From: "RLS4@NRC.GOV" <rls4@nrc.gov>
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Date: Mon, Jun 18, 2007 11:47 AM
Subject: CR and attached Input from Exponent on FENOC DFI

CC: "RLS4@NRC.GOV" <rls4@nrc.gov>

F-255

CONDITION REPORT

CR Number 07-22072

TITLE: ADDITIONAL DOCUMENT FROM EXPONENT PRESENTING THEIR PERSPECTIVES AND POSITIONS

ORIGINATION

DISCOVERY DATE	TIME	EVENT DATE	TIME	SYSTEM / ASSET#
6/14/2007	N/A	6/14/2007	N/A	

EQUIPMENT DESCRIPTION N/A

FLOC System **FLOC**

DESCRIPTION OF CONDITION and PROBABLE CAUSE (if known) Summarize any attachments. Identify what, when, where, why, how.

This condition report is being written to capture and review a 10 page document received from Exponent. This document was not transmitted in a formal manner (i.e. No author signature or unique transmittal cover letter). It appears that the document can be identified by a unique number at the bottom of each page, "CH11729.000 A0T0 0607 DB10". Recommend this condition report be closed and the review of this document be included in CR 07-21815 G201.

IMMEDIATE ACTIONS TAKEN / SUPV COMMENTS (Discuss CORRECTIVE ACTIONS completed, basis for closure.)

Wrote CR to ensure all information is captured. Contacted the person assigned to review CR 07-21815 and discussed including this additional document in the review. The context of this document offers opinons and perspectives from previous documents and discussions pertaining to the old DB reactor vessel head.

QUALITY ORGANIZATION USE ONLY
- Quality Org. Initiated ☐ Yes
- Quality Org. Follow-up ☐ Yes ☐ No

IDENTIFIED BY (Check one)
- ☐ Individual/Work Group
- ☑ Supervision/Management
- ☐ Self-Revealed
- ☐ Internal Oversight
- ☐ External Oversight

ATTACHMENTS ☑ Yes ☐ No

ORIGINATOR	ORGANIZATION	DATE	SUPERVISOR	DATE	PHONE EXT.
STEVENS, M	FMER	6/14/2007	WILCOX, JH	6/15/2007	4610

PLANT OPERATIONS

SRO REVIEW	EQUIPMENT OPERABLE	OPERABILITY ASSESSMENT REQUIRED	ORG. NOTIFIED	IMMEDIATE INVESTIGATION REQUIRED	ORG. NOTIFIED	MODE CHANGE RESTRAINT
☑ Yes ☐ No	☐ Yes ☐ No ☑ N/	☐ Yes ☑ No		☐ Yes ☑ No		☐ Yes ☑ No

MODE	ASSOCIATED TECH SPEC NUMBER(S)	ASSOCIATED LCO ACTION STATEMENT(S)
N/A	N/A	#1 N/A
		#2
		#3

DECLARED INOPERABLE (Date / Time)	REPORTABLE?		APPLICABLE UNIT(S)
N/A	☐ Yes ☑ No ☐ Eval Required	One Hour N/A Four Hour N/A Eight Hour N/A Other N/A	☑ U1 ☐ U2 ☐ Both

COMMENTS

CR was written to ensure additional documentation provided to FENOC is evaluated with a CR (07-21815) previously written. Discussion was held with Originator, information provided is the position of a FENOC contractor and operability of installed equipment is not in question. If the review of contractor paperwork reveals a condition could affect installed plant equipment operability another CR should be written. Therefore, Equipment Operable is marked N/A. This condition is not reportable, Reportable is marked No.

Current Mode - Unit 1	Power Level - Unit 1	Current Mode - Unit 2	Power Level - Unit 2
1	100	N/A	N/A

SRO - UNIT 1	SRO - UNIT 2	DATE
Kremer, B	Myers, LD	6/15/2007

EXPONENT PERSPECTIVES AND POSITIONS ON THE DRAFT RESPONSE TO THE NRC 5/14/07 DFI LETTER

The purpose of this summary is to present Exponent's perspective and positions on the current draft of the FENOC response to Demand B of the 5/14/07 NRC DFI letter. Exponent has a number of concerns about the tone and content of the draft response which are set forth below and in the subsequent sections of this summary.

Exponent's Failure Analysis of the Davis-Besse Event

Prior to the recent three days of meetings, Exponent was concerned at the apparent perception of the Exponent Report by the FENOC technical personnel. The Exponent Report does not just present the results of either hypothetical or theoretical mathematical modeling studies. Neither is it a report prepared ***just*** for litigation. At the same time, because it ***was*** prepared for litigation, it is not a full account of the work Exponent performed. While Exponent believes the FENOC technical personnel who participated in the recent meetings have a better perspective on the scope of the effort that went into the failure analysis, the current draft response to Demand B of the DFI still mischaracterizes the Exponent Report.

At Morgan Lewis's and FENOC's request, Exponent undertook a comprehensive failure analysis of the Davis-Besse event, taking into account not just the operational data that the FENOC Root Cause Report considered, but all of the data generated since 2002 that is described fully in the Exponent Report and briefly below. The Exponent failure analysis of the Davis-Besse event is typical of the failure analysis work Exponent has been involved in for over 40 years, which has always been focused on finding the underlying reason and causes for real failures in real components and equipment in the real world.

There is nothing academic, theoretical or hypothetical about failure analysis, and Exponent approached its failure analysis of the Davis-Besse event in the same way it has approached all failure analyses. This involves collecting all of the available data, subjecting it to rigorous scientific and engineering analysis using state-of –the-art analytical tools, and testing the results of that analysis against all of the available operational data surrounding the failure in question, as well as against similar failures and industry experience with similar components.

Exponent assembled a failure analysis team from the scientific and engineering disciplines best suited for the technical issues involved such as thermal analysis, fluid flow, stress analysis and crack growth, computational fluid dynamics, corrosion science, metallurgy, and nuclear power plant operations. The Exponent team has devoted over 6000 hours to this failure analysis, and it stands as the most comprehensive failure analysis of the Davis-Besse event conducted to date, since it takes into account and is based on the most complete collection of data available at this point in time.

Exponent is particularly concerned about the Conger and Elsea characterization of the Exponent Report in the current draft of the DFI response. Conger and Elsea state that a "root cause evaluation is meant to be broad in scope and fully address the organizational and contextual issues to discover why events occurred". In contrast, Conger and Elsea categorize the Exponent Report as "other technical analyses" which represent "reports of the opinions of technical experts in litigation [which] are much narrower in scope and typically address when and how events may occur".

With respect to the Root Cause Report, Exponent notes that a four page preliminary "Probable Cause Summary Report" was prepared and published internally by the root cause team on 3/22/02, just a couple of weeks after the "unexpected tool movement" on 3/5/02 that provided the first indication of the cavity at CRDM Nozzle 3. The 3/22/02 report by the root cause team contained a "key events timeline" for crack growth, leakage, and wastage growth that was essentially unchanged in the final Root Cause Report. The Root Cause Report timeline was "locked in" by 3/22/02 and did not change thereafter.

Conger and Elsea did not meet with any member of the Exponent team to discuss the Exponent failure analysis effort, and they have no concept of the depth and breadth of the data and information that the Exponent failure analysis team considered or used in its analyses and evaluations, nor of the evaluations and analyses themselves. For example, Sections 5 and 6 of the Exponent Report present the most complete account of the industry history and context on the key issues of Alloy 600 CRDM cracking and boric acid corrosion of steel components that has been assembled in a single report.

In the following sections, Exponent presents its perspective and positions on the following key issues as they are discussed in the current draft response to DFI Demand B:

- Likely NRC perspective and reaction to the current draft response to DFI Demand B
- Leak rate vs crack length
- Metallurgical examination of the nozzle, weld and wastage cavity
- Stress analysis
- Crack growth rate
- Computational fluid dynamics (CFD) analysis and RPV head corrosion due to wetted molten metaboric acid
- Exponent's consideration of plant operational data

Likely NRC Perspective and Reaction to the DFI Response

Demand B of the 5/14/07 NRC DFI letter requires that FENOC's response to the DFI provides a "detailed discussion of the differences in assumptions, analysis, conclusions and other related information of the Exponent Report and previous technical and programmatic root cause reports". DFI Demand B also requires that FENOC's response provides a discussion of how the plant operational data are explained by or do not contradict the timeline of crack growth and wastage cavity growth presented in the Exponent Report.

The current, and presumably almost final, draft response to DFI Demand B presents both the basis for and FENOC's overall conclusion that the plant operational data, taken in total, is better explained by the original 2002 FENOC Root Cause Report than it is by the Exponent Report.

As discussed in the following sections of this statement, Exponent disagrees with this conclusion, and continues to believe that while FENOC's compilation and interpretation of the operational data - which was the sole basis for the Root Cause Report timeline of cracking, leakage, and cavity growth - was reasonable in 2002, it is simply untenable in the face of the data and information that has become available since that time.

Both NRR's May 2003 evaluation[1] of the FENOC Root Cause Report and NRR's February 2003 risk and preliminary significance assessments[2 3] that the NRC staff recognized the deficiencies and shortcomings of the analysis set forth in the 2002 Root Cause Report.

It is clear that the NRC staff embarked on and supported research at ANL to develop basic quantitative data in at least two of these critical areas – crack growth rates in the Davis-Besse Nozzle 3 Alloy 600 material, and corrosion of low alloy RPV steel in molten boric acid species, both dry and wetted. It is also clear from the fact that the NRC did not release the "quarantine" on the old Davis-Besse head until the BWXT metallurgical examination of the nozzle, weld and cavity were completed and the final report provided to the NRC, that the NRC staff also regarded this as critical information. In addition, the NRC commissioned a realistic stress analysis of the CRDM nozzles from

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[1] "Davis-Besse Nuclear Power Station Degradation of Reactor Pressure Vessel Head Technical Sequence of Events, Docket No. 50-346", Office of Nuclear Reactor Regulation, Section 3.0 of Attachment 1 to NRC Integrated Inspection Report 50-346/03-04, May 9, 2003.

[2] "Response to Request for Technical Assistance - Risk Assessment of Davis-Besse Reactor Head Degradation (TIA 2002-01)", Davis-Besse SERP Attachment 2, December 6, 2002, Attachment A at pages 8, 9.

[3] "Davis-Besse Control Rod Drive Mechanism Penetration Cracking and Reactor Pressure Vessel Head Degradation Preliminary Significance Assessment (Report No. 50-346/2002-08(DRS))", February 25, 2003 letter from J.E. Dyer, NRC Regional Administrator Response to Lew Myers, Chief Operating Officer, FENOC.

Engineering Mechanics Corporation (EMC^2) [4] that, while generic to B&W plants, is very similar in scope and detail to that performed by Exponent for Davis-Besse Nozzle 3.

By continuing to endorse the Root Cause Report timeline of crack growth, leak rate through those cracks, and wastage cavity growth, FENOC is essentially telling the NRC that it does not believe the very data the NRC itself ensured were developed to allow further analysis and understanding of the Davis-Besse event, and which in large part formed the basis for Exponent's timeline. Since the current draft response contains no discussion whatsoever of this issue, the NRC's predictable response to this position will be a further DFI that requires FENOC to explain how the Root Cause Report timeline of events is compatible with or not called into question by these new data. Exponent believes that FENOC will be unable to provide any such explanation to the NRC.

First, Exponent firmly believes that the analysis set forth in the Exponent Report represents the most comprehensive synthesis of both the data developed since 2002 and the plant operational data. Second, in the recent three day meeting with FENOC technical staff, Exponent presented its collective engineering judgment that the Root Cause Report timeline of events is simply not possible, and that further effort on Exponent's part will only reinforce that judgment.

Third, Exponent believes that any scientific and engineering analysis of the same body of data will reach similar conclusions about the crack growth, leak rate, and wastage cavity growth timelines to those presented in the Exponent Report. The NRC was not developing the data it developed in a vacuum, and absent the Exponent Report, would likely have conducted or commissioned its own analysis to synthesize the new data with plant operational data. Whether or not the NRC will now do this is debatable, and the NRC may simply use the Exponent Report as a vehicle for staff evaluation.

Leak Rate vs. Crack Length

Exponent's work and conclusions with regard to the leak rate from the CRDM Nozzle 3 weld crack, and the dependence of the leak rate from an axial crack on the crack length above the CRDM nozzle weld are summarized in Section 9.4 and Appendix D of the Exponent Report.

The approach used by Exponent utilized friction factors and discharge coefficients validated by experimental flow data derived from both artificial and actual cracks. Exponent is confident that the resultant leak rate vs crack length correlation shown in Figure 9.4 of the Exponent Report is a reasonable estimate for such leak rates. At the lower end of the crack length scale in this figure, the rapid drop-off in leak rate for cracks

[4] D. Rudland et al., "Analysis of Weld Residual Stresses and Circumferential Through-Wall Crack K-solutions for CRDM Nozzles," *Proceedings of the Conference on Vessel Penetration Inspection, Crack Growth and Repair*, NUREG/CP-0191, U.S. Nuclear Regulatory Commission, September 2005.

shorter than about 0.5 inch is supported by the very small leaks and boric acid accumulations over a fuel cycle reported for the Oconee-1 and Oconee-3 plants.

At the time the Root Cause Report was finalized in August 2002, the existence of the weld crack at Nozzle 3 was not known, and only the existence of the axial nozzle crack was considered in the Root Cause Report. The root cause team had no option but to conclude that all of the leakage that it assumed was present from 1996 on (from its review of boric acid deposits) came from the growing crack at Nozzle 3, with some contribution from the cracks at Nozzle 2.

In contrast, Exponent's work showed that the leak rate from a 1.2 inch long crack was only around 0.02 gpm, and that in fact it is impossible for an axial PWSCC crack 1.2 inches long in a CRDM nozzle to leak at the 0.15 gpm rate that the Root Cause Report assumed it did. Thus, the conclusions of the Root Cause Report first, that an axial crack and leak of this magnitude existed at CRDM Nozzle 3 for a long period of time; and second, that this was the cause of most of the boric acid accumulation on the RPV head from 1996 on, are both incorrect.

Exponent concluded that the leak rate from the large weld crack found in the CRDM Nozzle 3 weld by the BWXT metallurgical examination accounted for the approximately 0.14 gpm increase in unidentified leak rate evident in the October/November 2001 time period.

Metallurgical analysis of the nozzle, weld and wastage cavity

This subject was discussed at length during the three days of meetings between Exponent and the FENOC technical staff, and as noted above, the results of this work were not available at the time the FENOC Root Cause Report was being prepared.

The principal findings that were critical to Exponent's development of the timeline for leak rate and wastage cavity growth were first, the finding of the large axial weld crack at CRDM Nozzle 3 at the 10° orientation on the nozzle in line with the wastage cavity, and second, the morphology of the wastage cavity.

The weld crack was instrumental in explaining the jump in leak rate noted above that was suggested by the radiation monitoring and unidentified leak rate operational data. The morphology of the cavity supported Exponent's corrosion engineering conclusions that the lower portion of the cavity showed evidence of metal removal by high velocity fluid and flow assisted corrosion, while both the smooth upper portion of the cavity and its growth to around 12 inches in diameter were indications of a rapid "top-down" corrosion process. Exponent concluded that this was the result of a molten metaboric acid layer on the RPV head fed by a high flow of moisture to the upper RPV head surface from the uncovered weld crack.

The Root Cause Report speculates on the possible corrosion mechanisms, because it did not have the results of this examination available to it. Nonetheless, the Root Cause Report held open the possibility of a rapid corrosion process near the end of Cycle 13, as did the NRR assessments referred to previously.

Stress Analysis

Exponent is concerned that some members of the FENOC root cause team seem to view stress analysis of CRDM nozzles and welds as a theoretical model that can not provide meaningful stress results for use in a failure analysis. Exponent respectfully disagrees with this view.

Finite element stress analysis is one of the basic tools of failure analysis, and has been in use for at least as long as computers have been available to perform the complex calculations involved, and is one of the first analysis steps in any failure analysis of cracked components.

Exponent's stress analysis is not a conservative, bounding stress analysis of the type used in safety assessments. Stress analyses performed for this purpose (such a s the B&W 1993 and the MRP-110 2004 safety assessments) are designed to conservatively generate higher predicted stresses than would be expected in service, and typically simulate just one or two weld passes.

In contrast, the Exponent stress analysis uses a thirteen weld pass simulation (as well as simulation of other steps in the CRDM manufacturing and assembly process) in order to develop realistic "best estimate" residual stress levels for use in fracture mechanics analysis and crack growth determination in actual plant operation. This is the same approach as used by EMC^2 in the work performed for the NRC reported in 2005.

The finite element model is an "idealized" simulation of the welding process, in that it assumes uniform weld bead lay down, constant heat input, and other parameters. Since the CRDM J-groove welding process is a manual one, the stress analysis does take into account the many variables inherent and unpredictable in such a process, such as non-uniform weld beads, starting/stopping welds, weld cracking, grinding and reworking, nozzle straightening, and other such operations. However, these uncertainties generally result in increased residual stress levels, and, if present in Nozzle 3, would result in higher stress levels and higher crack growth rates than the Exponent Report used in the development of its crack growth timeline.

It should also be noted that the type of finite element stress analysis used by Exponent has been bench-marked and validated against actual residual stress measurements in CRDM nozzle mock-ups, thereby providing confidence that the stress analysis results predicted for a specific nozzle and geometry are realistic and representative of in-service stress levels.

Crack Growth Rate and Crack Growth Timeline

This was the subject of much discussion during the three days of technical meetings between Exponent and FENOC technical staff. In summary, Exponent's position is that the ANL data represent the most appropriate and reliable data for use in projecting crack growth in Davis-Besse CRDM Nozzle 3. Exponent has no reason to doubt the ANL data, and considers the use of industry standard crack growth rate data to be inapplicable and inappropriate for this purpose.

In the preparation of the FENOC Root Cause Report in 2002, there was no option but to use the industry standard crack growth rate data. However, the possibility that this may be incorrect was considered by the NRC staff in evaluating the Root Cause Report, and led to the NRC sponsored program at ANL. The existence of this data simply cannot be brushed aside and ignored, and, along with the other data and engineering analyses discussed here, presents a direct contradiction to the Root Cause Report timeline of crack growth and nozzle leakage.

Exponent noted during the meetings that the timeline for crack growth in the Exponent Report used a "best curve fit" through the most appropriate ANL data. Exponent further pointed out that the use of the lower bound of the ANL CGR data would likely push the estimated time at which the Nozzle 3 crack reached the top of the weld to the beginning rather than the middle of 1999. However, Exponent further pointed out that while such an earlier time would increase the estimated leak rate and boric acid accumulation slightly at 12RFO, the 2001 timeline for wastage cavity growth would be unaffected.

It should be noted that the ANL data were obtained on samples cut from above the actual Nozzle 3 OD crack location, but included part of the ID crack in this nozzle. Detailed microscopy work on the Nozzle 3 crack by Battelle Pacific Northwest Laboratory for EPRI (MRP-193, June 2006) showed conclusively that sulfur species were present in the crack tips, and concluded that the likely source of such sulfur species was reactor coolant contamination, possibly from demineralizer resin ingress. This information was not available at the time of the Root Cause Report in 2002, but was available to Exponent.

Exponent requested but never received RCS chemistry data for Cycles 11, 12 and 13. Therefore, Exponent did not perform a detailed review of RCS chemistry at Davis-Besse for possible sulfur contamination of the RCS. However, we note here that "spikes" in RCS sulfate concentration were clearly evident during shutdowns at Davis-Besse for 7RFO through 10RFO (BAW-2301, July 1997, response to NRC GL 97-01). This is indicative of "hide-out return" of sulfate contamination of the RCS, and indicates that sulfate contamination of the RCS may well have been a persistent operational condition. High levels of sulfur and soluble sulfur species such as sulfates are evident in the analysis results for all the RPV head deposits taken from the head in 2002.

Since sulfur species are known to accelerate crack growth in Alloy 600, it is likely that the crack growth rate for the long axial crack at Nozzle 3 was higher than that for the un-cracked ANL specimens. Such acceleration was not considered in the Exponent analysis.

but would shorten the cracking timeline by some indeterminate amount. To quantify the effect of sulfur species, a detailed review of Davis-Besse chemistry data for at least Cycles 12 and 13 would be needed, especially across the 11RFO and 12RFO shutdowns.

Computational Fluid Dynamics (CFD) Analysis and RPV Head Corrosion due to Wetted Molten Metaboric Acid

The NRC/ANL work that showed high corrosion rates due to molten metaboric acid in the presence of moisture is discussed in detail in the Exponent Report, and was also discussed in the recent three days of meetings between Exponent and FENOC technical personnel.

Corrosion rates of 5 to 6 inches per year were measured in the ANL work at experimental conditions relevant both to the thermal hydraulic conditions predicted to be present in the growing wastage cavity prior to October/November 2001, and to the thermal hydraulic conditions predicted to be present at the RPV upper head surface after that time.

Exponent's CFD analyses described in Section 9 of the Exponent Report showed that for leak rates of around 0.01 gpm and below – the leak rate estimated for the long axial crack at CRDM Nozzle 3 in April/May 2001 – moisture penetration occurs into the lower region of a wastage cavity equivalent in size to that found at Nozzle 2. For a leak rate of 0.02 gpm into a cavity about seven times that size, moisture penetration reaches higher into the wastage cavity but not to the top surface of the RPV head. Thus "top down" wastage due to molten metaboric acid and moisture is not predicted to occur for these leak rates.

However, for a leak rate of around 0.17 gpm, such as Exponent predicts in the October/November 2001 time period when the weld crack uncovered, considerable moisture is carried up through the growing wastage cavity to the upper surface of the RPV head. Based on these thermal hydraulic conditions and the NRC/ANL work on boric acid corrosion, Exponent concluded that rapid "top down" corrosion of the RPV steel began in October/November 2001 as the weld crack uncovered, and that significant enlargement of the upper region of the cavity occurred in only a few months.

Exponent further concluded that had a leak rate of the magnitude of around 0.1 to 0.15 gpm existed from the Nozzle 3 cracks for the period of time that the Root Cause Report concluded it did – at least 4 years from 1998-2002, then the enlargement of the wastage cavity by boric acid corrosion processes, continuously fed by moisture from the leak, would have continued, and would have likely been limited only by the extent of the boric acid deposit in the SE quadrant.

Therefore, based on the corrosion rates for the conditions at the upper head surface due to boric acid corrosion processes, cavity enlargement would have occurred to a much greater extent than that observed for the final cavity, perhaps as much as an order of magnitude greater. The final cavity size observed at Nozzle 3 is therefore supportive of the Exponent timeline, but not the Root Cause Report timeline.

Exponent's Consideration of Plant Operational Data

In the recent three day meeting with FENOC technical staff, Exponent presented its interpretation of the plant operational data, and its assessment that these data did not conflict with, and in fact supported the timeline for crack growth, leak rate, and wastage cavity growth presented in the Exponent Report. Exponent has also presented in writing this same assessment to FENOC for consideration in the response to DFI Demand B.

It is not necessary to repeat the same assessment in detail here. In summary, Exponent believes that the data related to CRDM flange leakage and boric acid accumulation on the Davis-Besse RPV head between 1990 and 2002 can "fit" either the Root Cause Report or Exponent Report timelines, since these data are both qualitative and subjective in nature. Exponent and FENOC technical personnel are in agreement that the link between containment air cooler cleanings and nozzle flange or crack leakage is tenuous and not convincing.

The only real area of disagreement is in the cause and origin of the iron deposits on the radiation monitor filters. In this respect, as noted above, use of the lower bound of the ANL CGR data would likely push the estimated time at which the Nozzle 3 crack reached the top of the weld to the beginning rather than the middle of 1999. Therefore, even with the assumption that the only possible source of the iron deposits was a nozzle crack leak, then this plant observation is not necessarily in conflict with Exponent's failure analysis or timeline.

However, Exponent also notes that it has never been provided with the SWRI July 1999 analysis of the filter deposits, the November 1999 Sargent & Lundy assessment (Project 10294-033) of both the SWRI analysis and the possible source of the filter deposits (RCR Att. 2, pages 146-147), or the relevant Condition Report (CR 99-1300). Review of the data in these reports and comparison with the reported elemental analysis of the deposits from the underside of Nozzle 3 flange at 13RFO may shed additional light on whether the filter deposits in 1999 were in fact from the A533 Grade B RPV low alloy steel or some other carbon steel source.

Exponent also notes that the Root Cause Report did not report on the cesium dating of this 13RFO Nozzle 3 sample as it did for other samples from the RPV head (RCR pages 7-9). The Root Cause Report made the relevant and critical point that an age determination could "dispel or help to confirm" the theory presented in the Root Cause Report that the Nozzle 3 flange acquired the deposits in the early stages of annulus enlargement, but noted that "confirmation of this effect is beyond the necessary scope of this report."

In this regard, while there is doubt expressed in the Root Cause Report about the reliability of the sample deposit results, the analytical data clearly reports first, that the oldest sample retrieved was dated at June 1999 (by aging analysis from the Cesium isotope ratio) shows, and that the deposit from around Nozzle 3 was dated at August 2001. In addition, the Framatome report notes that "the range of boron-to-lithium ratios indicates the boron and lithium in these samples may have originated from a CRDM leak near the end of cycle (EOC), assuming no volatile loss of boron and lithium". These results are more consistent with the Exponent Report timeline than the Root Cause Report timeline.