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Light Water Reactor Sustainability Constellation Pilot Project FY13 Summary Report

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CONTENTS

FIGURES

ACRONYMS

BWR	Boiling Water Reactor
CENG	Constellation Energy Nuclear Group
DIC	Digital Image Correlation
DOE	Department of Energy
EPRI	Electric Power Research Institute
Ginna	R.E. Ginna Nuclear Power Plant
IASCC	Irradiation-Assisted Stress Corrosion Cracking
INL	Idaho National Laboratory
ISP	Integrated Surveillance Program
LTO	Long Term Operation Program (EPRI)
LWRS	Light Water Reactor Sustainability Program (DOE)
MAaD	Materials Aging and Degradation Pathway in LRWS
NMP1	Nine Mile Point Unit 1 Nuclear Power Plant
ORNL	Oak Ridge National Laboratory
PWR	Pressurized Water Reactor
RPV	Reactor pressure vessel
SCC	Stress Corrosion Cracking

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1. INTRODUCTION

As a partner in research for operations beyond 60 years, Constellation Energy Nuclear Group (CENG) has volunteered two of its nuclear power plants: R. E. Ginna and Nine Mile Point Unit 1 (NMP1). The coordinated work to be performed with CENG is a joint effort involving the Electric Power Research Institute (EPRI) Long Term Operation (LTO) Program and the Department of Energy (DOE) Light Water Reactor Sustainability (LWRS) Research & Development Program. The following report summarizes the activities performed in FY11 at Ginna and NMP1 power plants.

The R. E. Ginna nuclear power plant is located on Lake Ontario approximately 20 miles from Rochester, NY. The 581 MW capacity unit is a pressurized water reactor (PWR) which began commercial operation in 1970. The Nine Mile Point Unit 1 (NMP1) nuclear power plant is located on Lake Ontario approximately 40 miles from Syracuse, NY. The 620 MW capacity unit is a boiling water reactor (BWR) which began commercial operation in 1969. Both units have entered into their 60 year license renewal period, which makes them ideal units to gain further insight into the potential issues for license renewal beyond 60 years.

This report summarizes the activities in focus areas performed from October 1, 2012 through September 30, 2013. (FY13). Refer to INL/EXT-11-23461, Light Water Reactor Sustainability Constellation Pilot Project FY11 Summary Report for the period from October 1, 2010 through September 30, 2011. (FY11) and INL/EXT-12-27304, Light Water Reactor Sustainability Constellation Pilot Project FY12 Summary Report, for the period from October 1, 2011 through September 30, 2012 (FY12).

2. FY12 FOCUS AREAS

2.1 Reactor Metals

2.1.1 Ginna Baffle Bolts

Material degradation of the baffle-former bolts has been identified as a reactor vessel internals aging issue since the 1980s. In 1999, the utility operating Ginna Station (Rochester Gas and Electric) was acting in a proactive manner relative to potential cracking due to SCC and IASCC, as well as other possible degradation mechanisms. The original baffle-former bolt material is Type 347 stainless steel, which some data suggest could have a more pronounced susceptibility to damage than other stainless steels. Cracking of the bolts generally will occur at the shank to bolt head interface, which makes it impossible to see using visual testing (VT) methods since the head is captured with a weld and locking cup. Therefore, current guidance is to use ultrasonic testing (UT) methods to inspect 100% of the accessible bolts or justify a plant-specific plan, such as using a minimum integrity bolt pattern.

As result of the industry-wide programs on baffle bolt cracking, the Ginna plant replaced 56 baffle bolts in 1999. Some bolts were sent out for evaluation, resulting in approximately 42 bolts left on location at the plant site. As part of the aging management plant for Ginna, approximately 180 bolts were anticipated to be replaced during Spring 2011 outage to ensure the minimum bolting pattern to assure structural integrity under limiting operating conditions. The higher fluence baffle bolts from the 2011 replacement were identified as potential candidates for use in the MAaD pathway studies. However, the bolt material is 347 stainless steel which is not as ideal as 316 stainless steel for the studies.

The original spring 2011 schedule anticipated replacement of 18 bolts per day. However, bolt replacement during the outage proved to be significantly more difficult than anticipated. Only 28 bolts were removed and 3 could not be replaced. Bolt replacement was activities were stopped and a recently developed ultrasonic approach was implemented to confirm integrity of the minimum bolting pattern. Ultrasonic testing (UT) was performed on twenty-four of the removed bolts and no indications were identified.

The difficulty encountered during the bolt replacement has developed renewed interest in the baffle bolt replacement guidelines. Although the new probe design utilized at Ginna was successful, the use of welded cross bars limits access to the socket for other plant designs. Additionally, long term behavior of the baffle bolts may need to be better understood to support extended operation beyond 60 years. Therefore, further evaluation was recommended to develop a path forward for baffle bolt study. This evaluation was started in the second quarter of FY12. A fundamental requirement of this study is to understand the fluence levels to which the bolts have been exposed. In FY13, the fluence levels were evaluated and six bolts were selected as potential candidates for further evaluation. Two of the six bolts are anticipated to be evaluated under the LWRS program. The shipping requirements (Type A or Type B) for the bolts are currently under evaluation and need to be resolved prior to shipping. These requirements are anticipated to be resolved early to mid FY 14.

2.1.2 NMP1 Steam Dryer Lug Cracking

Indications were identified during the visual inspections of the steam dryer support brackets (or lugs). These indications led to subsequent supplementary UT examination to verify the extent and validity of the cracking indications. The support brackets had been previously inspected in 2001 using a similar inspection technique without any reportable indications being found. A flaw evaluation and crack growth analysis conservatively estimated that the lugs are acceptable for at least one more operating cycle. Re-inspection of the dryer lug was performed in the 2013 outage. The evaluation of the cracks determined the dryer lug was acceptable for another cycle.

Concrete monitoring at Ginna and NMP1were focused on augmented tests which can be deployed with available technology:

- Ginna Tendon Monitoring
- Ginna and NMP1 Liner Inspection
- Temperature Monitoring
- Crack Monitoring.

2.1.3 Ginna Tendon Monitoring

The cylindrical containment wall is pre-stressed with 160 vertical tendons within the wall of the containment that are equally spaced circumferentially around the containment. At penetrations in the containment (e.g. equipment hatch), the tendons are curved around the penetrations. These tendons are incorporated into the containment design in order to keep the cylindrical containment walls in compression during an internal pressurization.

In FY10, twenty of the vertical tendons and one exposed circumferential rebar were outfitted with a fiber optic strain gauges (Figures 1 and 2) connected to a Data Acquisition System (DAS) to monitor temperature and strain of the containment wall and tendons. Tendon strain gage data has been collected except for the period from 4/14/11 to 10/12/11 and from 2/28/12 to 5/8/12. The data gap resulted from a power disruption which exceeded the capability of the UPS. The data indicates that the tendon load is not significantly affected by shim temperature since the lines are relatively flat except for the SIT (pressure test) performed in early June 2011.

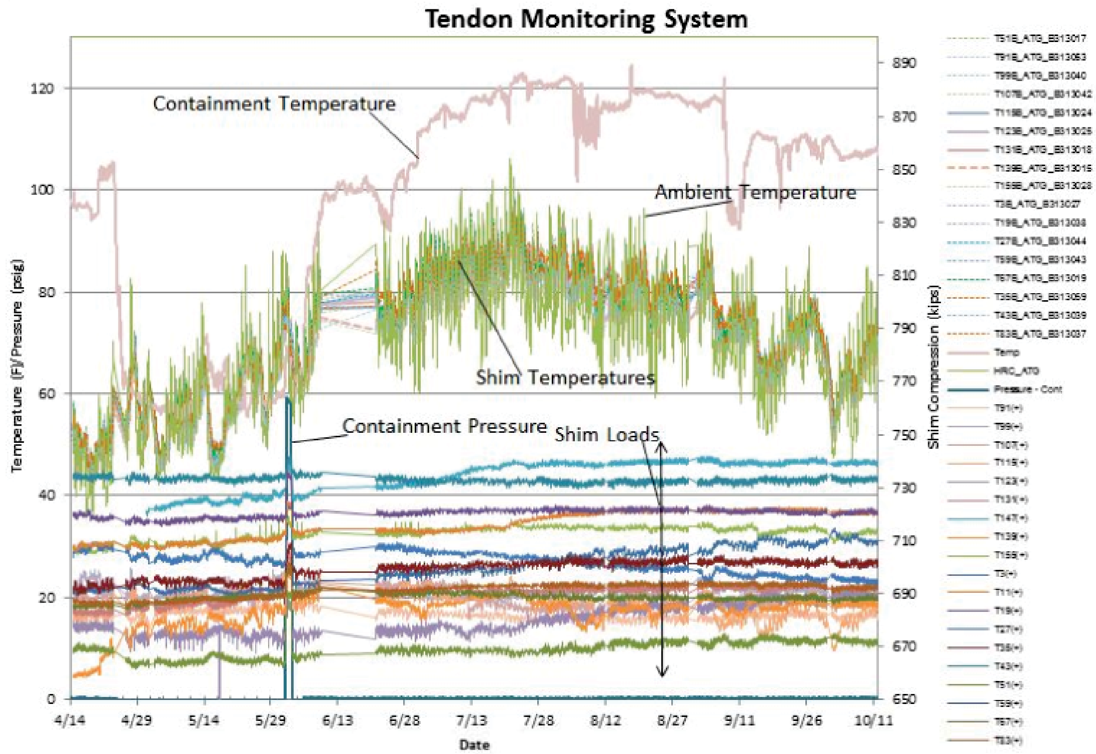

Figure 1. Tendon data from 4/14/11 to 10/12/11.

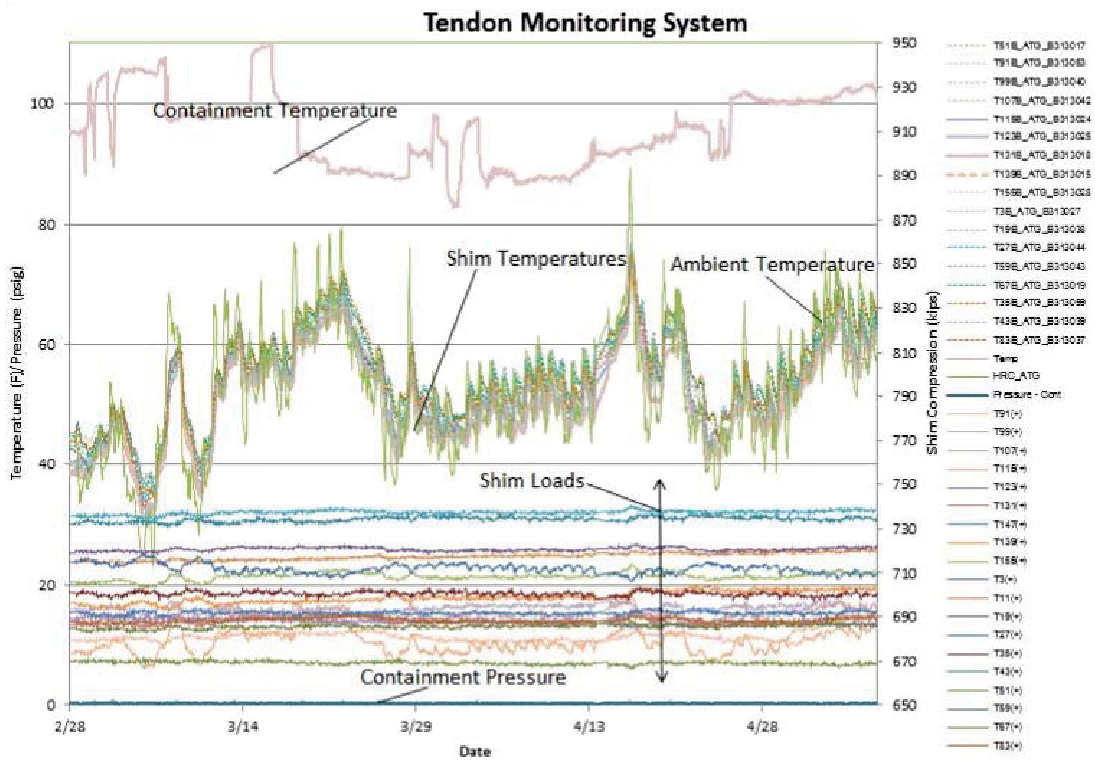

Figure 2. Tendon data from 2/28/12 to 5/8/12.

The data from the tendon, rebar, and concrete strain gage instrumentation has been collected for the past 2-1/2 years and compared. Some gaps in data exist due to the system being off-line due to power interruptions. However, the response of the tendons and the concrete during the pressurization test was consistent with analyses that were performed. The change in tendon loads over a two year period showed that the tendon loads were fully acceptable at the end of the monitoring period. A small number of strain gages on tendons are not providing data that is consistent with the expected performance of the tendons. These gages should be monitored in the future with additional data to improve the understanding of their behavior.

Additional information on the Ginna tendon monitoring system and results are in Reference 2 and 3.

2.1.4 Ginna and NMP1 Liner Inspections

Containment liners are susceptible to degradation mechanisms such as pitting and uniform corrosion. This degradation may occur in accessible and inaccessible regions. Detection of degradation will be tested using existing technology in representative containment configurations.

Mockups of the Ginna and NMP1 containment structures were fabricated in FY11. Three mockups were chosen to represent typical scenarios for this testing as follows:

- The Ginna containment mockup which represents a section of the liner that is near the base-mat. See Figure 3.
- The Ginna Alpha Sump mockup which represents an area below the reactor vessel. See Figure 4.
- The NMP1 containment mockup which represents a section of the drywell shell near the sand cushion. See Figure 5.

The liners were fabricated and tested without flaws prior to concrete placement. The flaws were introduced to simulate reproducible flaws representing corrosion. The flaws are located in both accessible and inaccessible regions. Figure 6 shows the flaws located in the Ginna containment structure. Once the concrete was cured testing resumed using Guided Wave and SAFT-UT method.

Figure 3. Ginna containment mockup.

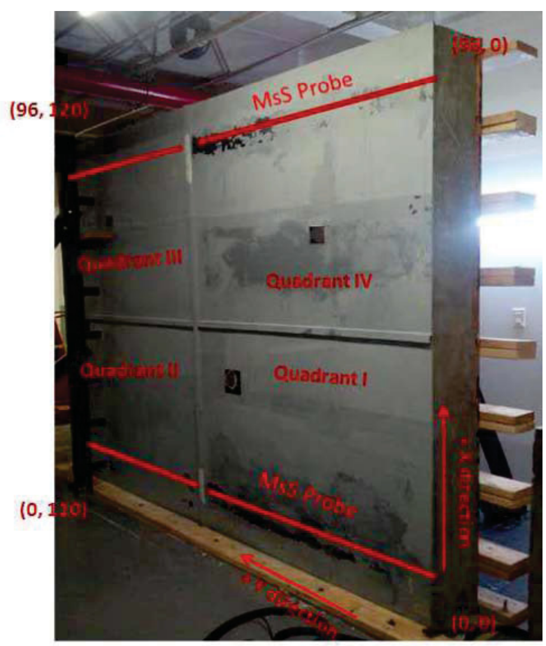

Figure 4. Ginna Alpha Sump region Mmockup.

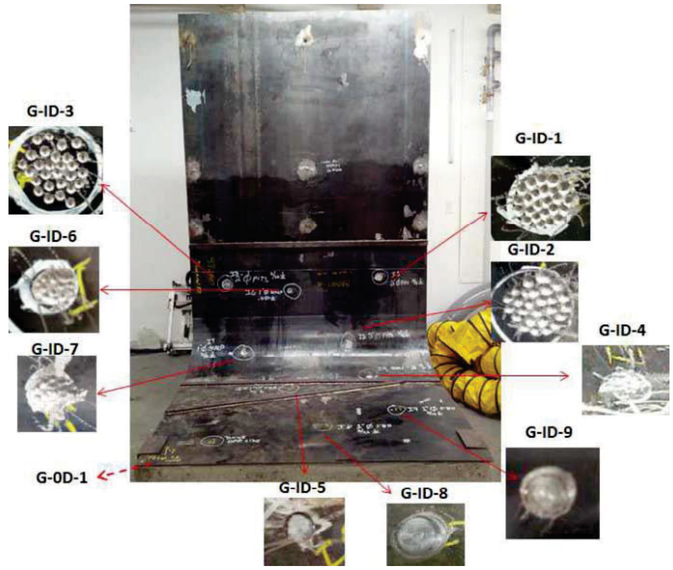

Figure 5. NMP1 containment mockup.

Figure 6. Flaws located in the Ginna containment mockup.

The testing of the mockups demonstrated the following:

- Flaw detection possible in visually inaccessible areas of the mockups is possible. Simulated corrosion-type flaws as small as 2 inches in diameter could be detected at a distance of several feet.
- Flaw presence was more effectively detected using the guided wave system
- Flaw size determination was better using the SAFT. However, both systems were not adequate.
- The SAFT system was more effective on thicker components (NMP1 drywell shell mockup).

Based on the results additional work is necessary to refine the detection methods. Refer to Reference 4 for additional information.

2.1.5 Temperature Monitoring

Temperature data loggers were installed right below each of the two hot leg penetrations through the reactor vessel support wall. Two additional data loggers were installed in the pressurizer cubicle. And the last two data loggers were installed in the vicinity of the reactor coolant pump motor stand. These data loggers will be left in place until the next outage. The temperature variation during the time between installation and removal will be available for future evaluation of temperature variation and effects within containment.

2.1.6 Crack Mapping

Cracks were mapped at Ginna and NMP1 during the augmented inspections as part of the demonstration project. The mapping was performed a high resolution digital camera to map the extent and the width of the concrete crack along its length. High resolution photography allows for precise measurements of the crack widths and layout. Calibrated markings placed on the wall, in the form of bars and dots, are used in benchmarking and scaling dimensions from the high definition photographs. The technique involves taking several photos with varying lighting conditions. The photos are then digitally analyzed with specialized computer software to produce a precise layout of the crack widths along the crack. An example of map cracking is shown in Figure 7. See Reference 3 for additional information.

Figure 7. Example of crack monitoring.

2.1.7 Augmented Containment Inspection Guideline

Based on the work performed as part of the Constellation Pilot project, an augmented containment inspection guideline has been developed to document the observations of maintenance and testing performed at the Constellation plants. The augmented inspections that are identified are intended to provide repeatable and quantitative data that can be compared with data that is taken in the future. These augmented inspections are not to replace but enhance current inspections. See Reference 5 for additional information.

3. RECOMMENDATIONS/FOLLOW-UP ACTIVITIES

The following activities were not completed and can be followed up in FY13 and beyond.

- Continuation of the evaluation of the path forward for the Ginna Baffle bolts. This will include the industry perspective based on long-term operation and the LWRS MAaD pathway goals.
- Removal and evaluation of the temperature monitoring instruments installed at Ginna.
- Continued evaluation and data interpretation of the tendon monitoring system installed at R.E. Ginna.

4. REFERENCES

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2. Lucius Pitkin, Inc., *Augmented Inspection Results,* A10551-R003, Rev. 0, Interim Release 2 August 2012.
3. Lucius Pitkin, Inc., *Augmented Inspection Results Supplement to LPI Report A12191-R-001,* A-12477-R-003, Draft, August 2013.
4. Lucius Pitkin, Inc., *T-SAFT and Guided Wave Examination of Containment Liners and Shells,* A-12477-R-001, Rev. 0, May 2013.
5. Lucius Pitkin, Inc., *Augmented Containment Inspection Guidelines,* Interim Report No. A-12477-R-004, Draft, September 2013.
6. Thomas C Esselman (Lucius Pitkin, Inc), Letter Report: *Augmented Containment Inspections Performed at the Ginna Station in 2012 Outage -- Work Performed under BEA Contract 00126388*, December 19, 2012.