ATTACHMENT 1

MRP-227-A: APPLICANT/LICENSEE ACTION ITEM #7 ANALYSIS FOR THE OCONEE NUCLEAR STATION UNITS - LICENSING REPORT

. (ANP-3267NP, REVISION 0)

[NON-PROPRIETARY VERSION]

AREVA

# MRP-227-A Applicant/Licensee Action Item #7 Analysis for the Oconee Nuclear Station Units

ANP-3267NP
Revision 0

Licensing Report

November 2013

AREVA NP Inc.

## Nature of Changes

| Item | Section(s) or Page(s) | Description and Justification |
|---|---|---|
| 1 | All | Initial Issue |

## Contents

## Nomenclature

| Acronym | Definition |
|---|---|
| A/LAI | Applicant/Licensee Action Item |
| ASTM | American Society of Materials |
| CASS | Cast Austenitic Stainless Steel |
| CMTR | Certified Material Test Report |
| CRA | Control Rod Assembly |
| CRGT | Control Rod Guide Tube |
| CSS | Core Support Shield |
| EFPY | Effective Full Power Year |
| EPRI | Electric Power Research Institute |
| FIV | Flow-Induced Vibration |
| I&E | Inspection and Evaluation |
| IE | Irradiation Embrittlement |
| IMI | Incore Monitoring Instrumentation |
| LOCA | Loss of Coolant Accident |
| LR | License Renewal |
| MRP | Materials Reliability Program |
| NDE | Non-Destructive Evaluation |
| NRC | Nuclear Regulatory Commission |
| NSSS | Nuclear Steam Supply System |
| ONS | Oconee Nuclear Station |
| ONS-1 | Oconee Nuclear Station Unit 1 |
| ONS-2 | Oconee Nuclear Station Unit 2 |
| ONS-3 | Oconee Nuclear Station Unit 3 |
| PH | Precipitation Hardened |
| PT | Dye Penetrant Testing |
| PWR | Pressurized Water Reactor |
| RCP | Reactor Coolant Pump |
| RCS | Reactor Coolant System |
| RT | Radiographic Testing |
| RV | Reactor Vessel |
| SCC | Stress Corrosion Cracking |
| SER | Safety Evaluation Report |
| TE | Thermal Aging Embrittlement |
| US | United States |
| UT | Ultrasonic Testing |

## ABSTRACT

The purpose of this document is to summarize the analyses performed for the applicable component items at the ONS units to complete applicant/licensee action item #7 from MRP-227-A for the ONS units. The summary includes a discussion of the purpose, the methodology utilized, a summary of the background, evaluation inputs, evaluation, and conclusion for each component item, and an overall conclusion.

## 1.0 INTRODUCTION AND PURPOSE

The Electric Power Research Institute (EPRI) Materials Reliability Program (MRP) developed inspection and evaluation (I&E) guidelines in document MRP-227-A [1] for managing long-term aging reactor vessel (RV) internal components of PWRs. Specifically, the I&E guidelines are applicable to RV internal structural components; they do not address fuel assemblies, reactivity control assemblies, or welded attachments to the RV. The I&E guidelines concentrate on eight aging degradation mechanisms and their aging effects, such as loss of fracture toughness. The I&E guidelines define requirements for inspections that will allow owners of pressurized water reactors (PWRs) to demonstrate that the effects of aging degradation are adequately managed for the period of extended operation. These guidelines contain mandatory and needed requirements and an implementation schedule for nuclear units employing B&W nuclear steam supply systems (NSSS) currently operating in the United States (U. S.).

MRP-227-A includes a safety evaluation report (SER) prepared by the U. S. Nuclear Regulatory Commission (NRC). The NRC staff determined whether the guidance contained in the report provided reasonable assurance that the I&E guidelines ensured that the RV internal components will maintain their intended functions during the period of extended operation. From the determination, seven topical report conditions and eight plant-specific applicant/licensee action items (A/LAIs) were contained in the SER to alleviate issues and concerns of the NRC staff. The plant-specific A/LAIs address topics related to the implementation of MRP-227 that could not be effectively addressed on a generic basis in MRP-227. The seventh A/LAI (A/LAI #7) addresses NRC staff concerns regarding thermal aging embrittlement (TE) and irradiation embrittlement (IE).

During the performance of this A/LAI, three component items were identified as requiring further aging management for the ONS units based on material type:

- Control Rod Guide Tube (CRGT) Spacer Castings (Grade CF-3M)
  - Screened as potentially susceptible to TE, but not IE

- Incore Monitoring Instrumentation (IMI) Guide Tube Spiders (Grade CF-8)
  - Screened as potentially susceptible to IE, but not TE
- Vent Valve Retaining Rings (Type 15-5 PH)
  - Screened as potentially susceptible to TE, but not IE

The purpose of this document is to summarize analyses performed for these three component items for Duke Energy's (hereafter referred to as Duke) Oconee Nuclear Station (ONS) Units 1, 2, and 3 (ONS-1, ONS-2, and ONS-3). This document will fulfill the A/LAI for these component items; that is, to develop a plant-specific analysis for ONS-1, ONS-2, and ONS-3 to demonstrate that the component items will maintain their functionality during the period of extended operation, considering the loss of fracture toughness due to TE and/or IE (whichever is applicable).

The methodology used to evaluate all three components items is similar and is illustrated in Section 2.0. Each component item has its own section (CRGT Spacer Castings – Section 3.0, IMI Guide Tube Spider Castings – Section 4.0, Vent Valve Retaining Rings – Section 5.0) and each section contains the following high-level subsections:

- Background (Section X.1)
- Evaluation inputs (Section X.2)
- Evaluation (Section X.3)
- Conclusion (Section X.4)

Information considered by AREVA to be proprietary is marked with brackets: **[ ]**

## 2.0 METHODOLOGY

The purpose of this section is to provide various potential methodologies and identify the ultimate methodology used to evaluate the component items for the ONS units.

### 2.1 *WCAP-17096 Methodology Applicability*

WCAP-17096 provides a methodology for developing evaluation procedures to assess the functional impacts of degradation in component items with "observed relevant indications." [

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### 2.2 *MRP-227-A Suggested Methodologies*

As described in A/LAI #7, to address the NRC staff concerns regarding TE and IE of potentially susceptible materials, applicants/licensees are required to perform a plant-specific analysis or evaluation demonstrating that certain component items will maintain their functionality during the period of extended operation. Per MRP-227-A, possible acceptable approaches may include, but are not limited to:

- Functionality analyses for the set of like components or assembly-level functionality analyses, or
- Component level flaw tolerance evaluation justifying that the MRP-227 recommended inspection technique(s) can detect a structurally significant flaw for the component in question, taking into account the reduction in fracture toughness due to IE and TE; or

- For CASS, if the application of applicable screening criteria for the component's material demonstrates that the components are not susceptible to either TE or IE, or the synergistic effects of TE and IE, then no other evaluation would be necessary. For assessment of CASS materials, the licensees or applicants for license renewal (LR) may apply the criteria in the NRC letter of May 19, 2000, "License Renewal Issue No. 98-0030, Thermal Aging Embrittlement of Cast Stainless Steel Components" [2] as the basis for determining whether the CASS materials are susceptible to the TE mechanism.

### 2.2.1 Utilized Methodology

[

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# 3.0 CRGT SPACER CASTINGS

This section summarizes the analysis performed of the CRGT spacer castings to fulfill A/LAI #7 from MRP-227-A.

## 3.1 *Background*

MRP-227-A provides I&E guidelines for the various component items including the CRGT spacer castings, which are considered a "Primary" item in MRP-227-A. The I&E guidelines specify applicability, effect and mechanism, expansion link, examination method/frequency, and examination coverage.

### 3.1.1 Description of the Component Item

This section contains an abbreviated description, including a short description of the functionality, consequence of failure, and operating experience of the component items.

The plenum assembly (upper internals) contains 69 vertical CRGT assemblies which are welded to the plenum cover plate and bolted to the upper grid. The outer portion of the CRGT assemblies is a pipe weldment consisting of an eight inch pipe welded to the CRGT assembly flange. The inside of each CRGT assembly consists of a brazement sub-assembly with ten parallel horizontal spacer castings to which are brazed 12 perforated vertical rod guide tubes (also called "C" tubes) and 4 pairs of vertical rod tube guide sectors (also called split tubes). There are a total of 690 spacer castings at each ONS unit. The CRGT spacer castings are made from American Society of Materials (ASTM) A 351-65, Grade CF-3M castings.

The CRGT assemblies provide control rod assembly (CRA) guidance, protect the CRA from the effects of coolant cross-flow, and structurally connect the upper grid assembly to the plenum cover. The outer pipe portion of the CRGT assembly provides the structural connection between the upper grid and the plenum cover. There are openings in the lower region of the pipe to allow some of the fluid entering the CRGT assembly from the core to exit to the plenum region. [

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The function of the CRGT spacer castings is to provide structural support and alignment to the 12 perforated vertical rod guide tubes and 4 pairs of vertical rod guide sectors within each CRGT assembly. [

] The control rod spider, which in turn supports the control rods, is guided by the brazement sub-assembly over the entire range of the vertical withdrawal path. In addition, the guide tube envelope limits reactor coolant cross-flow on the control rods to limit flow induced vibration. The spacer castings do not have a core support function; however, they do have a safety function relative to control rod alignment, insertion and reactivity issues. Degradation of the spacer castings could result in degradation in the unit shutdown capability by hindering the insertion of the control rods into the core in the normal anticipated time.

As of the MRP-227-A date, no cracking has been reported in the PWR RV internals as being attributed to embrittlement for CASS materials.

## 3.2 *Evaluation Inputs*

This section will describe the quantitative inputs for the evaluation, such as flaw size, degraded material properties, and stresses.

### 3.2.1 Flaw Size

[

]

### 3.2.2 Degraded Material Properties

A [ ] of the CRGT spacer castings at the ONS units exceed the screening criteria for TE and are therefore considered potentially susceptible. For the potentially susceptible CRGT spacer castings, [

]

### 3.2.3 Distortion Evaluation

[

]

## 3.3 *Evaluation*

The results of the methodology utilized are organized into several conclusions as discussed in the following sections.

### 3.3.1 Failure is Unlikely

[redacted]

### 3.3.2 Effect of Failure on Functionality

[redacted]

[

]

## 3.4 *Conclusions*

CASS materials are known to be potentially susceptible due to TE after exposure at PWR RV internals temperatures for long periods of time, especially those containing higher levels of ferrite and molybdenum. [

] The CRGT spacer casting material that does not exceed the screening criteria is not considered potentially susceptible to TE.

Based on the discussion above, it is concluded that the CRGT spacer castings will maintain functionality during the period of extended operation.

# 4.0 IMI GUIDE TUBE SPIDER CASTINGS

## 4.1 *Background*

MRP-227-A provides I&E guidelines for the various component items including the IMI guide tube spider castings, which are considered a "Primary" item in MRP-227-A. The I&E guidelines specify applicability, effect and mechanism, expansion link, examination method/frequency, and examination coverage.

### 4.1.1 Description of the Component Item

This section contains an abbreviated description, including a short description of the functionality, consequence of failure, and operating experience of the component items.

The lower grid assembly provides alignment and support for the fuel assemblies, supports the thermal shield and flow distributor, and aligns the incore instrument guide tubes with the fuel assembly instrument tubes. The IMI spiders are part of the RV lower internals and their function is to provide lateral support for the upper end of the IMI guide tubes although they have a minimal role in actually supporting the IMI guide tubes and do not provide a core support function. The IMI spider resembles a four eared butterfly nut and each of the 52 IMI guide tube spiders is custom machined to fit within the lower grid rib section. The outer edges of each of the four spider legs is fillet welded to the walls of the lower grid rib section (two fillet welds per spider leg). The relatively tight tolerance fit provides the lateral support for the guide tube while providing an axial slip fit to accommodate the axial expansion of the guide tube. The IMI guide tube spiders are fabricated from ASTM A 351-65 Grade CF-8 material.

[

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As of the MRP-227-A date, no cracking has been reported in the PWR RV internals as being attributed to embrittlement for CASS materials.

## 4.2 *Evaluation Inputs*

This section will describe the quantitative inputs for the evaluation, such as flaw size, degraded material properties, and stresses.

### 4.2.1 Flaw Size

[

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### 4.2.2 Degraded Material Properties

[redacted]

### 4.2.3 Flow-Induced Vibration Analysis

A FIV analysis was prepared for the IMI guide tube spiders installed at the ONS units. Three configurations of the spider and its associated welds were considered:

[redacted]

[

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### 4.2.4 Stress Analysis

[

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## 4.3 *Evaluation*

The results of the methodology utilized are organized into several conclusions as discussed in the following sections.

### 4.3.1 Failure is Unlikely

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[

] Additionally, the operating experience for the IMI guide tube spider castings at the ONS units has been good. [

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[

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### 4.3.2 Top Versus Bottom

[

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### 4.3.3 Effect of Failure on Functionality

The function of the IMI guide tube spider castings is to provide lateral restraint for the IMI guide tubes and the function of the spider fillet welds is to hold the spiders in place.

[

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As stated previously, the function of the IMI guide tube spider castings is to provide lateral restraint for the IMI guide tubes (i.e., maintain tube alignment). [

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## 4.4 *Conclusions*

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[ ]

Therefore, the IMI guide tube spider castings are expected to perform their function for the period of extended operation.

# 5.0 VENT VALVE RETAINING RINGS

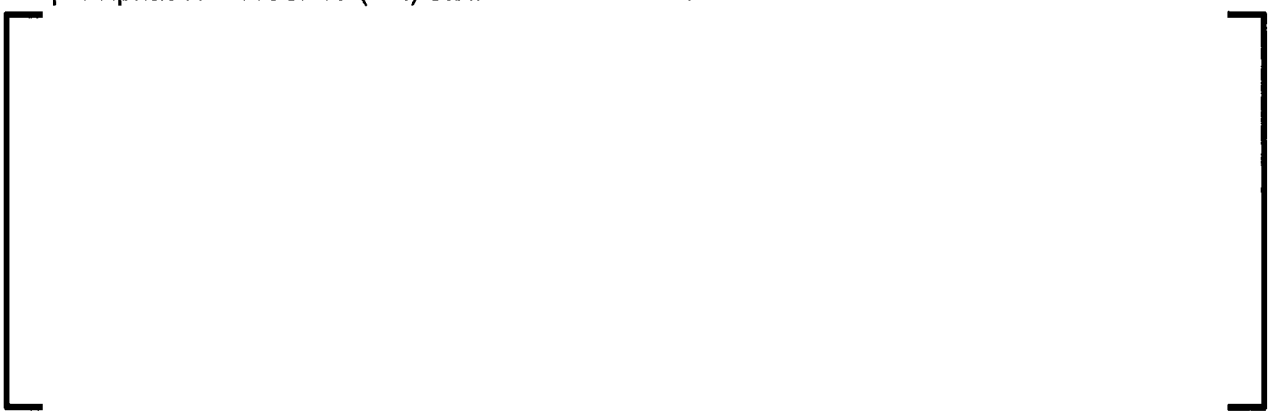
## 5.1 *Background*

MRP-227-A provides I&E guidelines for the various component items including the vent valve retaining rings, which are considered a "Primary" item in MRP-227-A. The I&E guidelines specify applicability, effect and mechanism, expansion link, examination method/frequency, and examination coverage.

### 5.1.1 Description of the Component Item

This section contains an abbreviated description, including a short description of the functionality, consequence of failure, and operating experience of the component items.

Each of the three ONS units has eight vent valves installed in the core support shield (CSS) cylinder. Each vent valve is mounted in a vent valve mounting ring (also called vent valve nozzle) which is welded into the CSS cylinder. For all normal operating conditions, the vent valve is closed but in the event of a pipe rupture in the reactor vessel inlet pipe, the valve will open to permit steam generated in the core to flow directly to the break, and will permit the core to be flooded and adequately cooled after emergency core coolant has been supplied to the reactor vessel. Each valve assembly includes two retaining rings with varying thicknesses and have integral threaded bosses at both ends to accept the jackscrews. They are fabricated from AMS 5658 Type 15-5 precipitation hardened (PH) stainless steel in the H1100 condition.



As of the MRP-227-A date, there is no known cracking of the vent valve retaining rings; there are several known instances of more susceptible types of PH stainless steel materials in other component systems failing.

## 5.2 *Evaluation Inputs*

This section will describe the quantitative inputs for the evaluation, including inputs such as flaw size, degraded material properties, and stresses.

### 5.2.1 Flaw Size

[
]

### 5.2.2 Degraded Material Properties

[

]

### 5.2.3 Stresses

[

]

## 5.3 *Evaluation*

The results of the methodology utilized are organized into several conclusions as discussed in the following sections.

### 5.3.1 Failure is Unlikely

[

] Additionally, as of the publication of MRP-227-A, there is no known cracking of the vent valve retaining rings. [

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[

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### 5.3.2 Effect of Failure on Functionality

[

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[redacted]

## 5.4 *Conclusions*

[

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Therefore, the vent valve retaining rings are expected to perform their function for the period of extended operation and in the unlikely event of failure, the primary vent valve functions is not expected to be impaired and the secondary vent valve function that could possibly be impaired would be detectable.

## 6.0 OVERALL CONCLUSIONS

A/AI#7 is applicable to CRGT spacer castings, vent valve retaining rings, and IMI guide tube spider castings for the ONS units. Based on the extensive evaluation summarized above, failure during the period of extended operation was found to be improbable for each of these three components. In the unlikely event of a failure occurring, the intended function of the component items is expected to be maintained or the failure will be detectable.

## 7.0 REFERENCES

1. Materials Reliability Program: Pressurized Water Reactor Internals Inspection and Evaluation Guidelines (MRP-227-A). EPRI, Palo Alto, CA: 2011. 1022863.

2. Letter from Christopher I. Grimes (NRC) to Douglas J. Walters (NEI), "License Renewal Issue No. 98-0030, "Thermal Aging Embrittlement of Cast Austenitic Stainless Steel Components," May 19, 2000, NRC Accession No. ML003717179.

ATTACHMENT 2

AREVA AFFIDAVIT

# AFFIDAVIT

COMMONWEALTH OF VIRGINIA )
) ss.
CITY OF LYNCHBURG )

1. My name is Gayle F. Elliott. I am Manager, Product Licensing, for AREVA NP Inc. (AREVA NP) and as such I am authorized to execute this Affidavit.

2. I am familiar with the criteria applied by AREVA NP to determine whether certain AREVA NP information is proprietary. I am familiar with the policies established by AREVA NP to ensure the proper application of these criteria.

3. I am familiar with the AREVA NP information contained in ANP-3267P, "MRP-227-A Applicant/Licensee Action Item #7, Analysis for the Oconee Nuclear Station Units," dated November 2013, and referred to herein as "Document." Information contained in this Document has been classified by AREVA NP as proprietary in accordance with the policies established by AREVA NP for the control and protection of proprietary and confidential information.

4. This Document contains information of a proprietary and confidential nature and is of the type customarily held in confidence by AREVA NP 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 Document as proprietary and confidential.

5. This Document has been made available to the U.S. Nuclear Regulatory Commission in confidence with the request that the information contained in this Document 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 qualifies under 10 CFR 2.390(a)(4) "Trade secrets and commercial or financial information."

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

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

(b) Use of the information by a competitor would permit the competitor to significantly reduce its expenditures, in time or resources, to design, produce, or market a similar product or service.

(c) The information includes test data or analytical techniques concerning a process, methodology, or component, the application of which results in a competitive advantage for AREVA NP.

(d) The information reveals certain distinguishing aspects of a process, methodology, or component, the exclusive use of which provides a competitive advantage for AREVA NP in product optimization or marketability.

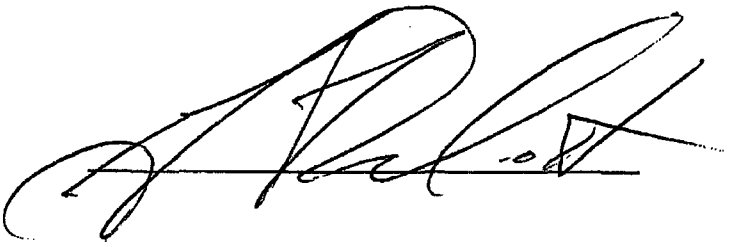
(e) The information is vital to a competitive advantage held by AREVA NP, would be helpful to competitors to AREVA NP, and would likely cause substantial harm to the competitive position of AREVA NP.

The information in this Document is considered proprietary for the reasons set forth in paragraphs 6(c) and 6(d) above.

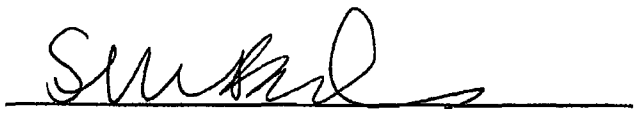
7. In accordance with AREVA NP's policies governing the protection and control of information, proprietary information contained in this Document has been made available, on a limited basis, to others outside AREVA NP only as required and under suitable agreement providing for nondisclosure and limited use of the information.

8. AREVA NP policy requires that proprietary information be kept in a secured file or area and distributed on a need-to-know basis.

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



SUBSCRIBED before me this 19th day of November, 2013.



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NOTARY PUBLIC, COMMONWEALTH OF VIRGINIA
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