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U.S. Nuclear Regulatory Commission (NRC)
Washington, D.C. 20555-0001

ATTENTION: Document Control Desk

Duke Energy Carolinas, LLC (Duke Energy)
McGuire Nuclear Station, Units 1 and 2
Docket Nos. 50-369 and 50-370
Renewed Facility Operating Licenses NPF-9 and NPF-17

SUBJECT: Response to Request for Additional Information (RAI) Regarding License Amendment Request to Revise Technical Specification 3.3.1, "Reactor Trip System (RTS) Instrumentation"

In a letter dated July 9, 2015, Duke Energy requested a change to TS 3.3.1, "Reactor Trip System (RTS) Instrumentation) for McGuire Nuclear Station, Units 1 and 2. In an email dated November 10, 2015, the NRC submitted RAIs. Enclosure 1 of this letter provides Duke Energy's response to those RAIs.

Pursuant to 10 CFR 50.91, a copy of this RAI response is being sent to the designated official of the State of North Carolina.

No regulatory commitments are associated with this RAI response.

If there are any questions or if additional information is needed, please contact Brian Richards at 980-875-5171.

I declare under the penalty of perjury that the foregoing is true and correct. Executed on January 7, 2016.

Sincerely,

Jimmy Nexon for

Steven D. Capps

Enclosure 1

A001
NRR

xc with enclosure:

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ENCLOSURE 1

Response to Requests for Additional Information

**REQUEST FOR ADDITIONAL INFORMATION
BY THE OFFICE OF NUCLEAR REACTOR REGULATION
TECHNICAL SPECIFICATIONS AMENDMENT CHANGES TO REVISE TECHNICAL SPECIFICATION 3.3.1, "REACTOR TRIP SYSTEM INSTRUMENTATION"
DUKE ENERGY CAROLINAS, LLC
MCGUIRE NUCLEAR STATION, UNITS 1 AND 2
(DOCKET NOS. 50-369 AND 50-370)**

By letter dated July 9, 2015 (Agencywide Documents Access and Management System Accession No. ML15198A151) Duke Energy Carolinas, LLC (the licensee) submitted a license amendment request (LAR) to revise Technical Specifications (TS) 3.3.1, "Reactor Trip System (RTS) Instrumentation," to resolve an Operable But Degraded Non-conforming issue associated with the Reactor Coolant Pump (RCP) Underfrequency trip setpoint Allowable Value (AV) for McGuire Nuclear Station, Units 1 and 2.

The LAR proposes to modify the allowable value for Function 11, Undervoltage RCPs, and incorporate Option A of TSTF-493, Revision 4, "Clarify Application of Setpoint Methodology for LSSS Functions," calibration requirements for Functions 11 and 12, Undervoltage RCPs and Underfrequency RCPs, respectively, within Table 3.3.1-1, Reactor Trip System Instrumentation.

The staff of the Instrumentation and Controls Branch is reviewing the applicant's submittal for the areas under our scope and determined that additional information is needed to complete the review, as outlined in the enclosure.

RAI 1:

The LAR states that changes are required to resolve a latent design error, which resulted when the RCP Underfrequency and Undervoltage relays were replaced with more accurate relays.

Please describe the latent design error, how it was identified, and what actions were taken to prevent a similar error from occurring in the future.

McGuire Response:

While performing an engineering change to replace the undervoltage and underfrequency relays, the setpoint uncertainty calculation of record was not recognized as being affected. Therefore, it did not get revised as appropriate. This condition was identified when a similar change was being made at a sister plant (Catawba). Since the administrative procedure governing engineering changes was determined to include sufficient guidance to ensure that the appropriate calculations are reviewed and updated as appropriate, this omission was found to be an isolated historical issue not indicative of current performance.

RAI 2:

The LAR states the existing TS AV was determined based on the original setpoint methodology for the prior model relays. When a revision to this setpoint calculation was prepared for the more precise replacement relays, using the original setpoint methodology, the existing TS Underfrequency AV was no longer conservative. To address this non-conservatism, a new setpoint uncertainty calculation was developed based on the more current setpoint methodology.

a. Please describe the differences between the original setpoint methodology and the revised setpoint methodology. Please describe the reasons behind these differences.
b. Please describe what aspects of the original setpoint methodology result in a non- conservative AV for the Underfrequency RCPs.

McGuire Response:

a. The original setpoint methodology used two methods (Methods 2 and 3 as described in Section 7.3 Figure 6 of ISA RP67.04-1994, Part II) to calculate the AV. The more limiting of the two calculations was then used as the AV for the channel. This usually resulted in the limiting AV being established by Method 3.

   When the more precise replacement equipment was considered in the AV calculation using Method 3, the result was found to be more limiting than the value given in the Technical Specifications. This occurred due to the smaller uncertainties of the replacement relays and their impact on the Method 3 calculation. With the advent of TSTF-493, the As-Found tolerance essentially replaces the AV calculation using Method 3 from the standard. Therefore, when the methodology was revised to include TSTF-493, the calculation of the AV using Method 3 was dropped. The current methodology (which includes TSTF-493) calculates the AV using only one method (Method 2 as described in Section 7.3 Figure 6 of ISA RP67.04-1994, Part II).

b. See response to RAI 2.a. above.

RAI 3:

The LAR states the setpoint calculations were performed in accordance with Duke Energy Engineering Directives Manual (EDM)-102, "Instrument Setpoint/Uncertainty Calculations," Revision 4. The LAR further states EDM-102 is consistent with the intent of Instrument Society of America (ISA) Standard RP67.04-1994 Part II, "Methodologies for the Determination of Setpoints for Nuclear Safety-Related Instrumentation."

a. Please describe how EDM-102 is consistent with the intent of ISA RP67.04-1994, Part II, and identify the sections of ISA RP67.04-1994, Part II, used to develop EDM-102.
b. Please describe how EDM-102 differs from ISA RP67.04-1994, Part II.

McGuire Response:

a. EDM-102 was originally developed using the recommended practices described in ISA RP67.04-1994, Part II. The considerations and methods used in the EDM are similar to, if not identical to, those described in the standard. Similar to the standard, the EDM describes a process and methodology for performing setpoint and uncertainty calculations. Sections 3 through 10 and Appendices A through L of the standard were used to develop EDM-102.

b. The primary difference between EDM-102 and ISA RP67.04-1994, Part II is that EDM-102 was revised to include discussion of the TSTF-493, Revision 4 methodology. Material was added to describe the methodology for the use of As-Found and As-Left tolerances for RPS/ESFAS functions described in the Technical Specifications.

   With the advent of TSTF-493, the AV determination in EDM-102 has been limited to Method 2 as described in Section 7.3, Figure 6 of the ISA standard.

   Definitions were added and others modified for clarification from those described in the ISA standard. Generally, these changes are related to TSTF-493 implementation.

RAI 4:

Page 5 of 12 of LAR Enclosure 1 includes the equations for the Total Loop Uncertainty (TLU) and lists the sources of instrument uncertainty and biases that go into the TLU calculation. This page also includes a table containing the values of some of the uncertainty contributions (in % span).

For Underfrequency RCPs and Undervoltage RCPs, please provide a summary calculation of the TLU listing the values of all the variables that are part of the equation, and showing how they were combined to arrive at the TLU values. Please include the conversion from % span to voltage and frequency.

McGuire Response:

The applicable sections of the uncertainty calculation for the Underfrequency and Undervoltage relays are included as Attachment A of this enclosure. Reference Sections 7.2 and 7.3 of the calculation.

RAI 5:

The LAR proposes to revise the Undervoltage RCPs AV from '≥ 5016 V', to '≥ 4870 V'. Page 7 of 12 of LAR Enclosure 1 includes the equation for the AV and lists the factors that are part of the equation. This page also includes a table containing the calculated AV values for the Underfrequency RCPs and Undervoltage RCPs.

a. Please provide the Analytical Limit values for the Underfrequency RCPs and the Undervoltage RCPs.
b. Please provide summary calculations for the Underfrequency RCPs AV and the Undervoltage RCPs AV, listing the values of all the variables that are part of the equation and showing how they were combined to arrive at the AVs.

McGuire Response:

a. As documented in the uncertainty calculation, the analytical limit for reactor coolant pump trip setpoint conservatively corresponds to a frequency of 55.0 Hz.

   The calculation states that the reactor coolant pump undervoltage trip setpoint is not credited in any transients, so an analytical limit has not been established. However, the calculation goes on to state that for analyses where modeling the actual undervoltage setpoint is required, an analytical limit of 4800 V should be used.

b. The applicable sections of the uncertainty calculation for the Underfrequency and Undervoltage relays are included as Attachment A of this enclosure. The AV determinations for the Underfrequency and Undervoltage relays are found in Section 7.4.

RAI 6:

Page 8 of 12 of LAR Enclosure 1 includes two tables containing the As-found and As-left Tolerances for the Underfrequency RCPs and the Undervoltage RCPs setpoints.

Please provide summary calculations for the following:

a. As-found Tolerance for the Underfrequency RCPs setpoint.
b. As-found Tolerance for the Undervoltage RCPs setpoint.
c. As-left Tolerance for the Underfrequency RCPs setpoint.
d. As-left Tolerance for the Undervoltage RCPs setpoint.

McGuire Response:

The applicable sections of the uncertainty calculation for the Underfrequency and Undervoltage relays are included as Attachment A of this enclosure.

As-found and as-left tolerances for the Underfrequency and Undervoltage RCP setpoints are found in Sections 7.2.1.1 and 7.2.1.2.

Attachment A

Applicable Sections of Reactor Coolant Pump Underfrequency and Undervoltage Relay Loop Uncertainty Calculation

7. Calculation

7.1 Instrument Loop and Logic

The EME System is divided into four independent and physically separate channels. Each channel is comprised of one undervoltage relay, one underfrequency relay, five auxiliary relays (as shown in Section 1.2), two test blocks, one selector test switch, five indicating lights, and three sliding link terminal blocks.

Input signals to the undervoltage relays are taken from the motor side of the reactor coolant pump motor feeder breakers and transformed via 7200/120 VAC potential transformers. Input signals to the underfrequency relays are taken from the bus side of the reactor coolant pump motor feeder breakers and transformed by an identical set of potential transformers. Control power for the relays are supplied by the EPL system - 125 VDC Vital I&C Power (Ref. 5.K.b).

Redundancy requirements are met by employing a 2/4 logic scheme to initiate reactor protective action. Further, separation requirements are met by physically separating the components inside the reactor coolant pump power monitoring cabinet from the components in the other channels. All cabling and associated wiring was designed to observe the four channel separation.

Separation and channel independence are maintained from the point of the "process sensor"; the PTs which transform the voltage from 6900V to 120V AC are the process sensors for the EME system. Input from the process sensors are directed to the undervoltage and underfrequency relays and in turn to the Reactor Protection System.

7.2 Device/Loop Uncertainty Term Identification

This portion of the calculation will be divided into the underfrequency relay section and the undervoltage relay section. Uncertainty terms for the entire underfrequency and undervoltage relay for each relay will be provided. Each individual uncertainty term will be identified and documented. Then the individual uncertainty terms will be statistically combined to determine a total loop uncertainty for underfrequency and undervoltage relays.

7.2.1 EME System

All uncertainties in this section are for the underfrequency (Reference 5.C) and undervoltage relays (Reference 5.D). Since the undervoltage and underfrequency relays are stand-alone devices, a specific uncertainty for the rack and transmitter are not calculated. However, a total loop uncertainty for each device will be calculated.

From Reference 5.C, the frequency may vary from 54 to 63 Hz (i.e., a span of 9.0 Hz) with the output circuit rating of 5 Amperes continuous at 125 Vdc for the underfrequency relay.

From Reference 5.D, the input circuit rating can vary from 60 to 110 Volts (i.e. 50 Volt operating range), with an output contact rating of 5 Amperes continuous at 125 Vdc for the undervoltage relay.

All uncertainties given below are random-independent terms unless stated otherwise.

7.2.1.1 Underfrequency Relay

A - Accuracy
Per Reference 5.C, calibrated accuracy for the specified range are as follows.

$$\mathbf{Accuracy := 0.008\ Hz}$$

$$\mathbf{f\_Range := 9.0\ Hz}$$

$$\mathbf{A\_FR := \left(\frac{Accuracy}{f\_Range}\right)}$$

$$\mathbf{A\_FR = 0.089\,\%}\quad \text{span}$$

D - Drift
Since vendor data is unavailable, drift is assumed to be equal to the reference accuracy as stated in assumption 6.1.2. As a result, underfrequency relay drift is as follows. Per assumption 6.1.4, drift is not extrapolated for the 25% grace period.

$$\mathbf{D\_FR := A\_FR}$$

$$\mathbf{D\_FR = 0.089\,\%}\quad \text{span}$$

M&TE - Measuring and Test Equipment
Per Reference 5.E, the following calibrated test equipment is used for the calibration of the underfrequency relay.

DMM, Keithley 2001 or equivalent (</= 0.2% Tolerance)
Dynamic Fault Reconstructor (DFR-1), Powertech or equivalent (harmonic voltage distortion </= 0.3%)

Per Assumption 6.1.6, the M&TE uncertainty for the Keithley 2001 is as follows.

$$\mathbf{K\_2001\_MTE = 0.36\,\%}\quad \text{span}$$

Per corrective action #4 of PIP M-98-01363, Powertech is now known as Manta Test Systems and the DFR-1 test set to calibrate RCP UV/UF Relays is now known as the MTS-1710. Per Reference 5.O, the uncertainty for the MTS-1710 for a 60 hz range is 0.0142 hz. For the underfrequency relays 9.0 hz range, this uncertainty is as follows.

$$\mathbf{MTS\_1710\_freq\_MTE := \frac{0.0142 \cdot Hz}{f\_Range}}$$

$$\mathbf{MTS\_1710\_freq\_MTE = 0.158\,\%\ span}$$

Therefore, the overall M&TE for the Underfrequency Relay is as follows.

$$\mathbf{MTE\_FR := \sqrt{K\_2001\_MTE^2 + MTS\_1710\_freq\_MTE^2}}$$

$$\mathbf{MTE\_FR = 0.39\,\%}\quad \text{span}$$

TE - Temperature Effect
Per Reference 5.K.a, the EME System underfrequency relay is mounted in the control room and is rated to operate for a temperature range of -4 F to 131 F (-20 to +55 C as stated in Reference 5.C.a). Thus, temperature effect is expected to be negligible. Further proof of this is apparent in the Reference 5.C.c temperature test. Therefore the temperature effect is negligible for the underfrequency trip.

The temperature effect is assumed to be negligible under normal conditions. Since this device is only required during normal conditions for the loss of flow analysis (Ref. 5.J) and calibration will occur under normal conditions, the temperature effect is assumed to be negligible during calibration and when the system is required to operate.

TE_FR := 0.0% span

RES - Resolution/Readability
Since the underfrequency relay is not providing indication for the trip function, there will be no resolution associated with the underfrequency relays.

RES_FR := 0.0% span

PSE - Power Supply Effect
The plant power supply to the relays is from the vital inverters. Per Reference 5.C, at 125 V nominal, the allowable variation in voltage is from 100 to 140 VDC. Since the voltage variation from the 125 VDC Vital I&C Power will remain between 100 and 140 VDC, the PSE is negligible and specified as +/- 0.0%.

PSE_FR := 0.0% span

S - Seismic Effect (Not needed in Calculation - Included as added information only)
Per Section 2.4.2 of Reference 5.K.a, the enclosure was seismically tested. The panel and enclosed equipment shall remain structurally sound, operate functionally correct, and provide minimum seismic amplification during and after a safe shutdown earthquake. Also, it is assumed that following a seismic event the plant will be shutdown and all effected instrumentation re-calibrated. Therefore, the seismic allowance will be assumed to be 0.0% of span.

S_FR := 0.0% span

R - Radiation Effect
Since the instrument is mounted in the control room (Reference 5.K.a - Section 2.3.10), the normal radiation effect is negligible. As a result, the radiation effects are considered negligible.

R_FR := 0.0% span

EA - Environmental Allowance (Not needed in Calculation - Included as added information only)
The EA term is considered as a bias in either the positive or negative direction depending upon the direction of the error. Since the undervoltage relay is located in the control room (Reference 5.K.a - Section 2.3.10), an environmental term is not included in the uncertainty calculation for the NCP motor bus underfrequency trip.

EA_FR := 0.0% span

CL - Current Leakage Effect (Not needed in Calculation - Included as added information only)
The current leakage effect occurs due to elevated humidity and temperature conditions associated with a high energy line break. The underfrequency relays are credited in the Loss of Flow Analysis (Reference 5.J.a) which does not involve a high energy line break. Thus, current leakage will not be present when this equipment is needed.

$$CL\_FR := 0.0\% \quad \text{span}$$

As Found (AFT) and As Left (ALT) Tolerances

"As-Found" is the condition in which a channel, or portion of a channel, is found after a period of operation and before recalibration, if necessary. The As-Found Tolerance is the allowance that the channel, or portion thereof, is expected to be within based on uncertainty calculations which ensure the channel is capable of producing a trip prior to reaching the Safety Analysis Analytical Limit.

Per Reference 5.A.a, the uncertainty terms which make up the As-Found Tolerance for the portion of the channel under surveillance would typically include the square root sum of squares combination of reference accuracy, drift and measurement and test equipment uncertainty effects (e.g. M&TE Uncertainty and M&TE Reading Resolution).

"As-Left" is the condition in which a channel, or portion of a channel, is left after calibration or final setpoint device setpoint verification. The As-Left Tolerance is the acceptable setting variation about the setpoint that the technician may leave the setting following calibration.

Per Reference 5.A.a, the uncertainty terms which make up the As-Left Tolerance for the portion of the channel under surveillance would typically include the square root sum of squares combination of reference accuracy and measurement and test equipment uncertainty effects (e.g. M&TE Uncertainty and M&TE Reading Resolution).

Per Reference 5.B & 5.E, the desired dropout frequency (Nominal Trip Setpoint) is set at 56.4 Hz.

$$uf\_NTSP := 56.4\ Hz$$

Reactor Coolant Pump Underfrequency As Found Tolerance

$$AF\_tol\_FR := \sqrt{A\_FR^2 + D\_FR^2 + MTE\_FR^2}$$

$$AF\_tol\_FR = 0.410 \cdot \% \quad \text{span}$$

$$AF\_tol\_FR\_e := AF\_tol\_FR \times f\_Range = 0.037 \cdot Hz$$

$$AF\_FR\_value := uf\_NTSP - AF\_tol\_FR\_e = 56.363 \cdot Hz$$

Reactor Coolant Pump Underfrequency As Left Tolerance

$$AL\_tol\_FR := \sqrt{A\_FR^2 + MTE\_FR^2}$$

$$AL\_tol\_FR = 0.400 \cdot \% \text{ span}$$

$$AL\_tol\_FR\_e := AL\_tol\_FR \times f\_Range = 0.036 \cdot Hz$$

$$AL\_FR\_value := uf\_NTSP - AL\_tol\_FR\_e = 56.364 \cdot Hz$$

CTE - Calibration Tolerance Effect
Per Assumption 6.1.5 the calibration tolerance effect (CTE) will be set equal to the As-Left Tolerance.

$$CTE\_FR := AL\_tol\_FR = 0.4 \cdot \% \text{ span}$$

Random Uncertainty for Underfrequency Relay Terms

Combination of Underfrequency Relay Terms
The formulas below combine the error terms to determine the overall random uncertainty for the underfrequency relay. The underfrequency relay is used during the loss of coolant flow event (Reference 5.J). The loss of coolant flow event does not involve adverse containment conditions. Therefore, the uncertainty calculation for the NCP motor bus underfrequency trip is calculated for normal conditions only. Accident uncertainties are not required. Note: Since the seismic uncertainty is 0.0%, underfrequency relay seismic uncertainty is the same as the normal uncertainty.

Normal

$$RU\_FR\_Nor := \sqrt{A\_FR^2 + D\_FR^2 + MTE\_FR^2 \ldots + TE\_FR^2 + RES\_FR^2 + PSE\_FR^2 \ldots + R\_FR^2 + CTE\_FR^2}$$

$$RU\_FR\_Nor = 0.57 \cdot \% \text{ span}$$

Underfrequency Relay Bias

Deadband
Per Section 2.4.1 of Reference 5.K.a, the underfrequency relays incorporate a one (1) Hz deadband on the high side of the trip setpoint. This deadband makes it necessary for the input signal to rise in frequency by a minimum of one hertz before reset logic would be initiated. Per Reference 5.C, the frequency can range from 54 to 63 Hz which is a total range of 9 Hz. For a 9 Hz range, this 1 Hz rise is equivalent to an uncertainty of 11.11%. However, the deadband is for resetting the trip and is on the high side of the trip above the trip setpoint. Therefore, it does not add to the uncertainty associated with the trip setpoint. As a result, the uncertainty in the trip setpoint due to a bias associated with the deadband or any other parameter is 0.0%.

$$Bias\_FR := 0.0\% \text{ span}$$

7.2.1.2 Undervoltage Relay

A - Undervoltage Relay Accuracy
Per Reference 5.D, the pickup and dropout settings with respect to dial markings (factory calibration) is +/- 2.0 %. Per Reference 5.F, the pickup voltage tap is the 90 V tap. Thus, the accuracy is as follows for a 50 V range.

$$Tol\_VR := 2.0\% \quad \text{span}$$

$$pickup\_V\_tap := 90 \cdot V$$

$$V\_Range := 50 \cdot V$$

$$A\_VR := \frac{Tol\_VR \cdot (pickup\_V\_tap)}{V\_Range}$$

$$A\_VR = 3.6 \cdot \%$$

Per, Reference 5.D, the pickup and dropout settings also have uncertainty due to repeatability at constant temperature and constant control voltage and repeatability over "allowable" dc control power range. Since these values are both +/- 0.1%, these are considered negligible and will be ignored. Similarly, the pickup and dropout settings have an uncertainty for repeatability over a temperature range. However, since the relay will be in the control room, the temperature change will be relatively small and the associated repeatability uncertainty will be negligible.

D - Drift
Since vendor data is unavailable, drift is assumed to be equal to the reference accuracy per assumption 6.1.2. As a result, undervoltage relay drift is as follows. Per assumption 6.1.4, drift is not extrapolated for the 25% grace period.

$$D\_VR := A\_VR$$

$$D\_VR = 3.6 \cdot \% \quad \text{span}$$

M&TE - Measuring and Test Equipment
Per Reference 5.F, the following calibrated test equipment is used for the calibration of the undervoltage relay.

DMM, Keithley 2001 or equivalent (</= 0.2% Tolerance)
Dynamic Fault Reconstructor (DFR-1), Powertech or equivalent (harmonic voltage distortion </= 0.3%)

Per Assumption 6.1.6, the M&TE uncertainty for the Keithley 2001 is as follows.

$$K\_2001\_MTE = 0.36 \cdot \% \quad \text{span}$$

Per corrective action #4 of PIP M-98-01363, Powertech is now known as Manta Test Systems and the DFR-1 test set to calibrate RCP UV/UF Relays is now known as the MTS-1710. Per Reference 5.O, the uncertainty for the MTS-1710 for a range of 82 VAC to 120 VAC is MTS_1710_unc. For the M&TE associated operating range (MTE_V_Range), the MTS-1710 M&TE (MTS_1710_volt_MTE) for the undervoltage relay is as follows.

$$MTS\_1710\_unc := 1.1921 \cdot V$$

$$MTE\_V\_Range := 120.0 \cdot V - 82.0 \cdot V$$

$$MTE\_V\_Range = 38\,V$$

$$MTS\_1710\_volt\_MTE := \frac{MTS\_1710\_unc}{MTE\_V\_Range}$$

$$MTS\_1710\_volt\_MTE = 3.14 \cdot \% \quad \text{span}$$

Therefore, the overall M&TE for the Undervoltage Relay is as follows.

$$MTE\_VR := \sqrt{K\_2001\_MTE^2 + MTS\_1710\_volt\_MTE^2}$$

$$MTE\_VR = 3.16 \cdot \% \quad \text{span}$$

TE - Temperature Effect
Per Reference 5.K.a Section 2.3.2, The EME System undervoltage relay is mounted in the control room which is a temperature controlled area. The undervoltage relay is rated to operate for a temperature range of -4 F to 158 F (-20 C to +70 C as stated in Ref. 5.D.a). Therefore, the temperature effect is negligible for the undervoltage trip.

The temperature effect is assumed to be negligible under normal conditions. Since this device is only required during normal conditions for the loss of flow analysis (Ref. 5.J) and calibration will occur under normal conditions, the temperature effect is assumed to be negligible during calibration and when the system is required to operate.

TE_VR := 0.0% span

RES - Resolution/Readability
Since the undervoltage relay is not providing indication, there will be no resolution associated with the undervoltage relay.

RES_VR := 0.0% span

PSE - Power Supply Effect
The plant power supply to the relays is from the 125 VDC Vital I&C Power. Per Reference 5.D, at 125 V nominal, the allowable variation in voltage is from 100 to 140 VDC. Since the voltage variation from the 125 VDC Vital I&C Power will remain between 100 and 140 VDC, the PSE is negligible and specified as +/- 0.0%.

PSE_VR := 0.0% span

S - Seismic Effect (Not needed in Calculation - Included as added information only)
Per Section 2.4.2 of Reference 5.K.a, the enclosure was seismically tested. The panel and enclosed equipment shall remain structurally sound, operate functionally correct, and provide minimum seismic amplification during and after a safe shutdown earthquake. Also, it is assumed that following a seismic event, the plant will be shutdown and all effected instrumentation re-calibrated. Therefore, the seismic allowance will be assumed to be 0.0% of span.

S_VR := 0.0% span

R - Radiation Effect
Since the instrument is mounted in the control room (Reference 5.K.a - Section 2.3.10), the normal radiation effect is negligible. As a result, the radiation effects are considered negligible.

R_VR := 0.0% span

EA - Environmental Allowance (Not needed in Calculation - Included as added information only)
The EA term is considered as a bias in either the positive or negative direction depending upon the direction of the error. Since the undervoltage relay is located in the control room (Reference 5.K.a - Section 2.2.8), an environmental term is not included in the uncertainty calculation for the NCP motor bus undervoltage trip.

EA_VR := 0.0% span

CL - Current Leakage Effect (Not needed in Calculation - Included as added information only)
The current leakage effect occurs due to elevated humidity and temperature conditions associated with a high energy line break. The cables routed from the field sensors (potential transformers) to the relays are not routed through areas where they could be exposed to a high energy line break. Therefore, a current leakage term is not included in the uncertainty calculation.

$$CL\_VR := 0.0\% \quad \text{span}$$

As Found (AFT) and As Left (ALT) Tolerances

Per Reference 5.F, the desired dropout voltage (Nominal Trip Setpoint) is set at 84.7 VAC or 5082.0 VAC bus volts. As discussed in Section 7.2.1.2, the Voltage Range is 50.0 Volts. This range is then converted to bus volts by multiplying by a factor of 7,200 VAC/120 VAC = 60 (bus volts/volt)).

$$bus\_v\_Range := 60 \cdot V\_Range = 3000\,V$$

$$uv\_NTSP := 84.7V \cdot 60\,\frac{V}{V} = 5082\,V$$

Reactor Coolant Pump Undervoltage As Found Tolerance

$$AF\_tol\_VR := \sqrt{A\_VR^2 + D\_VR^2 + MTE\_VR^2}$$

$$AF\_tol\_VR = 5.991 \cdot \% \quad \text{span}$$

$$AF\_tol\_VR\_e := AF\_tol\_VR \times V\_Range = 2.995\,V$$

$$AF\_VR\_value := uv\_NTSP - AF\_tol\_VR\_e \times \frac{bus\_v\_Range}{V\_Range} = 4902.3 \cdot V$$

Reactor Coolant Pump Undervoltage As Left Tolerance

$$AL\_tol\_VR := \sqrt{A\_VR^2 + MTE\_VR^2}$$

$$AL\_tol\_VR = 4.788 \cdot \% \quad \text{span}$$

$$AL\_tol\_VR\_e := AL\_tol\_VR \times V\_Range = 2.394\,V$$

$$AL\_VR\_value := uv\_NTSP - AL\_tol\_VR\_e \times \frac{bus\_v\_Range}{V\_Range} = 4938.3\,V$$

CTE - Calibration Tolerance Effect
Per Assumption 6.1.5 the calibration tolerance effect (CTE) will be set equal to the As-Left Tolerance.

$$CTE\_VR := AL\_tol\_VR = 4.788 \cdot \% \quad \text{span}$$

Random Uncertainty for Undervoltage Relay Related Terms

Combination of Undervoltage Relay Terms

The formulas below combine the error terms to determine the overall random uncertainty for the undervoltage relay. The undervoltage relay is used during the loss of coolant flow event (Reference 5.J). The loss of coolant flow event does not involve adverse containment conditions. Therefore, the uncertainty calculation for the NCP motor bus undervoltage trip is calculated for normal conditions only. Accident uncertainties are not required. The random uncertainty is given as a negative value below Note: Since the seismic uncertainty is 0.0%, undervoltage relay seismic uncertainty is the same as the normal uncertainty.

Normal

$$RU\_VR\_Nor := \sqrt{A\_VR^2 + D\_VR^2 + MTE\_VR^2 \ldots + TE\_VR^2 + RES\_VR^2 + PSE\_VR^2 \ldots + R\_VR^2 + CTE\_VR^2}$$

$$RU\_VR\_Nor = 7.67 \cdot \%\ \text{span}$$

Undervoltage Relay Bias

There are no applicable bias terms in the calculation of the undervoltage relay total loop uncertainty.

$$Bias\_VR := 0.0\%\ \text{span}$$

7.3 Total Loop Uncertainty Determination

Underfrequency Relay

The total loop uncertainty combines the uncertainty of the random terms and the bias terms. The bias is applied if it causes a delay to the trip. In this case, the bias for the underfrequency relay is zero. However, the bias is included in the total loop uncertainty equation for completeness.

Normal Conditions

$$TLU\_FR\_Nor := \sqrt{RU\_FR\_Nor^2} + Bias\_FR$$

$$TLU\_FR\_Nor = 0.57 \cdot \% \text{ span}$$

$$TLU\_FR\_Nor\_e := TLU\_FR\_Nor \times f\_Range = 0.052 \cdot Hz$$

$$TLU\_FR\_value := uf\_NTSP - TLU\_FR\_Nor\_e = 56.348 \cdot Hz$$

Undervoltage Relay

The total loop uncertainty combines the uncertainty of the random terms and the bias terms. The bias is applied if it causes a delay to the trip. In this case, the bias for the undervoltage relay is zero. However, the bias is included in the total loop uncertainty equation for completeness.

Normal Conditions

$$TLU\_VR\_Nor := \sqrt{RU\_VR\_Nor^2} + Bias\_VR$$

$$TLU\_VR\_Nor = 7.67 \cdot \% \text{ span}$$

$$TLU\_VR\_Nor\_e := TLU\_VR\_Nor \times V\_Range = 3.835 \cdot V$$

$$TLU\_VR\_value := uv\_NTSP - TLU\_VR\_Nor\_e \cdot \frac{bus\_v\_Range}{V\_Range} = 4851.923 \cdot V$$

7.4 Allowable Value Determination

7.4.1 Underfrequency Relay Allowable Value

MNS Technical Specifications (Ref. 5.B) defines the Underfrequency Nominal Trip Setpoint (uf_NTSP) as follows.

uf_NTSP = 56.4·Hz

Per Reference 5.A.a the Allowable Value is calculated using the following equation:

$AV = AL \pm (RU_{NT} \pm \text{Biases})$

Where: AL = Analytical Limt
RU_{NT} = uncertainty associated with the portion of the loop not tested during channel operational test (COT), calibration, etc.
Biases = bias/abnormal distribution uncertainties

Per Appendix I of Reference 5.J.a (last paragraph on page 140), the analysis trip setpoint is modeled as a delay time which conservatively corresponds to a frequency of 55.0 Hz. Therefore the analytical limit for this and any analyses which credit this trip in the future is:

uf_Analytical_Limit := 55.0 Hz

Since the underfrequency relay is a stand-alone device and all of the equipment is tested during the calibration, there are no untested uncertainty components. Therefore,

uf_RUNT := 0.0% span

Per the Specification Section of Reference 5.C.c, the range for the underfrequency relay is 9 Hz (54 to 63 Hz).

f_Range = 9·Hz

AV_UF_Trip := uf_Analytical_Limit + (uf_RUNT + Bias_FR)·(f_Range)

AV_UF_Trip = 55.0·Hz

7.4.2 Undervoltage Relay Allowable Value

MNS Technical Specifications (Ref. 5.B) defines the Undervoltage Nominal Trip Setpoint (uv_NTSP) as follows.

uv_NTSP = 5082 V

Safety Analysis does not currently credit the reactor coolant pump undervoltage trip setpoint explicitly in any transients. It should be noted that the loss of coolant flow analyses (Reference 5.J.a) assume the reactor coolant pump trips at the start of the event at time 0.0 seconds. This leads to a reactor trip within 1.5 seconds (with/without a delay of 0.65 seconds). As a result, the reactor trip in the analyzed event was based upon an elapsed time and not upon an actual voltage setpoint. Therefore, a safety analysis analytical limit for undervoltage has not been established. In future analyses, where modeling the actual undervoltage setpoint is required, a safety analysis analytical limit of 4,800 Volts for the reactor coolant pump undervoltage should be used.

uv_Analytical_Limit := 4800.0 V

As with the underfrequency setpoint, the undervoltage relay is a stand-alone device and all of the equipment is tested during the calibration, there are no untested uncertainty terms.

uv_RUNT := 0.0% span

As discussed in Section 7.2.1 the Voltage Range is 50.0 Volts. This range is then converted to bus volts by multiplying by a factor of 7,200 VAC/120 VAC = 60 (bus volts/volt)).

bus_v_Range = 3000 V

AV_UV_Trip := uv_Analytical_Limit + (uv_RUNT + Bias_VR)·(bus_v_Range)

AV_UV_Trip = 4800.0 V

7.5 Loop Scaling

Per Reference 5.C, the frequency can range from 54 to 63 Hz which is a total range of 9 Hz. Therefore, the scaling for the underfrequency relay corresponds to this 9 Hz range or span. Per Reference 5.D, the voltage range is from 60 to 110 V which is a 50 V range. Since the potential transformers for the undervoltage relay have a ratio of 60/1 (Section 2.2.1.1.1 of Reference 5.K.a), the scaling for the voltage range of 60 to 110 VAC of the undervoltage relay corresponds to a bus voltage range of 3,600 to 6,600 bus Volts.

7.6 Setpoint Analysis and/or Acceptability of Loop Uncertainty and Allowable Value

The tables below summarize the TLUs, As-Left and As-Found tolerances and Allowable Value results for the underfrequency and undervoltage trips.

Summary of Calculated Uncertainties

Underfrequency Trip Uncertainty Allowance Results (NTSP = 56.4 Hz)

Underfrequency =

"Uncertainty"	"Allowance, % span"	"Allowance, Hz "	"NTSP - Uncert, Hz"
"Normal UF TLU"	0.572	0.052	56.348
"As-Left Tolerance"	0.400	0.036	56.364
"As-Found Tolerance"	0.410	0.037	56.363

UF_Allowable_Value =

"Current TS AV, Hz"	"Calculated Allowable Value, Hz"
55.9	55.0

Undervoltage Trip Uncertainty Allowance Results (NTSP=5082 Volts)

Undervoltage =

"Uncertainty"	"Allowance, % span"	"Allowance, Volts"	"NTSP - Uncert, Volts"
"Normal UV TLU"	7.67	230.08	4851.92
"As-Left Tolerance"	4.79	143.65	4938.35
"As-Found Tolerance"	5.99	179.72	4902.28

UV_Allowable_Value =

"Current TS AV, Volts"	"Calculated Allowable Value, Volts"
5016	4800

Based on the uncertainties provided above, there are no Technical Specification changes required for the underfrequency and undervoltage reactor trip setpoints or safety analysis analytical limits. Also, the Allowable Value results indicate that the current Technical Specification values are more limiting than the calculated values and revision of the Technical Specification Allowable Values is not required.

As-Left Tolerance Acceptability

Underfrequency As-Left Tolerance

The calibration procedure As-Left tolerance must be equal to or conservative with respect to the tolerance calculated above. Per Reference 5.E, the calibration procedure As-Left tolerance is ± 0.036 Hz about the nominal trip setpoint of 56.4 Hz. Therefore, the procedure As-Left tolerance matches the As-Left tolerance calculated above and no changes to the procedure are necessary.

Undervoltage As-Left Tolerance

The calibration procedure As-Left tolerance must be equal to or conservative with respect to the tolerance calculated above. Per Reference 5.F, the NTSP, As-Left tolerance and Allowable Value are implemented in terms of the voltage range of the instrumentation by dividing the bus volts by bus volt to instrument voltage span conversion of 60 bus volts/volt, i.e. the NTSP = 5082 volts/60 busvolts/volt = 84.7 volts. The calibration procedure As-Left tolerance is ± 0.8 volts about the nominal trip setpoint of 84.7 volts. This equates to a tolerance of ± 48 volts about the NTSP of 5082 volts. The calibration procedure As-Left tolerance is much tighter than the tolerance calculated above of ± 143.65 volts. Therefore, the current procedure As-Left tolerance is acceptable, but may be revised to allow an expanded As-Left tolerance.