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March 13, 2003

U. S. Nuclear Regulatory Commission
Washington, DC 20555

ATTENTION: Document Control Desk

SUBJECT: Calvert Cliffs Nuclear Power Plant
Unit Nos. 1 & 2; Docket Nos. 50-317 & 50-318
Response to Request for Additional Information Regarding Interim Inspection Requirements for Reactor Pressure Vessel Head (TAC NOS. MB7752 and MB7753)

REFERENCES:

(a) Letter from Mr. P. E. Katz (CCNPP) to Document Control Desk (NRC), dated February 18, 2003, Response to Issuance of Order Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors

(b) Letter from Mr. S. J. Collins (NRC) to Holders of Licenses for Operating Pressurized Water Reactors, dated February 11, 2003, Issuance of Order Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors (EA-03-009)

(c) Letter from Mr. P. S. Tam (NRC) to Mr. P. E. Katz (CCNPP), dated February 28, 2003, Calvert Cliffs Nuclear Power Plant, Unit Nos. 1 and 2 – Request for Additional Information Regarding Interim Inspection Requirements for Reactor Pressure Vessel Head (TAC Nos. MB7752 and MB7753)

By letter dated February 18, 2003 (Reference a), Calvert Cliffs Nuclear Power Plant, Inc. submitted a request for relaxation from the inspection requirements of Section IV.C(1)(b)(1) of Reference (b). This letter provides Calvert Cliffs Nuclear Power Plant's response to the February 28, 2003, letter (Reference c) request from the Nuclear Regulatory Commission for additional information regarding that relaxation request. The requested information and our responses are contained in Attachment (1) to this letter.

A101

Should you have questions regarding this matter, we will be pleased to discuss them with you.

Very truly yours,

Peter E. Katz

STATE OF MARYLAND :
: **TO WIT:**
COUNTY OF CALVERT :

I, Peter E. Katz, being duly sworn, state that I am Vice President - Calvert Cliffs Nuclear Power Plant, Inc. (CCNPP), and that I am duly authorized to execute and file this response on behalf of CCNPP. To the best of my knowledge and belief, the statements contained in this document are true and correct. To the extent that these statements are not based on my personal knowledge, they are based upon information provided by other CCNPP employees and/or consultants. Such information has been reviewed in accordance with company practice and I believe it to be reliable.

Peter E. Katz

Subscribed and sworn before me, a Notary Public in and for the State of Maryland and County of Calvert, this 13th day of March, 2003.

WITNESS my Hand and Notarial Seal:

Denise D. Sanders
Notary Public

My Commission Expires:

2/1/06
Date

PEK/JKK/bjd

Attachment: (1) Response to NRC Request for Additional Information

cc: J. Petro, Esquire
J. E. Silberg, Esquire
Director, Project Directorate I-1, NRC
G. S. Vissing, NRC
H. J. Miller, NRC
Resident Inspector, NRC
R. I. McLean, DNR

ATTACHMENT (1)

RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION

Calvert Cliffs Nuclear Power Plant, Inc.
March 13, 2003

ATTACHMENT (1)

RESPONSE TO NRC REQUEST FOR ADDITIONAL INFORMATION

NRC Request:

What is the justification that coverage up to 0.75 inches above the weld will provide an adequate level of quality and safety? In other words, provide justification that increasing the scope of inspection to 2 inches above the J-groove will not provide an increase in quality and safety. Are there residual stress data that indicates that 0.75 inches is a sufficient level above the weld, or is there any other basis that demonstrates an acceptable level of quality and safety for the restricted inspections?

CCNPP Response:

Calvert Cliffs requested relaxation of the requirement of Section IV.C(1)(b)(i) of Reference 1, to perform Ultrasonic Testing (UT) of each reactor pressure vessel (RPV) head penetration nozzle (i.e., nozzle base material) from 2 inches above the J-groove weld, to the bottom of the nozzle. Calvert Cliffs proposes, as an alternative, a minimum of 0.75 inches above the J-groove weld. This relaxation request would typically be applied to a limited portion of most of the nozzles, for a minimal azimuthal extent around the nozzle. Coverage for the full 2 inches above the J-groove weld is anticipated for most of the azimuthal extent of most penetrations. Additional coverage can only be achieved by removal of thermal sleeves. The geometry of the nozzle and thermal sleeve creates a gap that will accept a blade UT probe for a certain distance above the bottom of the nozzle. The hillside J-groove weld configuration does not place the weld a full 2 inches above this point for the full 360 degrees around the nozzle. The limitations are predominantly on the uphill sides of the nozzles.

Increasing the minimum required inspection coverage from 0.75 inches above the J-groove weld to 2 inches above the J-groove weld would not provide additional safety or quality. The ultrasonic examination provides assurance that the Alloy 600 nozzle base material does not have axial or circumferential cracks. Cracking, if present, would be attributable to primary water stress corrosion cracking (PWSCC), which has been observed in a number of other pressurized water reactor RPV heads in the U.S. as well as several pressurized water reactors in other countries.

Primary water stress corrosion cracking in RPV heads is caused by susceptible materials under high residual stresses usually caused by mechanical working and/or shrinkage stresses associated with welding. A diagram of the Calvert Cliffs RPV head configuration is presented in Figure 1. A Finite Element Analysis was used to calculate the distribution of residual stresses in the Calvert Cliffs RPV head nozzles (Reference 2). Representative results are provided in Figures 2 through 7, with the proposed 0.75-inch minimum coverage superimposed. The residual hoop stress declines along a steep gradient above the weld. Within the first 0.75 inches above the weld, the maximum residual (plus operating) hoop stress decreases to below approximately 40 ksi in all cases. Therefore, the residual plus operating stress existing 0.75 inches above the J-groove weld is less than, or equal to, the minimum stress that would make crack initiation possible. Both crack growth rate and time-to-initiation have been shown to be strongly dependent on applied stress, with damage rate proportional to σ^{-m}, where m ranges between 4 and 5.5 (References 3 and 4). This correlation indicates that a 50% reduction in stress will result in a 16-fold reduction in damage rate (or a 16-fold increase in PWSCC initiation time.) Both a threshold stress, or stress-based, time-to initiation model indicate a very low likelihood of the initiation of cracks above 0.75 inches above the top of the uphill side of the nozzle penetration.

Considering the reduced level of stress 0.75 inches above the J-groove weld, it is very unlikely that PWSCC would initiate in the region for which the relaxation is being requested. It is extremely likely that if PWSCC does initiate in the RPV head material, it will initiate in the area that we will be able to inspect. We intend to inspect the region of the penetrations where cracking has the highest driving force for initiation. The additional 1.25 inches of coverage (up to 2 inches above the J-groove weld) would be in a region where crack initiation is not expected. The inspection contractor has evaluated approximately 260 cracks in RPV heads at other nuclear power plants; all of the cracks had a bottom end lower than

0.75 inches above the top of the high hillside portion of the J-groove weld (Figure 8). Analytical residual stress analysis and field experience both indicate that all PWSCC cracks, in RPV heads, have a bottom end at or below the elevation of the top of the high hillside portion of the J-groove weld. We expect to achieve examination coverage at least 0.75 inches above this location. Inspection to higher elevations provides no additional safety or quality.

It is possible that cracking could initiate in the highly stressed area adjacent to the J-groove weld, and that the cracks could subsequently propagate upward into the lower stressed region above the J-groove weld. In this case, the UT, in accordance with this relaxation request, would still identify the lower end of the crack. If the lower end of a crack is detected during the UT examination, our inspection plans include provisions to fully characterize the extent of the indication.

REFERENCES:

1. Letter from Mr. S. J. Collins (NRC) to Holders of Licenses for Operating Pressurized Water Reactors, dated February 11, 2003, Issuance of Order Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors (EA-03-009)
2. Fleming, M. R. and J. E. Broussard, "Calvert Cliffs Units 1 and 2 CEDM and ICI Stress Analysis," Dominion Engineering, Inc. (DEI) Calculation C-3655-00-01, Revision 0, December 21, 2001
3. P. Scott, "Prediction of Alloy 600 Component Failures in RWP System," Research Topical Symposia Part 1 – Life Prediction of Structures Subject to Environmental Degradation, NACE, Houston, pp 135-160 (1997)
4. R. Bandy and D. van Rooyen, "Quantitative Examination of Stress Corrosion Cracking of Alloy 600 in High Temperature Water," Nuclear Engineering and Design, Vol. 86, No. 1 pp. 49-56 (Apr 1982)

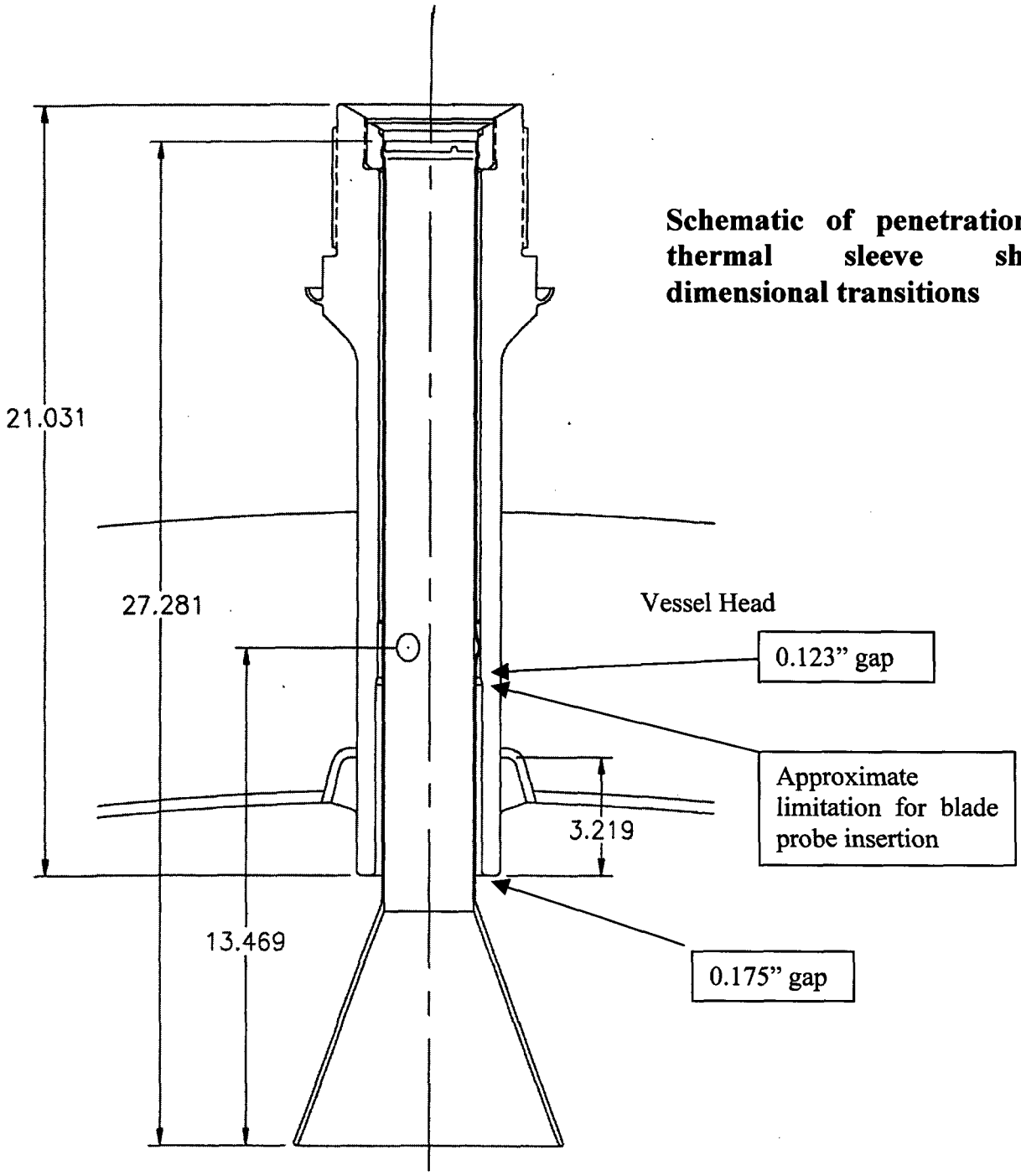

Figure 1: Schematic of a nozzle with thermal sleeve installed. For peripheral nozzles the weld beads are oblique to the axis of the nozzle. The ID of the nozzle changes along the length of the nozzle. For peripheral nozzles the higher side J-groove weld is located closer to the ID step change, limiting the maximum possible length for blade probe insertion.

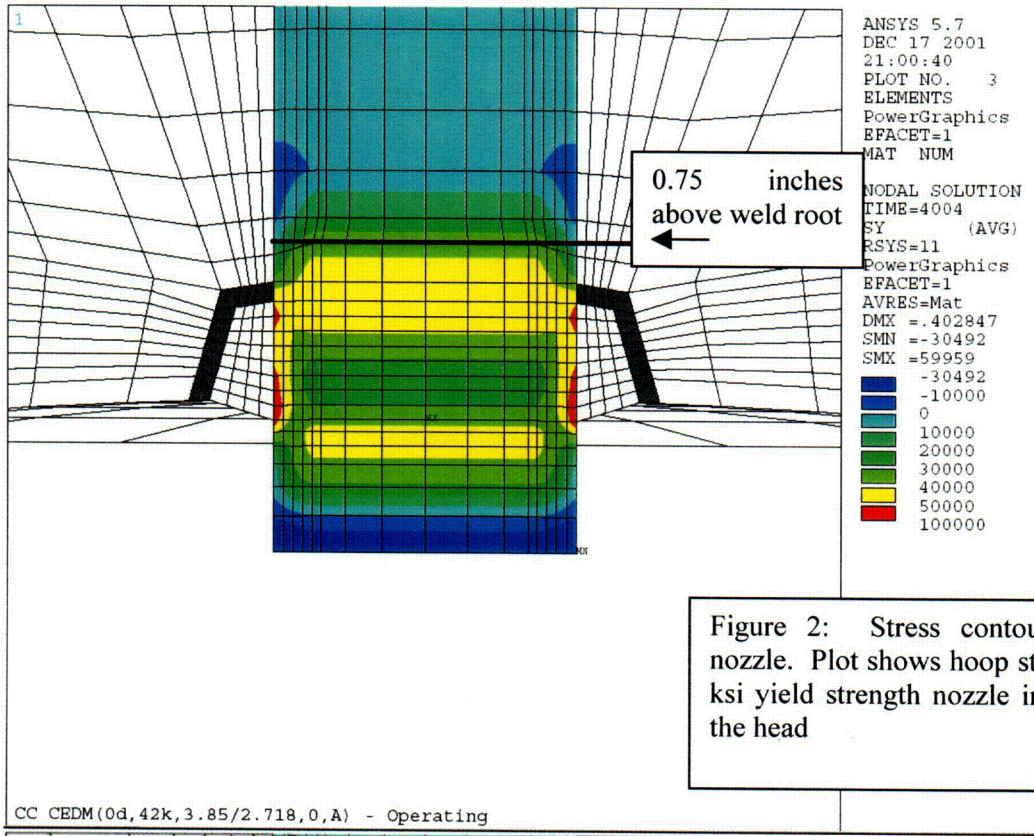

Figure 2: Stress contour for CEDM nozzle. Plot shows hoop stresses for a 42 ksi yield strength nozzle in the center of the head

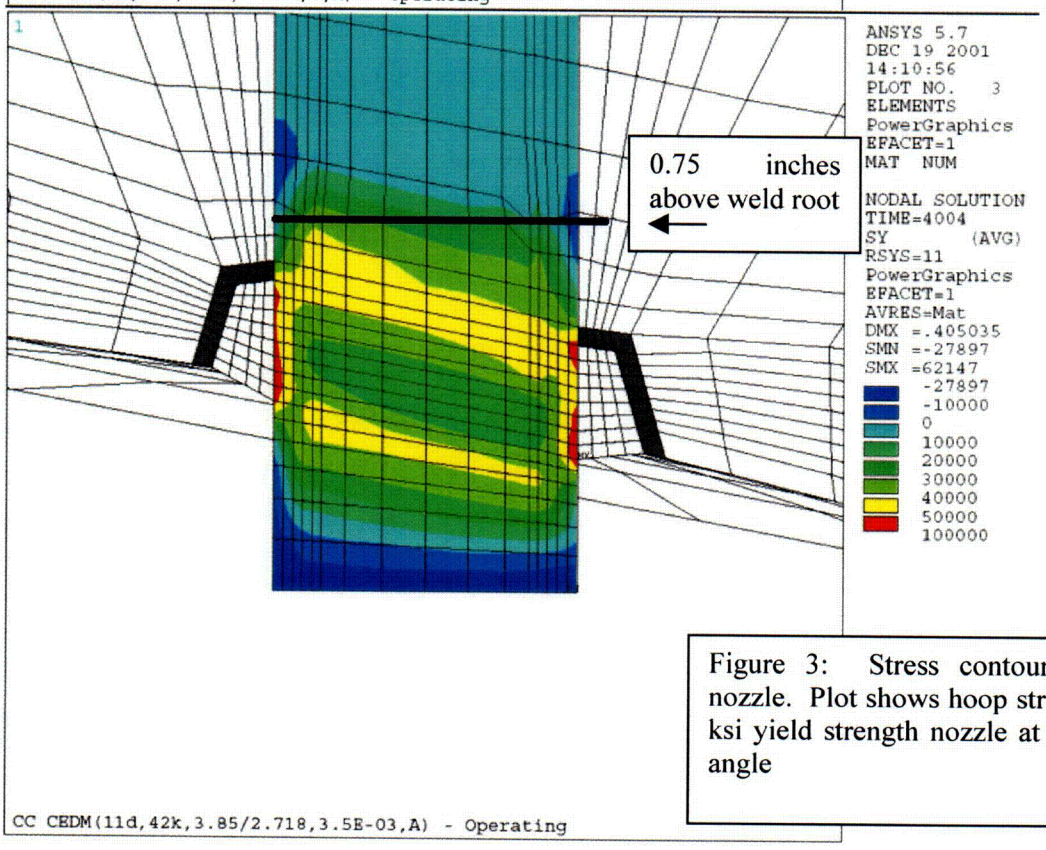

Figure 3: Stress contour for CEDM nozzle. Plot shows hoop stresses for a 42 ksi yield strength nozzle at an 11 degree angle

C01

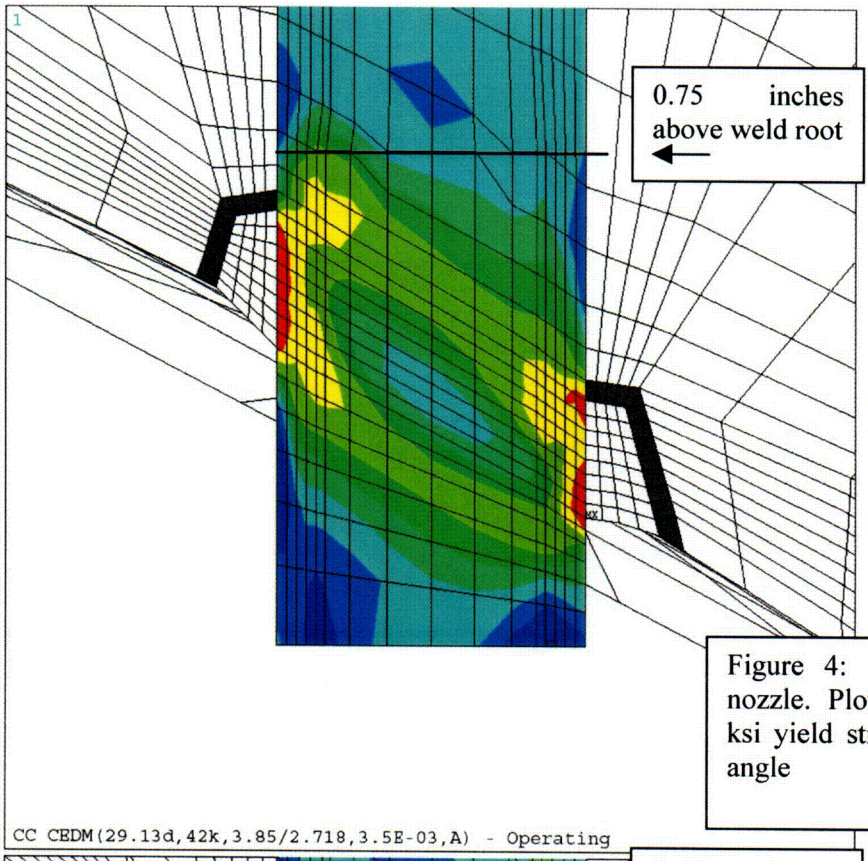

Figure 4: Stress contour for CEDM nozzle. Plot shows hoop stresses for a 42 ksi yield strength nozzle at a 29 degree angle

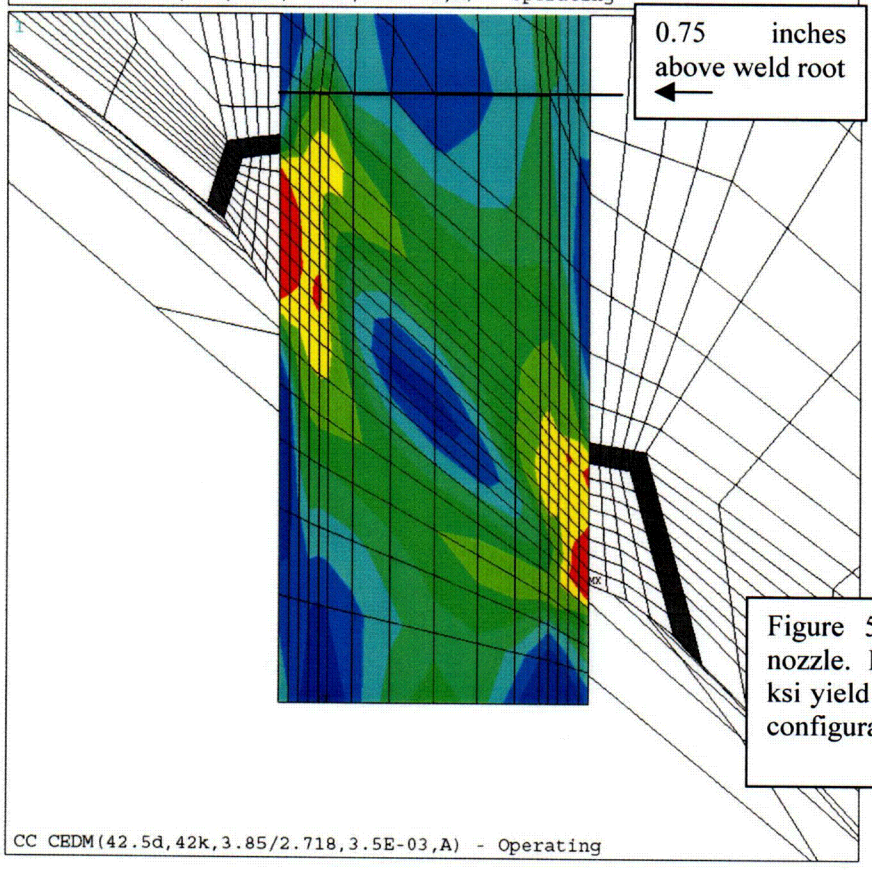

Figure 5: Stress contour for CEDM nozzle. Plot shows hoop stresses for a 42 ksi yield strength nozzle in the peripheral configuration (42.5 degrees)

C02

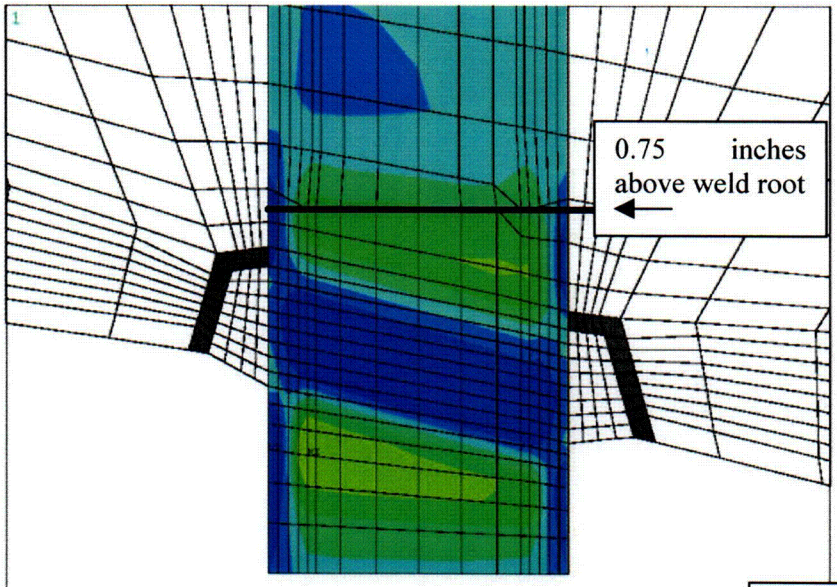

Figure 6: Stress contour for CEDM nozzle. Plot show axial stresses for a 42 ksi yield strength nozzle at an 11 degree angle

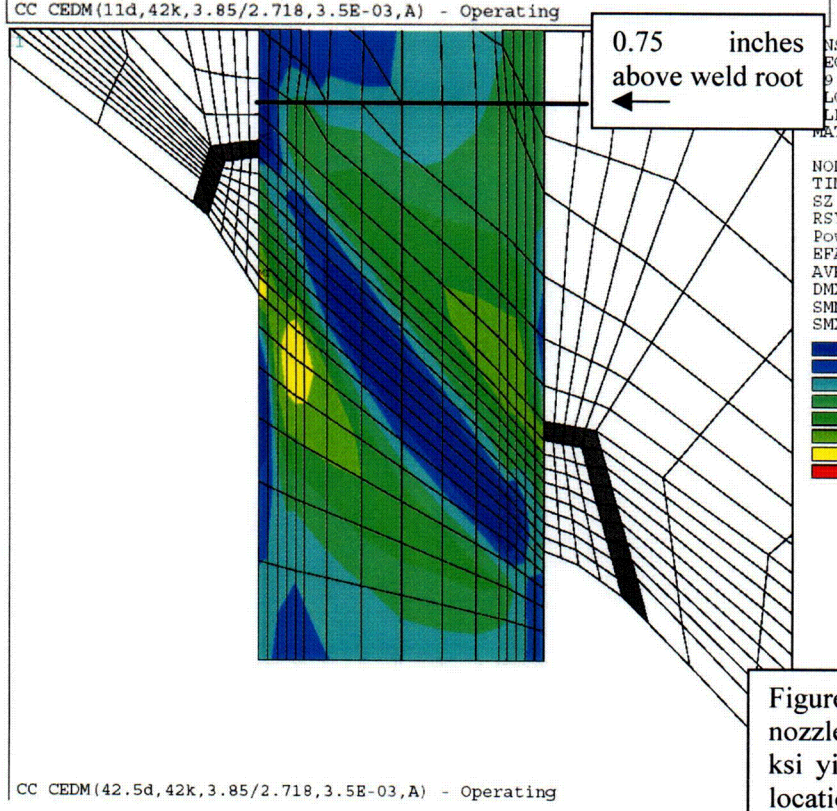

Figure 7: Stress contour for CEDM nozzle. Plot shows axial stresses for a 42 ksi yield strength nozzle at a peripheral location (42.5 degrees)

C03

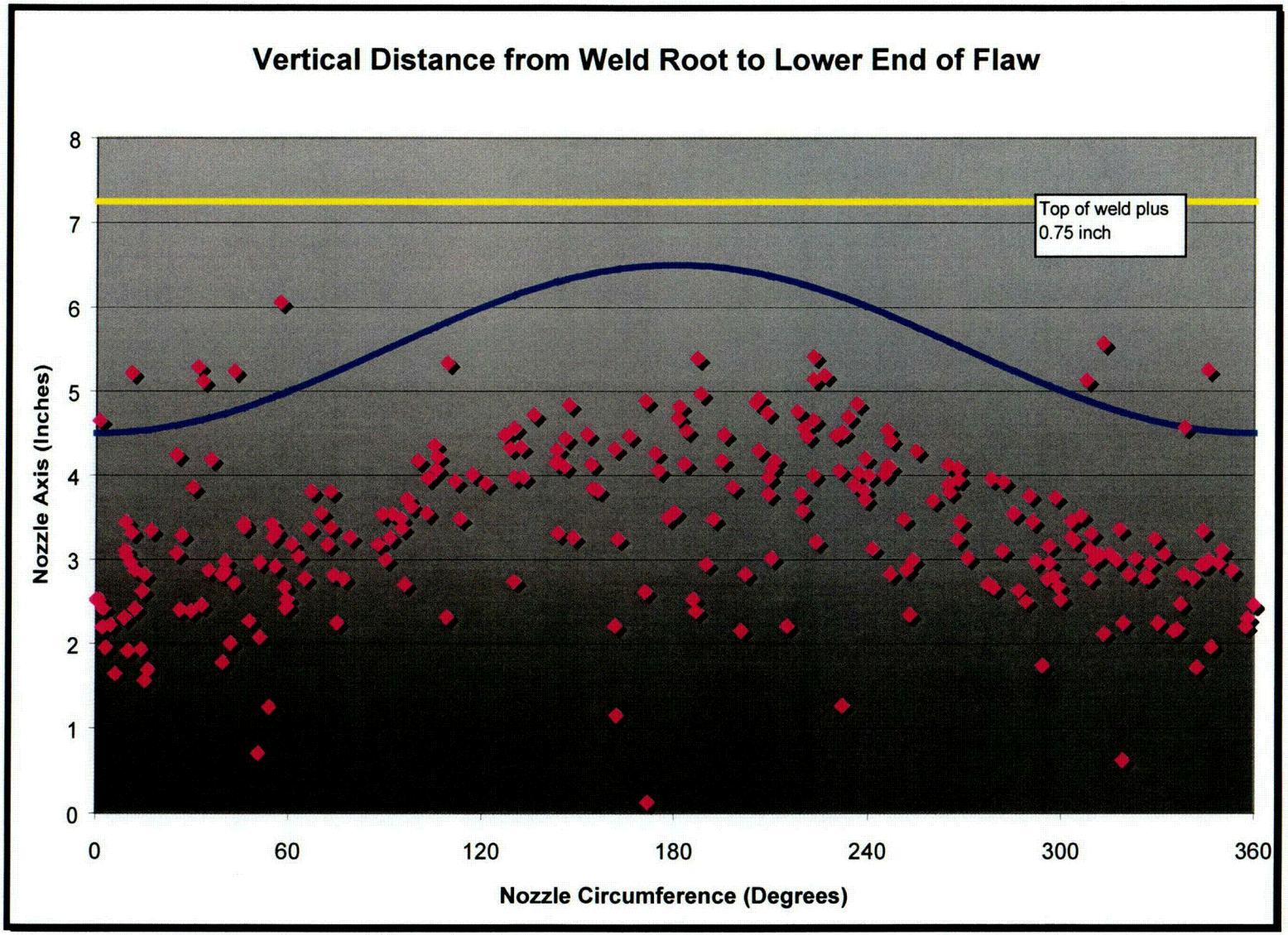

Figure 8: Illustration of the elevation of the lower end of every CEDM crack indication ever identified by inspection contractor.

C04