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

September 12, 2019

Mr. Daniel G. Stoddard
Senior Vice President and Chief Nuclear Officer
Innsbrook Technical Center
5000 Dominion Blvd.
Glen Allen, VA 23060-6711

SUBJECT: NORTH ANNA POWER STATION, UNIT NOS. 1 AND 2 – ISSUANCE OF AMENDMENT NOS. 282 AND 265 TO REVISE TECHNICAL SPECIFICATIONS REGARDING OPEN PHASE PROTECTION (EPID L-2018-LLA-0132)

Dear Mr. Stoddard:

The U.S. Nuclear Regulatory Commission has issued the enclosed Amendment Nos. 282 and 265 to Renewed Facility Operating License Nos. NPF-4 and NPF-7 for the North Anna Power Station (North Anna), Unit Nos. 1 and 2, respectively. These amendments are in response to your application dated April 30, 2018, as supplemented by letters dated May 24 and August 8, 2019.

The amendments revise North Anna Technical Specifications to add operability requirements, required actions, and surveillance requirements for the new 4160 volt emergency bus voltage unbalance protection systems. As indicated in your application, the system was installed as part of the Virginia Electric Power Company response to NRC Bulletin 2012-01.

A copy of the related Safety Evaluation is also enclosed. A Notice of Issuance will be included in the Commission's biweekly *Federal Register* notice.

Sincerely,

G. Edward Miller, Project Manager
Special Projects and Process Branch
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-338 and 50-339

Enclosures:
1. Amendment No. 282 to NPF-4
2. Amendment No. 265 to NPF-7
3. Safety Evaluation

cc: Listserv

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

VIRGINIA ELECTRIC AND POWER COMPANY

DOCKET NO. 50-338

NORTH ANNA POWER STATION, UNIT NO. 1

AMENDMENT TO RENEWED FACILITY OPERATING LICENSE

Amendment No. 282
Renewed License No. NPF-4

1. The Nuclear Regulatory Commission (the Commission) has found that:

   A. The application for amendment by Virginia Electric and Power Company et al., (the licensee) dated April 30, 2018, as supplemented by letters dated May 24 and August 8, 2019, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's rules and regulations as set forth in 10 CFR Chapter I;

   B. The facility will operate in conformity with the application, the provisions of the Act, and the rules and regulations of the Commission;

   C. There is reasonable assurance (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations;

   D. The issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public; and

   E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

2. Accordingly, the license is amended by changes to paragraph 2.C (2) of Renewed Facility Operating License No. NPF-4, as indicated in the attachment to this license amendment, and is hereby amended to read as follows:

   (2) Technical Specifications

   The Technical Specifications contained in Appendices A, as revised through Amendment No. 282, are hereby incorporated in the renewed license. The licensee shall operate the facility in accordance with the Technical Specifications.

3. This license amendment is effective as of its date of issuance and shall be implemented by the completion of the fall 2019 refueling outage.

FOR THE NUCLEAR REGULATORY COMMISSION

Michael T. Markley, Chief
Plant Licensing Branch II-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Operation

Attachment:
Changes to Renewed Facility
Operating License No. NPF-4
and Technical Specifications

Date of Issuance: September 12, 2019

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

VIRGINIA ELECTRIC AND POWER COMPANY

DOCKET NO. 50-339

NORTH ANNA POWER STATION, UNIT NO. 2

AMENDMENT TO RENEWED FACILITY OPERATING LICENSE

Amendment No. 265
Renewed License No. NPF-7

1. The Nuclear Regulatory Commission (the Commission) has found that:

   A. The application for amendment by Virginia Electric and Power Company et al., (the licensee) dated April 30, 2019, as supplemented by letters dated May 24 and August 8, 2019, complies with the standards and requirements of the Atomic Energy Act of 1954, as amended (the Act), and the Commission's rules and regulations as set forth in 10 CFR Chapter I;

   B. The facility will operate in conformity with the application, the provisions of the Act, and the rules and regulations of the Commission;

   C. There is reasonable assurance (i) that the activities authorized by this amendment can be conducted without endangering the health and safety of the public, and (ii) that such activities will be conducted in compliance with the Commission's regulations;

   D. The issuance of this amendment will not be inimical to the common defense and security or to the health and safety of the public; and

   E. The issuance of this amendment is in accordance with 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

2. Accordingly, the license is amended by changes to paragraph 2.C (2) of Renewed Facility Operating License No. NPF-7, as indicated in the attachment to this license amendment, and is hereby amended to read as follows:

   (2) Technical Specifications

   The Technical Specifications contained in Appendix A, as revised through Amendment No. 265, are hereby incorporated in the renewed license. The licensee shall operate the facility in accordance with the Technical Specifications.

3. This license amendment is effective as of its date of issuance and shall be implemented by the completion of the fall 2020 refueling outage.

FOR THE NUCLEAR REGULATORY COMMISSION

Michael T. Markley, Chief
Plant Licensing Branch II-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Operation

Attachment:
Changes to Renewed Facility
Operating License No. NPF-7
and Technical Specifications

Date of Issuance: September 12, 2019

ATTACHMENT TO

NORTH ANNA POWER STATION, UNIT NOS. 1 AND 2

LICENSE AMENDMENT NO. 282

RENEWED FACILITY OPERATING LICENSE NO. NPF-4

DOCKET NO. 50-338

AND LICENSE AMENDMENT NO. 265

RENEWED FACILITY OPERATING LICENSE NO. NPF-7

DOCKET NO. 50-339

Replace the following pages of the Renewed Facility Operating Licenses with the attached revised pages. The revised pages are identified by amendment number and contain marginal lines indicating the areas of change.

Remove	Insert
NPF-4, page 3	NPF-4, page 3
NPF-7, page 3	NPF-7, page 3

Replace the following pages of the Appendix A Technical Specifications with the attached revised pages. The revised pages are identified by amendment number and contain marginal lines indicating the areas of change.

Remove	Insert
3.3.5-1	3.3.5-1
3.3.5-2	3.3.5-2
3.3.5-3	3.3.5-3
--	3.3.5-4

(2) Pursuant to the Act and 10 CFR Part 70, VEPCO to receive, possess, and use at any time special nuclear material as reactor fuel, in accordance with the limitations for storage and amounts required for reactor operation, as described in the Updated Final Safety Analysis Report;

(3) Pursuant to the Act and 10 CFR Parts 30, 40, and 70, VEPCO to receive, possess, and use at any time any byproduct, source, and special nuclear material as sealed neutron sources for reactor startup, sealed sources for reactor instrumentation and radiation monitoring equipment calibration, and as fission detectors in amounts as required;

(4) Pursuant to the Act and 10 CFR Parts 30, 40, and 70, VEPCO to receive, possess, and use in amounts as required any byproduct, source, or special nuclear material, without restriction to chemical or physical form, for sample analysis or instrument calibration or associated with radioactive apparatus or component; and

(5) Pursuant to the Act and 10 CFR Parts 30 and 70, VEPCO to possess, but not separate, such byproduct and special nuclear materials as may be produced by the operation of the facility.

C. This renewed operating license shall be deemed to contain and is subject to the conditions specified in the following Commission regulations in 10 CFR Chapter I; Part 20, Section 30.34 of Part 30, Section 40.41 of Part 40, Sections 50.54 and 50.59 of Part 50, and Section 70.32 of Part 70; is subject to all applicable provisions of the Act and to the rules, regulations, and orders of the Commission now or hereafter in effect; and is subject to the additional conditions specified or incorporated below:

(1) Maximum Power Level

VEPCO is authorized to operate the North Anna Power Station, Unit No. 1, at reactor core power levels not in excess of 2940 megawatts (thermal).

(2) Technical Specifications

Technical Specifications contained in Appendix A, as revised through Amendment No. 282 are hereby incorporated in the renewed license. The licensee shall operate the facility in accordance with the Technical Specifications.

(3) Pursuant to the Act and 10 CFR Parts 30, 40, and 70, VEPCO to receive possess, and use at any time any byproduct, source, and special nuclear material as sealed neutron sources for reactor startup, sealed sources for reactor instrumentation and radiation monitoring equipment calibration, and as fission detectors in amounts as required;

(4) Pursuant to the Act and 10 CFR Parts 30, 40, and 70, VEPCO to receive, possess, and use in amounts as required any byproduct, source, or special nuclear material, without restriction to chemical or physical form, for sample analysis or instrument calibration or associated with radioactive apparatus or component; and

(5) Pursuant to the Act and 10 CFR Parts 30, 40, and 70, VEPCO to possess, but not separate, such byproduct and special nuclear materials as may be produced by the operation of the facility.

C. This renewed license shall be deemed to contain and is subject to the conditions specified in the Commission's regulations as set forth in 10 CFR Chapter I and is subject to all applicable provisions of the Act and to the rules, regulations, and orders of the Commission now or hereafter in effect; and is subject to the additional conditions specified or incorporated below:

(1) Maximum Power Level

VEPCO is authorized to operate the facility at steady state reactor core power levels not in excess of 2940 megawatts (thermal).

(2) Technical Specifications

The Technical Specifications contained in Appendix A, as revised through Amendment No. 265 are hereby incorporated in the renewed license. The licensee shall operate the facility in accordance with the Technical Specifications.

(3) Additional Conditions

The matters specified in the following conditions shall be completed to the satisfaction of the Commission within the stated time periods following the insurance of the condition or within the operational restrictions indicated. The removal of these conditions shall be made by an amendment to the renewed license supported by a favorable evaluation by the Commission:

a. If VEPCO plans to remove or to make significant changes in the normal operation of equipment that controls the amount of radioactivity in effluents from the North Anna Power Station, the

3.3 INSTRUMENTATION

3.3.5 Loss of Power (LOP) Emergency Diesel Generator (EOG) Start Instrumentation

LCO 3.3'.5 Three channels per bus of the loss of voltage Function and three channels per bus of the degraded voltage Function, and three channels per bus of the negative sequence Function for the following 4160 VAC buses shall be OPERABLE:

a. The Train Hand Train J buses; and

b. One bus on the other unit for each required shared component.

APPLICABILITY: MODES 1, 2, 3, and 4,
When associated EOG is required to be OPERABLE by LCO 3.8.2, "AC Sources-Shutdown."

ACTIONS

------------------------------------ NOTE ------------------------------------
Separate Condition entry is allowed for each Function.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. One or more Functions with one channel per bus inoperable.	A.1 ---------NOTE--------- The inoperable channel may be bypassed for up to 12 hours for surveillance testing of other channels. --------------------- Place channel in trip.	72 hours

ACTIONS

CONDITION	REQUIRED ACTION		COMPLETION TIME
8. One or more Functions with two or more channels per bus inoperable.	B.1	-----------NOTE----------- If the negative sequence voltage protection function cannot be performed (e.g., the 4160V to 480V Balance Relay is tripped), the negative sequence voltage protection does not have to be declared inoperable provided verification is performed at least once per 24 hours that an open phase condition does not exist on the primary side of transformer TX-3 and the Reserve Station Service Transformers, as well as the Unit 1/Unit 2 Main Step-up Transformers when power is supplied by the dependable alternate source. The negative sequence voltage protection function shall be restored within 72 hours. ------------------------------ Restore all but one channel to OPERABLE status.	1 hour
C. Required Action and associated Completion Time not met.	C.1	Enter applicable Condition(s) and Required Action(s) for the associated EDG made inoperable by LOP EDG start instrumentation.	Immediately

SURVEILLANCE REQUIREMENTS

	SURVEILLANCE	FREQUENCY
SR 3.3.5.1	--------------------NOTE---------------- Verification of setpoint is not required. -- Perform TADOT for LCD 3.3.5.a and LCD 3.3.5.b Loss of Voltage/Degraded Voltage Functions.	In accordance with the Surveillance Frequency Control Program
SR 3.3.5.2	--------------------NOTE---------------- Verification of setpoint is not required. -- Perform TADOT for LCD 3.3.5.a and LCD 3.3.5.b Negative Sequence Relay Functions.	In accordance with the Surveillance Frequency Control Program
SR 3.3.5.3	--------------------NOTE---------------- Negative Sequence Voltage is calculated as a percentage of nominal voltage. -- Peiform CHANNEL CALIBRATION with Allowable Values as follows: a. Loss of voltage Allowable Values 2935 V and 3225 V with a time delay of 2 ±1 seconds for LCD 3.3.5.a and LCO 3.3.5.b Functions. b. Degraded voltage Allowable Values 3720 V and 3772 V with: 1. A time delay of 7.5 ±1.5 seconds with a Safety Injection (SI) signal for LCD 3.3.5.a Function; and 2. A time delay of 56 ±7 seconds without an SI signal for LCD 3.3.5.a and LCD 3.3.5.b Functions. c. Negative Sequence Voltage 2.894% and 5.106% for LCO 3.3.5.a and LCD 3.3.5.b Functions.	In accordance with the Surveillance Frequency Control Program

SURVEILLANCE REQUIREMENTS

	SURVEILLANCE	FREQUENCY
	---NOTE--- ESF Response Times are only applicable to Loss of Voltage and Degraded Voltage Functions.	
SR 3.3.5.4	Verify ESF RESPONSE TIMES are within limit for LCO 3.3.5.a and LCO 3.3.5.b Functions.	In accordance with the Surveillance Frequency Control Program

UNITED STATES
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WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO

AMENDMENT NO. 282 TO RENEWED FACILITY OPERATING LICENSE NO. NPF-4

AND

AMENDMENT NO. 265 TO RENEWED FACILITY OPERATING LICENSE NO. NPF-7

VIRGINIA ELECTRIC AND POWER COMPANY

NORTH ANNA POWER STATION, UNIT NOS. 1 AND 2

DOCKET NOS. 50-338 AND 50-339

1.0 INTRODUCTION

By application dated April 30, 2018 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML18127A073), Virginia Electric and Power Company (Dominion Energy Virginia), the licensee for North Anna Power Station, Units 1 and 2, proposed to revise Technical Specifications (TS) 3.3.5 for Loss of Power (LOP) Emergency Diesel Generator Start Instrumentation. The license amendment request (LAR) addresses the potential for an Open Phase Condition (OPC) that could exist on one or two phases of a primary off-site power source and that would not be currently detected and mitigated by the existing station electrical protection systems. To address the OPC issue discussed in Bulletin 2012-01, "Design Vulnerability in Electrical Power System," dated July 27, 2012 (ADAMS Accession No. ML12074A115), the licensee has proposed OPC protective and detective systems in the LAR, to ensure that important-to-safety components are protected and remain available to perform their design basis functions. These OPC systems are the Class 1E Basler voltage unbalance relays for protection at the 4 kilo-Volt (kV) emergency buses, and a non-Class 1E Alstom Open Phase Detection (OPD) system at switchyard transformers TX-1 and TX-2. In response to the staff request, the licensee provided supplemental information in the letters dated May 24 and August 8, 2019 (ADAMS Accession Nos. ML19156A207 and ML19225D130 respectively). The supplemental letters did not expand the scope of the application as originally noticed, and did not change the U.S. Nuclear Regulatory Commission (NRC) staff's original no significant hazards consideration determination as published on September 11, 2018 (83 FR 45989).

This safety evaluation relates to the Class 1E Basler voltage unbalance relays for protection of the 4 kV emergency buses provided by the licensee. By letter dated May 24, 2019, the licensee

stated that non-Class 1E Alstom Open Phase Detection (OPD) system at the switchyard transformers TX-1 and TX-2 is within the scope of this LAR.

2.0 REGULATORY EVALUATION

2.1 Electrical System Design and Operation

As described in its submittals, the North Anna station electrical power distribution system consists of a 230/500 kV switchyard, which is an integral part of the transmission network and is the preferred source of offsite power to the station Class 1E electrical system. The distribution system to the station Class 1E electrical distribution system is comprised of a a minimum of two qualified off-site circuits between the 230/500 kV switchyard and the onsite Class 1E Electrical Power System and two separate and independent Emergency Diesel Generators (EDGs) per unit. Each one is qualified to meet the requirements of 10 *Code of Federal Regulations* (CFR) 50, Appendix A, General Design Criteria (GDC) 17.

By letter dated October 24, 2012 (ADAMS Accession No. ML12305A017), the licensee provided its initial response to NRC Bulletin 2012-01 which described the normal operating configuration of the ESF buses at power as follows:

> [T]here are four 4160 VAC Engineered Safeguards Features (ESF) buses (two per unit) at North Anna Power Station (NAPS) (1H, 1J, 2H, and 2J). In the normal operating configuration (at power), the ESF buses are powered from their preferred power source, which are the three reserve station service transformers (RSSTs) (A, B, and C). Each RSST receives power at 34.5 kV from three 34.5kV buses (Bus 3, 4, and 5), which are separated by normally open circuit breakers with open disconnect switches.
>
> The 34.5 kV buses receive power from three transformers (XFMR 1, 2 and 3) that are provided power from the point of interconnect on the 500 kV and 230 kV levels.
>
> 500-34.5 kV XFMR 1 in the switchyard normally supplies 34.5kV Bus 3. Bus 3 normally supplies 34.5-4.16 kV RSST-C which is the preferred source for ESF buses 1H and 2J.
>
> 500-34.5 kV XFMR 2 in the switchyard normally supplies 34.5kV Bus 4. Bus 4 normally supplies 34.5-4.16 kV RSST-B which is the preferred source for ESF bus 2H.
>
> 230-34.5 kV XFMR 3 in the switchyard normally supplies 34.5 kV Bus 5. Bus 5 normally supplies 34.5-4.16 kV RSST-A which is the preferred source for ESF Bus 1J.
>
> The above alignment is typical. Only two of the three 34.5 kV buses are required for operation. It is permissible to supply RSST-A and RSST-B from a single source. However, RSST-C is maintained separate from RSST-A and RSST-B in order to maintain separation of the associated ESF buses in accordance with Technical Specifications (TS).

The Updated Final Safety Analysis Report (UFSAR), Section 8.1.2 provides the following additional information regarding the electrical power distribution system:

> The preferred or reserve ac power source is the switchyard, which is connected to both units via three reserve station service transformers. The reserve station service power is available at all times to the safety-related equipment and has the capacity to drive the station auxiliaries in the event of a loss of the normal ac power supply. Upon a loss of power from the normal source on Unit 2, the normal station distribution system will transfer automatically to the reserve station service supply, provided no fault exists on the normal 4160V bus. On Unit 1, a main generator breaker has been installed. This allows Unit 1 to have its normal station service buses supplied from its normal station service transformers (backfed from the 500-kV switchyard) for most Unit 1 trips. This arrangement reduces the probability of combined loading from both Units 1 and 2 normal and emergency buses on the reserve station service transformer.

In the LAR, the licensee stated that three sets of potential transformers (PTs) are installed on each Emergency Bus (phase to ground). The transformers feed undervoltage (UV) relays that are provided on each Class 1E bus at the 4160 V level for detecting a loss of bus voltage or a sustained degraded voltage (DV) condition. Each set of relays are combined in a two-out-of-three logic to generate a Loss of Offsite Power (LOOP) signal. A loss of bus voltage signal initiates starts of the associated EDG when the bus voltage is less than 74 percent of rated voltage and lasts for approximately 2 seconds. A degraded bus voltage signal starts the associated EDG when the bus voltage is less than 90 percent of rated voltage sustained for approximately 56 seconds. The time delay for the degraded voltage signal is reduced to approximately 7.5 seconds in the presence of a Safety Injection on the unit.

In the event of a loss of the preferred power supply, a standby EDG supplies power to the associated safety-related bus/equipment within 10 seconds of a start signal. The Class 1E loads are loaded onto the EDGs sequentially.

2.2 Regulatory Requirements

The NRC staff applied the following NRC regulations for review of the LAR:

2.2.1 Technical Specifications

10 CFR 50.36, "Technical Specifications," states, in part, "each applicant for a license authorizing operation of a production or utilization facility shall include in his application proposed technical specifications (TSs) in accordance with the requirements of this section." Section 50.36(c)(1)(ii)(A) states, in part, "Limiting safety system settings for nuclear reactors are settings for automatic protective devices related to those variables having significant safety functions. Where a limiting safety system setting is specified for a variable on which a safety limit has been placed, the setting must be so chosen that automatic protective action will correct the abnormal situation before a safety limit is exceeded. If, during operation, it is determined that the automatic safety system does not function as required, the licensee shall take appropriate action, which may include shutting down the reactor."

Section 50.36(c)(2)(ii)(C), Criterion 3, states "A structure, system, or component that is part of the primary success path and which functions or actuates to mitigate a design basis accident or

transient that either assumes the failure of or presents a challenge to the integrity of a fission product barrier."

Section 50.36(c)(3), Surveillance Requirements, states "Surveillance requirements are requirements relating to test, calibration, or inspection to assure that the necessary quality of systems and components is maintained, that facility operation will be within safety limits, and that the limiting conditions for operation will be met."

2.2.2 General Design Criteria (GDC)

North Anna UFSAR, Section 3.1 "Conformance with AEC General Design Criteria," states: "North Anna Power Station, Units 1 and 2, was issued construction permit nos. CPPR-77 and CPPR-78 dated February 1971, based on the station design being in conformance with the *General Design Criteria for Nuclear Power Plants*, published in 1966." The UFSAR also provides discussion of the design of the station relative to the new GDC published in 1971. In particular, the UFSAR Section 3.1.13.2 provides the following discussion regarding meeting the intent of GDC 17, "Electric Power Systems":

> Onsite and offsite power systems are provided that can independently supply the electric power required for the operation of safety-related systems. This capability is maintained even with the failure of any single active component in either the onsite or offsite system. In the unlikely event of total loss of offsite power, the emergency buses are energized by the emergency diesel generators. Four diesel generators are available for two units. Two diesels are assigned to Unit No. 1 and two are assigned to Unit No. 2. There are two redundant buses in each unit serving engineered safety features; these buses ensure operation of minimum ESF equipment under all conditions, including a failure of a single component in the onsite power system.

UFSAR Section 3.1.9.2 provides the following discussion regarding meeting the intent of GDC 13, "Instrumentation and Control":

> Instrumentation and control systems are provided in the North Anna Power Station to monitor and maintain plant variables, including those variables that affect the fission process, integrity of the reactor core, the reactor coolant pressure boundary, and the containment over their prescribed ranges for normal operation, for anticipated operational occurrences, and under accident conditions.

2.2.3 NRC Bulletin 2012-01

Following the OPC event at Byron Nuclear Power Station (BNPS) in 2012, the NRC issued Bulletin 2012-01, "Design Vulnerability in Electric Power Systems." The Bulletin 2012-01 requested information regarding the facilities' electric power system design in light of the OPC event that involved the loss of one of the three phases of the off-site power circuits at BNPS Unit 2. The Bulletin required licensees to comprehensively verify their compliance with the regulatory requirements of GDC 17 in Appendix A to 10 CFR Part 50, or the applicable principal design criteria in the updated final safety analysis report. An OPC can impact adequacy of offsite power and onsite power systems, thus potential compliance with GDC 17, unless adequate protection/mitigation measures are taken.

2.3 Regulatory Guidance and Industry Documents

2.3.1 NRC Branch Technical Position (BTP) 8-9 "Open Phase Conditions in Electric Power System"

NRC issued BTP 8-9 in July 2015 (ADAMS Accession No. ML15057A085), to provide the NRC reviewer guidance for evaluating the adequacy of a licensee's design for addressing a potential OPC in its offsite electric power system. In the LAR, the licensee stated that North Anna used the BTP as guidance during the development of the negative sequence voltage protection for mitigating an OPC.

2.3.2 Regulatory Guide (RG) 1.105, Revision 3, "Setpoints for Safety-Related Instrumentation"

RG 1.105, Revision 3, "Setpoints for Safety-Related Instrumentation," dated December 1999, (ADAMS Accession No. ML993560062) describes a method acceptable to the NRC staff for complying with the NRC's regulations for ensuring that setpoints for safety-related instrumentation are initially within and remain within the TS limits. RG 1.105 endorses Part I of Instrument Society of America (ISA) Standard (S) 67.04-1994, "Setpoints for Nuclear Safety-Related Instrumentation." The staff used this guide to establish the adequacy of the licensee's setpoint calculation methodologies and the related plant surveillance procedures. In addition, Section 4.3, "LSSS," of ISA-S67.04 states, in part, "The LSSS is derived from the analytical limit in a manner determined by the setpoint calculation methodology. Depending on the methodology, the LSSS may be the allowable value, the trip setpoints, or both."

2.3.3 National Electrical Manufacturers Association (NEMA) MG-1 2009, Motor and Generators"

NEMA MG-1 2009 assists users in the proper selection and application of motors and generators. It contains practical information concerning performance, safety, testing, and construction and manufacture of ac and dc motors and generators.

2.3.4 Basler Electric Instruction Manual for BE1-47N Voltage Phase Sequence Relay, Publication # 9170400990 Revision K

The instruction manual describes the usage and specifications of the relays proposed for use by the licensee. This includes wiring diagrams and response characteristics.

3.0 TECHNICAL EVALUATION

3.1 Proposed TS Changes

The licensee proposed the following TS changes. The changes are indicated in **BOLD**.

LCO 3.3.5, "Loss of Power (LOP) Emergency Diesel Generator (EDG) Start Instrumentation" will be revised as follows:

> Three channels per bus of the loss of voltage Function and three channels per bus of the degraded voltage Function**, and three channels per bus of the negative sequence Function** for the following 4160 VAC buses shall be OPERABLE:

a. The Train H and Train J buses; and
b. One bus on the other unit for each required shared component.

ACTION B (under LCO 3.3.5, Condition B) will be revised (Note added) as follows:

Condition B: One or more functions with two or more channels per bus inoperable.

Required Action B.1: ----------------------------------**NOTE**--------------------------------------

If the negative sequence voltage protection function cannot be performed (e.g., the 4160V to 480V Balance Relay is tripped), the negative sequence voltage protection does not have to be declared inoperable provided verification is performed at least once per 24 hours that an open phase condition does not exist on the primary side of transformer TX-3 and the Reserve Station Service Transformers, as well as the Unit 1/Unit 2 Main Step-up Transformers when power is supplied by the dependable alternate source. The negative sequence voltage protection function shall be restored within 72 hours.

--

Restore all but one channel to Operable status.

Completion Time: 1 hour

SURVEILLANCE REQUIREMENTS will be revised as follows:

SR 3.3.5.1 ---NOTE---

Verification of setpoint is not required.

Perform TADOT for LCO 3.3.5.a and LCO 3.3.5.b **Loss of Voltage/Degraded Voltage** Functions.

SR 3.3.5.2 **---NOTE---**

Verification of setpoint is not required

Perform TADOT for LCO 3.3.5.a and LCO 3.3.5.b Negative Sequence Relay Functions.

SR 3.3.5.**3** **---NOTE---**

Negative Sequence Voltage is calculated as a percentage of nominal voltage.

Perform CHANNEL CALIBRATION with Allowable Values as follows:

a. Loss of voltage Allowable Values ≥ 2935 V and ≤ 3225 V with a time delay of 2 ± 1seconds for LCO 3.3.5.a and LCO 3.3.5.b Functions.

b. Degraded voltage Allowable Values ≥ 3720 V and ≤ 3772 V with:

1. A time delay of 7.5 seconds ±1.5 seconds with a Safety Injection (SI) signal for LCO 3.3.5.a Function; and

2. A time delay of 56 seconds ±7 seconds without a Safety Injection (SI) signal for LCO 3.3.5.a Function; and LCO 3.3.5.b Functions.

c. Negative Sequence Voltage ≥ 2.894% and ≤ 5.106% for LCO 3.3.5.a and LCO 3.3.5.b Functions.

SR 3.3.5.4 --NOTE--

ESF Response Times are only applicable to Loss of Voltage and Degraded Voltage Functions.

Verify ESF Response Times are within limit for LCO 3.3.5.a and LCO 3.3.5.b Functions.

No change in Frequency of SRs is proposed. The frequency of new SR 3.3.5.2 will be the same as frequency of other SRs in TS 3.3.5 (i.e., In accordance with the Surveillance Frequency Control Program).

3.2 Reason for the Proposed Change

As stated in the LAR, an OPC is a single or double open electrical phase in a three-phase circuit, with or without ground, which is located on the primary or high voltage side of a transformer connecting a credited offsite power circuit to the onsite power system. The potential for an OPC to exist in an offsite power source was not recognized previously as a design vulnerability in the nuclear power industry, therefore, was not considered in the original design of the North Anna electrical power distribution system. Based on the review of the January 2012 event at the Byron Nuclear Power Station and the issuance of response to NRC Bulletin 2012-01, the licensee determined that North Anna Power Station could also be susceptible to an OPC. Specifically, some OPC scenarios (consequential OPC) could cause an offsite power source (i.e., the primary or preferred power source) being incapable of supplying sufficient power to perform its safety function.

Without the implementation of design modifications, these OPCs may go undetected and un-isolated using the existing plant protection equipment. If a failed circuit remains connected to the downstream Class 1E Engineered Safety Features (ESF) 4160V buses, the downstream onsite emergency power system could be rendered incapable of performing its designated safety function.

As part of its design effort to detect and mitigate a potentially undetected consequential OPC (OPC which can adversely impact the safety-related equipment), the licensee has proposed to install a Class 1E protective relaying scheme on the ESF buses that provides an additional pathway for actuating the existing undervoltage protection function which directly interfaces with the ESF actuation logic. Therefore, the necessary operability requirements, required actions, and SRs for the voltage unbalance function are proposed to be incorporated into the North Anna TS 3.3.5 to ensure this protection circuitry would perform its design safety function.

Although the proposed plant and TS changes are being implemented to address the Bulletin, final closure of the Bulletin will be addressed through separate correspondence.

3.3 Design Features of OPC Detection and Protection

In the LAR, the licensee stated that an open phase detection and protection system at North Anna will be installed which will utilize Class 1E voltage unbalance (negative sequence) relays (Basler BE1-47N relays) that will provide consequential OPC detection and protection on the 4160V Emergency Switchgear 1H, 1J, 2H, and 2J buses. The relays will be configured in a two-out-of-three logic scheme that will detect OPCs, trigger an annunciator in the control room indicating an OPC event, and automatically initiate protection actions to mitigate the event. The LAR states that Basler BE1-47N (a negative sequence voltage relay) has inverse time characteristics. At a nominal pickup setting of 4 percent negative sequence, the BE1-47N relay will energize [trip] and send a start signal [to EDG] in approximately 11 seconds; a larger percent of negative sequence will generate a faster start signal. According to the guidance provided in National Electrical Manufacturers Association (NEMA) Standard (MG-1), the motors should be secured when the voltage unbalance is 5 percent or greater. The 4 percent nominal pickup setting of the BE1-47N relay ensures the relay will not cause nuisance trips while ensuring the guidance of NEMA MG-1 is met.

The LAR also states that the BE1-47N relay has a time dial adjustable from 01 to 99 in increments of 1. The timing is based on the percent difference from the nominal system voltage. The time dial setting of 10.0 provides sufficient time to allow existing overcurrent relaying to trip first on the downstream faults, thus providing adequate coordination with the BE1-47N relay. In the letter dated May 24, 2019, the licensee stated that BE1-47N relay operates with an inverse time characteristic, which would result in a range of time delays for various OPC events. Therefore, the inclusion of the allowable values for the full range of time delays in TS is not considered practical. The North Anna Technical Requirements Manual (TRM) will be revised to incorporate the setpoint for the BE1-47N relay, which will include the time dial setting. In the supplement dated August 8, 2019, the licensee provided a markup of the TRM, according to which the negative sequence relay (BE1-47N) will be set at a nominal time dial setting of 10. The licensee also stated that changes to TRM are controlled in accordance with station procedures that require a 50.59/72.48 Applicability Review and a detailed Technical Analysis and Safety Review. The staff finds specifying the nominal time dial setting of negative sequence relay in TRM acceptable since it will be subject to 50.59 review, and since specifying time dial setting in the typical TS format is not considered practical.

The LAR states that upon receiving a sustained degraded voltage, undervoltage, or voltage unbalance condition while exceeding time delay setpoints, the following conditions result:

1. The EDG is started,
2. The Emergency Bus is isolated,
3. All loads are stripped from the 4160V Emergency Bus and the 480V load centers except the Charging Pumps, the Low Head Safety Injection Pumps, and the feeds to the 480V Motor Control Center Load,
4. Once the EDG reaches 95% of its nominal output voltage and no residual voltage exists, the EDG output breaker closes automatically,
5. Loads are sequentially connected to the Emergency Bus.

The LAR states that only two output contacts are available for the negative sequence function of BE1-47N relay. Additional contacts are required for the two-out-of-three scheme. Therefore, a Cutler Hammer ARD (auxiliary) relay is installed downstream of the main output contact as a multiplier relay for each BE1-47N relay. The output of each multiplier relay is

configured into the required two-out-of-three logic. A final auxiliary relay installed downstream of the new two-out-of-three logic would ultimately energize the existing Undervoltage/ Degraded Voltage circuit. The Undervoltage/Degraded Voltage circuit trips the bus feeder breakers and automatically starts and loads the EDG. This relay also sends a signal to an existing spare annunciator window for a voltage unbalance trip.

In addition, to enhance the reliability of the protection system and prevent the protection scheme from automatically starting and loading an EDG in the event of a failed fuse on a Potential Transformer (PT) or a failed PT (which would result in an OPC signal), the licensee will also install a voltage balance ASEA Brown Boveri relay (ABB-60) per bus to detect failed fuse or a failure of PT. This relay will be used to block the negative sequence two-out-of-three logic from energizing, and thus provide security against a false OPC signal.

Therefore, the NRC staff finds that Class 1E voltage unbalance (negative sequence) relays at the 4160V Emergency Switchgear 1H, 1J, 2H, and 2J buses, in a two-out-of-three logic scheme will detect OPCs, trigger an annunciator in the control room indicating an OPC, and automatically initiate protection actions to mitigate the OPC event. In addition, the voltage balance relay (ABB-60) will provide security against a false OPC signal due to a failed fuse on a PT or failure of PT. Therefore, the NRC staff finds that the design features of OPC detection and protection meet the intent of BTP 8-9 and are, therefore, acceptable.

3.4 Open Phase Scenarios

The licensee stated that it considered NRC BTP 8-9 guidance to define North Anna's OPC vulnerabilities. The licensee considered the following scenarios of OPCs, locations, generating conditions, and loading conditions.

3.4.1 Open Phase Conditions

The following open phase conditions were considered:

- Single open phase without a ground connection
- Single open phase with a 350-ohm grounded connection
- Single open phase with a solid grounded connection

In the supplement dated May 24, 2019, and the supplement dated August 8, 2019, the licensee provided background information relating to the assumption of 350-ohm ground connection resistance. Based on its review of background information, the staff finds the 350-ohm ground connection resistance value to be reasonable, conservative, and therefore acceptable.

The licensee also considered and simulated double open phase conditions for both transformer styles (Wye Solid Grounded-Delta and Delta-Wye solid grounded). The licensee found these cases produced a higher negative sequence voltage than their comparative single open phase conditions. Therefore, single open phase conditions were considered to be bounding, and in-depth-analysis of double open phase conditions was not performed.

Single open phase conditions were considered and simulated for each phase for both transformer styles (Wye solid grounded-Delta, and Delta-Wye solid grounded). In these cases, the licensee found that the negative sequence voltage for any one open phase was comparable to any other open phase when the switchyard is balanced. Therefore, only one open phase was evaluated for each event configuration.

The staff finds the Open Phase Conditions as described above comprehensive and consistent with the intent of BTP 8-9, and therefore is acceptable.

3.4.2 Open Phase Locations

The analysis considered the following locations:

- High side terminals of the Switchyard Transformer TX-1
- High side terminals of the Switchyard Transformer TX-2
- High side terminals of the Switchyard Transformer TX-3
- High side terminals of the RSST A Transformer
- High side terminals of the RSST B Transformer
- High side terminals of the RSST C Transformer
- High side terminals of the Unit 1 Generator (Main) Step-up Transformer (GSU-1)
- High side terminals of the Unit 2 Generator (Main) Step-up Transformer (GSU-2)

In its letter dated May 24, 2019, the licensee provided the following clarification for not considering Open Phase on the low voltage side of the above transformers:

> For the Switchyard Transformers, the low side of transformers TX-1, TX-2, and TX-3 equate to the high side of the RSSTs. It is expected that the analysis results in these cases would be similar or equivalent to those for the high side of the RSSTs.
>
> For the RSSTs, any OPC event on the low side of the RSSTs trips the existing Under Voltage relays. In these cases, OPC protection would not be required.
>
> For the GSUs, the low side of the GSUs is terminated to a rigid isophase bus, so an OPC is not considered credible.

The NRC staff finds the licensee's consideration of the Open Phase Locations as described above to be reasonable, consistent with the intent of BTP 8-9, and therefore acceptable.

3.4.3 Generating and Loading Conditions

In the LAR, the licensee stated that open phase events were considered with Units 1 and 2 at 0 percent rated thermal power and Units 1 and 2 at 100 percent rated thermal power.

For accident scenarios, the open phase event is assumed to occur coincident with Safety Injection (SI) and Containment Depressurization Actuation (CDA) signals. The open phase events are also analyzed with coincident start signal of a large motor of a Reactor Coolant Pump or a Main Feedwater Pump.

Two emergency bus loading initial conditions were considered: Minimum and Normal. Minimum emergency bus loading consists of the Service Water, Charging and Component Cooling Pumps secured on the evaluated bus, with the opposite train in operation. Normal emergency bus loading consists of the Service Water, Charging and Component Cooling Pumps in operation on the evaluated bus with the opposite train secured.

In the letter dated May 24, 2019, the licensee provided the configurations of various Generating Conditions and Loading Conditions, and stated that an OPC event was considered for each of following configurations:

Generating Condition	Bus Loading	SI/CDA Initiation	Large Motor Start
Offline	Minimum Loading	No	No
Offline	Minimum Loading	No	Yes
Offline	Minimum Loading	Yes	No
Offline	Normal Loading	No	No
Offline	Normal Loading	No	Yes
Offline	Normal Loading	Yes	No
Online	Minimum Loading	No	No
Online	Minimum Loading	No	Yes
Online	Minimum Loading	Yes	No
Online	Normal Loading	No	No
Online	Normal Loading	No	Yes
Online	Normal Loading	Yes	No

The NRC staff finds the above set of generating and loadings conditions covers appropriate operating conditions, meets the intent of BTP 8-9, and is, therefore, acceptable.

3.5 Open Phase Analyses/Calculations Results

The licensee provided the following description and the results of analyses/calculations performed for OPC detection and protection.

3.5.1 Motor Negative Sequence Voltage and Thermal Capability

In the LAR, the licensee stated that analyses/calculations were performed to analyze the various OPC scenarios to determine the levels of voltage unbalance on the ESF buses from a connected failed source due to a single or double OPC. The analytical voltage unbalance limits were determined for the negative sequence voltage protection relay settings to ensure power sources will remain capable to power the safety-related equipment during any open phase condition.

The licensee stated that according to NEMA Standard MG-1, for a voltage unbalance between 1 percent and 5 percent (percent of motor nameplate voltage), the motor horsepower should be de-rated to account for additional heating due to unbalance. Operation of the motor above 5 percent voltage unbalance is not recommended. For a voltage unbalance between 1 percent and 5 percent, the NEMA MG-1 de-rating factor is applied to the motor rating. If the (required) brake horsepower (BHP) of the motor is less than the de-rated horsepower rating, then continuous operation of the motor is determined to be acceptable. In cases where the (required)

BHP is greater than the de-rated horsepower rating, the motor must be isolated from the faulted source, unless justified otherwise. The licensee performed calculations to determine the time duration for which the motor can be safely operated on the faulted source before the negative sequence current heating capability is exhausted. The resulting time duration was used to determine if manual action (alarm) is acceptable or if automatic action (trip) is necessary.

Based on the proposed BE1-47N relay setting (nominal 4 percent voltage unbalance and time dial of 10.0), the licensee determined that for cases where the voltage unbalance is greater than 5 percent, the BE1- 47N relays will trip and isolate the motor loads before the integrated negative sequence thermal value (1_2^2 * t) values reach 20 per unit (pu), and before the motor load's associated overcurrent relay trips.

In the letter dated May 24, 2019, the licensee provided the following additional information regarding how the BE1-47N settings will protect motors against negative sequence currents:

> Continuous duty motors are susceptible to additional heating during an open phase condition due to negative sequence current. Induction motors have a withstand capability against unbalanced voltages which is calculated using an integrated per-unit negative sequence current (I_2) squared times time (t) in seconds [$(I_2{}^2 \times t)$]. An evaluation performed in the North Anna Open Phase Analysis Calculation determined that a conservative value of 20 pu (40pu/2 motor starts) should be used to ensure all motors have enough thermal capability [remain capable] to perform their design functions [under OPC conditions.]
>
> The EMTP-RV [computer program] simulations conservatively do not include the effect of motor cooling.... Operation of the motor with a voltage unbalance above 5% is not recommended. Therefore, for a voltage unbalance greater than 5%, the BE1-47N relays should isolate the motor loads from the OPC condition prior to the $I_2{}^2 \times t$ value reaching 20 pu.
>
> To validate this condition was met for the BE1-47N relays, a model was created in EMTP-RV to calculate the time until the $I_2{}^2 \times t$ value for each monitored motor reached 20 pu. This value was compared to the trip time of the BE1-47N relay for each event modeled.

Therefore, the NRC staff finds the above description as to how the BE1-47N relays will protect motors considering limitation of motor negative sequence voltage and thermal capability reasonable.

3.5.2 <u>Negative Sequence Voltages Under Various Open Phase Conditions and Voltage Settings of the Basler BE1-47N Relay</u>

In Section 3.2.5 of the LAR, the licensee provided Table-1 which summarizes the minimum and maximum Negative Sequence Voltages calculated at each of safety related buses (1H, 1J, 2H, and 2J) for various open phase locations at TX-1, TX-2, TX-3, RSST-A, RSST-B, RSST-C, GSU 1-1H, GSU 1-2J, GSU 2-1J, GSU 2-2H.

The licensee described the results of Table-1 of LAR as follows:

- For open phase conditions on Transformers TX-1 and TX-2 (Wye Solid Grounded-Delta Transformers) the minimum negative sequence voltage on the impacted emergency buses is insufficient to actuate the BE1-47N relay. The minimum negative sequence voltage is 1.871 V (2.7%) for TX-1 and 2.398 V (3.46%) for TX-2 and the [proposed] minimum setting on the BE1-47N relay is 2% on a 69.28 V base [120V/1.732 – phase to neutral – nominal voltage input to relay]. These cases shall be detected by the proposed Alstom open phase detection (non-Class 1E) relays on Switchyard Transformers TX-1 and TX-2.

- For open phase conditions on Transformers TX-3, RSST A, RSST B, and RSST C (Delta-Wye Transformers) the minimum negative sequence voltage on the impacted emergency buses is above the [proposed nominal] minimum possible setting [of 4%] for the BE1- 47N relay. The minimum observed negative sequence voltage is 12.318V (17.78%), located on Bus 1H for an open phase condition on RSST C.

- For open phase conditions on Transformers GSU 1 and GSU 2, the minimum negative sequence voltage is insufficient to actuate the BE1-47N relay. The minimum negative sequence voltage is 0.937V (1.35%) for GSU 1 and 0.654V (0.94%) for GSU 2 and the minimum setting on the BE1-47N relay is 2% on a 69.28V base.

The licensee analyzed further these cases related to OPC on Transformers GSU 1 and GSU 2 in Section 3.3.2.1 of the LAR and based on thermal capability analyses of the impacted safety-related motors concluded that no additional protection is needed for these cases.

In supplement dated August 8, 2019, the licensee provided tabulation of all study cases in which the voltage unbalance is 1 percent and 5 percent and for which Negative Sequence voltage protection may not be adequate. The licensee described the following three types of results:

(1) "Yes" - for which the motor HP remain adequate even after applying the NEMA derating factor between 1% and 5% voltage unbalance.

(2) "Yes***" - applicable for Auxiliary Feedwater (AFW) and Inside Recirculation Spray (ISRS) for certain OPC cases where NEMA derating factor was unacceptable. However, based on further thermal margin evaluation of related motors, the cases were found acceptable.

(3) "No" - where sufficient NEMA derating was not available. In these cases, motor damage could occur after an extended duration of operation, degrading life of the motor. Therefore, to preclude this from occurring, the licensee will also install non-Class 1E relays on Switchyard Transformers TX-1 and TX-2, that will provide an alarm function to the Main Control Room when these conditions exist. The alarm will alert the operators of the need to isolate the impacted emergency bus. The settings of these non-Class 1E protection relays are not part of this LAR.

Based on the above, the staff finds that a combination of Class 1E OPC protection provided at safety-related buses and Non-Class 1E OPC protection at the switchyard transformers will provide adequate protection against any OPC event and is therefore acceptable.

The licensee concluded that based on minimum and maximum Negative Sequence Voltages calculated at each of the safety related buses under various conditions, a 4 percent negative sequence voltage setting of BE1-47N would provide desired protection. The maximum uncertainty for the Basler BE1-47N relay at the 4kV emergency buses was calculated to be ±1.106% of span. With a 4% relay pickup setting, the relay will energize in the range of 2.894% to 5.106% negative sequence voltage. This value is specified in TS SR 3.3.5.3.c.

Therefore, the NRC staff finds the proposed setting of Negative Sequence Voltage ≥ 2.894% and ≤ 5.106% for LCO 3.3.5.a and LCO 3.3.5.b Functions, as specified in TS SR 3.3.5.3.c, is based on reasonable technical analyses, meets the intent of BTP 8-9, and is, therefore, acceptable.

3.5.3 OPC Protection Time Delay

In the LAR, the licensee stated that for an open phase event coincident with a SI or CDA signal, the emergency buses will be re-energized by the EDG within 10 seconds. To be within the time-frame considered in the accident analysis, the open phase protection relay tripping time delay should be less than or equal to 7 seconds. This is consistent with the time delay used for degraded voltage protection during accident conditions (7.5 seconds). OPC analysis results show that for most open phase events in which the BE1-47N relays trip, the tripping time is less than 6 seconds after the open phase event occurs. For cases in which the BE1-47N does not trip in less than 6 seconds (for OPC events on TX-1 and TX-2), the Alstom open phase detection relay (non-Class 1E protection, mentioned in section 3.3.2 above) will detect the open phase event and initiate a trip of the offsite source. This is within the time considered in the accident analysis for a loss of offsite power coincident with an accident. Time delay provided on the voltage unbalance (open phase) is such that OPC protective relays will not spuriously actuate for non-OPC events.

Therefore, the NRC staff finds that the time delay setting of the BE1-47N relay (i.e., the Time Dial Setting which will be provided in the TRM) is reasonable, meets the intent of BTP 8-9, and is, therefore, acceptable.

3.6 Failure Mode and Security Analysis of OPC Protection

In the LAR, the licensee described the failure mode and security analysis of BE1-47N relays, as follows:

> The new Basler BE1-47N relays will be energized from the DC source. If the power source to the new relays is removed, the relay contacts will not change state when there is a voltage unbalance condition, in which case the voltage unbalance two-out-of-three logic scheme would fail to start the EOG. However, there is an annunciator (1K-4F, LOSS CONT PWR SFGDS UV CKTS) that notifies the Control Room if voltage is not available on degraded/undervoltage circuits. An auxiliary relay will be installed in the new circuit which will be tied into the existing alarm and will notify Operations if DC power is not available on the new circuit.
>
> In the event one of the three relays fail due to loss of DC power (i.e., a power supply failure), the reliance would be on the other two functional relays to make up the two-out-of-three logic scheme.
>
> On the AC sensing side, there is a single set of fuses on the primary side of the PTs. There will also be a new set of fuses on the secondary side dedicated for the new

protection scheme (there is already a set of fuses for the UV/DV and metering circuits). If any of these fuses blow, there will be enough negative sequence generated to inadvertently actuate the BE1-47N relays..... In the new scheme, a primary side fuse failure (or upstream secondary) will cause all three BE1-47N relays to pick up, time out, isolate the bus and start the EDG....In order to ensure a fuse failure does not lead to actuating of the BE1-47N relays on a false signal, an ABB-60 (voltage balance relay) will be installed on the 4kV and 480V PTs. In the event of a blown PT fuse or a failed PT, an annunciator (4KV PT FUSE BLOWN) will alarm in the Control Room.

The BE1-47N relays can also fail to output on a true voltage unbalance signal. On an electrical failure, the relay will fail in the shelf (non-trip) state. For this reason, three voltage unbalance relays are being installed in a two-out-of-three scheme downstream of the bus PTs on each emergency bus, which provides a high level of assurance the circuit will operate on a voltage unbalance condition whether or not a relay failure has occurred.

The ABB-60 (voltage balance relay) will also block negative sequence relay scheme operation in the event of a blown fuse or failed PT. Therefore, the staff finds the NOTE proposed to be added to TS 3.3.5 reasonable and acceptable.

Based on the above, the NRC staff finds the negative sequence voltage protection scheme is adequately designed to cover various failure modes of BE1-47N relay, meets the intent of BTP 8-9 and is therefore acceptable.

3.6 Setpoint Methodology

3.6.1 Licensee Methodology

As discussed above, the licensee has determined that the existing protection circuitry of North Anna Power Station may not detect some consequential single or double OPCs on an off-site power source. This design vulnerability could result in the affected off-site power source being unable to supply sufficient power to perform its safety function. Also, the design needs to ensure that the negative sequence voltage (open phase) function will not actuate spuriously for minor voltage imbalances that may be present during normal operating conditions.

Based on an analysis of modelled phase voltage differentials, using the Electromagnetic Transients Program - Restructured Version (EMTP-RV), and under the potential OPC conditions that are described in sections 3.1.1 to 3.1.4 of the LAR, the licensee calculated the maximum negative sequence voltages appearing on switchyard buses 1H, 1J, 2H, and 2J due to postulated steady-state voltage negative sequence.

The LAR Table 1, "Summary of Negative Sequence Voltages for Open Phase Conditions on Each Transformer," provides a summary of maximum and minimum historical steady-state negative sequence voltages modelled for buses 1H, 1J, 2H, and 2J for open phase events on the high side of each transformer.

In Section 3.2.5, "Setpoint," of Attachment 1 of LAR, the licensee states in part:

"Considering the uncertainty of the channel, the lowest negative sequence voltage and the highest security case negative sequence voltage, a setpoint of 4% was selected. A calculation was performed to determine the CSA [Channel Statistical Allowance] for the Basler BE1-47N voltage phase sequence relays. The relay and potential transformer (PT)

inaccuracies and the final relay settings for the negative sequence voltage detection scheme were evaluated. The maximum uncertainty (i.e., CSA) for the Basler relay at the 4kV emergency buses was calculated to be ±1.106% of span. With a 4% relay pickup setting, the relay may energize in the range of 2.894% to 5.106% negative sequence voltage."

In a request for additional information, the NRC staff noted that "a similar license amendment for Surry to modify the plant Technical Specifications to address surveillance requirements for an identical manufacturer and model number negative sequence voltage relay used a 6% relay pickup setting with a ± 2.4% CSA. This LAR specifies a CSA of ± 1.106% for North Anna with identical relays. It is unclear if the small operating margin provided by this CSA sufficiently accounts for all the uncertainties that could lead to spurious trips of the power supply system as a result of routine fluctuations in power conditions." The NRC staff requested the licensee to provide a description regarding each of the uncertainties included within the proposed CSA ± 1.106% of span. In its letter dated May 24, 2019, the licensee stated that:

> The North Anna BE1-47N Channel Statistical Allowance Calculation included the following uncertainties:
>
> - Rack Calibration Accuracy of ±1% (based on BE1-47N pickup uncertainty)
> - Process Measurement Uncertainty of ±0.365%. This was determined by taking the PT uncertainty of 0.3% and taking into account phase errors as defined in IEEE C57.13-2016.
> - Sensor Measuring and Test Equipment Uncertainty of ±0.3%
>
> The differences between the uncertainty bands at North Anna and Surry can be attributed to the variations in the Process Measurement Uncertainty.
>
> The licensee noted that differences in PT uncertainties between the North Anna design and the Surry design are due to the use of different editions of IEEE C57.13, "IEEEE Standard Requirements for Instrument Transformers." North Anna used the 2016 edition of IEEE C57.13 and Surry used the 2008 edition of IEEE C57.13.
>
> The licensee proposed CSA (± 1.106%) was calculated by the square root of the sum of squares (SRSS) method for combining the random errors:
>
> $$CSA = ((\pm 1)^2 + (\pm 0.365)^2 + (\pm 0.3)^2)^{1/2}\ \% = \pm 1.1059\ \% \sim \pm 1.106\%$$

This methodology is consistent with the guidance of RG 1.105 to ensure the calculated instrument setpoints are, and will remain, within their technical specification limits and is, therefore, acceptable.

3.6.2 <u>NRC Staff Evaluation of Proposed Negative Sequence Voltage Setting in proposed TS SR 3.3.5.3 c</u>

The NRC staff evaluated the values for negative sequence voltage specified in proposed SR 3.3.5.3 c to verity they are consistent with required plant safety functions to assure that protective actions will be initiated before the associated plant process parameter exceeds its analytical limit.

3.6.2.1 Proposed Negative Sequence Voltage for the 1E Voltage Unbalance Protection System Setting

The licensee proposed to add the new Negative Sequence Voltage setting (SR 3.3.5.3.c for LCO 3.3.5 a and LCO 3.3.5 b bus functions) into the proposed SR 3.3.5.3. This change is described in Section 2.2.1 of this SE. In Section LCO 3.3.5 of North Anna TS, the LCO 3.3.5 a and LCO 3.3.5 b are:

LCO 3.3.5 a	The Train H and Train J buses; and
LCO 3.3.5 b	One bus on the other unit for each required shared component.

To evaluate the proposed 4% of the relay pickup setting for the negative sequence voltage, the NRC staff evaluated the NEMA MG-1. NEMA MG-1, Section 14.36, "Effects of Unbalanced Voltages on the Performance of Polyphase Induction Motors," states, in part, "When the line voltages applied to a polyphase induction motor are not equal, unbalanced currents in the stator windings will result. A small percent voltage unbalance will result in a much larger percentage current unbalance." That is because the motor with voltage unbalance condition will create additional heating that is detrimental to its operation.

In the Figure 14.1, "Medium Motor Derating Factor Due to Unbalance Voltage," of NEMA-MG1, the derating curve shows when voltages are unbalanced, the rated horsepower of the motor should be multiplied by the factor to reduce the possibility of damage to the motor, as shown in Figure 1 below:

Figure 1: Figure 14.1 of the NEMA-MG1

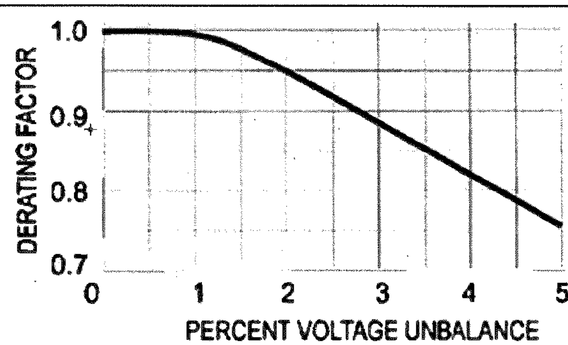


Figure 14-1
MEDIUM MOTOR DERATING FACTOR DUE TO UNBALANCED VOLTAGE

NEMA MG-1 states, in part, "Operation of the motor above a 5-percent unbalance voltage condition is not recommended."

As discussed in Section 3.0 of Attachment 1 of LAR, the Basler BE1-47N relays will be used in the negative sequence voltage protection circuitry. The instruction manual for the Basler BE1-47N voltage phase sequence relay states the negative sequence voltage pickup setpoints are only adjustable from 2 to 32 percent (%) of the nominal voltage in 2% increments. Therefore, the relay is capable of being set in ± 2% increments. A magnitude of 4% is evaluated in the following section to verify whether a 4% relay pickup setting is adequate to protect the loads as required by 10 CFR 50.36(c)(1)(ii)(A).

In Section 3.2.5 of the LAR, the licensee determined the maximum applicable uncertainty terms through a computation of the channel statistical allowance (CSA). The licensee evaluated the accuracies of the relay and PTs to calculate the CSA for the Basler BE1-47N voltage phase sequence relays used in the negative sequence voltage mode of operation. Based on the calculation, a setpoint of 4% was selected. The licensee stated that the maximum uncertainty (i.e., CSA) for the Basler relay at the 4kV emergency buses was calculated to be ± 1.106 %.

In the LAR, the licensee also requested to add a new NOTE, "Negative Sequence Voltage is calculated as a percentage of nominal voltage" into the TS SR 3.3.5.3. This new NOTE ensures that the proposed Negative Sequence Voltage in new TS SR 3.3.5.3 c would be calculated as a percentage of the nominal voltage.

Span 120V (line-to-line (L-L)) = 120V / √3 = 69.28V (line-to-neutral (L-N))

CSA is ± 1.106% of span 69.28V = ± (69.28V x (1.106 / 100)) = ± 0.766V (L-N)

Or

CSA is ± 1.106% of span 120 V = ± (120 V x (1.106 / 100)) = ±1.327 V (L-L)

The NRC staff applied the guidance within RG 1.105 to confirm independently whether the licensee's selection of the 4% setting leaves adequate margin for instrument channel performance uncertainty. Based on definitions in ANSI/ISA-67-04.01-1994 and Westinghouse Generic Setpoint Control Program Recommendations (ADAMS Accession No. ML12058A445), the total uncertainty is between the nominal trip setpoint (NTSP) and associated analytical limit (AL) and would be calculated by the following equation.

NTSP = AL - (TLU + Margin to Trip) Equation (1)

AL: Analytical Limit
NTSP: Nominal Trip Setpoint
TLU: Total Loop Uncertainty

In the Westinghouse Generic Setpoint Control Program Recommendations (ADAMS Accession No. ML12058A445), the definition of the term Channel Statistical Allowance (CSA) is:

> CSA is "the combination of the various channel uncertainties via the Square-Root-Sum-of-the-Squares (SRSS), statistical, or algebraic techniques. It includes instrument (both sensor and process rack) uncertainties and non-instrument related effects."

This parameter is compared with the total of all uncertainties to determine the minimum required instrument channel margin, therefore:

Equation (1) => NTSP = AL - (CSA + Margin to Trip)

=> Margin to Trip = AL – (NTSP+CSA) Equation (2)

Section 3.2.5, "Setpoint" of Attachment 1 of the LAR contains Table 1, "Summary of Negative Sequence Voltages for Open Phase Conditions on Each Transformer," which provides a summary of the maximum and minimum steady-state Negative Sequence voltages that could

likely be present at Buses 1H, 1J, 2H, and 2J. The licensee used these steady-state Negative Sequence voltages (which are for open phase events on the high side of each transformer) to determine whether the selected setpoints for the Basler relays would be adequate to protect the motors connected to the emergency buses, no matter which combination of transformers were feeding the emergency buses.

Lower levels of voltage negative sequence are provided only for TX-1 and TX-2 during OPCs. The licensee noted that: "The minimum negative sequence voltage is 1.871V (2.7%) for TX-1 and 2.398 (3.46%) for TX-2 and the minimum setting on the BE1-47N relay is 2% on a 69.28V base. These cases shall be detected by the proposed Alstom open phase detection relays on Switchyard Transformers TX-1 and TX-2."

For open phase conditions on transformers (TF) TX-3, RSST A, RSST B, and RSST C, Section 3.2.5 of the LAR states that "the minimum negative sequence voltage on the impacted emergency buses is above the minimum possible setting for the BE1- 47N relay. The minimum observed negative sequence voltage was 12.318V (17.78%), located on Bus 1H for an open phase condition on RSST C."

The NRC staff requested the licensee to confirm that the negative sequence voltage of 12.318 V (17.78%) can be considered as an Analytical Limit for calculating various margins with respect to the nominal 4% pickup setting of the BE1-47N relay. In its letter dated May 24, 2019, the licensee stated that:

> "The BE1-47N relays are calculated to always trip at > 3.538V. For OPCs at TX-3 and RSSTs A/B/C, the lowest negative sequence voltage observed is 12.318V, which ensures the OPC is detected. A 4% setpoint was chosen for the BE1-47N relay and calculated to have a ±1.106% maximum uncertainty. The BE1-47N relay may detect the OPC from 2.005V to 3.538V. Voltages below 2.005V will not result in a trip of the BE1- 47N relays."

The NRC staff evaluated the licensee's calculated AL (Analytical Limit) and NTSP (Nominal Trip Setpoint) values for the OPC Negative Sequence Voltage when the selected 4% setpoint was implemented by the Basler relays, as follows:

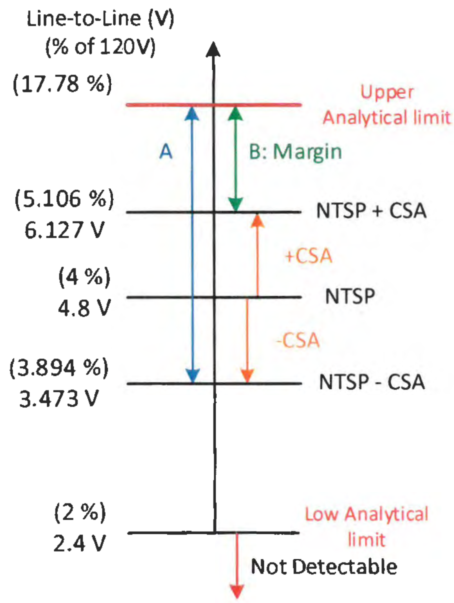
Upper Analytical Limit (UAL)	: 17.78% (12.318V * √3 =21.36V L-L)
Nominal Trip Setpoint (NTSP)	: 4% (4.8V L-L)
Nominal Trip Setpoint (+ CSA)	: 4% Setpoint + 1.106% = 5.106 %
	: 69.28V * 5.106 % = 3.538V (L-N) (6.12V L-L)
Nominal Trip Setpoint (- CSA)	: 4% Setpoint – 1.106% = 2.894 %
	: 69.28V * 2.894 % = 2.005V (L-N) (3.47V L-L)
Lower Analytical Limit (LAL)	: 2% (1.39 V (L-N) or 2.4V (L-L))

(Note: The minimum negative voltage is 0.94% (for GSU 2), however, the minimum setting on the BE1-47N relay is 2% on 120 V line-to-line. Therefore, the NRC staff treats the minimum 2% setting limit as the Lower Analytical Limit.)

The NRC staff calculated independently the margin between AL and NTSP. The NRC calculation results are reflected in the Negative Sequence Voltage Figure 2 below.

Figure 2: NRC Staff Margin Calculation

North Anna Allowable Value & Trip Setpoints Relationships



NTSP Margin Calculation

Row #		% Setting Voltage	Line-to-Neutral Setting Voltage (V)	Line-to-Line Setting Voltage (V)
1	Upper AL (UAL)	17.78	12.318	21.336
2	B = CSA (TLU)	1.106	0.766	1.327
3	NTSP + CSA	5.106	3.537	6.127
4	NTSP	4	2.771	4.800
5	NTSP - CSA	2.894	2.005	3.473
6	Lower AL (LAL)	2	1.386	2.400
7	A (Total Allowable) A = UAL - (NTSP - CSA)		10.313	17.863
8	B (Margin to Trip) B = UAL - (NTSP + CSA)		8.014	13.882
9	% Margin = (B/A)*100	%	77.711	77.711

Therefore, the NRC staff determined from its independent calculation of the Margin to Trip between AL and NTSP that there is significant margin (as indicated in the Figure 2 above) at a value of 77.71 %. This margin reflects that the trip setpoints have been chosen to assure that a trip or safety actuation will occur automatically before the measured process reaches the Upper Analytical Limit (UAL) level.

The NRC staff determined that the proposed settings, 4% relay pickup setting ± 1.106% of span, have been chosen so that automatic protective action will prevent a safety limit from being exceeded. Therefore, these proposed settings are acceptable, consistent with RG 1.105, and satisfy the requirements of 10 CFR 50.36(c)(1)(ii)(A).

3.6.2.2 <u>Proposed Time Delay</u>

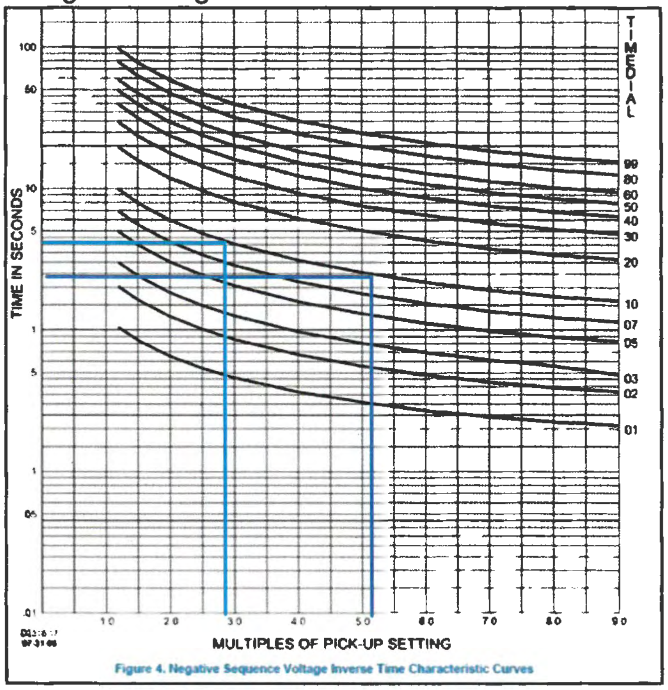
In Section 3.2.3, "Open Phase Event Timing," of Attachment 1 of the LAR, the licensee states:

> "It should be noted the channel statistical analysis (CSA) for the negative sequence voltage relay may delay the relay response time. A 4% relay pickup setting with a 10.0 time delay setting account for both positive and negative CSA and will ensure the relay would trip within the time considered in the accident analysis for a loss of off-site power coincident with an accident."

The NRC staff reviewed Figure 4, "Negative Sequence Voltage Inverse Time Characteristic Curves," of the instruction of the BE1-47N to verify that the time in seconds of the time dial setting of "10" has a maximum at 10 seconds, at a minimum of multiples of pick-up setting of (1.2% * 120 = 1.44V L-L). This diagram (see Figure 3 below) shows that the pick-up setting is inverse with respect to the time (in seconds). Therefore, the licensee's proposed 4% relay pickup setting with a time dial setting of 10 accounts for both positive and negative CSA uncertainty (≥ 2.894% and ≤ 5.106% of span). This range spans from approximately ≥ 3.3

seconds to ≤ 4.7 seconds.

Figure 3: Figure 4 of the BE1-47N Instruction



This time delay setting ensures that the actuation will occur in less than 10 seconds.

Therefore, this time delay setting is consistent with the time requirement of the emergency buses that shall be re-energized by the Emergency Diesel Generator within 10 seconds, which is consistent with the performance requirement stated in Section 3.2.3 of the LAR.

The NRC staff finds the proposed time delay setting within the range of approximately ≥ 3.3 seconds and ≤ 4.7 seconds (as shown in Figure 3 of this SE) for the proposed UVRs time delay setting for North Anna Units 1 and 2 provides reasonable assurance that a trip or safety actuation will occur within the allowable time to protect safety related equipment. Hence, an automatic protective action will correct the abnormal situation before a safety limit is exceeded. Therefore, the NRC staff determines that this time delay setting satisfies the requirements of 10 CFR 50.36(c)(1)(ii)(A) and is, therefore, acceptable.

3.6.2.3 Proposed Technical Specifications

Revise Surveillance Requirements (SR) 3.3.5.1:

The licensee proposed to insert "UV/DV" (Undervoltage/Degraded Voltage) into the Note of TS SR 3.3.5.1 as described in Section 2.2.2 (3) of this SE. The NRC staff verified that this change addresses the TS SR 3.3.5.1 that requires the performance of the Trip Actuating Device Operational Test (TADOT) for the currently-installed Undervoltage and Degraded Voltage Function LCOs (LCO 3.3.5.a and LCO 3.3.5.b).

The NRC staff finds that this proposed change does not change nor affect the existing surveillance requirements of TS SR 3.3.5.1, and thus, will continue to satisfy the criteria of 10 CFR 50.36(c)(3) and meet the requirements of GDC 13, and is, therefore, acceptable.

Add new SR 3.3.5.2 into TS 3.3.5:

The licensee proposed to add new SR 3.3.5.2 as described in Section 2.2.2 (4) of this SE.

SR 3.3.5.1 was determined to be an adequate test to meet 10 CFR 50.36(c)(3) during initial licensing. The newly proposed SR 3.3.5.2 would require the performance of the TADOT for the proposed LCO 3.3.5.a and LCO 3.3.5.b Negative Sequence Relay Functions that is the same as that currently required by SR 3.3.5.1 for LCO 3.3.5.a and LCO 3.3.5.b UV/DV. Since the same test will also test the newly installed auxiliary relays for the loss of voltage/degraded voltage functions SR 3.3.5.1 will continue to be adequate to meet 10 CFR 10 CFR 50.36(c)(3). Additionally, the new SR 3.3.5.2 will adequately test the new Negative Sequence Relay Functions, as described in this SE.

The NRC staff verified that the new SR 3.3.5.2 would be in support of the proposed addition of the Undervoltage Unbalance Protection System into North Anna Units 1 and 2, as described in Section 3.2.1 of this SE, because the TADOT should be required for the new Negative Sequence Relay Function such as UV/DV.

Thus, this proposed change does not affect the other current TS SRs and will continue to satisfy the criteria of 10 CFR 50.36(c)(3) and meet the requirements of GDC 13 and is, therefore, acceptable.

Renumber of the Surveillance Requirements of TS 3.3.5:

With the addition of the new SR 3.3.5.2, the licensee proposed to renumber the SRs described in Section 2.2.2 (5) of this SE.

The NRC staff reviewed these proposed changes and concludes that the changes are considered administrative (editorial in nature) and do not affect the requirements of the current TS or the proposed TS changes. These proposed changes will continue to satisfy the criteria of 10 CFR 50.36(c)(3) and the requirements of GDC 13, and are, therefore, acceptable.

3.7 NRC Conclusion

Based on the above, the NRC staff finds that the OPC protection and detection design proposed by the licensee meets the intent of BTP 8-9. The OPC protection and detection systems would ensure that the offsite and onsite power distribution systems continue to supply safety-related equipment in any OPC event, and thus continue to meet the regulatory requirements of GDCs 13 and 17, as incorporated in the North Anna Units 1 and 2 UFSAR. Additionally, the proposed TS changes add the appropriate LCO and surveillance requirements and, therefore, meet the requirements of 10 CFR 50.36.

4.0 STATE CONSULTATION

In accordance with the Commission's regulations, the Commonwealth of Virginia official was notified of the proposed issuance of the amendments on August 26, 2019. The state official confirmed that the Commonwealth had no comments.

5.0 ENVIRONMENTAL CONSIDERATION

The amendments change requirements with respect to installation or use of a facility component located within the restricted area as defined in 10 CFR Part 20 and change surveillance requirements. The NRC staff has determined that the amendments involve no significant increase in the amounts, and no significant change in the types, of any effluents that may be released offsite, and that there is no significant increase in individual or cumulative occupational radiation exposure. The Commission has previously issued a proposed finding that the amendments involve no significant hazards consideration, and there has been no public comment on such finding published in the *Federal Register* on September 11, 2018 (83 FR 45989). Accordingly, the amendments meet the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the issuance of the amendments.

6.0 CONCLUSION

The NRC staff has concluded, based on the considerations discussed above, that: (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) there is reasonable assurance that such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendments will not be inimical to the common defense and security or to the health and safety of the public.

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Date: September 12, 2019

SUBJECT: NORTH ANNA POWER STATION, UNIT NOS. 1 AND 2 – ISSUANCE OF AMENDMENT NOS. 282 AND 265 TO REVISE TECHNICAL SPECIFICATIONS REGARDING OPEN PHASE PROTECTION (EPID L-2018-LLA-0132) DATED SEPTEMBER 12, 2019

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