement of 2 inches above the highest point of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis) as required by the First Revised NRC Order EA-03-009, dated February 20, 2004. The table is provided below.

CEDM Number	Nozzle Angle	Minimum Axial Distance Achieved Above Uphill Weld Root (inches)	Stress Level Above the Uphill Weld Root at the Axial Distance for Nozzles Without Complete Coverage (ksi)	Minimum Axial Distance Achieved Above Downhill Weld Root for Nozzles with Coverage < 2" above Uphill Weld Root (inches)	Stress Level Above the Downhill Weld Root at the Axial Distance for Nozzles without Complete Coverage (ksi)
1	0	1.7	ID: 2.4 OD: -3.6	1.7	ID: 2.4 OD: -3.6
3	11.1	1.91	ID: 2.2 OD: -1.9	2.72	ID: 4.7 OD: 2.4
4	11.1	1.5	ID: 3.8 OD: -5.0	2.31	ID: 2.8 OD: 0.5
7	12.0	1.71	ID: 2.7 OD: -4.3	2.52	ID: 3.8 OD: 2.0
8	12.0	1.2	ID: 5.4 OD: -3.2	2.01	ID: 4.1 OD: -1.4

CEDM Number	Nozzle Angle	Minimum Axial Distance Achieved Above Uphill Weld Root (inches)	Stress Level Above the Uphill Weld Root at the Axial Distance for Nozzles Without Complete Coverage (ksi)	Minimum Axial Distance Achieved Above Downhill Weld Root for Nozzles with Coverage < 2" above Uphill Weld Root (inches)	Stress Level Above the Downhill Weld Root at the Axial Distance for Nozzles without Complete Coverage (ksi)
10	22.6	1.92	ID: 6.0 OD: -3.0	4.27	ID: 10.1 OD: 3.5
11	22.6	1.90	ID: 5.9 OD: -3.3	4.25	ID: 10.1 OD: 3.6
15	24.1	1.90	ID: 5.9 OD: -3.3	4.25	ID: 10.1 OD: 3.6
18	25.5	1.61	ID: 6.2 OD: -6.7	3.96	ID: 9.9 OD: 3.2
19	25.5	1.50	ID: 6.9 OD: -6.6	3.85	ID: 9.7 OD: 2.7
20	25.5	1.61	ID: 6.2 OD: -6.7	3.96	ID: 9.9 OD: 3.2
21	25.5	1.80	ID: 5.5 OD: -4.5	4.15	ID: 10.0 OD: 3.6
22	25.5	1.55	ID: 6.6 OD: -6.6	3.90	ID: 9.8 OD: 2.9
23	25.5	1.61	ID: 6.2 OD: -6.7	3.96	ID: 9.9 OD: 3.2
26	29.3	1.81	ID: 5.5 OD: -4.4	4.16	ID: 10.0 OD: 3.6
27	29.3	1.75	ID: 5.3 OD: -5.1	4.1	ID: 9.9 OD: 3.7
29	29.3	1.80	ID: 5.5 OD: -4.5	4.15	ID: 10.0 OD: 3.6
32	29.3	1.84	ID: 5.7 OD: -4.0	4.19	ID: 10.0 OD: 3.6

CEDM Number	Nozzle Angle	Minimum Axial Distance Achieved Above Uphill Weld Root (inches)	Stress Level Above the Uphill Weld Root at the Axial Distance for Nozzles Without Complete Coverage (ksi)	Minimum Axial Distance Achieved Above Downhill Weld Root for Nozzles with Coverage < 2" above Uphill Weld Root (inches)	Stress Level Above the Downhill Weld Root at the Axial Distance for Nozzles without Complete Coverage (ksi)
34	34.9	1.66	ID: 5.9 OD: -6.2	4.01	ID: 9.9 OD: 3.4
35	34.9	1.48	ID: 7.0 OD: -6.5	3.83	ID: 9.6 OD: 2.7
36	34.9	1.61	ID: 6.2 OD: -6.7	3.96	ID: 9.9 OD: 3.2
37	34.9	1.79	ID: 5.5 OD: -4.6	4.14	ID: 10.0 OD: 3.6
38	38.5	1.63	ID: 9.9 OD: -7.7	5.47	ID: 15.7 OD: 1.6
39	38.5	1.30	ID: 10.6 OD: -10.4	5.14	ID: 16.2 OD: 2.0
40	38.5	1.30	ID: 10.6 OD: -10.4	5.14	ID: 16.2 OD: 2.0
41	38.5	1.55	ID: 10.1 OD: -8.4	5.39	ID: 15.8 OD: 1.7
42	38.5	1.75	ID: 9.7 OD: -6.7	5.59	ID: 15.5 OD: 1.4
43	38.5	1.77	ID: 9.7 OD: -6.6	5.61	ID: 15.4 OD: 1.4
44	38.5	1.27	ID: 10.7 OD: -10.6	5.11	ID: 16.2 OD: 2.0
45	38.5	1.40	ID: 10.4 OD: -9.6	5.24	ID: 16.0 OD: 1.8
46	41.8	1.56	ID: 10.0 OD: -8.3	5.40	ID: 15.8 OD: 1.6

CEDM Number	Nozzle Angle	Minimum Axial Distance Achieved Above Uphill Weld Root (inches)	Stress Level Above the Uphill Weld Root at the Axial Distance for Nozzles Without Complete Coverage (ksi)	Minimum Axial Distance Achieved Above Downhill Weld Root for Nozzles with Coverage < 2" above Uphill Weld Root (inches)	Stress Level Above the Downhill Weld Root at the Axial Distance for Nozzles without Complete Coverage (ksi)
47	41.8	1.21	ID: 10.1 OD: -11.1	5.05	ID: 16.3 OD: 2.1
48	41.8	1.50	ID: 10.2 OD: -8.8	5.34	ID: 15.9 OD: 1.7
49	41.8	1.44	ID: 10.3 OD: -9.3	5.28	ID: 16.0 OD: 1.8
50	41.8	1.58	ID: 10.0 OD: -8.1	5.42	ID: 15.7 OD: 1.6
51	41.8	1.30	ID: 10.6 OD: -10.4	5.14	ID: 16.2 OD: 2.0
52	41.8	1.60	ID: 10.0 OD: -8.0	5.44	ID: 15.7 OD: 1.6
53	41.8	1.47	ID: 10.3 OD: -9.0	5.31	ID: 15.9 OD: 1.8
54	42.5	1.60	ID: 10.0 OD: -9.0	5.44	ID: 15.7 OD: 1.6
55	42.5	1.67	ID: 9.9 OD: -7.4	5.51	ID: 15.6 OD: 1.5
56	42.5	1.75	ID: 9.7 OD: -6.7	5.59	ID: 15.5 OD: 1.4
57	42.5	1.60	ID: 10.0 OD: -8.0	5.44	ID: 15.7 OD: 1.6
58	42.5	1.55	ID: 10.1 OD: -8.4	5.39	ID: 15.8 OD: 1.7
59	42.5	1.47	ID: 10.3 OD: -9.0	5.31	ID: 15.9 OD: 1.8

CEDM Number	Nozzle Angle	Minimum Axial Distance Achieved Above Uphill Weld Root (inches)	Stress Level Above the Uphill Weld Root at the Axial Distance for Nozzles Without Complete Coverage (ksi)	Minimum Axial Distance Achieved Above Downhill Weld Root for Nozzles with Coverage < 2" above Uphill Weld Root (inches)	Stress Level Above the Downhill Weld Root at the Axial Distance for Nozzles without Complete Coverage (ksi)
60	42.5	1.25	ID: 10.7 OD: -10.8	5.09	ID: 16.3 OD: 2.0
61	42.5	1.60	ID: 10.0 OD: -8.0	5.44	ID: 15.7 OD: 1.6
62	42.5	1.66	ID: 9.9 OD: -7.5	5.50	ID: 15.6 OD: 1.5
63	42.5	1.36	ID: 10.5 OD: -9.9	5.20	ID: 16.1 OD: 1.9
64	42.5	1.35	ID: 10.5 OD: -10.0	5.19	ID: 16.1 OD: 1.9
65	42.5	1.37	ID: 10.5 OD: -9.8	5.21	ID: 16.1 OD: 1.9

Based upon the inspection results provided from the tables above, most nozzles received considerable UT coverage, from the weld portion where the stresses are high to locations away from the weld where stresses decrease considerably. The licensee shows from the tables above, that the area of the nozzles that did not have complete UT coverage have low stresses. The staff has determined that the likelihood of crack initiation and growth in these low stress areas is low.

The safety issues that are addressed by the inspections mandated by the Order are degradation (corrosion) of the low-alloy steel RPV head, and reactor coolant pressure boundary integrity. Based on the above information, the inspection performed by the licensee on the 50 CEDM nozzles, with a minimum coverage of 1.2 inches above the highest point of the root of the J-groove weld (on a horizontal plane perpendicular to the nozzle axis), provides reasonable assurance of the structural integrity of the RPV head, CEDM penetrantion nozzles, and welds.

2.5 Conclusion

The NRC staff concludes that the licensee's proposed alternative examination of the 50 CEDM nozzles, with a minimum coverage of 1.2 inches above the highest point of the root of the

J-groove weld (on a horizontal plane perpendicular to the nozzle axis) provides reasonable assurance of the structural integrity of the RPV head, VHP nozzles, and welds. Further inspections of these CEDM nozzles in accordance with Section IV, paragraph C.(5)(b), or the First Revised NRC Order EA-03-009, dated February 20, 2004, would result in hardship without a compensating increase in the level of quality and safety. Therefore, pursuant to Section IV, paragraph F, of the Order, for good cause shown, the staff authorizes the proposed alternative inspection for the 50 CEDMs at CCNPP 2, subject to the following condition:

> If the NRC staff finds that the crack-growth formula in industry report MRP-55 is unacceptable, the licensee shall revise its analysis that justifies relaxation of the First Revised Order within 30 days after the NRC informs the licensee of an NRC-approved crack growth formula. If the licensee's revised analysis shows that the crack growth acceptance criteria are exceeded prior to the end of the current operating cycle, this relaxation is rescinded and the licensee shall, within 72 hours, submit to the NRC written justification for continued operation. If the revised analysis shows that the crack growth acceptance criteria are exceeded during the subsequent operating cycle, the licensee shall, within 30 days, submit the revised analysis for NRC review. If the revised analysis shows that the crack growth acceptance criteria are not exceeded during either the current operating cycle or the subsequent operating cycle, the licensee shall, within 30 days, submit a letter to the NRC confirming that its analysis has been revised. Any future crack-growth analyses performed for this and future cycles for RPV head penetrations must be based on an acceptable crack growth rate formula.

3.0 FIRST REVISED NRC ORDER EA-03-009 RELAXATION REQUEST FOR EXAMINATION COVERAGE FOR REACTOR PRESSURE VESSEL HEAD PENETRATION NOZZLES BELOW THE J-GROOVE WELD

3.1 First Revised NRC Order Requirements for Which Relaxation is Requested

The licensee has requested relaxation from Section IV, paragraph C.(5)(b)(i) of the First Revised NRC Order. The specific relaxation is identified below.

3.2 Licensee's Proposed Alternative

The licensee seeks relaxation from Section IV.C.(5)(b)(i) of the Order for UT each RPV head penetration nozzle (i.e., nozzle base material) to the bottom of the nozzle, specifically, missed examination coverage near the bottom of the CEDM nozzles due to instrument limitation.

The licensee proposes to meet the Order requirements, or to examine each CEDM nozzle below the J-groove weld to the maximum extent possible. The licensee stated the minimum UT examination coverage expected will be approximately 0.35 inch below the toe of the J-groove weld on the downhill side.

3.3 Reason for Relaxation Request

The licensee stated that compliance with the requirements specified in the Order would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

3.4 Licensee's Basis for Proposed Alternative

The licensee's relaxation request applies to all CCNPP 2 CEDM penetrations 1 through 65, except for nozzles 3, 14, 18, 26, 38, and 46, each of which were successfully scanned for the full length below the nozzle with an axial probe. The licensee stated that during the current UT examination of the Calvert Cliffs Unit 2 RPV head, difficulties were being encountered maintaining contact with the nozzle wall when using the Axial Blade Probe. The difficulties were encountered due to nozzle wall distortion particularly at the downhill side of the nozzle. The licensee stated that this condition worsens for those nozzles toward the periphery and is compounded by the position of the thermal sleeve that is anchored by the centering tabs located above the J-groove weld. Probe contact is dependent on maintaining a nominal gap dimension between the thermal sleeve and the nozzle ID as the probe is stroked axially and circumferentially around the nozzle. The design of the Circumferential Blade Probe is more robust and compliant than the Axial Blade Probe. The licensee stated that the Circumferential Blade Probe has a smaller footprint in the circumferential direction and has more spring force to keep the probe in contact with the nozzle. These features enable the Circumferential Blade Probe to provide better contact with the nozzle wall where nozzle distortion and thermal sleeve eccentricity exist.

The Circumferential Blade Probe has separate transducers for sending and receiving the ultrasonic signal. The transducers are arranged one above the other nominally 0.86 inch apart. With this configuration, the lower transducer will not contact the inside wall on the nozzle until the upper transducer is inserted greater than approximately 0.86 inch into the nozzle. Since the scanning process requires that both transducers be in contact with the surface, the probe cannot scan the outer portion of the bottom of the nozzle. Based on the geometry involved in the transducer location and nozzle configuration, the portion that cannot be scanned is the portion extending from the bottom of the nozzle upward for a distance of approximately 0.56 inch.

3.5 Evaluation

The NRC staff's review of this request was based on criterion (2) of paragraph F of Section IV of the Order which states:

> [C]ompliance with this Order for specific nozzles would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Regarding the required examination of the RPV head penetration nozzles, the licensee has demonstrated that hardship or unusual difficulty would result from implementing examinations to the bottom end of these nozzles, without a compensating increase in the level of quality and safety. The hardship identified by the licensee is due to nozzle wall distortion particularly at the downhill side of the nozzles. Due to the wall distortion, difficulties were encountered maintaining contact with the nozzle wall using the Axial Blade Probe. The licensee decided to change to a Circumferential Blade Probe. The licensee stated that the Circumferential Blade Probe is more robust and compliant than the Axial Blade Probe. The Circumferential Blade

Probe has a smaller footprint in the circumferential direction and has more spring force to keep the probe in contact with the nozzle. This probe has two separate transducers for sending and receiving the ultrasonic signal and are arranged one above the other approximately 0.86 inch apart. Due to the configuration, the lower transducer will not contact the inside wall on the nozzle until the upper transducer is inserted greater than approximately 0.86 inch into the nozzle. Since the scanning process requires that both transducers be in contact with the surface, the probe cannot scan the outer portion of the bottom of the nozzle. The licensee stated that based on the geometry involved in the transducer location and nozzle configuration, the portion that cannot be scanned is the portion extending from the bottom of the nozzle upward for a distance of approximately 0.56 inch.

In a letter dated March 4, 2005, the licensee stated that examination of the bottom of the nozzle could be accomplished by surface examination. However, the licensee stated that this alternative would have prohibitive worker dose implications without a commensurate increase in quality or safety. Removal of the thermal guide sleeves to provide access for a rotating probe has similar dose implications that present hardship with no increase in safety or quality. The licensee also stated that the uninterrogated area involves a portion of the nozzle at the very bottom below the J-groove weld. At this area of the nozzle, the nozzle is essentially open-ended and the nozzle wall in this portion is not part of the reactor coolant system pressure boundary.

The phenomenon of concern is PWSCC, which typically initiates in the areas of highest stress. The area of RPV head penetration nozzles that has the highest residual stress is the area adjacent to the J-groove attachment weld. Therefore, it is most likely that PWSCC will initiate in an area adjacent to the J-groove attachment weld.

The licensee’s proposed minimum inspection distance of the nozzle base material below the J-groove weld is supported by the licensee’s analysis which demonstrated that no flaw below that portion of the nozzle would propagate to a level adjacent to the J-groove weld within the next operating period (2 years). The licensee stated in a supplemental letter dated March 8, 2005, that a crack growth evaluation was performed using the methods of MRP-55 for crack growth caused by PWSCC at a head temperature of 594 EF. The licensee postulated through wall axial flaws extending from the bottom of the nozzle towards the weld to determine the maximum length of the flaws that would not grow to the bottom of the weld in a single 2-year inspection interval. The analysis was performed for four penetration angles. The results are tabulated below:

Location	Downhill Side (A)	Uphill Side (B)
0E Nozzle	0.324"	0.324"
11E Nozzle	0.179"	0.386"
29E Nozzle	0.191"	0.361"
43E Nozzle	0.200"	0.360"

The licensee has performed UT inspection on each CEDM nozzle to the maximum achievable axial distance below the toe of the J-groove weld. The minimum inspection distance below the toe of the J-groove weld on any CEDM nozzle was 0.35 inch on CEDM 31 on the downhill side. CEDM 31 is a 29 degree nozzle, which according to the results of the licensee's flaw tolerance evaluation must be inspected a minimum of 0.191 inch at this location. As shown in the table for the extent of UT coverage in reactor vessel head penetration nozzle material in Section 2.4, the minimum inspection distances achieved on every nozzle exceeded the minimum required distances based on the licensee's flaw tolerance evaluation.

The licensee also provided a finite element analysis specific to Calvert Cliffs to determine the operating stresses in the CEDM nozzles. Results were used to define the loading and were previously submitted and reviewed in supplemental data packages dated April 9, 2003, January 30, 2004, April 13, 2004, and April 27, 2004 (ADAMS Accession Nos. ML031040010, ML040370331, ML041130293, and ML041240028, respectively). The finite element analysis was performed for the 42 ksi yield strength material used to fabricate the CEDM penetrations in Calvert Cliffs Unit 1. The yield strength for the material used to fabricate the CEDM penetrations in Calvert Cliffs Unit 2 is 37.5 ksi. As a result, the finite element method (FEM) analysis is bounding for Calvert Cliffs Unit 2. Based upon the information, the NRC staff finds the licensee's FEM analysis to be acceptable.

The NRC staff notes that the referenced flaw tolerance evaluations discussed above were done for Calvert Cliffs Unit 1 RPV head. Since the design for Unit 2 RPV is identical, the use of the subject evaluation for Unit 2 is acceptable.

3.6 Conclusion

Based upon the information provided by the licensee, the NRC staff finds the licensee's proposed inspection of the CEDM nozzles below the J-groove weld to be acceptable, since the licensee's UT inspection exceeded the minimum required distances below the toe of the J-groove weld based on the licensee's flaw tolerance evaluation.

The licensee's crack growth calculations were performed in accordance with the crack growth formula in EPRI MRP Report, MRP-55, "Material Reliability Program (MRP Crack Growth Rates for Evaluation Primary Water Stress Corrosion Cracking (PWSCC) of Thick Wall Alloy 600 Material (MRP-55), Revision 1." The NRC staff has made a preliminary assessment of the crack growth formula, but has not yet made a final determination on the acceptability of the subject industry report. Should the NRC staff determine the crack growth formula used by the licensee to be unacceptable, the licensee will be required to revise its analysis to incorporate an acceptable crack growth formula as described below.

> If the NRC staff finds that the crack-growth formula in industry report MRP-55 is unacceptable, CCNPP [the licensee] shall revise its analysis that justifies relaxation of the First Revised Order dated February 20, 2004, within 30 days after the NRC informs the licensee of an NRC-approved crack growth formula. If our [the licensee's] revised analysis shows that the crack growth acceptance criteria are exceeded prior to the end of the current operating cycle, this relaxation can be rescinded and CCNPP shall, within 72 hours, submit to the NRC written justification for continued operation. If the revised analysis shows that the crack growth acceptance criteria are exceeded during the

> subsequent operating cycle, CCNPP shall, within 30 days, submit the revised analysis for NRC review. If the revised analysis shows that the crack growth acceptance criteria are not exceeded during either the current operating cycle or the subsequent operating cycle, the licensee shall, within 30 days submit a letter to the NRC confirming that its analysis has been revised. Any future crack growth analyses performed for this and future cycles for reactor pressure vessel head penetrations must be based on an acceptable crack growth rate formula.

The licensee concurred with the above statement in a letter dated March 8, 2005.

4.0 CONCLUSION

The NRC staff concludes that the licensee's proposed alternative UT examination for 50 control element drive mechanism (CEDM) penetration nozzles to a minimum of 1.2 inches above the highest point of the root of the J-groove weld and for 59 CEDM penetration nozzles below the J-groove weld to the maximum extent possible, provides reasonable assurance of the structural integrity of the RPV head, RPV penetration nozzles, and welds.

Further inspections of these RPV penetration nozzles in accordance with Section IV, paragraph C.(5)(b)(i), of the First Revised NRC Order EA-03-009 dated February 20, 2004, would result in hardship without a compensating increase in the level of quality and safety. Therefore, pursuant to Section IV, paragraph F, of the First Revised NRC Order EA-03-009 dated February 20, 2004, for good cause shown, the staff authorizes the proposed alternative inspections for the 50 RPV CEDM penetration nozzles above the highest point of the root of the J-groove weld and the 59 RPV penetration nozzles below the J-groove weld at CCNPP 2, subject to the following condition:

> If the NRC staff finds that the crack-growth formula in industry report MRP-55 is unacceptable, CCNPP [the licensee] shall revise its analysis that justifies relaxation of the First Revised Order dated February 20, 2004, within 30 days after the NRC informs the licensee of an NRC-approved crack growth formula. If our [the licensee's] revised analysis shows that the crack growth acceptance criteria are exceeded prior to the end of the current operating cycle, this relaxation can be rescinded and CCNPP shall, within 72 hours, submit to the NRC written justification for continued operation. If the revised analysis shows that the crack growth acceptance criteria are exceeded during the subsequent operating cycle, CCNPP shall, within 30 days, submit the revised analysis for NRC review. If the revised analysis shows that the crack growth acceptance criteria are not exceeded during either the current operating cycle or the subsequent operating cycle, the licensee shall, within 30 days submit a letter to the NRC confirming that its analysis has been revised. Any future crack growth analyses performed for this and future cycles for reactor pressure vessel head penetrations must be based on an acceptable crack growth rate formula.

Principal Contributors: E. Reichart
W. Koo

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