**MITSUBISHI HEAVY INDUSTRIES, LTD.**
**16-5, KONAN 2-CHOME, MINATO-KU**
**TOKYO, JAPAN**

October 21, 2010

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

Attention: Mr. Jeffrey A. Ciocco

Docket No. 52-021
MHI Ref: UAP-HF-10286

**Subject: MHI's Response to US-APWR DCD RAI No. 633-4857 Revision 0**

**Reference:** 1) "Request for Additional Information No. 633-4857 Revision 0, SRP Section 09.01.04 - Light Load Handling System (Related to Refueling) - Application Section: 9.1.4 dated 09 17, 2010.

With this letter, Mitsubishi Heavy Industries, Ltd. ("MHI") transmits to the U.S. Nuclear Regulatory Commission ("NRC") a document entitled "Response to Request for Additional Information No. 633-4857 Revision 0."

Enclosed is the response to a question contained within Reference 1.

Please contact Dr. C. Keith Paulson, Senior Technical Manager, Mitsubishi Nuclear Energy Systems, Inc. if the NRC has questions concerning any aspect of the submittals. His contact information is below.

Sincerely,

Y. Ogata

Yoshiki Ogata,
General Manager- APWR Promoting Department
Mitsubishi Heavy Industries, LTD.

Enclosure:

1. Response to Request for Additional Information No. 633-4857 Revision 0

CC: J. A. Ciocco
C. K. Paulson

Contact Information
C. Keith Paulson, Senior Technical Manager
Mitsubishi Nuclear Energy Systems, Inc.
300 Oxford Drive, Suite 301
Monroeville, PA 15146
E-mail: ck_paulson@mnes-us.com
Telephone: (412) 373-6466

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Enclosure 1

UAP-HF-10286
Docket No. 52-021

Response to Request for Additional Information No. 633-4857
Revision 0

October 2010

## RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

10/21/2010

**US-APWR Design Certification**

**Mitsubishi Heavy Industries**

**Docket No. 52-021**

| | |
|---|---|
| **RAI NO.:** | **NO. 633-4857 REVISION 0** |
| **SRP SECTION:** | **09.01.04 – LIGHT LOAD HANDLING SYSTEM (RELATED TO REFUELING)** |
| **APPLICATION SECTION:** | **09.01.04** |
| **DATE OF RAI ISSUE:** | **09/17/2010** |

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**QUESTION NO.: 09.01.04- 21 Follow Up to RAI 09.01.04-16**

The staff requested that Mitsubishi Heavy Industries, LTD (MHI or the applicant) address operating experience considerations associated with refueling cavity seals in Request for Additional Information (RAI) 09.01.04-16 dated December 15, 2009. The applicant provided its response to the staff's request in a letter dated February 22, 2010 (MHI response to RAI No. 507-3993, Rev. 0). In general, the staff has determined that the applicant's response is incomplete and needs to be revised as appropriate to include consideration of the following items:

1. The response indicated that the permanent cavity seal (PCS) is a stainless structure that is permanently attached to both the reactor vessel flange and the refueling cavity floor with both bolted joints and welds. The response included a figure to show the PCS, but it did not indicate where the welds are located or how the bolted joints are sealed to prevent leakage. The DCD also needs to explain/specify:

   a. if the seal is treated as a structure or mechanical component,

   b. codes or standards that apply to the seal assembly,

   c. codes/standards that apply to welds, and distinction between shop vs. field welds, and

   d. why catastrophic failure of welds will not occur.

2. Item (a) of the RAI requested the applicant to provide information concerning the PCS and any other seals that will be used and whose failure could cause the refueling cavity to drain. Except for the PCS and seals on the cask pit and fuel inspection pit gates, other seals and plugs that fit this description were not described in the response. For example, seals that are typically installed in the steam generator hot leg and cold leg nozzles to facilitate inspection and repair activities were not described. Additional information is also needed to explain how leakage through the

seals on the cask pit and fuel inspection pit gates will cause the refueling pit to drain down (i.e. diagrams showing relative elevations and flow paths need to be provided).

3. The response indicated that the leak rate from the PCS is limited to less than 1 gpm. This is based on the expected flow rate through a very small crack in a PCS weld. However, because the PCS is not designated as safety-related, seismic Category I, catastrophic failure of the PCS is not precluded by the design. In order to ensure that catastrophic failure will not occur, the PCS should also include primary and backup seals; leakage detection with annunciation in the control room; and provisions to ensure that periodic maintenance is performed (such as flushing after use and gasket replacement), inspections are conducted prior to use, and periodic NDE of welds is performed in accordance with welding codes/standards.

4. The response referred to a leak detection system for the PCS but did not provide any specific information about the design and safety classification of this system or other systems that are available during refueling to alert operators in the control room and in the vicinity of the refueling machine of abnormal conditions.

5. It isn't clear from the response how many fuel assemblies can be located in the refueling cavity at the same time, including any fuel bundles that are located in temporary storage racks for performing maintenance, inspection, and shuffling activities.

6. The response indicated that if a rapid drain down of the refueling cavity were to occur, fuel in transit can be put back into the reactor vessel. However, this isn't really a viable option due to limitations that exist in manipulating the refueling machine and unforeseen delays that can occur when trying to align fuel to place it back into the reactor vessel. Also, the number of fuel assemblies that have to be relocated is an important factor and needs to be considered and addressed for rapid drain-down of the refueling cavity.

7. Item (d) of the RAI requested that the applicant provide information concerning all of the paths (other than the PCS and other seals) that are capable of inadvertently draining the refueling cavity. The response indicated that there are no paths that are capable of draining the refueling cavity other than those referred to in response to item (a). The only path that fits this description from item (a) is the refueling cavity drain valve. Based on the response, there are several cavity drain valves involved and they need to be described. Also, while the response indicated that these valves are confirmed to be in their proper position prior to filling the refueling cavity, how this action is assured by COL applicants has not been explained. Furthermore, other potential refueling cavity drain paths were not recognized and described, such as misalignment of the residual heat removal system. All potential refueling cavity drain paths need to be described and addressed.

8. Item (f) of the RAI requested that the applicant revise the DCD as appropriate to reflect the information that was provided in response to this RAI. The response indicated that the DCD would be revised to include the design specifications for the PCS in Tier 2 Table 3.2-2. However, this is insufficient in that the DCD needs to include descriptions and design details of seals and drain paths that can potentially cause a rapid loss of water from the refueling cavity. The DCD also needs to describe provisions that will be implemented by COL applicants to ensure that rapid

drain down of the refueling cavity is not likely to occur and that emergency response procedures are established and implemented for such events as appropriate. For example, the DCD needs to explain how seals and flow paths will be maintained and controlled to ensure adequate performance and integrity over the life of the plant, what indication and annunciation will be available to alert operators in the control room and in the vicinity of the refueling machine of a loss of refueling cavity inventory; and to what extent emergency response procedures need to be established for addressing loss of refueling cavity inventory events. COL information items or other means as appropriate to ensure that COL applicants establish and implement procedures for:

a. responding to pool drain down events,

b. performing periodic maintenance and inspection of the PCS and other seals and plugs in accordance with vendor recommendations, and

c. monitoring cavity seal leakage.

While the information referred to above can be reflected in those Tier 2 Sections of the DCD deemed most appropriate by the applicant, it is the staff's preference to include this information in Tier 2 Section 9.1.3 to the extent this is practical and convenient.

Reference: MHI's Responses to US-APWR DCD RAI No. 507-3993; MHI Ref: UAP-HF-10050; dated February 22, 2010; ML100550211.

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**ANSWER:**

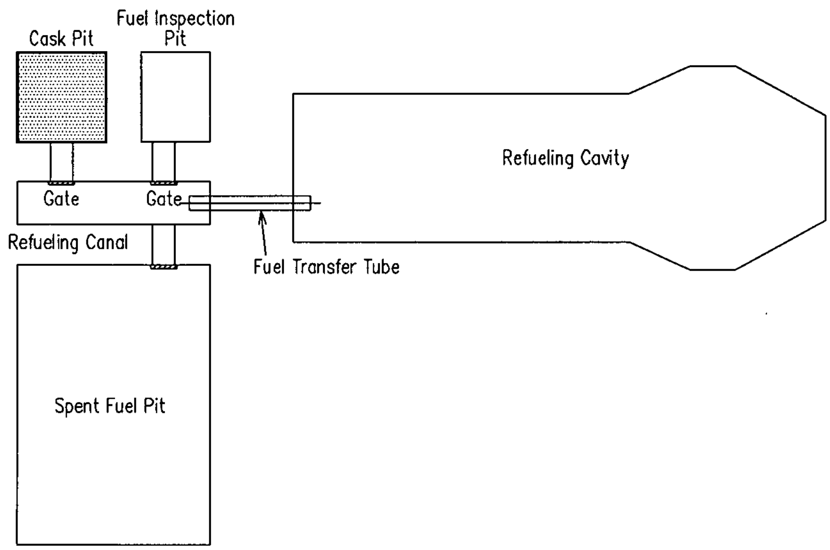
Item No.1
Additional information regarding the permanent cavity seal is provided as follows:

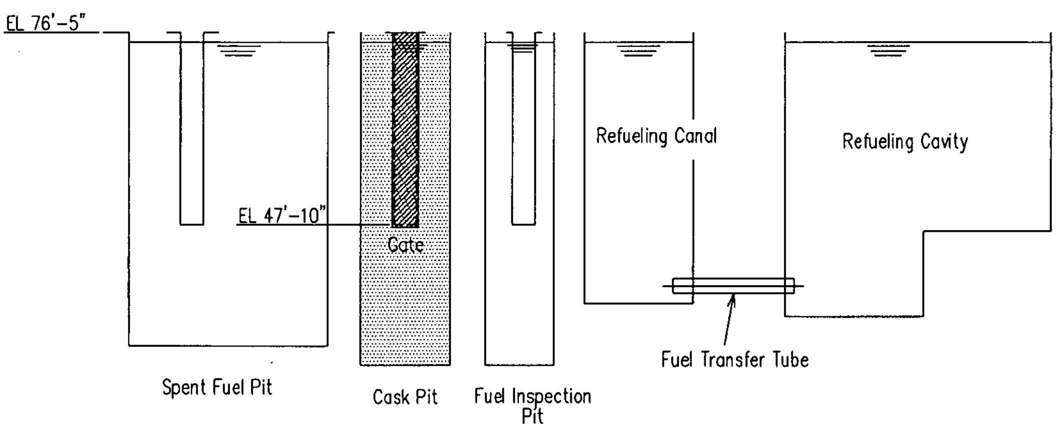
a) The PCS is treated as a mechanical component.
b) Material selection and seal manufacture are performed in accordance with the appropriate ASME criteria or criteria recommended by the manufacturers.
c) Welding is performed in accordance with appropriate ASME criteria. Segments of the PCS are assembled by welding the fixed parts and segments of the seal plates on both ends. The segments are shaped into a ring by welding one another at the shop or on-site depending on transportation conditions for a specific site. The ring of the PCS is fixed on the reactor vessel flange and refueling cavity floor with bolts, and seal welding is performed around the PCS and the bolts to ensure on-site seal performance.
d) The integrity of the PCS is confirmed through evaluation in terms of fatigue caused by thermal stress over the life of the plant, and strength against water pressure during refueling operation. Since the PCS is protected by the lid against an accidental fuel drop, catastrophic failure of the welds will not occur.

Item No.2
All the paths that are capable of inadvertently draining the refueling cavity are mentioned in the reply of RAI 507-3993, Rev. 2, Question 09.01.04-16. However, as this RAI identified, there is the cover that is temporarily installed in the steam generator hot leg and cold leg nozzles to facilitate inspection and repair activities. A pressurized leakage test for this nozzle cover is performed at the shop when manufactured. The condition of the consumable parts on the cover is confirmed periodically, and any deteriorated parts are replaced appropriately. Thus, it is assumed that an

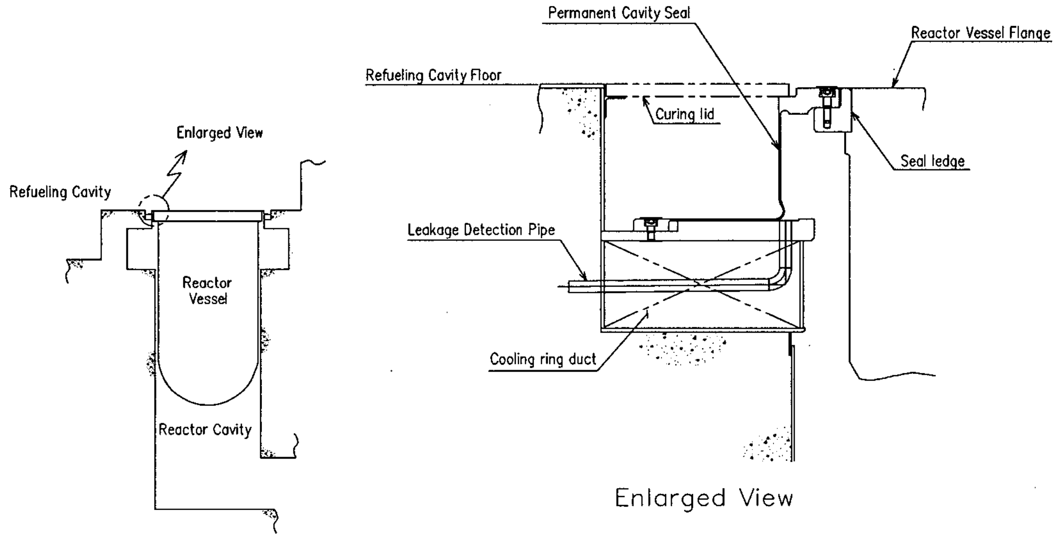
undetected aging deterioration of a seal causing leakage of 1 gpm is an unlikely event. This leak rate condition is the same as the assumption in RAI 507-3993, Rev. 2, Question 09.01.04-16. It is concluded in that RAI reply that the minimum water depth above the active fuel during fuel handling does not fall below the minimum required value.

Regarding the leakage through the seal on the cask pit and the fuel inspection pit gates, the relative elevation of the bottom of the pit gate, refueling cavity, and other structures are shown in the figure below. The cask pit has no water during refueling operation and is isolated from the refueling canal with a gate. If unexpected leakage from the gate occurs, the water flows from the refueling cavity, refueling canal and spent fuel pit into the cask pit through the gate.




<u>Item No.3</u>
Since catastrophic failure of the PCS welds from a fuel drop is precluded, as indicated in the response to the item No.1, a single seal structure is adopted. A leak detection pipe is installed to detect leakage from PCS as shown in the figure below. Liquid penetrant tests and ultrasonic tests for the PCS will be performed periodically, in addition to visual inspections before refueling.




Item No.4
The leakage detection systems mentioned in the response to RAI 507-3993 are utilized for the PCS, and the detection pipe is installed to detect leakage from the PCS. If leakage from the PCS occurs, the detection system will alarm in the MCR and locally near the fuel handling system for abnormal water level conditions in the refueling cavity.

Regarding the safety class of the detection system, US-APWR SSCs are classified as defined in DCD Section 3.2, correlating with the ASME Code, Section III, RG 1.26, NRC Quality group classes, RG1.29 seismic category, 10 CFR 50 Appendix B, and other applicable industry codes and standards. Based on these classifications, the leak detection system is Equipment Class 8.

Item No.5
The maximum number of fuel assemblies that can be arranged in the refueling cavity at the same time is six including all fuel bundles arranged in the temporary storage rack for repair, inspection and shuffle (i.e. two racks containing three assemblies each)

Item No.6
MHI agrees with the NRC comment that unforeseen delays can occur when trying to align fuel to place back into the reactor vessel.

A rapid drain-down of the refueling cavity is considered an unlikely event as mentioned in the response to RAI 507-3993, Rev. 2, Question 09.01.04-16 and RAI 524-4020, Rev. 1, Question 12.03-12.04-35. However, MHI will postulate a rapid cavity drain-down event. In the event, fuel in transit is transferred to the temporary rack in the refueling cavity and the workers will evacuate from the vicinity of the refueling cavity. The worker exposure evaluation in this unlikely event is described in RAI 12.03-12.04 and concluded that the workers will not be exposed to a significant amount of radiation during the rapid cavity drain-down event.

Item No.7
In the original RAI response (RAI 507-3993, Rev. 2, Question 09.01.04-16, Items a and d), MHI listed the worst-case flow paths which require further consideration. All other flow paths were evaluated and were found to have significantly less potential for a rapid drain down event.

In this response, an outline of this evaluation is given below in order to show that the paths identified in the previous RAI response were worst case potential drain paths.

In the evaluation below, all potential drain paths are identified and anticipated scenarios are evaluated to determine if a rapid drain event is considered likely to occur.

The evaluation is based on the assumption that the operators will follow defined operating procedures, and therefore the probability of 2 or more sequential incorrect operator actions is extremely low and negligible. Likewise, 2 or more valve failures on the same line are also considered unlikely. Furthermore, it is assumed that operating procedures are followed to check and verify that drain and vent valves are in the correct position at the time of filling before use of the system.

MHI assumes that an inadvertent drain event does not occur under the following conditions:

- There are 2 or more closed valves in series on the same line.
- The scenario requires 2 or more steps (e.g. bypassing interlock and operating switch) to actuate valves for which actuation is limited by interlocks.
- The scenario requires 2 or more steps (e.g. enabling the valve power source and operating switch) to open locked closed motor operated valves.

For each anticipated drain scenario, drain pipe diameter and drain detection systems are also identified. This is because large diameters can cause large drain flows, and no detection systems can delay countermeasures to stop drain down.

The summary of the evaluation is shown in Table 7-1.

For all anticipated drain scenarios, there are countermeasures to detect the drain-down, so that operators can take action.

Since the refueling cavity drain line has the largest diameter pipe among the anticipated drain scenarios shown in Table 7-1, incorrect operation of the refueling cavity drain valve would have the greatest influence (as identified in the original RAI 507-3993, Rev. 2, Question 09.01.04-16 response).

In the RAI response to DCD Chapter 12 (RAI 524-4020 Revision 1, Question No.12.03-12.04-35), MHI described the effects of this worst case scenario (Refueling cavity drain valve is opened.) and how it would be prevented, detected, and corrected by the operators.

In order for the COL applicant to ensure the correct operation, the following description will be added to DCD Subsection 9.1.4.2.2.2:

"Plant procedures contain measures to prevent and mitigate inadvertent reactor cavity drain-down events. Reactor refueling procedures require that valve positions of potential reactor cavity drain paths are verified prior to filling the refueling cavity. Operation procedures direct operators to monitor control room indications for reactor cavity seal leakage during refueling operations. Maintenance procedures address periodic maintenance and inspection of the permanent cavity seal and other seals and plugs in accordance with vendor recommendations. Emergency response procedures provide direction to operators regarding the proper response to pool drain down events."

Table 7-1 Summary of Potential Drain Path Evaluation (1/3)

| System | Potential Drain path | Possibility of Drain Occurrence | Reason for No Drain Occurrence (Note 1) | Anticipated Drain Scenario | Pipe Diameter of Drain Path | Countermeasure to Detect Drain from the Refueling Cavity |
|---|---|---|---|---|---|---|
| General | Local drain | No | D | - | - | - |
| | Local vent | No | D | - | - | - |
| | Equipment drain | No | D | - | - | - |
| RCS | R/V flange leak detection line to the C/V drain Tank | No | A | - | - | - |
| | R/V vent line to the pressurizer relief tank | No | A | - | - | - |
| | Loop drain line to C/V drain tank | No | A | - | - | - |
| CVCS | Low pressure letdown line to the holdup tank | Yes | - | The discharge of the 3 way valve on the upstream of the volume control tank (VCT) is changed from VCT to the holdup tank. | 4inch | Low water level alarm of VCT notifies operator of abnormal condition. |
| SIS | Emergency letdown line to RWSP | No | A | - | - | - |
| RHRS | CS/RHR pump full flow test line to RWSP | No | C | - | - | - |
| | SFP cooling line to SFP | No | A | - | - | - |
| CSS | CS/RHR pump suction line to RWSP | No | B (Note 2) | - | - | - |
| | C/V spray line to C/V atmosphere | No | A | - | - | - |

Table 7-1 Summary of Potential Drain Path Evaluation (2/3)

| System | Potential Drain path | Possibility of Drain Occurrence | Reason for No Drain Occurrence (Note 1) | Anticipated Drain Scenario | Pipe Diameter of Drain Path | Countermeasure to Detect Drain from the Refueling Cavity |
|---|---|---|---|---|---|---|
| SS | Sampling hood to the equipment drain sump tank | Yes | - | After taking sample, operators forget to close valve inside the sampling hood. | 3/8inch | Leak detection of the sample hood notifies operator of abnormal condition. |
| RWS | Refueling cavity drain line to RWSP | Yes | - | Refueling cavity drain line stop valve connected to RWSP is opened. | 8inch | Low water level alarm of the refueling cavity notifies operator of abnormal condition and operator confirms RWSP water level is increasing. |
| | Refueling cavity drain line to C/V sump | Yes | - | Refueling cavity drain line stop valve connected to C/V is opened. | 2inch | High water level alarm of C/V Sump notifies operator of abnormal condition and operator confirms the refueling cavity water level is decreasing. |
| | Refueling cavity circulation line to RWSP | Yes | - | Stop valve on the transfer line connected to RWSP is opened during the refueling cavity purification operation. | 6inch | Low water level alarm of Refueling Cavity notifies operator of abnormal condition and operator confirms RWSP water level is increasing. |
| | Refueling cavity circulation line to RWSAT | Yes | - | Stop valve on the RWSAT circulation line or its return line is opened during the refueling cavity purification operation. | 4inch | Low water level alarm of the refueling cavity notifies operator of abnormal condition and operator confirms RWSAT water level is increasing. |
| | Refueling cavity circulation line to CCW surge tank | No | A | - | - | - |

Table 7-1 Summary of Potential Drain Path Evaluation (3/3)

| System | Potential Drain path | Possibility of Drain Occurrence | Reason for No Drain Occurrence (Note 1) | Anticipated Drain Scenario | Pipe Diameter of Drain Path | Countermeasure to Detect Drain from the Refueling Cavity |
|---|---|---|---|---|---|---|
| RWS | Refueling cavity circulation line to SFP via SFP demineralizer. | Yes | - | Stop valve on the SFP downstream of SFP demineralizer is opened during the refueling cavity purification operation. | 6inch | High water level alarm of the SFP notifies operator of abnormal condition and operator confirms the refueling cavity water level is decreasing. |
| | Refueling cavity circulation line to SFP via SFP supply line. | No | A | - | - | - |

Note 1: Types (A, B, C and D) are as follows:

A: There are 2 or more closed valves in series on the same line.

B: It requires 2 or more steps (interlock bypass and switch operations) to actuate valves.

C: It requires 2 or more steps (lock release and switch operations) to open locked closed motor operated valves.

D: Drain and vent valves are checked whether they are in correct position at the time of filling system before use of the system.

Note 2:

Interlock does not allow the CS/RHR pump RWSP suction isolation valve and RHR hot leg suction isolation valve to be open simultaneously.

Item No.8

Based on the considerations cited above, it can be determined that the most significant cavity rapid drain-down event is the valve position error associated with the largest pipeline attached to the refueling cavity. To prevent this event and establish the emergency response procedures, the DCD needs to describe provisions that will be implemented by the COL applicant.

MHI will add the following to the DCD section 9.1.4.2.2.2:

"Plant procedures contain measures to prevent and mitigate inadvertent reactor cavity drain-down events. Reactor refueling procedures require that valve positions of potential reactor cavity drain paths are verified prior to filling the refueling cavity. Operating procedures direct operators to monitor control room indications for reactor cavity seal leakage during refueling operations. Maintenance procedures address periodic maintenance and inspection of the permanent cavity seal and other seals and plugs in accordance with vendor recommendations. Emergency response procedures provide direction to operators regarding the proper response to pool drain down events."

**Impact on DCD**

Add following sentence after the last paragraph of 9.1.4.2.2.2

> "Plant procedures contain measures to prevent and mitigate inadvertent reactor cavity drain-down events. Reactor refueling procedures require that valve positions of potential reactor cavity drain paths are verified prior to filling the refueling cavity. Operating procedures direct operators to monitor control room indications for reactor cavity seal leakage during refueling operations. Maintenance procedures address periodic maintenance and inspection of the permanent cavity seal and other seals and plugs in accordance with vendor recommendations. Emergency response procedures provide direction to operators regarding the proper response to pool drain down events."

**Impact on COLA**

There is no impact on the COLA.

**Impact on PRA**

There is no impact on the PRA.