UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

December 9, 2020

Mr. John A. Krakuszeski
Vice President
Brunswick Steam Electric Plant
Duke Energy Progress, LLC
8470 River Rd., SE (M/C BNP001)
Southport, NC 28461

SUBJECT: TRANSMITTAL OF FINAL BRUNSWICK STEAM ELECTRIC PLANT, UNIT 1 – ACCIDENT SEQUENCE PRECURSOR REPORT (LICENSEE EVENT REPORT 325-2020-003)

Dear Mr. Krakuszeski:

By letter dated September 21, 2020 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML20265A162), Brunswick Steam Electric Plant, Unit 1, submitted Licensee Event Report (LER) 325-2020-003, "Automatic Specified System Actuations due to Loss of Offsite Power," to the U.S. Nuclear Regulatory Commission (NRC) staff pursuant to Title 10 of the *Code of Federal Regulations* Section 50.73. As part of the Accident Sequence Precursor (ASP) Program, the NRC staff reviewed the event to identify potential precursors and to determine the probability of the event leading to a core damage state. The results of the analysis are provided in the enclosure to this letter.

The NRC does not request a formal analysis review, in accordance with Regulatory Issue Summary 2006-24, "Revised Review and Transmittal Process for Accident Sequence Precursor Analyses" (ADAMS Accession No. ML060900007), because the analysis resulted in a conditional core damage probability (CCDP) of less than $1\times10^{-4}$.

**Final ASP Analysis Summary.** A brief summary of the final ASP analysis, including the results, is provided below.

*Loss of Offsite Power During Hurricane Isaias*. This event is documented in LER 325-2020-003.

*Executive Summary*. On August 3, 2020, a loss of offsite power (LOOP) occurred at Brunswick Steam Electric Plant, Unit 1, that resulted in a reactor scram. Emergency diesel generators 1 and 2 automatically started and loaded to their respective emergency buses. Operators manually started reactor core isolation cooling and high-pressure coolant injection to maintain reactor water level and provide pressure control, respectively. An Unusual Event was declared at 11:12 p.m. At the time of the event, Unit 1 was in the process of shutting down for maintenance associated with a ground on the main generator and was not synchronized to the grid.

As a result of the reactor trip, reactor water level reached low level 1, which results in an isolation signal of the Group 2 (i.e., floor and equipment drains), Group 6 (i.e., monitoring and sampling), and Group 8 (i.e., shutdown cooling) valves. The Group 8 valves were closed at the time of the event. Per design, the LOOP also caused a Group 1 (i.e., main steam isolation

valve) isolation. The Unit 1 LOOP did not affect Unit 2, which remained at 100-percent power. Operators restored offsite power to the Unit 1 non-safety-related buses from the unit auxiliary transformer in approximately 37 minutes. Offsite power was restored to the two safety buses via the station auxiliary transformer, and the Unusual Event was exited at 2:54 p.m. on August 4, 2020.

This ASP analysis reveals that the most likely core damage sequence is a LOOP initiating event, and the successful operation of the emergency diesel generators providing safety-related alternating current power with subsequent (postulated) failure of both high pressure coolant injection and reactor core isolation cooling and operators failing to depressurize the reactor. This accident sequence accounts for approximately 72 percent of the total CCDP for this event. FLEX mitigation strategies were credited in this analysis; however, the risk impact was minimal because postulated station blackout scenarios are not a dominant risk contributor.

*Summary of Analysis Results*. This operational event resulted in a best estimate CCDP of $2\times10^{-5}$.

If you have any questions, please contact me at 301-415-8480 or by e-mail to Andrew.Hon@nrc.gov.

Sincerely,

***/RA/***

Andrew Hon, Project Manager
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 05000325

Enclosure:
Final ASP Analysis - Precursor

cc: Listserv

# ENCLOSURE

Final ASP Analysis – Precursor

Brunswick Steam Electric Plant, Unit 1 – Loss of Offsite Power During Hurricane Isaias (LER 325-2020-003)

# Final ASP Analysis – Precursor

| Accident Sequence Precursor Program – Office of Nuclear Regulatory Research | | | |
|---|---|---|---|
| **Brunswick Steam Electric Plant, Unit 1** | Loss of Offsite Power during Hurricane Isaias | | |
| **Event Date:** 8/3/2020 | **LER:** 325-2020-003<br>**IR:** TBD | | **CCDP =** $2\times10^{-5}$ |
| **Plant Type:** | General Electric Type 4 Boiling-Water Reactor (BWR) with a Mark I Containment | | |
| **Plant Operating Mode (Reactor Power Level):** | Mode 1 (19% Reactor Power) | | |
| **Analyst:** Christopher Hunter | **Reviewer:** Mehdi Reisi Fard | **Completion Date:** 11/12/2020 | |

## 1 EXECUTIVE SUMMARY

On August 3, 2020, a loss of offsite power (LOOP) occurred on Brunswick Steam Electric Plant Unit 1 that resulted in a reactor scram. Emergency diesel generators (EDGs) 1 and 2 automatically started and loaded to their respective emergency buses. Operators manually started reactor core isolation cooling (RCIC) and high-pressure coolant injection (HPCI) to maintain reactor water level and provide pressure control, respectively. An Unusual Event was declared at 11:12 p.m. At the time of the event, Unit 1 was in the process of shutting down for maintenance associated with a ground on the main generator and was not synced to the grid.

As a result of the reactor trip, reactor water level reached low level 1, which results in an isolation signal of the Group 2 (i.e., floor and equipment drains), Group 6 (i.e., monitoring and sampling) and Group 8 (i.e., shutdown cooling) valves. The Group 8 valves were closed at the time of the event. Per design, the LOOP also caused a Group 1 (i.e., main steam isolation valve) isolation. The Unit 1 LOOP did not affect Unit 2, which remained at 100-percent power. Operators restored offsite power to the Unit 1 nonsafety-related buses from the UAT in approximately 37 minutes. Offsite power was restored to the two safety buses via the station auxiliary transformer (SAT) and the Unusual Event was exited at 2:54 p.m. on August 4th.

This accident sequence precursor (ASP) analysis reveals that the most likely core damage sequence is a loss of offsite power (LOOP) initiating event and the successful operation of the EDGs providing safety-related alternating current (AC) power with subsequent (postulated) failure of both HPCI and RCIC and operators failing to depressurize the reactor. This accident sequence accounts for approximately 72 percent of the total conditional core damage probability (CCDP) for this event. FLEX mitigation strategies were credited in this analysis; however, the risk impact was minimal because postulated station blackout (SBO) scenarios are not a dominant risk contributor. The ASP analysis results reinforce that a LOOP resulting from natural phenomenon outside the licensees' control is a substantial risk contributor; however, plant and operator response were timely and appropriate to mitigate the risk of the event.

# 2 EVENT DETAILS

## 2.1 Event Description

On August 3, 2020, a LOOP occurred on Brunswick Steam Electric Plant Unit 1 that resulted in a reactor scram. EDGs 1 and 2 automatically started and loaded to their respective emergency buses. Operators manually started RCIC and HPCI to maintain reactor water level and provide pressure control, respectively. An Unusual Event was declared at 11:12 p.m. At the time of the event, Unit 1 was in the process of shutting down for maintenance associated with a ground on the main generator and was not synced to the grid.

As a result of the reactor trip, reactor water level reached low level 1, which results in an isolation signal of the Group 2 (i.e., floor and equipment drains), Group 6 (i.e., monitoring and sampling) and Group 8 (i.e., shutdown cooling) valves. The Group 8 valves were closed at the time of the event. Per design, the LOOP also caused a Group 1 (i.e., main steam isolation valve) isolation. The Unit 1 LOOP did not affect Unit 2, which remained at 100-percent power.[1] Operators restored offsite power to the Unit 1 nonsafety-related buses from the UAT in approximately 37 minutes. Offsite power was restored to the two safety buses via the SAT and the Unusual Event was exited at 2:54 pm. on August 4th. Additional information is provided in licensee event report (LER) 325-2020-002, "Automatic Specified System Actuations due to Loss of Offsite Power," (ADAMS Accession No. ML20265A162).

## 2.2 Cause

The licensee determined that the electrical fault that resulted in the transformer bus powering the SAT to trip and the subsequent LOOP was caused storm-generated debris from Hurricane Isaias.

# 3 MODELING

## 3.1 SDP Results/Basis for ASP Analysis

The ASP Program performs independent analyses for initiating events. ASP analyses of initiating events account for all failures/degraded conditions and unavailabilities (e.g., equipment out for maintenance) that occurred during the event, regardless of licensee performance.[2]

Additional LERs were reviewed to determine if concurrent unavailabilities existed during the August 3rd event. No windowed events were identified. Discussions with Region 2 staff indicate that no licensee performance deficiency associated with this event has been identified; however, the LER remains open.

## 3.2 Analysis Type

An initiating event analysis was performed using Revision 9.33 of the standardized plant analysis risk (SPAR) model for Brunswick Steam Electric Plant (Unit 1) created on July 31, 2020. This event was modeled as a switchyard-centered LOOP initiating event.

---

[1] The Unit 2 EDGs started but did not load onto their respective safety buses because they remained energized via offsite power throughout the event.

[2] ASP analyses also account for any degraded condition(s) that were identified after the initiating event occurred if the failure/degradation exposure time(s) overlapped the initiating event date.

### 3.3 SPAR Model Modifications

No SPAR model modifications were needed for this analysis.

### 3.4 Analysis Assumptions

The following modeling assumptions were determined to be significant to the modeling of this initiating event assessment:

- The probability of IE-LOOPSC (*loss of offsite power (switchyard-centered)*) was set to 1.0 due to the loss of offsite power. All other initiating event probabilities were set to zero.

- Basic event OEP-VCF-LP-SITESC (*site LOOP (switchyard-centered)*) was set to FALSE because the event was single unit LOOP.

- The probability of basic event FLX-XHE-XM-ELAP (*operators fail to declare ELAP when beneficial*) was set to it nominal value of $1\times10^{-2}$ to activate the credit for FLEX mitigation strategies for SBO scenarios for which an extended loss of AC power (ELAP) is declared. Sensitivity analyses show that the amount of FLEX credit has a minimal impact on the analysis results.

- Offsite power was restored to the two safety buses via the SAT in approximately 15 and 17 hours, respectively. It is believed that operators could have restored offsite power more quickly if postulated SBO had occurred. However, an exact determination on when the offsite power could have been restored is not available. Given this uncertainty, basic events OEP-XHE-XL-NR30MSC (*operators fail to recover offsite power in 30 minutes*) and OEP-XHE-XL-NR02HSC (*operators fail to recover offsite power in 2 hours*) were set to TRUE. Although this assumption is potentially conservative, sensitivity analyses show credit for the offsite power recovery has a minimal impact on the analysis results.

## 4 ANALYSIS RESULTS

### 4.1 Results

The mean CCDP for this analysis is calculated to be $2.0\times10^{-5}$. The ASP Program threshold for initiating events is a CCDP of $10^{-6}$ or the plant-specific CCDP of an uncomplicated reactor trip with a non-recoverable loss of feed water or the condenser heat sink, whichever is greater. This CCDP equivalent for Brunswick Steam Electric Plant (Unit 1) is $1.5\times10^{-5}$. Therefore, this event is a precursor.

The parameter uncertainty results for this analysis provided below:

**Table 1. Parameter Uncertainty Results**

| 5% | Median | Point Estimate | Mean | 95% | Sample Size | Method |
|---|---|---|---|---|---|---|
| 1.65E-6 | 9.68E-6 | 1.69E-5 | 1.97E-5 | 7.17E-5 | 5000 | Monte Carlo |

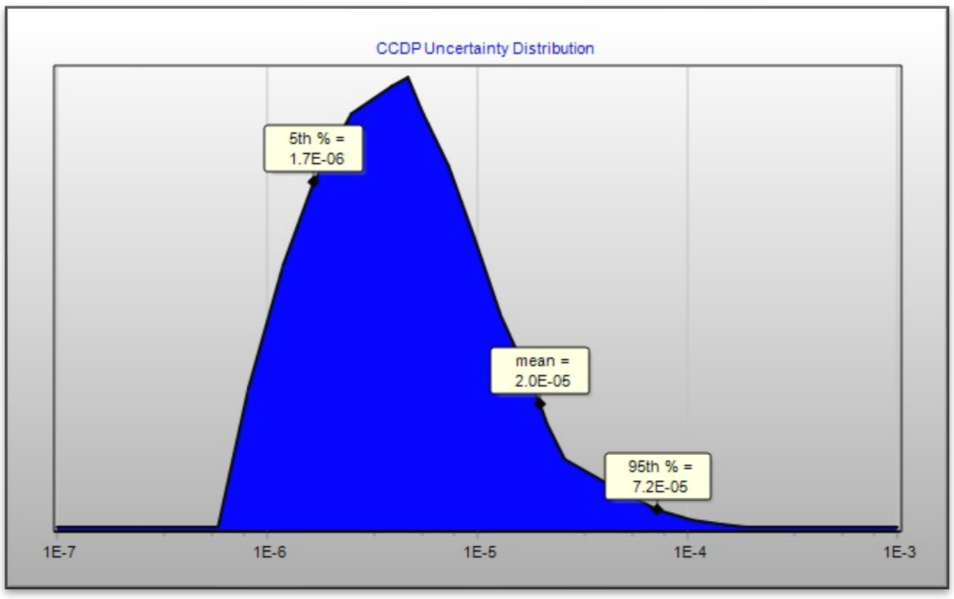


**Figure 1. CCDP Uncertainty Distribution**

## 4.2 Dominant Sequences[3]

The dominant accident sequence is a switchyard LOOP sequence 25 (ΔCDP = $1.2\times10^{-5}$), which contributes approximately 72 percent of the total CCDP. The sequences that contribute at least 5.0 percent to the total CCDP are provided in the following table. The event tree with the dominant sequence is shown graphically in Figure A-1 of Appendix A.

**Table 2. Dominant Sequences**

| Sequence | ΔCDP | % | Description |
|---|---|---|---|
| LOOPSC 25 | $1.22\times10^{-5}$ | 72.3% | Switchyard LOOP initiating event occurs; successful reactor trip; EDGs successfully provide power to at least one 4-kV safety-related bus; all high-pressure injection sources fail; and reactor depressurization fails resulting in core damage |
| LOOPSC 6 | $1.46\times10^{-6}$ | 8.7% | Switchyard LOOP initiating event occurs; successful reactor trip; EDGs successfully provide power to at least one 4-kV safety-related bus; at least one high-pressure injection source is successful; suppression pool cooling fails; reactor depressurization succeeds; low-pressure injection is successful; containment spray fails; and containment venting fails resulting in core damage |
| LOOPSC 28 | $9.88\times10^{-7}$ | 5.9% | Switchyard LOOP initiating event occurs; successful reactor trip; the SRVs fail to open resulting in core damage |

[3] The CCDPs in this section are point estimates.

### 4.3 Key Uncertainties

A review of the analysis assumptions and results did not reveal key modeling uncertainties. Because of the minimal risk impact of postulated SBO scenarios, the typical modeling uncertainties (e.g., hardware and human reliability of FLEX mitigation strategies, stuck-open SRV probabilities and modeling) were not significant to this analysis.

# Appendix A: Key Event Tree

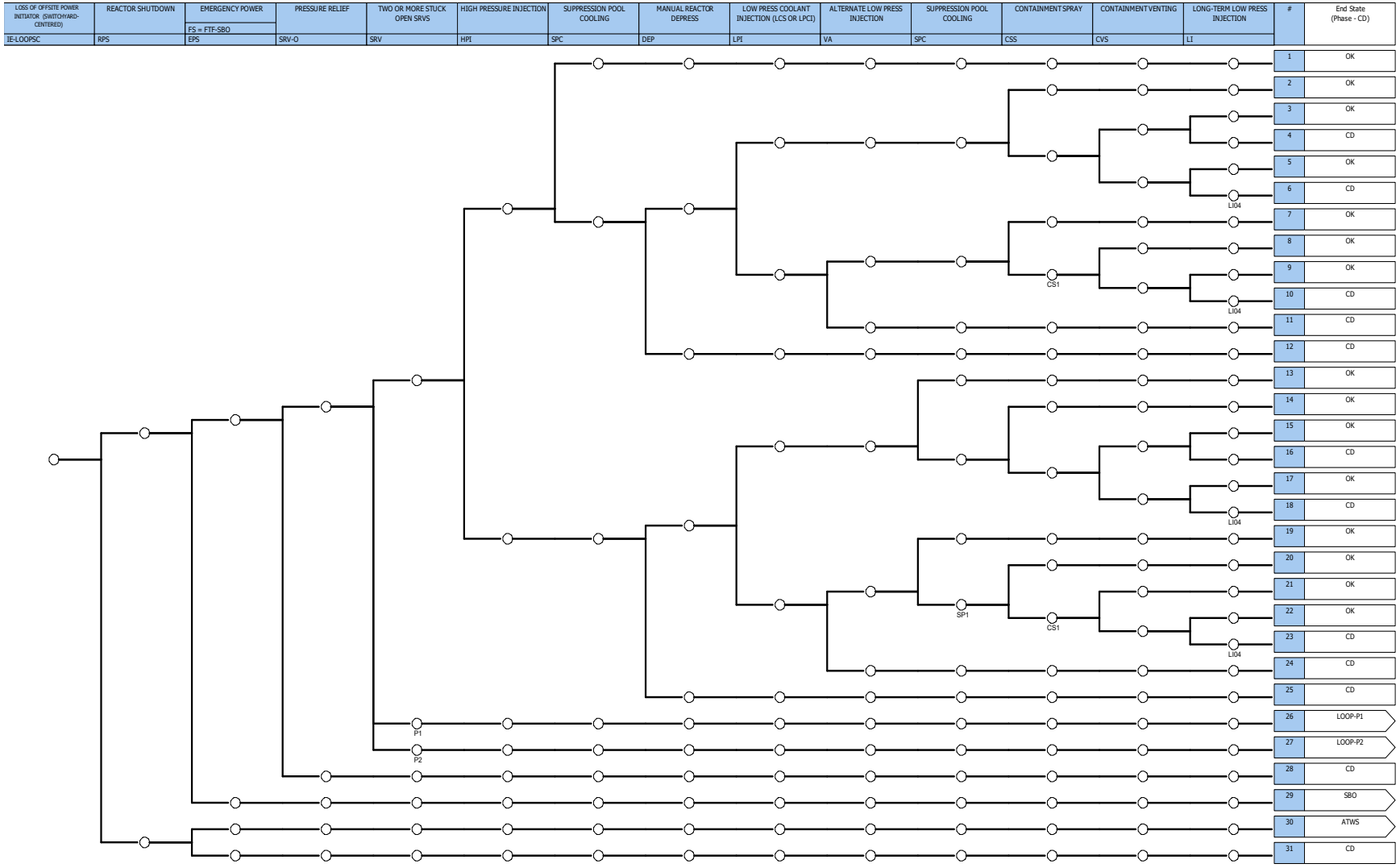


**Figure A-1. Brunswick (Unit 1) Switchyard LOOP Event Tree**

SUBJECT: TRANSMITTAL OF FINAL BRUNSWICK STEAM ELECTRIC PLANT, UNIT 1 – ACCIDENT SEQUENCE PRECURSOR REPORT (LICENSEE EVENT REPORT 325-2020-003) DATED DECEMBER 9, 2020

**DISTRIBUTION**:
PUBLIC
PM File Copy
RidsACRS_MailCTR Resource
RidsNrrDorlLpl2-2 Resource
RidsNrrLABAbeywickrama Resource
RidsNrrPMBrunswickResource
RidsRgn2MailCenter Resourc
CHunter, RES

**ADAMS Accession Nos.:**
**ML20321A190 (Package)**
**ML20321A157 (Letter)**
**ML20294A552 (ASP Report)** ***via e-mail**

| OFFICE | NRR/DORL/LPL2-2/PM* | NRR/DORL/LPL2-2/LA* | NRR/DORL/LPL2-2/PM* |
|---|---|---|---|
| NAME | AHon | BAbeywickrama (LRonewicz for) | AHon |
| DATE | 11/17/2020 | 11/17/2020 | 12/09/2020 |

**OFFICIAL RECORD COPY**