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UniStar
NUCLEAR ENERGY

10 CFR 50.4
10 CFR 52.79
10 CFR 2.390

February 14, 2012

UN#12-018

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: UniStar Nuclear Energy, NRC Docket No. 52-016
Response to Request for Additional Information for the Calvert Cliffs Nuclear Power Plant, Unit 3,
RAI 318, Turbine Missiles – Non-Proprietary Version

References:
1) Surinder Arora (NRC) to Paul Infanger (UniStar Nuclear Energy), "Final RAI 318 CIB1 4196," dated September 14, 2011

2) UniStar Nuclear Energy Letter UN#12-002, from Mark T. Finley to Document Control Desk, U.S. NRC, RAI 318, Turbine Missiles, dated January 13, 2012

The purpose of this letter is to respond to the request for additional information (RAI) identified in the NRC e-mail correspondence to UniStar Nuclear Energy, dated September 14, 2011 (Reference 1). This RAI addresses Turbine Missiles, as discussed in Section 3.5.1.3 of the Final Safety Analysis Report (FSAR), as submitted in Part 2 of the Calvert Cliffs Nuclear Power Plant (CCNPP) Unit 3 Combined License Application (COLA), Revision 7.

Reference 2 provided a February 14, 2012, schedule date for the response to RAI 318. Enclosure 1 provides our response to RAI No. 318, Questions 03.05.01-19, 03.05.01-20, 03.05.01-21, and 03.05.01-22.

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NRO

Our response does not include any new regulatory commitments and does not impact COLA content. This letter does not contain any sensitive or proprietary information.

Enclosure 2 contains an affidavit attesting to the proprietary nature of the Threshold Stress Approach document provided in Enclosure 3. Enclosure 3 is the PROPRIETARY Threshold Stress Approach document completed by ALSTOM. With Enclosure 3 removed, the entire letter is non-proprietary.

If there are any questions regarding this transmittal, please contact me at (410) 369-1907, or Mr. Wayne A. Massie at (410) 369-1910.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on February 14, 2012

Mark T. Finley

Enclosures:
1) Response to NRC Request for Additional Information, RAI No. 318, Questions 03.05.01-19, 03.05.01-20, 03.05.01-21, and 03.05.01-22, Turbine Missiles, Calvert Cliffs Nuclear Power Plant, Unit 3
2) Alstom Affidavit for Withholding of Proprietary Information in Accordance with 10 CFR 2.390
3) Alstom Document, Design Against SCC in Steam Turbines: Concept and Case Study (Proprietary) – Not attached to this non-Proprietary submittal.

cc: Surinder Arora, NRC Project Manager, U.S. EPR Projects Branch
Laura Quinn-Willingham, NRC Environmental Project Manager, U.S. EPR COL Application
Getachew Tesfaye, NRC Project Manager, U.S. EPR DC Application (w/o enclosure)
Patricia Holahan, Acting Deputy Regional Administrator, NRC Region II (w/o enclosure)
Silas Kennedy, U.S. NRC Resident Inspector, CCNPP, Units 1 and 2
David Lew, Deputy Regional Administrator, NRC Region I (w/o enclosure)

Enclosure 1

Response to NRC Request for Additional Information

RAI No. 318, Questions 03.05.01-19, 03.05.01-20, 03.05.01-21, and 03.05.01-22, Turbine Missiles
Calvert Cliffs Nuclear Power Plant, Unit 3

RAI No. 318

Question 03.05.01.03-19

Section 7.1.3 of the Alstom Report TSDMF 07-018 D, dated May 30, 2007, implies that the turbine rotors have both a fir tree blade attachment and pin-root blade attachment. In addition, Section 8.1.1 of the Alstom Report TSDMF 07-018 D, dated May 30, 2007, states that the operating experience of welded LP rotors is mainly of reaction type with circumferential blade grooves. The operating experience of welded rotors of impulse type with pin-root blade attachments is significant, but smaller than the operating experience of welded LP rotors of reaction type with circumferential blade grooves. This section also states that no stress corrosion cracks have ever been found in pin-root attachment of welded rotor.

a. Clarify the specific types of blade attachments for the LP and HIP rotors.
b. Provide the number of welded rotors with circumferential blade grooves and the number of welded rotors with pin-root blade attachments.
c. Discuss why the probabilities of crack initiation for each type of blade attachment is based on the total number of LP flows in lieu of total number of rotors.
d. Discuss why the probabilities of crack initiation for each type of blade attachment is not based on the corresponding operating experience of the specific blade attachment. (i.e., number of blade groove attachment is used to determine the probability of crack initiation for a groove blade attachment, and the number of pin-root blade attachment is used to determine the probability of crack initiation for a pin-root blade attachment).
e. Discuss how the stress corrosion cracks were detected and the locations in the operating rotors (i.e., visual inspection, surface inspection or ultrasonic inspection, etc.).
f. Provide operating experience for these types of welded rotors. Also provide operating experience for each type of blade attachment used, since this is the area where the stress corrosion cracking is predicted to initiate and propagate.

Response

Question Item a:

The standard blades in the low-pressure (LP) and high intermediate pressure (HIP) rotors are equipped with pin-root attachments. Only the special blades, i.e., the last and penultimate LP blades are equipped with fir-tree roots.

Question Item b:

In Alstom's operating experience, about 10% of the flows utilize pin-root blade attachments, the others utilize circumferential blade grooves. As stated in Alstom Report TSDMF 07-018 D[1], Section 8.1.1, the population of LP turbines considered is comprised of approximately 277 rotors and 554 LP flows.

[1] Transmitted by UniStar Nuclear Energy Letter UN#09-112, from Greg Gibson to Document Control Desk, U.S. NRC, Response to Request for Additional Information for the Calvert Cliffs Nuclear Power Plant, Unit 3, RAI No. 29, Questions 03.05.01.03-1 and 03.05.01.03-2, Turbine Missiles, dated March 2, 2009.

Question Item c:

The probability of crack initiation has been calculated per flow, and the probability of generating a missile (P1) has been calculated taking into account the number of flows. It is also possible to consider the probability of crack initiation per rotor and then calculate the probability of generating a missile taking into account the number of rotors. These two approaches are very similar but the use of flows allows for more precise evaluation of crack initiation and missile generation, by breaking down the component (the rotor) into smaller observable elements (flows). As an example, if a rotor is found to have stress corrosion cracking (SCC), the probability of crack initiation would be calculated and the probability of missile generation (P1) would be multiplied by 3 (due to the use of 3 rotors). However, assume that single rotor had SCC on 2 different flows. In this instance the probability of crack initiation would be multiplied by a factor of 2 (due to SCC on 2 flows) and the probability of missile generation (P1) would be multiplied by a factor of 6 (3 rotors with 2 flows per rotor). This leads to higher calculated probabilities (and thus more conservatism) for crack initiation and missile generation when examining occurrences per flow.

Question Item d:

The probability of crack initiation is a function of the rotor material, of the applied stress, and of the temperature. The blade attachment design does impact the crack initiation, but to a lesser degree. As a conservative assumption, the operating experience from welded LP rotors of reaction type with circumferential blade grooves has been chosen to determine probability of crack initiation. This assumption leads to a probability of crack initiation six times higher than the one calculated based on only the pin-root attachments experience.

The CCNPP Unit 3 turbine will be of a different design (welded LP rotors of impulse type with pin-root blade attachments). Operating experience information for the two blade attachment designs is provided below:

- experience of welded LP rotors of reaction type: 41 occurrences over 554 flows,
- experience of welded LP rotors of impulse type : 0 occurrence over 55 flows

Question Item e:

The Stress Corrosion cracks have been detected in reaction type rotors with old circumferential blade grooves design (also called T-attachment blade design) following ultrasonic examination (that is the best possible way to detect indication with this technology). Note that the US EPR is not a reaction type rotor and does not use the T-attachment blade design.

In the case of impulse type rotors with finger attachment (i.e., the type to be used for the US EPR), the indications can be detected with surface examination of the external finger. If surface examination finds flaws that require further characterization or evaluation, ultrasonic evaluation is possible once the specific area of the turbine is de-bladed.

Question Item f:

Operating experience is that the flows with pin-root attachments, corresponding to about 10% of the total number of flows inspected, have never experienced SCC. The 41 flows that experienced SCC are of circumferential groove type (i.e., T-attachment blade designs not planned for use on the US EPR), corresponding to 90% of the total number of flows inspected.

COLA Impact

The COLA FSAR will not be revised as a result of this response.

RAI No. 318

Question 03.05.01.03-20

Section 8.1.1 of the Alstom Report TSDMF 07-018 D, dated May 30, 2007, states that ALSTOM Power has designed the UNISTAR LP and HIP rotors according to the Threshold Stress Approach (TSA) to prevent stress corrosion cracking. Discuss what the TSA approach is and how it was applied to this rotor design.

Response

Alstom utilizes the Threshold Stress Approach (TSA) for calculation of allowable stresses in rotors for steam turbines in nuclear plants.

The TSA is presented in Enclosure 3 of the proprietary version of this response[2]. This Threshold Stress Approach document is deemed proprietary in accordance with 10 CFR 2.390 (a) (4) – *Trade Secrets.*

COLA Impact

The COLA FSAR will not be revised as a result of this response.

[2] UniStar Nuclear Energy Letter UN#12-006, from Mark T. Finley to Document Control Desk, U.S. NRC, Response to Request for Additional Information for the Calvert Cliffs Nuclear Power Plant, Unit 3, RAI No. 318, Turbine Missiles – Proprietary Version, dated February 14, 2012.

RAI No. 318

Question 03.05.01.03-21

Section 8.3 of the Alstom Report TSDMF 07-018 D[1], dated May 30, 2007, specifies that volumetric inspection is not necessary for detecting stress corrosion cracking. However, SRP Section 3.5.1.3, Paragraph II.3, specifies that the applicant should demonstrate the capability to perform visual, surface and volumetric (ultrasonic) examinations suitable for inservice inspection of turbine rotors for NRC review and approval.

a. Provide information to demonstrate the capability to perform these inservice inspections to maintain the reliability of the turbine rotors.
b. Discuss why volumetric inspection is not necessary for determining whether internal defects/cracks or internal surface cracks at the weld root or other location that may not have been detected would not propagate by another mechanism (i.e., fatigue, etc.) to a critical size leading to rupturing of the rotor.
c. Discuss in detail the first sentence in Section 8.3, taking into account the statement in Section 5.3 which describes the stress distribution within the rotor.

Response

<u>Question Item a:</u>

The reliability of the Alstom turbine rotors is maintained via in-service inspections, which can utilize visual, surface, or volumetric examinations as needed, based upon the as-found and inspected conditions. However, due to the construction method for the turbine rotor (welded forgings that are 100% volumetrically checked during manufacturing and the absence of an open center bore or annulus that could allow for SCC) the approach to the inspection can be graduated based upon observed findings.

As previously answered under RAI 211 Question 03.05.01.03-4[3], the probability of experiencing SCC and generating a missile has been conservatively calculated by assuming a crack in the attachment present at t=0 (start of the turbine inspection cycle). The crack is assumed to be on an internal finger which cannot be examined with the turbine blade attachment in place. Analysis shows the crack would propagate to the external finger service which is visible during inspection. The RAI 211 Question 03.05.01.03-4[3] response addressed in detail the topic of the timing of crack growth to a critical crack versus the inspection frequency.

Therefore, during in-service inspections, visual examinations can be done to identify potential defects or areas of defects along the external (visible) part of the blade attachment. If an indication is found or suspected, a surface examination can also be done on this external (visible) part of the blade attachment. If the surface exam provides further evidence of a defect or potential defect, further examination (including possibly volumetric examination) of the affected area would be required. In order to perform this further testing, the blade would need to be removed to provide complete access to the attachment area. With the blade removed, the attachment area, including the fingers, would then be open and visible. This provides the

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[3] UniStar Nuclear Energy Letter UN#10-188, from Greg Gibson to Document Control Desk, U.S. NRC, Response to Request for Additional Information for the Calvert Cliffs Nuclear Power Plant, Unit 3, RAI No. 211, Turbine Missiles, dated July 9, 2010.

capability to perform visual examination of the entire area, surface examination of the entire area, and, as needed based on the confirmed presence of a defect, volumetric examination of the area(s) in question.

Question Item b:

Please refer to document TNUD-EI 10-011 entitled, "Turbine Missile Analysis Fracture Mechanics Applied to the LP Rotor" which was transmitted by letter UN#10-188[3]. This report concludes that maximum acceptable defects during manufacturing will not grow to critical size during the life of the turbine.

Question Item c:

The highest stress area in the rotor body (Figure 4 of the Alstom Report TSDMF 07-018 D[1]) is not susceptible to SCC because it is not in contact with wet steam. (Please refer to previously answered RAI 211 Question 03.05.01.03-4[2] for more information regarding turbine rotor construction and testing to ensure its integrity).

Refer to Question Item b above for the crack growth under fatigue.

COLA Impact

The COLA FSAR will not be revised as a result of this response.

RAI No. 318

Question 03.05.01.03-22

Clarify and provide justification for using the maximum yield strength in lieu of the minimum yield strength for calculating the critical crack size and the turbine missile probability in Section 9 of the Alstom Report TSDMF 07-018 D, dated May 30, 2007.

Response

The probability of missile generation of an individual disc is defined as the probability that an existing crack will grow to the critical crack size. Therefore, crack growth rate and critical crack size are the main parameters considered. Typically, the physical properties of the turbine material are used to determine, given the environment and stress factors, when or under what conditions a crack could be generated. However, for maximum conservatism, Alstom's approach, as specified in the Turbine Missile Analysis (TSDMF 07-018 D[1]) Section 8.1.2.5, assumes a crack is already present at t=0. For a crack at t=0, the analysis then simplifies to the growth rate of the crack to determine when a crack reaches critical size. This crack growth rate is given by Equations 6 and 7 of TSDMF 07-018 D[1]. As shown in the equations, specifying a higher yield strength (i.e., larger R_e) leads to the maximum crack growth rate. Therefore, the combined assumptions of a crack initiating at T=0 and a maximum crack growth rate (contained by using the material's maximum yield strength) provide the most conservative calculation for determining the probability of turbine missile generation.

COLA Impact

The COLA FSAR will not be revised as a result of this response.

Enclosure 2

Alstom Affidavit for
Withholding of Proprietary Information
in Accordance with 10 CFR 2.390

AFFIDAVIT

STATE OF TENNESSEE)
) ss.
CITY OF CHATTANOOGA)

1. My name is Michael Carrato. I am the Legal Counsel for Alstom Power Turbomachines LLC ("Alstom") and, as such, I am authorized to execute this Affidavit.
2. I am familiar with the criteria applied by Alstom to determine whether certain Alstom information is proprietary. I am familiar with the policies established by Alstom to ensure the proper application of these criteria.
3. I am familiar with Alstom information contained in all the documentation associated with the Alstom Response to RAI 318 and referred to herein as "Documentation." Information contained in this Documentation has been classified by Alstom as proprietary in accordance with the policies established by Alstom for the control and protection of proprietary and confidential information.
4. This Documentation contains information of a proprietary and confidential nature and is the type customarily held in confidence by Alstom and not made available to the public. Based on my experience, I am aware that other companies regard information of the kind contained in this Documentation as proprietary and confidential.
5. The Documentation has been made available to the U.S. Nuclear Regulatory Commission in confidence with the request that the information contained in the

Documentation be withheld from public disclosure. The request for withholding of proprietary information is made in accordance with 10 CFR 2.390. The information for which withholding from disclosure is requested qualified under 10 CFR 2.390(a)(4) "Trade secrets and commercial or financial information."

6. The following criteria are customarily applied by Alstom to determine whether information should be classified as proprietary:

   (a) The information reveals details of Alstom's research and development plans and programs or their results.

   (b) The availability or use of any such confidential design information to or by a competitor of Alstom would provide such competitor with a substantial improvement in the ability to make competitive proposals that reflect knowledge of Alstom design effectiveness that is not otherwise available to the market. This competitive knowledge would allow such competitor to propose equipment performance with a greater than otherwise possible knowledge of Alstom's expected proposals, thereby improving the competitor's probability of selection and contract award.

   (c) The information includes test data or analytical techniques concerning a process, methodology, component, or the detailed test results conducted on turbine equipment supplied by Alstom, which would provide to a knowledgeable reader, insights into the effectiveness of individual elements of Alstom's designs, as well as in depth knowledge of the actual performance of the complete equipment package, the application of which results in a competitive advantage for Alstom.

(d) The information reveals certain distinguishing aspects of a process, methodology, or component, the exclusive use of which provides a competitive advantage for Alstom in product optimization or marketability. The use by a competitor of such information would be to the detriment of Alstom through the loss of contract awards, future sales and future profits. All such information is of great value to Alstom in its continuous design improvement process to meet the requirements of a competitive marketplace.

(e) The information is vital to a competitive advantage held by Alstom, would be helpful to competitors to Alstom, and would likely cause substantial and irreparable harm to the competitive position of Alstom. The information is of the type of information that Alstom zealously pursues and defends as confidential business information through the use of highly restrictive confidentiality agreements that are not time limited in their applicability.

The information in the Documentation is considered proprietary for the reasons set forth in paragraphs 7(b), 7(c), 7(d) and 7(e) above.

7. In accordance with Alstom's policies governing the protection and control of information, proprietary information contained in the Documentation has been made available, on a limited basis, to others outside of Alstom only as required and under stringent agreements providing for nondisclosure and limited use of the information.

8. The foregoing statements are true and correct to the best of my knowledge, information, and belief.

Michael Carrato, Legal Counsel

Subscribed before me this 12th day of January, 2012.

SHIRLEY STEWART STATE OF TENNESSEE NOTARY PUBLIC HAMILTON COUNTY

Shirley Stewart
Notary Public
My Commission Expires: 4/23/2014
Commission No. __________

Enclosure 3

Alstom Document, Design Against SCC in Steam Turbines: Concept and Case Study (Proprietary) – Not attached to this non-Proprietary submittal

The contents of this Enclosure are withheld in accordance with 10 CFR 2.390 (a)(4).