Tab F

NORTHERN STATES POWER COMPANY
PRAIRIE ISLAND NUCLEAR GENERATING PLANT
CALCULATION COVER SHEET

Calculation Number: SPCNI018

Calculation Rev. No.: 0

Calculation Title: Unit 2 Calorimetric Uncertainty

Calculation Type:

- Safety Related
- What if (information only)
- ☑ Non-Safety Related (review required)
- Non-Safety Related (review not required)

Plant Conditions:

- ☑ Normal
- LOCA
- Seismic
- Other
- Post Accident

Calculation Verification Method (check one):

- ✓ Design Review
- _____ Alternate Calculation
- _____ Qualification Testing

Scope of Revision: Original Issue

Documentation of Reviews and Approvals:

Originated By: John Harrison **Date:** 07/16/95
Reviewed By: Thomas M. VerBout **Date:** 09/27/95
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1.0 PURPOSE/RESULTS

1.1. Purpose and Acceptance Criteria

The purpose of this calculation is to determine the error of the Calorimetric calculation performed by ERCS. The error determination is based on the error of the four inputs to ERCS along with the error that ERCS introduces during the analog to digital conversion of the input signals. The four inputs to ERCS are:

SIGNAL	SENSOR	ERCS POINT
FEEDWATER FLOW	2FE-466	2F2511A
FEEDWATER TEMP	2TE-498	2T0418A
STEAM GENERATOR PRESSURE	2PT-468	2P0400A
BLOWDOWN FLOW	27191	2F0409A

1.2. Results

This calculation documents the values used by Attachment A to this calculation. Refer to Attachment A for the calorimetric uncertainty results.

2.0 METHODOLOGY

The following equations are based on the "Two Loop Group Setpoint Methodology," Revision 0, prepared by TENERA, L.P. for Northern States Power Company, Wisconsin Public Service Corporation, and Wisconsin Electric Power Company. This methodology is based on ISA Standard S67.04-1987, Setpoints for Nuclear Safety-Related Instrumentation Used in Nuclear Power Plants.

2.1. Calculation of Total Loop Error (TLE)

Total Loop Error (TLE) = The Square Root of the Sum of the Squares (SRSS) of the Random terms ± the sum of the Bias terms, or:

TLE_{pos} = SRSS + Bias positive terms
and
TLE_{neg} = - SRSS - Bias negative terms

For normal conditions:

$$SRSS = (A + D_R + M + OPE_R + SPEZ_R + SPES_R + P_R + T_{NR} + R_{NR} + H_{NR} + READ + PEA_{NR}{}^2 + PMA_{NR}{}^2 + PC_{NR}{}^2)^{1/2}$$

$$Bias_{pos} = D_{Bp} + OPE_{Bp} + SPEZ_{Bp} + SPES_{Bp} + P_{Bp} + T_{NBp} + R_{NBp} + H_{NBp} + PEA_{NBp} + PMA_{NBp} + PC_{NBp}$$

$$Bias_{neg} = D_{Bn} + OPE_{Bn} + SPEZ_{Bn} + SPES_{Bn} + P_{Bn} + T_{NBn} + R_{NBn} + H_{NBn} + PEA_{NBn} + PMA_{NBn} + PC_{NBn}$$

For accident conditions:

$$SRSS = (A + D_R + M + OPE_R + SPEZ_R + SPES_R + P_R + T_{AR} + R_{ANR} + H_{AR} + READ + SPT_R + PEA_{AR}{}^2 + PMA_{AR}{}^2 + PC_{AR}{}^2)^{1/2}$$

$$Bias_{pos} = D_{Bp} + OPE_{Bp} + SPEZ_{Bp} + SPES_{Bp} + P_{Bp} + T_{ABp} + R_{ANBp} + H_{ABp} + PEA_{ABp} + PMA_{ABp} + PC_{ABp} + IR_{Bp} + SPT_{Bp}$$

$Bias_{neg} = D_{Bn} + OPE_{Bn} + SPEZ_{Bn} + SPES_{Bn} + P_{Bn} + T_{ABn} + R_{ANBn} + H_{ABn} + PEA_{ABn} + PMA_{ABn} + PC_{ABn} + IR_{Bn} + SPT_{Bn}$

For loss of non-seismic HVAC due to a seismic event:

$SRSS = (A + D_R + M + OPE_R + SPEZ_R + SPES_R + P_R + T_{NSR} + R_{NR} + H_{NSR} + S_R + READ + PEA_{NR}{}^2 + PMA_{NR}{}^2 + PC_{NR}{}^2)^{1/2}$

$Bias_{pos} = D_{Bp} + OPE_{Bp} + SPEZ_{Bp} + SPES_{Bp} + P_{Bp} + T_{NSBp} + R_{NBp} + H_{NSBp} + S_{Bp} + PEA_{NBp} + PMA_{NBp} + PC_{NBp}$

$Bias_{neg} = D_{Bn} + OPE_{Bn} + SPEZ_{Bn} + SPES_{Bn} + P_{Bn} + T_{NSBn} + R_{NBn} + H_{NSBn} + S_{Bn} + PEA_{NBn} + PMA_{NBn} + PC_{NBn}$

For Post Accident conditions:

$SRSS = (A + D_R + M + OPE_R + SPEZ_R + SPES_R + P_R + T_{NR} + R_{NR} + H_{NR} + PDBE_R + READ + PEA_{NR}{}^2 + PMA_{NR}{}^2 + PC_{NR}{}^2)^{1/2}$

$Bias_{pos} = D_{Bp} + OPE_{Bp} + SPEZ_{Bp} + SPES_{Bp} + P_{Bp} + T_{NBp} + R_{NBp} + H_{NBp} + PDBE_{Bp} + PEA_{NBp} + PMA_{NBp} + PC_{NBp}$

$Bias_{neg} = D_{Bn} + OPE_{Bn} + SPEZ_{Bn} + SPES_{Bn} + P_{Bn} + T_{NBn} + R_{NBn} + H_{NBn} + PDBE_{Bn} + PEA_{NBn} + PMA_{NBn} + PC_{NBn}$

Where:

A = The sum of the squares of all of the random device accuracies (a).

D = The sum of the squares of all of the random device drift effects (d).

M = The sum of the squares of all of the random device M&TE effects (m).

OPE = The sum of the squares of all of the random device over pressure effects (ope).

SPEZ = The sum of the squares of all of the random device static pressure zero effects (spez).

SPES = The sum of the squares of all of the random device static pressure span effects (spes).

P = The sum of the squares of all of the random device power supply effects (p).

T = The sum of the squares of all of the random device temperature effects (t).

R = The sum of the squares of all of the random device radiation effects (r).

H = The sum of the squares of all of the random device humidity effects (h).

S = The sum of the squares of all of the random device seismic effects (s).

READ = The square of the indicator readability term (read).

PEA = The primary element accuracy.

PMA = The process measurement accuracy.

PC = The sum of all of the process considerations.

IR = The error introduced by insulation resistance.

PDBE = The sum of the squares of all of the random device post design basis event effects (pdbe).

The subscripts are defined as follows:

A = For accident conditions only.

N = For normal conditions only.

AN = For cumulative accident and normal conditions.

NS = For loss of non-seismic HVAC conditions only.

R = A Random term.

Bp = A Bias positive term.

Bn = A Bias Negative term.

Notes:

1. When a device's setting tolerance is greater than its accuracy, then the setting tolerance is used in place of that device's accuracy.

2. When accident conditions are being evaluated and a Steam Pressure/Temperature (SPT) effect is given on the vendor screen, the SPT effect will automatically be substituted for T_A and H_A.

3. During all conditions, when Plant Specific Drift is entered on the vendor screen, accuracy, M&TE effect, normal temperature effect, normal radiation effect, and normal humidity effect for that device default to zero since they are all considered to be included in the Plant Specific Drift value. During the calculation, the option to override the default for each effect is given.

2.2. Calculation of the Nominal Trip Setpoint (NTSP) for Safety Related Calculations

For an increasing process: $NTSP = AL - TLE_{neg}$

For a decreasing process: $NTSP = AL + TLE_{pos}$

Where:

AL = Analytical Limit

2.3. Calculation of the Nominal Trip Setpoint (NTSP) for Non-Safety Related Calculations

For an increasing process: $NTSP = PL - TLE_{neg}$

For a decreasing process: $NTSP = PL + TLE_{pos}$
Where:

PL = Process Limit

2.4. Calculation of Allowable Value (AV)

The term AV applies to safety related calculations only. Operational Limit (OL) is the equivalent term for non-safety related calculations.

For an increasing process: $AV = NTSP + LD + LD_{Bp}$

For a decreasing process: $AV = NTSP - LD - LD_{Bn}$
Where:

LD (Loop Drift) = $(A + D_R + M + R_{NR})^{1/2}$

$LD_{Bp} = D_{Bp} + R_{Bp}$

$LD_{Bn} = D_{Bn} + R_{Bn}$

2.5. Calculation of Operational Limit (OL)

The term OL applies to non-safety related calculations only.

For an increasing process: $OL = NTSP + LD + LD_{Bp}$

For a decreasing process: $OL = NTSP - LD - LD_{Bn}$
Where:

LD (Loop Drift) = $(A + D_R + M + R_{NR})^{1/2}$

$LD_{Bp} = D_{Bp} + R_{Bp}$

$LD_{Bn} = D_{Bn} + R_{Bn}$

2.6. Calculation of Rack Allowance (RA)

The term RA applies to safety related calculations only. There is no equivalent term for non-safety related calculations.

For an increasing process: $RA = NTSP + RD + RD_{Bp}$

For a decreasing process: $RA = NTSP - RD - RD_{Bn}$

Where:

$RD\,(\text{Rack Drift}) = (A + D_R + M + R_{NR})^{1/2}$

$RD_{Bp} = D_{Bp} + R_{Bp}$

$RD_{Bn} = D_{Bn} + R_{Bn}$

Note: Rack Drift includes the effects from all loop devices except the sensor.

3.0 ASSUMPTIONS

1. This calculation documents the values used by Attachment A to this calculation. Refer to Attachment A for the calorimetric uncertainty results.

2. Since the purpose of the calorimetric is to determine the plant's core thermal power, only normal environmental conditions are considered for this calculation.

3. Insulation Resistance (IR) error is not considered for this calculation since the IR error would be a result of a harsh environment and this calculation considers normal environmental conditions only.

4. Per WCAP-12485, Bases Document for Westinghouse Setpoint Methodology for Comanche Peak Protection Systems, for Feedwater flow venturies calibrated in laboratory controlled conditions to an accuracy of +/- 0.25% of true value, an additional allowance of +/- 0.25% is added to account for installation effects. Per Westinghouse, this uncertainty of +/- 0.5% "is believed to be a 95/95 value and is one of the most rigorously determined Westinghouse uncertainties." It is assumed that this value applies to the Prairie Island Feedwater flow venturi as well since the WCAP refers to the same venturi supplier, same accuracy, and same calibration laboratory that apply to the Prairie Island Feedwater flow venturi.

5. Per Section 11.4.1 of the USAR, the full load steam generating operating pressure is 750 psia. This calculation, however, is based on typical values obtained through ERCS. During full power, the 21 Steam Generator was typically shown by ERCS to operate at 702 psig. Accounting for atmospheric pressure results in 716.7 psia. Accounting for Westinghouse's pressure measurement bias for Unit 2 of 9.65 psi (Reference 50) results in 726.35 psia. Attachment A to this calculation will, therefore, use 726.35 psia as the Steam Generator pressure. Form 1: Loop/Process Data Sheet will, therefore, use 711.65 psig (726.35 psia - 14.7 psi atmospheric pressure) as the "Process Normal Op Pressure" and 730.85 psig (711.65 + 19.2 psi maximum measurement error ["srssp" error in part 3 of Attachment A]) as the "Process Max Op Pressure."

6. Per Section III of the Secondary Calorimetry Instrumentation Uncertainties calculation: the feedwater temperature at 100% power is assumed to be 427.3 °F, the accuracy of the Feedwater RTDs is 0.739 °F, and the drift of the RTD is 0.18 °F per year.
   The accuracy equates to:

$$\frac{0.739°F}{427.3°F} \times 100 = 0.17293\% \text{ Reading Error at Full Power}$$

Assuming the drift is cumulative over a twenty year life span consistent with the referenced calculation, the drift equates to:

$$\frac{(\frac{0.18°F}{yr})(20yrs)}{427.3°F} \times 100 = 0.84250\% \text{ Reading error at full power}$$

Combining accuracy and drift using the square root of the sum of the squares method:

$$\sqrt{0.17293^2 + 0.84250^2} = 0.86006\% \text{ Reading error at full power}$$

This value will be accounted for on the Process Considerations Screen

7. The calibration card for 2FT-495 shows that two different combinations of M&TE devices have been used over the last three years to provide an input signal to the transmitter during the calibration. Of these two combinations, the inaccuracy of the Transmation Flexitester with a 0-830 inwc sensor is greatest and will, therefore, be used in the calculation.

8. The calibration card for 23118 shows that three different combinations of M&TE devices have been used over the last three years to provide an input signal to the transmitter during the calibration. Of these three combinations, the inaccuracy of the Transmation Flexitester with a 0-100 inwc sensor is greatest and will, therefore, be used in the calculation.

9. The calibration card for 23118 shows that three different model Flukes have been used over the last three years to measure the output of the transmitters during the calibration. Of these three, the inaccuracy of the Fluke model 45 (assuming that the Fluke is in the fast resolution mode) is greatest for the calibrated range of interest and will, therefore, be used in the calculation.

10. The calibration cards for 2PT-468, 2FT-495 and 2TT-498 show that two different model Flukes have been used over the last three years to measure the output of the transmitters during the calibration. Of these two, the inaccuracy of the Fluke model 45 (assuming that the Fluke is in the fast resolution mode) is greatest for the

calibrated range of interest and will, therefore, be used in the calculation.

11. The calibration card for 2PT-468 shows that two different model Heise pressure indicators have been used over the last three years to measure the input to the transmitters during calibration. Of these, the inaccuracy of the Heise model 710A is greatest for the calibrated range of interest and will, therefore, be used in the calculation.

12. The calibration card for 2PM-468B shows that four different model Fluke multimeters have been used over the last three years to measure the input and output of the instrument during calibration. Of these, the inaccuracy of the Fluke model 45 (assuming that the Fluke is in the fast resolution mode) is greater for the calibrated range of interest and will, therefore, be used in the calculation for both the input and the output of the instrument.

13. The plant specific drift for 2TT-498 (Rochester SC-3372-39) was determined from the maximum difference between the As-Found and previous As-Left values on the calibration cards for 1TT-498 and 2TT-498. The greatest As-found / As-left difference found was 0.0011 Vdc. Converting Vdc to ohms equates to:

$$\frac{197.758\Omega - 93.058\Omega}{0.5Vdc - 0.1Vdc} \times 0.0011Vdc = 0.28793\Omega$$

Note: The range of 1TT-498 is used in the above equation and on the IISCS vendor screen to eliminate unneccessary duplication of records. The actual range of 2TT-498 is 92.89Ω to 197.47Ω as shown on the IISCS MCDS screen. The difference in ranges is considered insignificant.

14. The accuracy for 2TT-498 (Rochester SC-3372-39) was based on the typical linearity value of 0.3 °C given in the technical manual. Converting °C to ohms equates to:

$$0.3°C \times (\frac{9°F}{5°C}) \times \frac{197.758\Omega - 93.058\Omega}{500°F - 0°F} = 0.113076\Omega$$ See Assumption 13 Note.

15. The temperature effect for 2TT-498 (Rochester SC-3372-39) was based on the Square Root of the Sum of the Squares (SRSS) of the zero and span ambient temperature effects given in the technical manual (See Assumption 13 Note):

$$zeroeffect = \frac{\frac{RTD\min(\Omega)}{span(\Omega)} \times 0.002\% \times span(\Omega) + 0.008\% \times span(\Omega)}{°C}$$

$$= \frac{\frac{93.058\Omega}{104.7\Omega} \times 0.002\% \times 104.7\Omega + 0.008\% \times 104.7\Omega}{°C}$$

$$= \frac{0.010237\Omega}{°C}$$

$$zeroeffect(\Omega) = zeroeffect(\frac{\Omega}{°C}) \times tempspan(°C)$$

$$= 0.010237(\frac{\Omega}{°C}) \times (\frac{5°C}{9°F}) \times (105°F - 65°F)$$

$$= 0.22749$$

$$spaneffect = \frac{0.008\% \times span(\Omega)}{°C}$$

$$= \frac{0.008\% \times 104.7\Omega}{°C}$$

$$= 0.0083760$$

$$spaneffect(\Omega) = spaneffect(\frac{\Omega}{°C}) \times tempspan(°C)$$

$$= 0.0083760(\frac{\Omega}{°C}) \times (\frac{5°C}{9°F}) \times (105°F - 65°F)$$

$$= 0.18613$$

$$TEMPEFFECT = \sqrt{zeroeffect(\Omega)^2 + spaneffect(\Omega)^2}$$

$$= \sqrt{0.22749\Omega^2 + 0.18613\Omega^2}$$

16. The plant specific drift for 2PM-468B (Foxboro 66BC-O RFK) was determined from the maximum difference between the As-Found and previous As-Left values on the calibration cards for 1PM-468B and 2PM-468B. The greatest As-found / As-left difference found was 0.13 mAdc. Converting to percent span:

$$\frac{0.13mAdc}{50mAdc - 10mAdc} \times 100 = 0.325\% Span$$

17. Per the Advanced Digital Feedwater Control System (ADFCS) Block Diagram NX-39767, 2FT-495 is powered from a device designated as a Q16 C3 card. Per the ADFCS Technical Manual NX-39766-9 ("Q CARDS" tab) a Q16 C3 card is a type QAC Group 4 card. Per the ADFCS Technical Manual NX-39766-1 (section 3 tab) a QAC Group 4 card provides either 40.0 volts ± 2.0 Vdc or 24.0 volts ± 2.0 Vdc. The power supply voltage fluctuation is therefore ± 2.0 Vdc.

18. Using the same logic above, 2TT-498 is powered from a device determined to be a QAW Group 5 card. However, no power supply voltage fluctuation was given. It is assumed that the allowable fluctuation is the same as the QAC card; ± 2.0 Vdc.

4.0 DESIGN INPUT

4.1. Form 1: Loop/Process Data Sheet

Loop ID	CALORIMETRIC, UNIT 2
Configuration No.	1
Loop Description	Unit 2 Calorimetric Calculation
Process Span (PS)	0 To 100.00 PCT
Analytical/ Process Limit (AL/PL)	0 PCT
Normal Operation Upper Limit (NOUL)	PCT
Normal Operation Lower Limit (NOLL)	PCT
Process Max Op Pressure (PMOP)	730.85 PSIG
Process Normal Op Pressure (PNOP)	711.65 PSIG
Operating Time (Accident)	Min: Hours Max: Hours
Setpoint Direction	I

4.2. Form 2: Instrument Data Sheet

Unit	2
Instrument Tag No.	2FT-495
Function	
Other Tag No.	
System	RE
Functional Description	FEEDWATER TO SG 21 FLOW TRANSMITTER
Rack/Panel No.	
Power Supply Tag No.	213/212
EQ Zone	AXOP2B
Elevation	740.00 ft 0 in
Column	H.7
Row	11.3
Manuf. Name	HONEYWELL
Model Number	ST3000STD120
EQ	No
Seismic Category	NO
QA Elec.	
QA Mech.	
Input Span (CS)	0 To 369.30 INWC
Output Span (OS)	0.10000 To 0.50000 VDC
Readability (read)	
Surveillance/Calib. Procedure	SP2790
Calibration Interval (CI)	18.000 Months
Device Setting Tol. Allowance (st)	0.0004
Device M&TE Allowance mte1 : Device M&TE Cal Span mtecs1:	2.91e-03 VDC 0 To 3.0000 VDC
Device M&TE Allowance mte2 : Device M&TE Cal Span mtecs2:	1.1376 INWC 0 To 830.00 INWC
Device M&TE Allowance mte3 : Device M&TE Cal Span mtecs3:	To
Device M&TE Allowance mte4 : Device M&Te Cal Span mtecs4:	To
Device M&TE Allowance mte5 : Device M&TE Cal Span mtecs5:	To

Unit	2
Instrument Tag No.	2TT-498
Function	
Other Tag No.	
System	RE
Functional Description	FEEDWATER TO SG 21 TEMPERATURE TRANSMITTER
Rack/Panel No.	Local Panel
Power Supply Tag No.	213/212
EQ Zone	AXOP2B
Elevation	735.00 ft 0 in
Column	N.5
Row	11.0
Manuf. Name	ROCHESTER INSTRUMENT SYSTEMS
Model Number	SC-3372-3P
EQ	No
Seismic Category	NO
QA Elec.	
QA Mech.	
Input Span (CS)	92.890 To 197.47 OHMS
Output Span (OS)	0.10000 To 0.50000 VDC
Readability (read)	
Surveillance/Calib. Procedure	SP2790
Calibration Interval (CI)	18.000 Months
Device Setting Tol. Allowance (st)	0.0004
Device M&TE Allowance mte1 : Device M&TE Cal Span mtecs1:	0.09700 OHMS 0 To 200.00 OHMS
Device M&TE Allowance mte2 : Device M&TE Cal Span mtecs2:	2.91e-03 VDC 0 To 3.0000 VDC
Device M&TE Allowance mte3 : Device M&TE Cal Span mtecs3:	 To
Device M&TE Allowance mte4 : Device M&Te Cal Span mtecs4:	 To
Device M&TE Allowance mte5 : Device M&TE Cal Span mtecs5:	 To

Unit	2
Instrument Tag No.	2PT-468
Function	
Other Tag No.	21206
System	RP
Functional Description	SG 21 LOOP A PRESSURE TRANSMITTER
Rack/Panel No.	
Power Supply Tag No.	2PQ-468
EQ Zone	AXOP2X
Elevation	740.00 ft 0 in
Column	P.0
Row	12.0
Manuf. Name	ROSEMOUNT
Model Number	1154GP9RC
EQ	No
Seismic Category	YES
QA Elec.	2X2PM
QA Mech.	X11FM
Input Span (CS)	0 To 1400.0 PSIG
Output Span (OS)	0.10000 To 0.50000 VDC
Readability (read)	
Surveillance/Calib. Procedure	SP2790
Calibration Interval (CI)	18.000 Months
Device Setting Tol. Allowance (st)	0.002
Device M&TE Allowance mte1 : Device M&TE Cal Span mtecs1:	6.0000 PSIG 0 To 3000.0 PSIG
Device M&TE Allowance mte2 : Device M&TE Cal Span mtecs2:	2.91e-03 VDC 0 To 3.0000 VDC
Device M&TE Allowance mte3 : Device M&TE Cal Span mtecs3:	 To
Device M&TE Allowance mte4 : Device M&Te Cal Span mtecs4:	 To
Device M&TE Allowance mte5 : Device M&TE Cal Span mtecs5:	 To

Unit	2
Instrument Tag No.	2PM-468B
Function	
Other Tag No.	
System	RP
Functional Description	SG 21 LOOP A PRESSURE SIGNAL I/I ISOLATOR
Rack/Panel No.	2R2
Power Supply Tag No.	2PQ-468
EQ Zone	CNLRM
Elevation	735.00 ft 0 in
Column	H.7
Row	10.0
Manuf. Name	FOXBORO
Model Number	66BC-O RFK
EQ	No
Seismic Category	YES
QA Elec.	X11FM
QA Mech.	
Input Span (CS)	0.10000 To 0.50000 VDC
Output Span (OS)	0.10000 To 0.50000 VDC
Readability (read)	
Surveillance/Calib. Procedure	SP2002A
Calibration Interval (CI)	12.000 Months
Device Setting Tol. Allowance (st)	0.002
Device M&TE Allowance mte1 : Device M&TE Cal Span mtecs1:	2.91e-03 VDC 0 To 3.0000 VDC
Device M&TE Allowance mte2 : Device M&TE Cal Span mtecs2:	2.91e-03 VDC 0 To 3.0000 VDC
Device M&TE Allowance mte3 : Device M&TE Cal Span mtecs3:	 To
Device M&TE Allowance mte4 : Device M&Te Cal Span mtecs4:	 To
Device M&TE Allowance mte5 : Device M&TE Cal Span mtecs5:	 To

Unit	2
Instrument Tag No.	23118
Function	
Other Tag No.	
System	SB
Functional Description	SG 21 BLOWDOWN FLOW TRANSMITTER
Rack/Panel No.	LOCAL PANEL
Power Supply Tag No.	
EQ Zone	AXMZ2C
Elevation	720.00 ft 0 in
Column	K.0
Row	11.9
Manuf. Name	FOXBORO
Model Number	E13DM-B 20-205 INWC
EQ	No
Seismic Category	NO
QA Elec.	
QA Mech.	
Input Span (CS)	0 To 25.140 INWC
Output Span (OS)	0.10000 To 0.50000 VDC
Readability (read)	
Surveillance/Calib. Procedure	PM 2-019
Calibration Interval (CI)	12.000 Months
Device Setting Tol. Allowance (st)	0.002
Device M&TE Allowance mte1 : Device M&TE Cal Span mtecs1:	2.91e-03 VDC 0 To 3.0000 VDC
Device M&TE Allowance mte2 : Device M&TE Cal Span mtecs2:	0.11000 INWC 0 To 100.00 INWC
Device M&TE Allowance mte3 : Device M&TE Cal Span mtecs3:	 To
Device M&TE Allowance mte4 : Device M&Te Cal Span mtecs4:	 To
Device M&TE Allowance mte5 : Device M&TE Cal Span mtecs5:	 To

Unit	2
Instrument Tag No.	2F2511A
Function	
Other Tag No.	
System	RE
Functional Description	LOOP A FEEDWATER FLOW ERCS ANALOG INPUT POINT
Rack/Panel No.	RMU223/2PLP
Power Supply Tag No.	
EQ Zone	CNLRM
Elevation	735.00 ft 0 in
Column	H.0
Row	10.5
Manuf. Name	COMPUTER PRODUCTS INC.
Model Number	ERCS ANALOG INPUT POINT 0.0 - 0.640V
EQ	No
Seismic Category	NO
QA Elec.	
QA Mech.	
Input Span (CS)	0.10000 To 0.50000 VDC
Output Span (OS)	0 To 19.217 INWC
Readability (read)	
Surveillance/Calib. Procedure	
Calibration Interval (CI)	18.000 Months
Device Setting Tol. Allowance (st)	1.0*a
Device M&TE Allowance mte1 : Device M&TE Cal Span mtecs1:	3.1813e-04 VDC 0.62500 To 0.62500 VDC
Device M&TE Allowance mte2 : Device M&TE Cal Span mtecs2:	To
Device M&TE Allowance mte3 : Device M&TE Cal Span mtecs3:	To
Device M&TE Allowance mte4 : Device M&Te Cal Span mtecs4:	To
Device M&TE Allowance mte5 : Device M&TE Cal Span mtecs5:	To

Unit	2
Instrument Tag No.	2F0409A
Function	
Other Tag No.	
System	SB
Functional Description	LOOP A STM GEN BLOWDOWN FLOW ERCS ANALOG INPUT POINT
Rack/Panel No.	RMU224/2SA
Power Supply Tag No.	
EQ Zone	CNLRM
Elevation	735.00 ft 0 in
Column	H.0
Row	10.6
Manuf. Name	COMPUTER PRODUCTS INC.
Model Number	ERCS ANALOG INPUT POINT 0.0 - 0.640V
EQ	No
Seismic Category	NO
QA Elec.	
QA Mech.	
Input Span (CS)	0.10000 To 0.50000 VDC
Output Span (OS)	0 To 120.00 GPM
Readability (read)	
Surveillance/Calib. Procedure	
Calibration Interval (CI)	18.000 Months
Device Setting Tol. Allowance (st)	1.0*a
Device M&TE Allowance mte1 : Device M&TE Cal Span mtecs1:	3.1813e-04 VDC 0.62500 To 0.62500 VDC
Device M&TE Allowance mte2 : Device M&TE Cal Span mtecs2:	To
Device M&TE Allowance mte3 : Device M&TE Cal Span mtecs3:	To
Device M&TE Allowance mte4 : Device M&Te Cal Span mtecs4:	To
Device M&TE Allowance mte5 : Device M&TE Cal Span mtecs5:	To

Unit	2
Instrument Tag No.	2P0400A
Function	
Other Tag No.	
System	RP
Functional Description	LOOP A STEAM GENERATOR PRESSURE ERCS ANALOG INPUT
Rack/Panel No.	RMU222/2RSC
Power Supply Tag No.	
EQ Zone	CNLRM
Elevation	735.00 ft 0 in
Column	H.3
Row	10.6
Manuf. Name	COMPUTER PRODUCTS INC.
Model Number	ERCS ANALOG INPUT POINT 0.0 - 0.640V
EQ	No
Seismic Category	NO
QA Elec.	
QA Mech.	
Input Span (CS)	0.10000 To 0.50000 VDC
Output Span (OS)	0 To 1400.0 PSIG
Readability (read)	
Surveillance/Calib. Procedure	
Calibration Interval (CI)	18.000 Months
Device Setting Tol. Allowance (st)	1.0*a
Device M&TE Allowance mte1 : Device M&TE Cal Span mtecs1:	3.1813e-04 VDC 0.62500 To 0.62500 VDC
Device M&TE Allowance mte2 : Device M&TE Cal Span mtecs2:	To
Device M&TE Allowance mte3 : Device M&TE Cal Span mtecs3:	To
Device M&TE Allowance mte4 : Device M&Te Cal Span mtecs4:	To
Device M&TE Allowance mte5 : Device M&TE Cal Span mtecs5:	To

Unit	2
Instrument Tag No.	2T0418A
Function	
Other Tag No.	
System	RE
Functional Description	LOOP A STM GEN FEEDWATER TEMP ERCS ANALOG INPUT POINT
Rack/Panel No.	RMU222/2RSC
Power Supply Tag No.	
EQ Zone	CNLRM
Elevation	735.00 ft 0 in
Column	H.3
Row	10.6
Manuf. Name	COMPUTER PRODUCTS INC.
Model Number	ERCS ANALOG INPUT POINT 0.0 - 0.640V
EQ	No
Seismic Category	NO
QA Elec.	
QA Mech.	
Input Span (CS)	0.10000 To 0.50000 VDC
Output Span (OS)	0 To 500.00 DEG F
Readability (read)	
Surveillance/Calib. Procedure	
Calibration Interval (CI)	18.000 Months
Device Setting Tol. Allowance (st)	1.0*a
Device M&TE Allowance mte1 : Device M&TE Cal Span mtecs1:	3.1813e-04 VDC 0.62500 To 0.62500 VDC
Device M&TE Allowance mte2 : Device M&TE Cal Span mtecs2:	To
Device M&TE Allowance mte3 : Device M&TE Cal Span mtecs3:	To
Device M&TE Allowance mte4 : Device M&Te Cal Span mtecs4:	To
Device M&TE Allowance mte5 : Device M&TE Cal Span mtecs5:	To

4.3. Form 3: Make/Model Data Sheet

Manuf. Name	HONEYWELL
Model Number	ST3000STD120
Range	Min:0 Units:INWC Max:400.00
Design Pressure	3000.0 PSIG
Vendor Accuracy Allowance (va)	0.1%*R
Vendor Drift Allowance (vd)	0.25%*25*1.25
Drift Time (DT)	12.000 Months Linear or Non-Linear? L Vendor or Plant-Specific? V
Vendor Temp Effect (vte)	0.25%*S/50
Vendor Humidity Effect (vhe)	0
Vendor Over Pressure Effect (vope)	0
Vendor Static Pressure Effect Zero (vspez)	0.2%*S
Vendor Static Pressure Effect Span (vspes)	0
Vendor Power Supply Effect (vp)	0.005%*S
Vendor Seismic Effect (vse)	0
Vendor Radiation Effect (vre)	0
Vendor Steam Press/Temp. Effect (vspt)	0
Vendor Post-DBE Effect(vpdbe)	0

Manuf. Name	ROCHESTER INSTRUMENT SYSTEMS
Model Number	SC-3372-3P
Range	Min:93.058 Units:OHMS Max:197.76
Design Pressure	PSIG
Vendor Accuracy Allowance (va)	0.113076
Vendor Drift Allowance (vd)	0.28793
Drift Time (DT)	12.000 Months Linear or Non-Linear? L Vendor or Plant-Specific? P
Vendor Temp Effect (vte)	0.29393
Vendor Humidity Effect (vhe)	0
Vendor Over Pressure Effect (vope)	0
Vendor Static Pressure Effect Zero (vspez)	0
Vendor Static Pressure Effect Span (vspes)	0
Vendor Power Supply Effect (vp)	0.0025%*S/1
Vendor Seismic Effect (vse)	0
Vendor Radiation Effect (vre)	0
Vendor Steam Press/Temp. Effect (vspt)	0
Vendor Post-DBE Effect(vpdbe)	0

Manuf. Name	ROSEMOUNT
Model Number	1154GP9RC
Range	Min:0 Units:PSIG Max:3000.0
Design Pressure	4500.0 PSIG
Vendor Accuracy Allowance (va)	0.25%*S
Vendor Drift Allowance (vd)	0.2%*R
Drift Time (DT)	30.000 Months Linear or Non-Linear? L Vendor or Plant-Specific? V
Vendor Temp Effect (vte)	(0.75%*R+0.5%*S)/100
Vendor Humidity Effect (vhe)	0
Vendor Over Pressure Effect (vope)	{0<X<=4500,0}{X>4500,0.5%*R}
Vendor Static Pressure Effect Zero (vspez)	0
Vendor Static Pressure Effect Span (vspes)	0
Vendor Power Supply Effect (vp)	0.005%*S/1
Vendor Seismic Effect (vse)	0.5%*R
Vendor Radiation Effect (vre)	{0<=X<=0;0}{0<X<=5000000,1%*R}
Vendor Steam Press/Temp. Effect (vspt)	2.5%*R+0.5%*S
Vendor Post-DBE Effect(vpdbe)	2.5%*R

Manuf. Name	FOXBORO
Model Number	66BC-O RFK
Range	Min:10.000 Units:MADC Max:50.000
Design Pressure	PSIG
Vendor Accuracy Allowance (va)	0.5%*S
Vendor Drift Allowance (vd)	0.325%*S
Drift Time (DT)	12.000 Months Linear or Non-Linear? L Vendor or Plant-Specific? P
Vendor Temp Effect (vte)	0
Vendor Humidity Effect (vhe)	0
Vendor Over Pressure Effect (vope)	0
Vendor Static Pressure Effect Zero (vspez)	0
Vendor Static Pressure Effect Span (vspes)	0
Vendor Power Supply Effect (vp)	0
Vendor Seismic Effect (vse)	0
Vendor Radiation Effect (vre)	0
Vendor Steam Press/Temp. Effect (vspt)	0
Vendor Post-DBE Effect(vpdbe)	0

Manuf. Name	FOXBORO
Model Number	E13DM-B (20-205 INWC)
Range	Min:200.00 Units:INWC Max:850.00
Design Pressure	2000.0 PSIG
Vendor Accuracy Allowance (va)	0.522%*S
Vendor Drift Allowance (vd)	0.25%*S
Drift Time (DT)	12.000 Months Linear or Non-Linear? L Vendor or Plant-Specific? V
Vendor Temp Effect (vte)	0
Vendor Humidity Effect (vhe)	0
Vendor Over Pressure Effect (vope)	0
Vendor Static Pressure Effect Zero (vspez)	0
Vendor Static Pressure Effect Span (vspes)	0
Vendor Power Supply Effect (vp)	0
Vendor Seismic Effect (vse)	0
Vendor Radiation Effect (vre)	0
Vendor Steam Press/Temp. Effect (vspt)	0
Vendor Post-DBE Effect(vpdbe)	0

Manuf. Name	COMPUTER PRODUCTS INC.
Model Number	ERCS ANALOG INPUT POINT 0.0 - 0.640V
Range	Min:-0.64000 Units:VDC Max:0.64000
Design Pressure	PSIG
Vendor Accuracy Allowance (va)	0.03706%*2*R
Vendor Drift Allowance (vd)	0
Drift Time (DT)	18.000 Months Linear or Non-Linear? L Vendor or Plant-Specific? V
Vendor Temp Effect (vte)	0.008584%*2*R/1.8
Vendor Humidity Effect (vhe)	0
Vendor Over Pressure Effect (vope)	0
Vendor Static Pressure Effect Zero (vspez)	0
Vendor Static Pressure Effect Span (vspes)	0
Vendor Power Supply Effect (vp)	0
Vendor Seismic Effect (vse)	0
Vendor Radiation Effect (vre)	0
Vendor Steam Press/Temp. Effect (vspt)	0
Vendor Post-DBE Effect(vpdbe)	0

4.4. Form 4: Environmental Conditions Data Sheet

Eq Zone	AXOP2B
Room Description	Unit 2 Aux Building Elev 735 Cmprt B
Normal Temperature Range (NTMIN & NTMAX)	Min: 65.000 °F Max: 105.00 °F
Normal Humidity Range (NHMIN & NHMAX)	Min: 20.000 %RH Max: 90.000 %RH
Max. Normal Radiation (NR)	0 Rads/Hour
Accident Type	NORMAL
Accident Temperature (AT)	0 °F
Accident Humidity (AH)	0 %RH
Accident Radiation (AR)	0 Rads

Eq Zone	AXOP2X
Room Description	Unit 2 Aux Building Elev 735 Cmprt X
Normal Temperature Range (NTMIN & NTMAX)	Min: 65.000 °F Max: 105.00 °F
Normal Humidity Range (NHMIN & NHMAX)	Min: 20.000 %RH Max: 90.000 %RH
Max. Normal Radiation (NR)	0 Rads/Hour
Accident Type	NORMAL
Accident Temperature (AT)	0 °F
Accident Humidity (AH)	0 %RH
Accident Radiation (AR)	0 Rads

Eq Zone	CNLRM
Room Description	Unit 1 & 2 Control Room
Normal Temperature Range (NTMIN & NTMAX)	Min: 65.000 °F Max: 105.00 °F
Normal Humidity Range (NHMIN & NHMAX)	Min: 20.000 %RH Max: 90.000 %RH
Max. Normal Radiation (NR)	0 Rads/Hour
Accident Type	NORMAL
Accident Temperature (AT)	0 °F
Accident Humidity (AH)	0 %RH
Accident Radiation (AR)	0 Rads

Eq Zone	AXMZ2C
Room Description	Unit 2 Aux Building Elev 715 Cmprt C
Normal Temperature Range (NTMIN & NTMAX)	Min: 60.000 °F Max: 85.000 °F
Normal Humidity Range (NHMIN & NHMAX)	Min: 50.000 %RH Max: 50.000 %RH
Max. Normal Radiation (NR)	0 Rads/Hour
Accident Type	NORMAL
Accident Temperature (AT)	0 °F
Accident Humidity (AH)	0 %RH
Accident Radiation (AR)	0 Rads

5.0 ERROR ANALYSIS AND SETPOINT DETERMINATION

5.1. Given Conditions

5.1.1. Loop Instrument List

Device	Unit	Instrument Tag	Function
1	2	2FT-495	
2	2	2TT-498	
3	2	2PT-468	
4	2	2PM-468B	
5	2	23118	
6	2	2F2511A	
7	2	2F0409A	
8	2	2P0400A	
9	2	2T0418A	

5.1.2. Device Dependency Table

Unit	Instrument	Func	Cal	Pwr	Rad	Seismic	Temp	Humidity
2	2FT-495		A	A	A	A	A	A
2	2TT-498		B	B	A	B	A	A
2	2PT-468		C	C	B	C	B	B
2	2PM-468B		D	C	C	D	C	C
2	23118		E	D	D	E	D	D
2	2F2511A		F	A	C	F	C	C
2	2F0409A		G	D	C	G	C	C
2	2P0400A		H	C	C	H	C	C
2	2T0418A		I	B	C	I	C	C

Device Dependency Assumptions/References

Calibration: SP 2002A & 2002B

Power Supply: SP 2002A & 2002B

Radiation:	SP 2002A & 2002B
Seismic:	SP 2002A & 2002B
Temperature:	SP 2002A & 2002B
Humidity:	SP 2002A & 2002B

5.1.3. Calibration Static Pressure(CSP), Power Supply Stability(PSS)

Unit	Instrument	Function	CSP (PSIG)	PSS (VOLTS)
2	2FT-495		0	2.0000
2	2TT-498		0	2.0000
2	2PT-468		0	4.3000
2	2PM-468B		0	4.3000
2	23118		0	11.800
2	2F2511A		0	2.0000
2	2F0409A		0	11.800
2	2P0400A		0	4.3000
2	2T0418A		0	2.0000

Note: PSS values are only considered for devices with a Vendor Power Supply Effect which is expressed per volt.

CSP and PSS Assumptions/References

CSP: SP 2002B

PSS: Reference 7

5.1.4. Insulation Resistance(IR), Primary Element Accuracy(PEA), Process Measurement Accuracy(PMA) and other Process Considerations(PC)

Type	Magnitude (decimal%)	Sign	Acc/ Norm	Dependent Device	Dependent Uncertainty	PC/IR Assumptions/ References
PEA	0.05000	R	N			ASSMP 4
PC	8.6e-03	R	N			ASSMP 6
PC	0.01000	R	N			REF 5

Note: Magnitude is expressed in decimal percent of span, e.g. 0.02 equals 2% of span.

IR value per specific Loop Configuration IR calculation.

5.2. Calculation of Instrument Uncertainties

5.2.1. Instrument Accuracy (a_n)

$a_n = (va_n)(PS/CS_n)$

Where n = the number of the loop device
va= vendor's accuracy expression

Note: If the Device Setting Tolerance (st), per Form 2,is greater than the Instrument Accuracy (a) for a specific device, then (st) will be used in lieu of (a) in the equation shown above.

Instrument Accuracy(a)

Device	Random	Units
1	±0.10831	PCT
*2	±0	PCT
3	±0.50000	PCT
*4	±0	PCT
5	±0.52200	PCT
6	±0.11859	PCT
7	±0.11859	PCT
8	±0.11859	PCT
9	±0.11859	PCT

* = Uncertainty included with plant specific drift for this device

5.2.2. Instrument Drift (d_n)

d = (CI/DT)(vd)(PS/CS)

Where vd = vendor's drift expression

Note: The factor (CI/DT) is included in the above equation if Drift is linear over time. If Drift is non-linear over time, the factor is replaced by:

$(CI/DT)^{1/2}$

Instrument Drift(d)

Device	Random	+Bias	-Bias	Units
1	±0.03173	0	0	PCT
2	±0.41298	0	0	PCT
3	±0.25714	0	0	PCT
4	±0.32500	0	0	PCT
5	±0.25000	0	0	PCT
6	±0	0	0	PCT
7	±0	0	0	PCT
8	±0	0	0	PCT
9	±0	0	0	PCT

5.2.3. Instrument Measurement and Test Equipment Allowance (m_n)

$$mte_x = [(mtea_x + mtestd_x)^2 + (mtet_x)^2 + (mteread_x)^2]^{1/2}$$

$$m_n = [(mte_1/mtecs_1)^2 + (mte_2/mtecs_2)^2 + (mte_3/mtecs_3)^2 + (mte_4/mtecs_4)^2 + (mte_5/mtecs_5)^2]^{1/2} * PS$$

Where:

mte_x = the Measurement and Test Equipment allowance for one M&TE device.

$mtea_x$ = the accuracy of the M&TE device.

$mtet_x$ = the temperature effect of the M&TE device.

$mteread_x$ = the readability of the M&TE device.

$mtestd_x$ = the accuracy of the standard used to calibrate the M&TE device.

m_n = the Measurement and Test Equipment allowance for one loop device.

mtecs = the calibrated span of the M&TE device.

Instrument M&TE(m)

Device	Random	Units
1	±0.79003	PCT
*2	±0	PCT
3	±0.84435	PCT
*4	±0	PCT
5	±0.84894	PCT
6	±0.07953	PCT
7	±0.07953	PCT
8	±0.07953	PCT
9	±0.07953	PCT

* = Uncertainty included with plant specific drift for this device

5.2.4. Instrument Temperature Effect (t_N, t_A & t_{NS})

Normal: t_N = (NTMAX - NTMIN)(vte)(PS/CS)

Accident: t_A = [(AT - NTMIN)(vte)(PS/CS)] - t_N

Loss of non-seismic HVAC during a seismic event:

t_{NS} = [(NST - NTMIN)(vte)(PS/CS)] - t_N

Where vte = vendor's temperature effect expression

Notes: The factors (NTMAX - NTMIN), (AT - NTMIN) and (NST - NTMIN) are included in the equations shown above only if the Vendor's Temperature Effect (vte) for a specific device is expressed per degree. This is indicated by the character "/" in the Vendor's Temperature Effect equation shown on Form 3.

If the Vendor's Temperature Effect equation is expressed as a step function, then the values of NTMAX, AT and NST will be used to determine the value of "X" in the step function.

Normal Instrument Temperature Effect (t_N)

Device	Random	+Bias	-Bias	Units
1	±0.20000	0	0	PCT
*2	±0	0	0	PCT
3	±0.84286	0	0	PCT
*4	±0	0	0	PCT
5	±0	0	0	PCT
6	±0.38151	0	0	PCT
7	±0.38151	0	0	PCT
8	±0.38151	0	0	PCT
9	±0.38151	0	0	PCT

* = Uncertainty included with plant specific drift for this device

Accident Instrument Temperature Effect (t_A)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PCT
2	±0	0	0	PCT
3	±0	0	0	PCT
4	±0	0	0	PCT
5	±0	0	0	PCT
6	±0	0	0	PCT
7	±0	0	0	PCT
8	±0	0	0	PCT
9	±0	0	0	PCT

Loss of non-seismic HVAC during a seismic event
Temperature Effect (t_{NS})

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PCT
2	±0	0	0	PCT

3	±0	0	0	PCT
4	±0	0	0	PCT
5	±0	0	0	PCT
6	±0	0	0	PCT
7	±0	0	0	PCT
8	±0	0	0	PCT
9	±0	0	0	PCT

5.2.5. Instrument Humidity Effect (h_N, h_A & h_{NS})

Normal: h_N = (NHMAX - NHMIN)(vhe)(PS/CS)

Accident: h_A = [(AH - NHMIN)(vhe)(PS/CS)] - h_N

Loss of non-seismic HVAC during a seismic event:

h_{NS} = [(NSH - NHMIN)(vhe)(PS/CS)] - h_N

Where vhe = vendor's humidity effect expression

Notes: The factors (NHMAX - NHMIN), (AH - NHMIN) and (NSH - NHMIN) are included in the equations shown above only if the Vendor's Humidity Effect (vhe) for a specific device is expressed per degree. This is indicated by the character "/" in the Vendor's Humidity Effect equation shown on Form 3.

If the Vendor's Humidity Effect equation is expressed as a step function, then the values of NHMAX, AH and NSH will be used to determine the value of "X" in the step function.

Normal Instrument Humidity Effect (h_N)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PCT
*2	±0	0	0	PCT
3	±0	0	0	PCT
*4	±0	0	0	PCT
5	±0	0	0	PCT
6	±0	0	0	PCT

7	±0	0	0	PCT
8	±0	0	0	PCT
9	±0	0	0	PCT

* = Uncertainty included with plant specific drift for this device

Accident Instrument Humidity Effect (h_A)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PCT
2	±0	0	0	PCT
3	±0	0	0	PCT
4	±0	0	0	PCT
5	±0	0	0	PCT
6	±0	0	0	PCT
7	±0	0	0	PCT
8	±0	0	0	PCT
9	±0	0	0	PCT

Loss of non-seismic HVAC during a seismic event
Humidity Effect (h_{NS})

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PCT
2	±0	0	0	PCT
3	±0	0	0	PCT
4	±0	0	0	PCT
5	±0	0	0	PCT
6	±0	0	0	PCT
7	±0	0	0	PCT
8	±0	0	0	PCT
9	±0	0	0	PCT

5.2.6. Instrument Over Pressure Effect (ope)

ope = (PMOP - DP)(vope)(PS/CS)

Where vope = vendor's over pressure effect expression

Notes: The factor (PMOP -DP) is included in the equation shown above only if the Vendor's Over Pressure Effect (vope) for a specific device is expressed per PSI. This is indicated by the character "/" in the Vendor's Over Pressure Effect equation shown on Form 3.

If the Design Pressure for a specific device (DP) is greater than or equal to the Process Maximum Operating Pressure (PMOP), then the Over Pressure Effect (ope) is equal to zero.

Instrument Over Pressure Effect (ope)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PCT
2	±0	0	0	PCT
3	±0	0	0	PCT
4	±0	0	0	PCT
5	±0	0	0	PCT
6	±0	0	0	PCT
7	±0	0	0	PCT
8	±0	0	0	PCT
9	±0	0	0	PCT

5.2.7. Instrument Static Pressure Effect Zero (spez)

spez = (PMOP - CSP)(vspez)(PS/CS)

Where vspez = vendor's static pressure zero effect expression

Note: The factor (PMOP - CSP) is included in the equation shown above only if the Vendor's Static Pressure Effect Zero (vspez) for a specific device is linear for the given pressure change defined. This is indicated by the character " / " in the Vendor's Static

Pressure Effect Zero equation shown on Form 3.

Instrument Static Pressure Effect Zero (spez)

Device	Random	+Bias	-Bias	Units
1	±0.20000	0	0	PCT
2	±0	0	0	PCT
3	±0	0	0	PCT
4	±0	0	0	PCT
5	±0	0	0	PCT
6	±0	0	0	PCT
7	±0	0	0	PCT
8	±0	0	0	PCT
9	±0	0	0	PCT

5.2.8. Instrument Static Pressure Effect Span (spes)

spes = (PMOP - CSP)(vspes)(PS/CS)

Where vspes =vendor's static pressure span effect expression
Note: The factor (PMOP - CSP) is included in the equation shown above only if the Vendor's Static Pressure Effect Span (vspes) for a specific device is linear for the given pressure change defined. This is indicated by the character " / " in the Vendor's Static Pressure Effect Span equation shown on Form 3.

Instrument Static Pressure Effect Span (spes)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PCT
2	±0	0	0	PCT
3	±0	0	0	PCT
4	±0	0	0	PCT
5	±0	0	0	PCT
6	±0	0	0	PCT
7	±0	0	0	PCT
8	±0	0	0	PCT
9	±0	0	0	PCT

5.2.9. Instrument Power Supply Effect (p)

p = ((PSS)(vp)(PS/CS)

Where p = vendor's power supply effect expression

Note: The factor (PSS) is included in the equation shown above only if the Vendor's Power Supply Effect (vp) for a specific device is expressed per volt. This is indicated by the character " / " in the Vendor's Power Supply Effect equation shown on Form 3.

Instrument Power Supply Effect (p)

Device	Random	+Bias	-Bias	Units
1	±5.0e-03	0	0	PCT
2	±5.0e-03	0	0	PCT
3	±0.02150	0	0	PCT
4	±0	0	0	PCT
5	±0	0	0	PCT
6	±0	0	0	PCT
7	±0	0	0	PCT
8	±0	0	0	PCT
9	±0	0	0	PCT

5.2.10. Instrument Seismic Effect (s)

s = (vse)(PS/CS)
Where vse = vendor's seismic effect expression

Instrument Seismic Effect (s)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PCT
2	±0	0	0	PCT
3	±0	0	0	PCT
4	±0	0	0	PCT
5	±0	0	0	PCT
6	±0	0	0	PCT
7	±0	0	0	PCT
8	±0	0	0	PCT
9	±0	0	0	PCT

5.2.11. Instrument Radiation Effect (r_N, r_A & r_{AN})

Normal: r_N = (NTID)(vre)(PS/CS)

Accident: r_A = (ATID)(vre)(PS/CS)

Accident: r_{AN} = (ANTID)(vre)(PS/CS)

Where vre = vendor's radiation effect expression

NTID = total integrated dose for normal conditions

ATID = total integrated dose for accident conditions

ANTID = total integrated dose for accident plus normal conditions

Notes: The factors (NTID)(ATID) and (ANTID) are included in the equations only if the Vendor Radiation Effect (vre) for a specific device is expressed per Rad. This is indicated by the character " / " in the Radiation Effect equation shown on Form 3.

If the Radiation Effect equation is expressed as a step function, then the values NTID, ATID and ANTID will be used to determine the value of "X" in the step function.

If plant specific drift is entered for a loop device that is subject to accident radiation, r_A is used in place or r_{AN} if the user does not change the plant specific drift default value of 0

for the normal radiation effect.

Normal Instrument Radiation Effect (r_N)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PCT
*2	±0	0	0	PCT
3	±0	0	0	PCT
*4	±0	0	0	PCT
5	±0	0	0	PCT
6	±0	0	0	PCT
7	±0	0	0	PCT
8	±0	0	0	PCT
9	±0	0	0	PCT

* = Uncertainty included with plant specific drift for this device

Accident Instrument Radiation Effect (r_A)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PCT
2	±0	0	0	PCT
3	±0	0	0	PCT
4	±0	0	0	PCT
5	±0	0	0	PCT
6	±0	0	0	PCT
7	±0	0	0	PCT
8	±0	0	0	PCT
9	±0	0	0	PCT

Accident and Normal Instrument Radiation Effect (r_{AN})

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PCT
2	±0	0	0	PCT
3	±0	0	0	PCT
4	±0	0	0	PCT
5	±0	0	0	PCT
6	±0	0	0	PCT
7	±0	0	0	PCT
8	±0	0	0	PCT
9	±0	0	0	PCT

5.2.12. Instrument Steam Pressure/Temperature Effect (spt)

spt = (vspt)(PS/CS)

Where vspt = vendor's steam pressure/temperature effect expression

Instrument Steam Pressure/Temperature Effect (spt)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PCT
2	±0	0	0	PCT
3	±0	0	0	PCT
4	±0	0	0	PCT
5	±0	0	0	PCT
6	±0	0	0	PCT
7	±0	0	0	PCT
8	±0	0	0	PCT
9	±0	0	0	PCT

5.2.13. Instrument Post-DBE Effect (pdbe)

pdbe = (vpdbe)(PS/CS)

Where vpdbe = vendor's Post-DBE effect expression

Instrument Post-DBE Effect (pdbe)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PCT
2	±0	0	0	PCT
3	±0	0	0	PCT
4	±0	0	0	PCT
5	±0	0	0	PCT
6	±0	0	0	PCT
7	±0	0	0	PCT
8	±0	0	0	PCT
9	±0	0	0	PCT

5.3. Calculation of Combined Loop Effects

5.3.1. Loop Accuracy (A)

Accuracy contains only random terms. Since the individual device Accuracies are considered independent, they may be combined as follows:

$$A = (a_1)^2 + (a_2)^2 + ... + (a_n)^2$$

Using the equations for Instrument Accuracy and combining the results in accordance with the method described above;

$$A = \pm \quad 0.59047 \quad (PCT)^2$$

5.3.2. Loop Drift (D)

Drift may contain random and bias terms. The individual device drifts which are random are combined according to device calibration dependency groups.

For example, consider a loop which contains devices 1,2, and 3 which each have random, bias positive, and bias negative terms. If device 1 is calibrated alone (e.g. Calibration Group "A") and devices 2 and 3 are calibrated together (e.g. Calibration Group "B") then:

$$D_R = (d_{1R})^2 + (d_{2R} + d_{3R})^2$$

$$D_{BP} = (d_{1BP} + d_{2BP} + d_{3BP})$$

$$D_{BN} = (d_{1BN} + d_{2BN} + d_{3BN})$$

Combining the results of Instrument Drift calculated in section 5.2.2 in accordance with the method described above;

$$D_R = \pm\ 0.40581\ (PCT)^2$$

$$D_{BP} = 0\ PCT$$

$$D_{BN} = 0\ PCT$$

5.3.3. Loop Measurement & Test Equipment Allowance (M)

The M&TE Allowance contains a random term only. The individual device M&TE Allowances are combined according to device calibration dependency groups.

For example, consider a loop which contains devices 1, 2, and 3. If device 1 is calibrated alone (e.g. Calibration Group "A") and devices 2 and 3 are calibrated together (e.g. Calibration Group "B") then:

$$M = (m_1)^2 + (m_2 + m_3)^2$$

Combining the results of Instrument M&TE Allowance calculated in section 5.2.3 in accordance with the method described above;

$$M = \pm\ 2.0831\ (PCT)^2$$

5.3.4. Loop Temperature Effect (T_N, T_A and T_{NS})

The Temperature Effect (Normal, Accident and Loss of non-seismic HVAC during a

seismic event) contains a random term and bias terms. The individual device Temperature Effects which are random are combined according to device temperature dependency groups. Process Considerations that are considered to be temperature-related are also combined with the associated device Temperature Effect.

For example, consider a loop which contains devices 1,2, and 3 which each have a random, bias positive, and bias negative terms. The devices also have the following temperature-related process considerations (PC):

PCA_{1R} = Device 1 Accident Random PC

PCN_{1R} = Device 1 Normal Random PC

PCA_{2BP} = Device 2 Accident Bias Positive PC

PCN_{3BN} = Device 3 Normal Bias Negative PC

If device 1 is located in one temperature environment (e.g. Temperature Group "A") and devices 2 and 3 are located in another temperature environment (e.g. Temperature Group "B") then:

Normal:

$$T_{NR} = (t_{N1R} + PCN_{1R})^2 + (t_{N2R} + t_{N3R})^2$$

$$T_{NBP} = (t_{N1BP} + t_{N2BP} + t_{N3BP})$$

$$T_{NBN} = (t_{N1BN} + t_{N2BN} + t_{N3BN} + PCN_{3BN})$$

Accident:

$$T_{AR} = (t_{N1R} + t_{A1R} + PCA_{1R})^2 + (t_{N2R} + t_{A2R} + t_{N3R} + t_{A3R})^2$$

$$T_{ABP} = (t_{N1BP} + t_{A1BP} + t_{N2BP} + t_{A2BP} + t_{N3BP} + t_{A3BP} + PCA_{2BP})$$

$$T_{ABN} = (t_{N1BN} + t_{A1BN} + t_{N2BN} + t_{A2BN} + t_{N3BN} + t_{A3BN})$$

Loss of non-seismic HVAC during a seismic event:

$$T_{NSR} = (t_{N1R} + t_{NS1R} + PCA_{1R})^2 + (t_{N2R} + t_{NS2R} + t_{N3R} + t_{NS3R})^2$$

$$T_{NSBP} = (t_{N1BP} + t_{NS1BP} + t_{N2BP} + t_{NS2BP} + t_{N3BP} + t_{NS3BP} + PCA_{2BP})$$

$$T_{NSBN} = (t_{N1BN} + t_{NS1BN} + t_{N2BN} + t_{NS2BN} + t_{N3BN} + t_{NS3BN})$$

Combining the results of Instrument Temperature Effects calculated in Section 5.2.4 along with the appropriate temperature dependent process considerations in accordance with the method described above;

T_{NR} = ± 3.0792 $(PCT)^2$

T_{NBP} = 0 PCT

T_{NBN} = 0 PCT

T_{AR} = ± 3.0792 $(PCT)^2$

T_{ABP} = 0 PCT

T_{ABN} = 0 PCT

T_{NSR} = ± 3.0792 $(PCT)^2$

T_{NSBP} = 0 PCT

T_{NSBN} = 0 PCT

5.3.5. Loop Humidity Effect (H_N, H_A and H_{NS})

The Humidity Effect (Normal, Accident and Loss of non-seismic HVAC during a seismic event) contains a random term and bias terms. The individual device Humidity Effects which are random are combined according to device humidity dependency groups.

If device 1 is located in one humidity environment (e.g. Humidity Group "A") and devices 2 and 3 are located in another humidity environment (e.g. Humidity Group "B") then:

Normal:

$$H_{NR} = (h_{N1R})^2 + (h_{N2R} + h_{N3R})^2$$

$$H_{NBP} = (h_{N1BP} + h_{N2BP} + h_{N3BP})$$

$$H_{NBN} = (h_{N1BN} + h_{N2BN} + h_{N3BN})$$

Accident:

$$H_{AR} = (h_{N1R} + h_{A1R})^2 + (h_{N2R} + h_{A2R} + h_{N3R} + h_{A3R})^2$$

$$H_{ABP} = (h_{N1BP} + h_{A1BP} + h_{N2BP} + h_{A2BP} + h_{N3BP} + h_{A3BP})$$

$$H_{ABN} = (h_{N1BN} + h_{A1BN} + h_{N2BN} + h_{A2BN} + h_{N3BN} + h_{A3BN})$$

Loss of non-seismic HVAC during a seismic event:

$$H_{NSR} = (h_{N1R} + h_{NS1R})^2 + (h_{N2R} + h_{NS2R} + h_{N3R} + h_{NS3R})^2$$

$$H_{NSBP} = (h_{N1BP} + h_{NS1BP} + h_{N2BP} + h_{NS2BP} + h_{N3BP} + h_{NS3BP})$$

$$H_{NSBN} = (h_{N1BN} + h_{NS1BN} + h_{N2BN} + h_{NS2BN} + h_{N3BN} + h_{NS3BN})$$

Combining the results of Instrument Humidity Effects calculated in Section 5.2.5 in accordance with the method described above;

$$H_{NR} = \pm\ 0\ (PCT)^2$$

$$H_{NBP} = 0\ PCT$$

$$H_{NBN} = 0\ PCT$$

$$H_{AR} = \pm\ 0\ (PCT)^2$$

$$H_{ABP} = 0\ PCT$$

H_{ABN} = 0 PCT

H_{NSR} = ± 0 $(PCT)^2$

H_{NSBP} = 0 PCT

H_{NSBN} = 0 PCT

5.3.6. Loop Over Pressure Effect (OPE)

The Over Pressure Effect contains a random term and bias terms. Since the individual device Over Pressure Effects are considered independent, the random terms may be combined by the sum of the squares. The random and bias terms will combined as follows:

$$OPE_R = (ope_{1R})^2 + (ope_{2R})^2 + ... + (ope_{nR})^2$$

$$OPE_{BP} = (ope_{1BP} + ope_{2BP} + ... + ope_{nBP})$$

$$OPE_{BN} = (ope_{1BN} + ope_{2BN} + ... + ope_{nBN})$$

Combining the results of Instrument Over Pressure Effects calculated in Section 5.2.6 in accordance with the method described above;

OPE_R = ± 0 $(PCT)^2$

OPE_{BP} = 0 PCT

OPE_{BN} = 0 PCT

5.3.7. Loop Static Pressure Effect Zero (SPEZ)

The Static Pressure Zero Effect contains a random term and bias terms. Since the individual device Static Pressure Zero Effects are considered independent, the random terms may be combined by the sum of the squares. The random and bias terms will be combined as follows:

$$SPEZ_R = (spez_{1R})^2 + (spez_{2R})^2 + ... + (spez_{nR})^2$$

$$SPEZ_{BP} = (spez_{1BP} + spez_{2BP} + ... + spez_{nBP})$$

$$SPEZ_{BN} = (spez_{1BN} + spez_{2BN} + ... + spez_{nBN})$$

Combining the results of Instrument Static Pressure Zero Effects calculated in Section 5.2.7 in accordance with the method described above;

$$SPEZ_R = \pm\ 0.04000\ (PCT)^2$$

$$SPEZ_{BP} = 0\ PCT$$

$$SPEZ_{BN} = 0\ PCT$$

5.3.8. Loop Static Pressure Effect Span (SPES)

The Static Pressure Span Effect contains a random term and bias terms. Since the individual device Static Pressure Span Effects are considered independent, the random terms may be combined by the sum of the squares. The random and bias terms will be combined as follows:

$$SPES_R = (spes_{1R})^2 + (spes_{2R})^2 + ... + (spes_{nR})^2$$

$$SPES_{BP} = (spes_{1BP} + spes_{2BP} + ... + spes_{nBP})$$

$$SPES_{BN} = (spes_{1BN} + spes_{2BN} + ... + spes_{nBN})$$

Combining the results of Instrument Static Pressure Span Effects calculated in Section

5.2.8 in accordance with the method described above;

$SPES_R = \pm 0 \ (PCT)^2$

$SPES_{BP} = 0 \ PCT$

$SPES_{BN} = 0 \ PCT$

5.3.9. Loop Power Supply Effect (P)

The Power Supply Effect contains a random term and bias terms. The individual device Power Supply Effects which are random are combined according to device power dependency groups.

For example, consider a loop which contains devices 1,2, and 3 which each have random, bias positive, and bias negative terms. If device 1 is powered by one power supply (e.g. Power Supply Group "A") and devices 2 and 3 are powered by another Power Supply (e.g. Power Supply Group "B") then:

$P_R = (p_{1R})^2 + (p_{2R} + p_{3R})^2$

$P_{BP} = (p_{1BP} + p_{2BP} + p_{3BP})$

$P_{BN} = (p_{1BN} + p_{2BN} + p_{3BN})$

Combining the results of Instrument Power Supply Effects calculated in Section 5.2.9 in accordance with the method described above;

$P_R = \pm 5.1225e-04 \ (PCT)^2$

$P_{BP} = 0 \ PCT$

$P_{BN} = 0 \ PCT$

5.3.10. Loop Seismic Effect (S)

The Seismic Effect contains a random term and bias terms. The individual device Seismic Effects which are random are combined according to device seismic dependency groups.

For example, consider a loop which contains devices 1,2, and 3 which each have random, bias positive, and bias negative terms. If device 1 is located in one seismic environment (e.g. Seismic Group "A") and devices 2 and 3 are located in another seismic environment (e.g. Seismic Group "B") then:

$$S_R = (s_{1R})^2 + (s_{2R} + s_{3R})^2$$

$$S_{BP} = (s_{1BP} + s_{2BP} + s_{3BP})$$

$$S_{BN} = (s_{1BN} + s_{2BN} + s_{3BN})$$

Combining the results of Instrument Seismic Effects calculated in Section 5.2.10 in accordance with the method described above;

$$S_R = \pm\ 0\ (PCT)^2$$

$$S_{BP} = 0\ PCT$$

$$S_{BN} = 0\ PCT$$

5.3.11. Loop Radiation Effect (R_N & R_{AN})

The Radiation Effect contains a random term and bias terms. The individual device Radiation Effects which are random are combined according to device radiation dependency groups.

For example, consider a loop which contains devices 1,2, and 3 which each have random, bias positive, and bias negative terms. If device 1 is located in one radiation environment (e.g. Radiation Group "A") and devices 2 and 3 are located in another radiation environment (e.g. Radiation Group "B") then:

Normal:

$$R_{NR} = (r_{N1R})^2 + (r_{N2R} + r_{N3R})^2$$

$$R_{NBP} = (r_{N1BP} + r_{N2BP} + r_{N3BP})$$

$$R_{NBN} = (r_{N1BN} + r_{N2BN} + r_{N3BN})$$

Accident:

$$R_{ANR} = (r_{AN1R})^2 + (r_{AN2R} + r_{AN3R})^2$$

$$R_{ANBP} = (r_{AN1BP} + r_{AN2BP} + r_{AN3BP})$$

$$R_{ANBN} = (r_{AN1BN} + r_{AN2BN} + r_{AN3BN})$$

Combining the results of Instrument Radiation Effects calculated in Section 5.2.11 in accordance with the method described above;

$$R_{NR} = \pm\ 0\ (PCT)^2$$

$$R_{NBP} = 0\ PCT$$

$$R_{NBN} = 0\ PCT$$

$$R_{ANR} = \pm\ 0\ (PCT)^2$$

$$R_{ANBP} = 0\ PCT$$

$$R_{ANBN} = 0\ PCT$$

5.3.12. Loop Steam Pressure/Temperature Effect (SPT)

The Steam Pressure/Temperature Effect contains a random term and bias terms. Since the individual device Steam Pressure/Temperature Effects are considered independent, the random terms may be combined by the sum of the squares. The random and bias terms will be combined as follows:

$$SPT_R = (spt_{1R})^2 + (spt_{2R})^2 + ... + (spt_{nR})^2$$

$$SPT_{BP} = (spt_{1BP} + spt_{2BP} + ... + spt_{nBP})$$

$$SPT_{BN} = (spt_{1BN} + spt_{2BN} + ... + spt_{nBN})$$

Combining the results of Instrument Steam Pressure/Temperature Effects calculated in Section 5.2.12 in accordance with the method described above;

$$SPT_R = \pm \ 0 \ (PCT)^2$$

$$SPT_{BP} = 0 \ PCT$$

$$SPT_{BN} = 0 \ PCT$$

5.3.13. Loop Post-DBE Effect (PDBE)

The Post-DBE Effect contains a random term and bias terms. Since the individual device Post-DBE Effects are considered independent, the random terms may be combined by the sum of the squares. The random and bias terms will be combined as follows:

$$PDBE_R = (pdbe_{1R})^2 + (pdbe_{2R})^2 + ... + (pdbe_{nR})^2$$

$$PDBE_{BP} = (pdbe_{1BP} + pdbe_{2BP} + ... + pdbe_{nBP})$$

$$PDBE_{BN} = (pdbe_{1BN} + pdbe_{2BN} + ... + pdbe_{nBN})$$

Combining the results of Instrument Post-DBE Effects calculated in Section 5.2.13 in

accordance with the method described above;

$$PDBE_R = \pm\ 0\ (PCT)^2$$

$$PDBE_{BP} = 0\ PCT$$

$$PDBE_{BN} = 0\ PCT$$

5.3.14. Loop Readability Effect (READ)

The Readability Effect contains a random term only and is the square of the Readability term given on the MCDS table for the loop's indicator, if applicable. The Readability effect is is determined as follows:

$$READ_R = (read_{nR})^2$$

$$READ_R = \pm\ 0\ (PCT)^2$$

5.4. Calculation of Total Loop Error (TLE)

Total Loop Error (TLE) = The Square Root of the Sum of the Squares (SRSS) of the Random terms ± the Bias terms

or

$$TLE_{pos} = SRSS + \text{Bias positive terms}$$

and

$$TLE_{neg} = -\ SRSS - \text{Bias negative terms}$$

For normal conditions:

$$SRSSN = (A + D_R + M + OPE_R + SPEZ_R + SPES_R + P_R + T_{NR} + R_{NR} + H_{NR} + READ + PEA_{NR}{}^2 + PMA_{NR}{}^2 + PC_{NR}{}^2)^{1/2}$$

$$Bias_{pos} = D_{Bp} + OPE_{Bp} + SPEZ_{Bp} + SPES_{Bp} + P_{Bp} + T_{NBp} + R_{NBp} + H_{NBp} + PEA_{NBp} + PMA_{NBp} + PC_{NBp} + IR_{Bp}$$

$Bias_{neg} = D_{Bn} + OPE_{Bn} + SPEZ_{Bn} + SPES_{Bn} + P_{Bn} + T_{NBn} + R_{NBn} + H_{NBn} + PEA_{NBn} + PMA_{NBn} + PC_{NBn} + IR_{Bn}$

SRSSN = ± 5.8872 (PCT)

$Bias_{pos}$ = 0 PCT

$Bias_{neg}$ = 0 PCT

$TLEN_{pos} = SRSSN + Bias_{pos}$

$TLEN_{neg} = -SRSSN - Bias_{neg}$

$TLEN_{pos}$ = 5.8872 PCT = 5.8872 % of Process Span

$TLEN_{neg}$ = -5.8872 PCT = -5.8872 % of Process Span

6.0 CONCLUSIONS

Attachment A to this calculation shows that the calorimetric uncertainty is approximately 1.62%.

7.0 REFERENCES

1. Northern States Power Company Prairie Island Nuclear Generating Plant Design Basis Document for the Environmental Qualification of Electrical Equipment, DBD-TOP-03, Rev. 1.

2. Northern States Power Company Prairie Island Nuclear Generating Plant Updated Safety Analysis Report, Rev. 11.

3. Secondary Calorimetry Instrumentation Uncertainties, Revision 2, February, 1989. Prepared by James Hill.

4. Northern States Power Technical Manual Number X-HIAW 1-1637, Rev. 0, Feedwater Flow Elements.

5. Northern States Power Technical Manual Number NX-20332-1, Rev. 2, Annubar Manufacturer's Manual.

6. Northern States Power Technical Manual Number NX-20631-1, Rev. 5, Rochester Composite Manual.

7. Northern States Power Technical Manual Number NX-20728-1, Rev. 23, Rosemount Composite Manual.

8. Northern States Power Technical Manual Number NX-27801-2, Rev. 1, Honeywell ST3000 Smart Transmitter & Field Communicator.

9. Northern States Power Technical Manual Number NX-29968-1, Rev. 1, Computer Products, Inc. Generic Hardware Reference Manual, Vol. 1.

10. Northern States Power Technical Manual Number NX-33975-1, Rev. 0, Fluke Test Instruments - Standard.

11. Northern States Power Technical Manual Number NX-33976-1, Rev. 0, Heise Test Instruments - Gauges.

12. Northern States Power Technical Manual Number NX-33976-2, Rev. 0, RIS Test Instrument - DPG-600 Gauge.

13. Northern States Power Technical Manual Number NX-33977-1, Rev. 0,

W & T Test Instrument - Gauges & Calibrators.

14. Northern States Power Technical Manual Number NX-33978-1, Rev. 1, Fluke Test Instrument 4 1/2 Digit Voltmeter.

15. Northern States Power Technical Manual Number NX-33978-4, Rev. 1, Fluke Test Instrument - Models 8840A & 45 Voltmeter.

16. Northern States Power Technical Manual Number NX-34704-1, Rev. 0, Minco Temperature Sensing Equipment.

17. Northern States Power Technical Manual Number NX-39766-1, Rev. 0, ADFCS, System Operation & Maintenance.

18. Northern States Power Technical Manual Number NX-39766-9, Rev. 0, ADFCS, Engineering Drawings.

19. Northern States Power Technical Manual Number NX-48322-4-2, Rev. 1, ERCS, Attachment 2-Point I/O Summary List (Vol 1).

20. Northern States Power Technical Manual Number X-HIAW-1-1398-1, Foxboro Service & Maint. Instruction, Part B, Rev. 16.

21. Northern States Power Steam Generator 21 & 22 Blowdown Flow Loop Diagram NE-40412-83, Rev. E.

22. Northern States Power Main, Auxiliary Steam and Steam Dump Flow Diagram, Unit 2, NF-39219, Rev. AV.

23. Northern States Power Feedwater System Flow Diagram, Unit 2, NF-39223, Rev. AP.

24. Northern States Power Liquid Waste Disposal steam Generator Blowdown System Flow Diagram, Units 1 & 2, NF-39250, Rev. AM.

25. Northern States Power External Wiring Diagram 122 Misc. Systems Relay Rack, NF-40295-6, Rev. Q.

26. Northern States Power External Wiring Diagram 122 Misc. Systems Relay Rack Instruments, NF-40295-11, Rev. C.

27. Northern States Power External Wiring Diagram Process Protection System Rack 2R2 Red, Unit 2, NF-40621-2, Rev. C.

28. Northern States Power External Wiring Diagram Process Control System Rack 2RSC2 Rod Speed Control, Unit 2, NF-40622-1, Rev. J.

29. Northern States Power External Wiring Diagram Process Control System Rack 2SA Safety Injection & Aux Sys, Unit 2, NF-40622-4, Rev. P.

30. Northern States Power External Wiring Diagram Process Control System Rack 2PLP Pressurizer Level & Pressure, Unit 2, NF-40622-5, Rev. K.

31. Northern States Power External Wiring Diagram Process Control System Rack 2FW Feedwater System, Unit 2, NF-40622-8, Rev. L.

32. Northern States Power External Wiring Diagram Process Protection System Instruments Racks 2R1, 2R2, 2Y1, 2Y2, & 2B1, NF-40623-1, Rev. H.

33. Northern States Power External Wiring Diagram Process Control System Instruments Racks 2SA, 2PLP, 2FW, & 2SD, NF-40623-5, Rev. Y.

34. Northern States Power Interlock Logic Diagram Steam Generator Blowdown, Unit 2, NF-40775-1, Rev. P.

35. Northern States Power Typical Detail, Primary Piping, LP Flow Transmitter [SG Blowdown], NL-39776-14, Rev. Q.

36. Northern States Power Typical Detail, Primary Piping, Remote Mounted Flow Transmitter [FW Flow], NL-39776-506, Rev. Q.

37. Northern States Power Typical Detail, Primary Piping, Remote Mounted Pressure Transmitter [SG Pressure], NL-39776-512, Rev. Q.

38. Northern States Power Advanced Digital Feedwater Control System Block Diagram, NX-39767, Rev. A.

39. Northern States Power Interconnection Wiring Diagram, Miscellaneous System, X-HIAW-444-122-2, Rev. B.

40. Northern States Power Rack 2R2 Layout, Reactor Protection System, X-HIAW 1001-747, Rev. B.

41. Northern States Power Instrument Block Diagram, Reactor Control & Protection System, X-HIAW 1001-800, Rev. E.

42. Northern States Power Interconnection Wiring Diagram, Rack 1R2 / 2R2, X-HIAW 1001-806-1, Rev. F.

43. Northern States Power Computer Cabling Diagram, Rack 2FW, Remote Multiplexing Unit, X-HIAW 1001-1397, Rev. B.

44. Northern States Power Section Work Instruction I&C Section Test Instrument Calibration Control, I&C-TI-1, Rev. 9.

45. Bases Document for Westinghouse Setpoint Methodology for Comanche Peak Protection Systems, WCAP-12485, March, 1990.

46. Analog Protection System Calibration, SP 2002A, Rev. 13.

47. Feedwater Control System Calibration, SP 2790, Rev. 1.

48. Steam Generator Blowdown Flow Instruments Calibration, ICPM 2-019, Rev. 2.

49. Calculation SPC-RE-0017, Unit 1 ERCS Calorimetric Error.

50. Westinghouse paper titled "Determination of Net Heat Input and Calorimetric Evaluation for Prairie Island Units 1 & 2" identified by footer "testa.wpf/021695."

51. 1967 ASME Steam Tables, Second Edition.

8.0 ATTACHMENTS

ATTACHMENT A TO CALCULATION SPCNI018

CALORIMETRIC PROCESS SIGNAL ERRORS AND THEIR EFFECT ON PERCENT CORE THERMAL POWER

Rev. 0

INTRODUCTION

The purpose of this document is to provide an evaluation of the uncertainties associated with the determination of core thermal power. The equations used in this evaluation are taken from ERCS but modified to include information recently provided by Westinghouse (attached).

The results of this evaluation represent the uncertainty of core thermal power derived by ERCS if the ERCS equations were modified to include the Westinghouse information.

This evaluation contains four parts:

Part 1 presents the equations used by ERCS along with the variables and conventions used within the evaluation. This part also establishes a baseline calorimetric calculation using typical values obtained from ERCS during full power but modified to include pressure corrections and moisture carryover (MCO) values provided by Westinghouse. The values used in the baseline calculation are referred to as baseline values and represent the points of interest for each process parameter.

Part 2 considers a 5% error in each of the four process signals that provide an input to the calorimetric equation and also includes a 5% MCO error. This part also determines the resulting thermal power error for each 5% process error and MCO error by comparison to the baseline calorimetric calculation thereby eliminating any process errors that have an insignificant effect on calculated thermal power uncertainty.

Part 3 determines the uncertainty of each process signal input based on the errors identified within IISCS and by Westinghouse. This part also determines the resulting thermal power error for each process uncertainty by comparison to the baseline calorimetric calculation.

Part 4 combines the thermal power error for each process using the Square Root of the Sum of the Squares (SRSS) technique to yield an overall calorimetric uncertainty.

PART 1

Per Chapter 11 of the ERCS Training Manual, Volume 20-NSSS, NX-48341 Rev. 0, the following equation is used to calculate Core Thermal Power Percent (CTPPC):

CTPPC = [SGTP(1) + SGTP(2)] x K - NHL

Where: SGTP = Steam Generator Thermal Power
K = conversion constant to convert from BTU/hr to % thermal power
= 0.177576E-7 (incorrectly shown as 0.19276E-7 in the Training Manual)
NHL = Net Heat Loss (value provided by Westinghouse)

and:

SGTP = [FF x (Hout - Hin)] - [BDF x (Hout - BDHout)]

Where: FF = Feedwater Flow (lb/hr)

Hout = Heat out (Enthalpy (BTU/lb)) based on Steam Gen Press per ASME Steam Tables for saturated steam (pg. 92) and modified per Westinghouse supplied MCO values
Hin = Heat in (Enthalpy (BTU/lb)) based on Feedwater Temp and Steam Gen Press per ASME Steam Tables for compressed water (pg. 173)
BDF = Blowdown Flow (lb/hr) converted from gpm
BDHout = Blowdown Heat out (Enthalpy (BTU/lb)) based on Steam Gen Press per ASME Steam Tables for saturated water (pg. 92)

and:

Hout = (1-MCO) x Houtstm + MCO x Houtwtr (Correction of Enthalpy for Steam Quality)

Where: MCO = Moisture Carryover (value provided by Westinghouse)
Houtstm = Steam portion of Heat out (Enthalpy (BTU/lb))
Houtwtr = Water portion of Heat out (Enthalpy (BTU/lb))

In addition, the following variables will be used:
SGP = Steam Generator Pressure (psia)
SGPBD = Steam Generator Pressure (psia) at Blowdown orifice
FT = Feedwater Temperature (deg F)

Knf = Feedwater nozzle factor

Steam Table Interpolation and Extrapolation

Many of the values used in this evaluation are determined from the Steam Tables by interpolation and extrapolation. Though enthalpy and specific gravity are not linear functions of temperature and pressure, the segment of the curves being evaluated are small enough to consider any non-linearity as insignificant. The following conventions are used throughout this evaluation:

For single interpolations:

x3	cx3
x2	**cx2**
x1	cx1

Where xn are known values and cx1 and cx2 are the corresponding values of x, respectively, obtained from the steam tables and cx2 is the value derived from interpolation:

For double interpolations:

	y1	y2	y3
x3	cx3y1	cx3y2	cx3y3
x2		**cx2y2**	
x1	cx1y1	cx1y2	cx1y3

Where xn and yn are known values and cx1y1, cx1y3, cx3y1 and cx3y3 are the corresponding values of xn and yn, respectively, obtained from the steam tables. cx3y2 is the value derived from interpolating cx3y3 and cx3y1. cx1y2 is the value derived from interpolating cx1y3 and cx1y1. cx2y2 is the value derived from interpolating cx1y2 and cx3y2

For interpolations based on extrapolation:

	y1	y2	y3
x3	cx3y1	**cx3y2**	cx3y3
x2	cx2y1		cx2y3
x1	cx1y1	cx1y2	cx1y3

Where xn and yn are known values and cx1y1, cx2y1, cx1y3 and cx2y3 are the corresponding values of xn and yn, respectively, obtained from the steam tables. cx3y1 is the value derived from extrapolating cx1y1 and cx2y1. cx3y3 is the value derived from extrapolating cx1y3 and cx2y3. cx3y2 is the value derived from interpolating cx3y1 and cx3y3

Using values that approximate those displayed by ERCS along with the constants given in the Training Manual (See page 2 for a description of the following variables):

$K := 0.177576 \cdot 10^{-7}$

$FF := 3541500$

$Hout := 1201.273$

$Hin := 401.662$

$BDF := 22624$

$BDFgpm := 58$

$BDHout := 496.410$

$MCO := 0.1788 \cdot \%$

$Houtstm := 1201.273$

$Houtwtr := 496.543$

$Hout := (1 - MCO) \cdot Houtstm + MCO \cdot Houtwtr$

$SGP := 716.7 + 9.65$ Unit 2 Steam Generator Pressure measurement correction per Reference 50

$SGPBD := 716.7 + 28$ Unit 2 Steam Generator Pressure measurement correction for Blowdown pressure per Reference 50

$FT := 424$

$Knf := 1.006681$

$SGTP := FF \cdot (Hout - Hin) - BDF \cdot (Hout - BDHout)$ **(EQUATION 1)**

$SGTP = 2.81144 \times 10^{9}$

$NHL := 0.43 \cdot \%$

Assuming that any difference in operating parameters between the two Steam Generators is insignificant:

$SGTP1 := SGTP$

$SGTP2 := SGTP$

$CTPPC := (SGTP1 + SGTP2) \cdot K - NHL$ **(EQUATION 2)**

$CTPPC = 99.84461$ Percent Power

PART 2

CONSIDER 5% FEEDWATER FLOW INPUT SIGNAL ERROR

The feedwater flow signal originates at the feedwater flow nozzle, or venturi. The flow value used in equation 1 is based on a differential pressure across the flow nozzle.

Given:

Flow transmitter Input Span = 0 - 369.3 inwc per Instrument Data Sheet
Flow equivalent to transmitter Output Span = 0 - 4470000 lb/hr per calibration card

$InSpan := 369.3$

$OutSpan := 4470000$

Solve for the Feedwater Flow baseline differential pressure (FFdp) at the baseline flow:

$$FFdp := \left(\frac{FF}{Knf \cdot OutSpan}\right)^2 \cdot InSpan$$

$FFdp = 228.7468$ inwc

Add 5% full span error to the baseline differential pressure:

$FFdp5 := 0.05 \cdot InSpan + FFdp$

$FFdp5 = 247.21179$ inwc

Substitute the 5% differential pressure error and solve for the new 5% error flow signal input:

$$FF5 := Knf \cdot \sqrt{\frac{FFdp5}{InSpan}} \cdot OutSpan$$

$FF5 = 3.68167 \times 10^6$ lb/hr

Substitute the 5% flow error signal into equation 1:

$SGTP := FF5 \cdot (Hout - Hin) - BDF \cdot (Hout - BDHout)$

$SGTP = 2.92334 \times 10^9$

$SGTP1 := SGTP$

$SGTP2 := SGTP$

$CTPPCff := (SGTP1 + SGTP2) \cdot K - NHL$

$CTPPCff = 103.81881$ Percent Power

Therefore, a feedwater flow signal error of 5% results in the following Thermal Power Error (TPE):

$$TPE := \frac{CTPPCff - CTPPC}{CTPPC} \cdot 100$$

$TPE = 3.98038$ Percent Thermal Power Error

CONSIDER 5% BLOWDOWN FLOW INPUT SIGNAL ERROR

The blowdown flow signal originates at the blowdown flow orifice. The flow value used in equation 1 is based on a differential pressure across the flow nozzle.

Given:

Flow transmitter Input Span = 0 - 25.14 inwc per Instrument Data Sheet
Flow equivalent to transmitter Output Span = 0 - 120 gpm per calibration card

$InSpanbd := 25.14$

$OutSpanbd := 120$

Solve for the baseline Blowdown Flow differential pressure (BDFdp) at the baseline flow:

$$BDFdp := \left(\frac{BDFgpm}{OutSpanbd}\right)^2 \cdot InSpanbd$$

$BDFdp = 5.873$ inwc

Add 5% full span error to the baseline differential pressure:

$BDFdp5 := 0.05 \cdot InSpanbd + BDFdp$

$BDFdp5 = 7.12998$ inwc

Substitute the 5% differential pressure error and solve for the new 5% error flow signal input:

$$BDF5gpm := \sqrt{\frac{BDFdp5}{InSpanbd}} \cdot OutSpanbd$$

$BDF5gpm = 63.90618$ gpm

Determine the specific volume of the Blowdown in order to convert to lb/hr:

Per Reference 50, the steam generator pressure is 9.65 psi greater than the measured steam generator pressure and the pressure where the blowdown is measured is, on average, 28 psi greater than the measured steam generator pressure. Therefore, the Blowdown specific volume will be based on: 1) The corresponding temperature of the steam generator at saturated conditions (716.7 + 9.65 psi); and 2) The pressure where the blowdown is measured (716.7 + 28 psi).

Determine the Blowdown temperature (BDSVtmp) based on saturated conditions:

$x2 := SGP$

$x3 := 730 \quad cx3 := 507.78$

$x2 = 726.35$

$x1 := 720 \quad cx1 := 506.23$

$$cx2 := \frac{cx3 - cx1}{x3 - x1} \cdot (x2 - x3) + cx3$$

$cx2 = 507.21425$

$BDSVtmp := cx2$

$BDSVtmp = 507.21425$

Determine the Blowdown specific volume (BDSV) based on compressed water conditions:

$x3 := BDSVtmp$

$y2 := SGPBD$

$y1 := 700 \qquad y2 = 744.7 \qquad y3 := 750$

$x3 = 507.21425$

$x2 := 500 \qquad cx2y1 := 0.02043 \qquad cx2y3 := 0.02042$

$x1 := 490 \qquad cx1y1 := 0.02020 \qquad cx1y3 := 0.02018$

Determine cx3y1:

$$cx3y1 := \frac{x3 - x1}{x2 - x1} \cdot (cx2y1 - cx1y1) + cx1y1$$

$cx3y1 = 0.0206$

Determine cx3y3:

$$cx3y3 := \frac{x3 - x1}{x2 - x1} \cdot (cx2y3 - cx1y3) + cx1y3$$

$cx3y3 = 0.02059$

Determine cx3y2:

$$cx3y2 := \frac{cx3y3 - cx3y1}{y3 - y1} \cdot (y2 - y1) + cx3y1$$

$cx3y2 = 0.02059$

$BDSV := cx3y2$

$BDSV = 0.02059$

$BDF5 := BDF5gpm \cdot \frac{60}{7.48} \cdot \frac{1}{BDSV}$ $\qquad$ $Conversion := \frac{gal}{min} \cdot \frac{60 \cdot min}{hr} \cdot \frac{ft^3}{7.48 \cdot gal} \cdot \frac{lb}{ft^3}$

$BDF5 = 24892.22269$ lb/hr

Substitute the 5% blowdown flow error signal into equation 1:

$SGTP := FF \cdot (Hout - Hin) - BDF5 \cdot (Hout - BDHout)$

$SGTP = 2.80985 \times 10^9$

$SGTP1 := SGTP$

$SGTP2 := SGTP$

$CTPPCbdf := (SGTP1 + SGTP2) \cdot K - NHL$

$CTPPCbdf = 99.78793$ Percent Power

Therefore, a blowdown flow signal error of 5% results in the following Thermal Power Error (TPE):

$$TPE := \frac{CTPPCbdf - CTPPC}{CTPPC} \cdot 100$$

$TPE = -0.05677$ Percent Thermal Power Error

Since the Blowdown Flow Error:Thermal Power Error ratio is 88:1, it is considered mathematically insignificant and will not be considered in Part 3 of this calculation.

CONSIDER 5% STEAM GENERATOR PRESSURE INPUT SIGNAL ERROR

Steam generator pressure is used to determine the enthalpy of the Main Steam (Hout), the enthalpy of the Blowdown (BDHout) and the specific volume of the Blowdown (BDSV). Steam generator pressure along with feedwater temperature is used to determine the enthalpy of the feedwater (Hin).

The following evaluates the effect upon each of these terms as a result of a 5% full span increase in steam generator pressure:

Given:

Baseline Steam Generator Pressure (SGP) at 100% power = 726.35 psia

Steam Generator Pressure Transmitter Span (SGPS) = 0 - 1400 psig per Instrument Data Sheet

$SGP = 726.35$ psia

$SGPS := 1400$ psig

Add 5% full span error to the baseline steam generator pressure:

$SGP5 := 0.05 \cdot SGPS + SGP$

$SGP5 = 796.35$ psia

Using the new steam generator pressure value and referring to the steam tables, perform interpolations to determine new Hout, Hin, BDSV and BDHout values:

Determine new Hout value based on the Steam Generator Pressure Change (SGP5 = x2):

$x2 := SGP5$

$x3 := 800 \qquad cx3 := 1199.4$

$x2 = 796.35$

$x1 := 790 \qquad cx1 := 1199.7$

$$cx2 := \frac{cx3 - cx1}{x3 - x1} \cdot (x2 - x3) + cx3$$

$cx2 = 1199.5095$

$Houtsgp := cx2$

$Houtsgp = 1199.5095$

Determine new Houtwtr value based on the Steam Generator Pressure Change (SGP5 = x2):

$x2 := SGP5$

$x3 := 800 \quad cx3 := 509.8$

$x2 = 796.35$

$x1 := 790 \quad cx1 := 508.1$

$$cx2 := \frac{cx3 - cx1}{x3 - x1} \cdot (x2 - x3) + cx3$$

$cx2 = 509.1795$

$Houtsgpwtr := cx2$

$Houtsgpwtr = 509.1795$

Correct Houtsgp for MCO value provided by Westinghouse

$Houtsgp := (1 - MCO) \cdot Houtsgp + MCO \cdot Houtsgpwtr$

$Houtsgp = 1198.27519$

Determine new Hin value based on the Steam Generator Pressure Change (FT = x2 and SGP5 = y2):

$y2 := SGP5$

$x2 := FT$

$y1 := 750 \qquad y2 = 796.35 \qquad y3 := 800$

$x3 := 430 \quad cx3y1 := 408.25 \qquad cx3y3 := 408.29$

$x2 = 424$

$x1 := 420 \quad cx1y1 := 397.31 \qquad cx1y3 := 397.35$

Determine cx3y2:

$$cx3y2 := \frac{cx3y3 - cx3y1}{y3 - y1} \cdot (y2 - y1) + cx3y1$$

$cx3y2 = 408.28708$

Determine cx1y2:

$$cx1y2 := \frac{cx1y3 - cx1y1}{y3 - y1} \cdot (y2 - y1) + cx1y1$$

$cx1y2 = 397.34708$

Determine cx2y2:

$$cx2y2 := \frac{cx3y2 - cx1y2}{x3 - x1} \cdot (x2 - x1) + cx1y2$$

$cx2y2 = 401.72308$

$Hinsgp := cx2y2$

$Hinsgp = 401.72308$

Determine the new Blowdown Specific Volume (BDSVsgp) value based on the Steam Generator Pressure Change (SGP5 = x2)

Determine the new Blowdown temperature (BDSVtmpsgp) based on saturated conditions:

$x2 := SGP5$

$x3 := 800$ $\quad cx3 := 518.21$

$x2 = 796.35$

$x1 := 790$ $\quad cx1 := 516.76$

$$cx2 := \frac{cx3 - cx1}{x3 - x1} \cdot (x2 - x3) + cx3$$

$cx2 = 517.68075$

$BDSVtmpsgp := cx2$

$BDSVtmpsgp = 517.68075$

Determine the new Blowdown specific volume (BDSVsgp) based on compressed water conditions:

$x3 := BDSVtmpsgp$

$y2 := SGP5 + 18.35$ psi difference between corrected steam generator pressure and blowdown pressure per Reference 50

$y1 := 800$ $\quad y2 = 814.7$ $\quad y3 := 850$

$x3 = 517.68075$

$x2 := 510$ $\quad cx2y1 := 0.02065$ $\quad cx2y3 := 0.02064$

$x1 := 500$ $\quad cx1y1 := 0.02041$ $\quad cx1y3 := 0.02039$

Determine cx3y1:

$$cx3y1 := \frac{x3 - x1}{x2 - x1} \cdot (cx2y1 - cx1y1) + cx1y1$$

$cx3y1 = 0.02083$

Determine cx3y3:

$$cx3y3 := \frac{x3 - x1}{x2 - x1} \cdot (cx2y3 - cx1y3) + cx1y3$$

$cx3y3 = 0.02083$

Determine cx3y2:

$$cx3y2 := \frac{cx3y3 - cx3y1}{y3 - y1} \cdot (y2 - y1) + cx3y1$$

$cx3y2 = 0.02083$

$BDSVsgp := cx3y2$

$BDSVsgp = 0.02083$

Determine the new Blowdown Enthalpy (BDHout) based on compressed water conditions:

$x3 := BDSVtmpsgp$

$y2 := SGP5 + 18.35$ psi difference between corrected steam generator pressure and blowdown pressure per Reference 50

$y1 := 800$ $y2 = 814.7$ $y3 := 850$

$x3 = 517.68075$

$x2 := 510$ $cx2y1 := 499.84$ $cx2y3 := 499.80$

$x1 := 500$ $cx1y1 := 487.88$ $cx1y3 := 487.86$

Determine cx3y1:

$$cx3y1 := \frac{x3 - x1}{x2 - x1} \cdot (cx2y1 - cx1y1) + cx1y1$$

$cx3y1 = 509.02618$

Determine cx3y3:

$$cx3y3 := \frac{x3 - x1}{x2 - x1} \cdot (cx2y3 - cx1y3) + cx1y3$$

$cx3y3 = 508.97082$

Determine cx3y2:

$$cx3y2 := \frac{cx3y3 - cx3y1}{y3 - y1} \cdot (y2 - y1) + cx3y1$$

$cx3y2 = 509.0099$

$BDHoutsgp := cx3y2$

$BDHoutsgp = 509.0099$

Use the new Blowdown specific volume (BDSVsgp) to calculate the new Blowdown compensated flow (BDF):

$$BDFsgp := BDFgpm \cdot \frac{60}{7.48} \cdot \frac{1}{BDSVsgp} \qquad Conversion := \frac{gal}{min} \cdot \frac{60 \cdot min}{hr} \cdot \frac{ft^3}{7.48 \cdot gal} \cdot \frac{lb}{ft^3}$$

$BDFsgp = 22331.20479$ lb/hr

Substitute the new values based on a steam generator pressure increase of 5% into equation 1:

Original values	New values based on steam tables and interpolations
$Hout = 1200.01294$	$Houtsgp = 1198.27519$
$Hin = 401.662$	$Hinsgp = 401.72308$
$BDSV = 0.02059$	$BDSVsgp = 0.02083$
$BDHout = 496.41$	$BDHoutsgp = 509.0099$
$BDF = 22624$	$BDFsgp = 22331.20479$

$SGTP := FF \cdot (Houtsgp - Hinsgp) - BDFsgp \cdot (Houtsgp - BDHoutsgp)$

$SGTP = 2.8056 \times 10^9$

$SGTP1 := SGTP$

$SGTP2 := SGTP$

$CTPPCsgp := (SGTP1 + SGTP2) \cdot K - NHL$

$CTPPCsgp = 99.63704$ Percent Power

Therefore, a steam generator pressure signal error of 5% results in the following Thermal Power Error (TPE):

$$TPE := \frac{CTPPCsgp - CTPPC}{CTPPC} \cdot 100$$

$TPE = -0.20789$ Percent Thermal Power Error

CONSIDER 5% FEEDWATER TEMPERATURE INPUT SIGNAL ERROR

Feedwater temperature and steam generator pressure is used to determine the enthalpy of the feedwater (Hin) from the steam tables.

The following evaluates the effect upon Hin as a result of a 5% full span increase in feedwater temperature:

Given:

Baseline Feedwater Temperature (FT) = 424 deg F

Feedwater Temperature Span (FTS) = 0 - 500 deg F per calibration card

$FT = 424$ deg F

$FTS := 500$ deg F

Add 5% full span error to the baseline feedwater temperature signal:

$FT5 := 0.05 \cdot FTS + FT$

$FT5 = 449$ deg F

Using the new feedwater temperature value and referring to the steam tables, perform interpolation to determine new Hin value:

Determine new Hin value (FT5 = x2 and SGP = y2):

$y2 := SGP$

$x2 := FT5$

$y1 := 700$ $y2 = 726.35$ $y3 := 750$

$x3 := 450$ $cx3y1 := 430.38$ $cx3y3 := 430.4$

$x2 = 449$

$x1 := 440$ $cx1y1 := 419.24$ $cx1y3 := 419.28$

Determine cx3y2:

$$cx3y2 := \frac{cx3y3 - cx3y1}{y3 - y1} \cdot (y2 - y1) + cx3y1$$

$cx3y2 = 430.39054$

Determine cx1y2:

$$cx1y2 := \frac{cx1y3 - cx1y1}{y3 - y1} \cdot (y2 - y1) + cx1y1$$

$cx1y2 = 419.26108$

Determine cx2y2:

$$cx2y2 := \frac{cx3y2 - cx1y2}{x3 - x1} \cdot (x2 - x1) + cx1y2$$

$cx2y2 = 429.27759$

$Hinft := cx2y2$

$Hinft = 429.27759$

Substitute the new value based on a feedwater temperature increase of 5% into equation 1:

Original values	New values based on steam tables and interpolations
$Hin = 401.662$	$Hinft = 429.27759$

$SGTP := FF \cdot (Hout - Hinft) - BDF \cdot (Hout - BDHout)$

$SGTP = 2.71364 \times 10^9$

$SGTP1 := SGTP$

$SGTP2 := SGTP$

$CTPPCfwt := (SGTP1 + SGTP2) \cdot K - NHL$

$CTPPCfwt = 96.3712$ Percent Power

Therefore, a feedwater temperature signal error of 5% results in the following Thermal Power Error (TPE):

$$TPE := \frac{CTPPCfwt - CTPPC}{CTPPC} \cdot 100$$

$TPE = -3.47881$ Percent Thermal Power Error

CONSIDER 5% INCREASE OF MOISTURE CARRYOVER (MCO)

MCO is not an input to the ERCS calculation but may need to be considered as an adjustment to the ERCS calorimetric result. MCO reduces the efficiency of the Steam Generators since the moisture displaces steam and the moisture contains a reduced enthalpy.

The following evaluates the effect upon thermal power as a result of a 5% error in estimating the MCO:

Given:

Baseline MCO = 0.1788*%

$MCO = 0.001788$

Add 5% error to the baseline MCO value:

$MCO5 := 0.05 \cdot MCO + MCO$

$MCO5 = 0.00188$

Recalculate thermal power based on the new MCO:

$Hout := (1 - MCO5) \cdot Houtstm + MCO5 \cdot Houtwtr$

$SGTP := FF \cdot (Hout - Hin) - BDF \cdot (Hout - BDHout)$

$SGTP = 2.81122 \times 10^9$

Assuming that any difference in operating parameters between the two Steam Generators is insignificant:

$SGTP1 := SGTP$

$SGTP2 := SGTP$

$CTPPCmco := (SGTP1 + SGTP2) \cdot K - NHL$

$CTPPCmco = 99.83674$ Percent Power

Therefore, an MCO increase of 5% results in the following Thermal Power Error (TPE):

$$TPE := \frac{CTPPCmco - CTPPC}{CTPPC} \cdot 100$$

$TPE = -0.00789$ Percent Thermal Power Error

Since the MCO Error:Thermal Power Error ratio is 634:1, it is mathematically insignificant and will not be considered in Part 3 of this calculation.

PART 3

DETERMINE FEEDWATER FLOW SIGNAL ERROR BASED ON IISCS CALCULATION

This section considers all the errors identified in Rev. 0 of IISCS calculation SPCNI018 for the Feedwater Flow instruments and then converts each error into inwc (differential pressure) units:

2FE-466

Determine Accuracy of the FE:

$afe := 0.005 \cdot FF$ (accuracy of flow element = 0.5% of true flow error per Assumption 4)

$afe = 17707.5$ (accuracy converted to flow (lb/hr))

$FFfe := afe + FF$ (New Feedwater Flow including flow error)

$FFfe = 3.55921 \times 10^6$ lb/hr

Convert to differential pressure (inwc):

$$Fdpfe := \left(\frac{FFfe}{Knf \cdot OutSpan}\right)^2 \cdot InSpan$$

$Fdpfe = 231.04$ inwc

Subtract baseline flow differential pressure to obtain flow element error:

$afe := Fdpfe - FFdp$

$FFdp = 228.74679$

$afe = 2.29319$ inwc

2FT-495

Given:

$Sft := 369.3$ inwc (Span) per Instrument Data Sheet

$Rft := 400$ inwc (Range) per Make/Model Data Sheet

Determine Accuracy of the FT:

$aft := 0.1 \cdot \% \cdot Rft$ inwc per Make/Model Data Sheet

$aft = 0.4$ inwc

Determine Drift of the FT:

$dft := 0.25 \cdot \% \cdot 25 \cdot 1.25 \cdot \frac{18}{12}$ inwc per Make/Model Data Sheet for a Drift Time of 12 months per Make/Model Data Sheet and a Calibration Interval of 18 months per the Instrument Data Sheet

$dft = 0.11719$ inwc

Determine Temperature Effect of the FT:

$tft := 0.25 \cdot \% \cdot Sft \cdot \frac{105 - 65}{50}$ inwc per Make/Model Data Sheet for a 65 to 105 deg F temp change per Environmental Conditions Data Sheet

$tft = 0.7386$ inwc

Determine Static Pressure Effect, Zero of the FT:

$spezft := 0.2 \cdot \% \cdot Sft$ inwc per Make/Model Data Sheet

$spezft = 0.7386$ inwc

Determine Power Supply Effect of the FT:

$pft := 0.005 \cdot \% \cdot Sft$ inwc per Make/Model Data Sheet

$pft = 0.01847$ inwc

Determine M&TE Error for M&TE Device 1 of the FT:

$mft_1 := 0.9$ inwc per Instrument Data Sheet

Determine M&TE Error for M&TE Device 2 of the FT:

$mftv_2 := 0.00291$ vdc per Instrument Data Sheet

Convert vdc to inwc: (0.1 - 0.5 vdc corresponds to 0 - 369.3 inwc and the point of interest is at a differential pressure of 228.7 (FFdp) inwc):

Solve for voltage at point of interest:

$$vpoi := \sqrt{\frac{228.7}{369.3}} \cdot (0.5 - 0.1) + 0.1$$

$vpoi = 0.41478$ vdc

Add m&te voltage error:

$vpoi + mftv_2 = 0.41769$

Solve for new differential pressure:

$$mdpft_2 := \left(\frac{0.41769 - 0.1}{0.5 - 0.1}\right)^2 \cdot 369.3$$

$mdpft_2 = 232.95198$ inwc

Subtract baseline flow differential pressure to obtain m&te error:

$mft_2 := mdpft_2 - 228.7$

$mft_2 = 4.25198$ inwc

2F2511A (ERCS)

Given:

$Rercs := 0.64$ vdc Range per IISCS vendor screen

Determine Accuracy of the ERCS point:

$afercsv := 0.03706 \cdot \% \cdot 2 \cdot Rercs$ vdc per Make/Model Data Sheet

$afercsv = 0.00047$ vdc

Convert vdc to inwc: (0.1 - 0.5 vdc corresponds to 0 - 369.3 inwc and the point of interest is at a differential pressure of 228.7 inwc):

Solve for voltage at point of interest:

$$vpoi := \sqrt{\frac{228.7}{369.3}} \cdot (0.5 - 0.1) + 0.1$$

$vpoi = 0.41478$ vdc

Add ERCS accuracy voltage error:

$vpoi + afercsv = 0.41525$ vdc

Solve for new differential pressure:

$$afercsdpft := \left(\frac{0.41525 - 0.1}{0.5 - 0.1}\right)^2 \cdot 369.3$$

$afercsdpft = 229.38738$ inwc

Subtract baseline flow differential pressure to obtain ERCS accuracy:

$afercs := afercsdpft - 228.7$

$afercs = 0.68738$ inwc

Determine Temperature Effect of the ERCS point:

$tfercsv := 0.008584 \cdot \% \cdot 2 \cdot Rercs \cdot \frac{25}{1.8}$ vdc per Make/Model Data Sheet for a 25 deg F temp change per Environmental Conditions Data Sheet

$tfercsv = 0.00153$ vdc

Convert vdc to inwc: (0.1 - 0.5 vdc corresponds to 0 - 369.3 inwc and the point of interest is at a differential pressure of 228.7 inwc):

Solve for voltage at point of interest:

$$vpoi := \sqrt{\frac{228.7}{369.3}} \cdot (0.5 - 0.1) + 0.1$$

$vpoi = 0.41478$ vdc

Add ERCS temperature effect voltage error:

$vpoi + tfercsv = 0.4163$ vdc

Solve for new differential pressure:

$$tfercsdpft := \left(\frac{0.4163 - 0.1}{0.5 - 0.1}\right)^2 \cdot 369.3$$

$tfercsdpft = 230.91796$ inwc

Subtract baseline flow differential pressure to obtain ERCS temperature effect:

$tfercs := tfercsdpft - 228.7$

$tfercs = 2.21796$ inwc

Determine M&TE Error of the ERCS point:

$mfercsv := 0.00031813$ vdc per Instrument Data Sheet

Convert vdc to inwc: (0.1 - 0.5 vdc corresponds to 0 - 369.3 inwc and the point of interest is at a differential pressure of 228.7 inwc):

Solve for voltage at point of interest:

$$vpoi := \sqrt{\frac{228.7}{369.3}} \cdot (0.5 - 0.1) + 0.1$$

$vpoi = 0.41478$ vdc

Add ERCS voltage error:

$vpoi + mfercsv = 0.4151$ vdc

Solve for new differential pressure:

$$mfercsdpft := \left(\frac{0.4151 - 0.1}{0.5 - 0.1}\right)^2 \cdot 369.3$$

$mfercsdpft = 229.16914$ inwc

Subtract baseline flow differential pressure to obtain ERCS m&te error:

$mfercs := mfercsdpft - 228.7$

$mfercs = 0.46914$ inwc

Combine all flow errors:

$$srssf := \sqrt{afe^2 + aft^2 + dft^2 + tft^2 + spezft^2 + pft^2 + (mft_1)^2 + (mft_2)^2 + afercs^2 + tfercs^2 + mfercs^2}$$

$srssf = 5.57002$ inwc

Add this feedwater flow error to the baseline flow differential pressure of 228.7 inwc to obtain feedwater flow differential pressure max:

$FFdpmax := srssf + FFdp$

$FFdpmax = 234.31681$ inwc

Convert this max dp to max feedwater flow:

$$FFmax := Knf \cdot \sqrt{\frac{FFdpmax}{InSpan}} \cdot OutSpan$$

$FFmax = 3.58436 \times 10^6$ lb/hr

Substitute the new Feedwater flow into equation 1:

$SGTP := FFmax \cdot (Hout - Hin) - BDF \cdot (Hout - BDHout)$

$SGTP = 2.84543 \times 10^9$

$SGTP1 := SGTP$

$SGTP2 := SGTP$

$CTPPCffmax := (SGTP1 + SGTP2) \cdot K - NHL$

$CTPPCffmax = 101.05184$ Percent Power

Therefore, the feedwater flow signal error results in the following Thermal Power Error (TPE):

$$TPEffmax := \frac{CTPPCffmax - CTPPC}{CTPPC} \cdot 100$$

$TPEffmax = 1.20911$ Percent Thermal Power Error

DETERMINE STEAM GENERATOR PRESSURE SIGNAL ERROR BASED ON IISCS CALCULATION

This section considers all the errors identified in Rev. 0 of IISCS calculation SPCNI018 for the Steam Generator Pressure instruments and then converts each error into psig units:

2PT-468

Given:

$Spt := 1400$ psig Span per Instrument Data Sheet

$Rpt := 3000$ psig Range per Make/Model Data Sheet

Determine Accuracy of the PT:

$apt := 0.25 \cdot \% \cdot Spt$ psig per Make/Model Data Sheet

$apt = 3.5$ psig

Determine Drift of the PT:

$dpt := 0.2 \cdot \% \cdot Rpt \cdot \frac{18}{30}$ psig per Make/Model Data Sheet for a Drift Time of 30 months per Make/Model Data Sheet and a Calibration Interval of 18 months per the Instrument Data Sheet

$dpt = 3.6$ psig

Determine Temperature Effect of the PT:

$tpt := (0.75 \cdot \% \cdot Rpt + 0.5 \cdot \% \cdot Spt) \cdot \frac{105 - 65}{100}$ psig per Make/Model Data Sheet for a 65 to 105 deg F temp change per Environmental Conditions Data Sheet

$tpt = 11.8$ psig

Determine Power Supply Effect of the PT:

$ppt := 0.005 \cdot \% \cdot Spt \cdot \frac{4.3}{1}$ psig per Make/Model Data Sheet for a 4.3 volt power supply stability (PSS) per section 5.1.3

$ppt = 0.301$ psig

Determine M&TE Error for M&TE Device 1 of the PT:

$mpt_1 := 6.0$ psig per Instrument Data Sheet

Determine M&TE Error for M&TE Device 2 of the PT:

$mptv_2 := 0.00291$ vdc per Instrument Data Sheet

Convert vdc to psig (0.1 - 0.5 vdc corresponds to 0 - 1400 psig):

$$mpt_2 := \frac{1400 - 0}{0.5 - 0.1} \cdot 0.00291$$

$mpt_2 = 10.185$ psig

2PM468B

Given:

$Spm := 0.4$ vdc Span per per Instrument Data Sheet

Determine Plant Specific Drift (includes accuracy and m&te error) of the PM:

$dpmv := 0.325 \cdot \% \cdot Spm$ per IISCS Make/Model Data Sheet

$dpmv = 0.0013$ vdc

Convert vdc to psig (0.1 - 0.5 vdc corresponds to 0 - 1400 psig):

$$dpm := \frac{1400 - 0}{0.5 - 0.1} \cdot 0.0013$$

$dpm = 4.55$ psig

2P0400A (ERCS)

Given:

$Rercs := 0.64$ vdc Range per Make/Model Data Sheet

Determine Accuracy of the ERCS point:

$apercsv := 0.03706 \cdot \% \cdot 2 \cdot Rercs$ vdc accuracy per Make/Model Data Sheet

$apercsv = 0.00047$ vdc

Convert vdc to psig (0.1 - 0.5 vdc corresponds to 0 - 1400 psig):

$$apercs := \frac{1400 - 0}{0.5 - 0.1} \cdot 0.00047$$

$apercs = 1.645$ psig

Determine Temperature Effect of the ERCS point:

$tpercsv := 0.008584 \cdot 2 \cdot \% \cdot Rercs \cdot \frac{25}{1.8}$ vdc per Make/Model Data Sheet for a 25 deg F temp change per Environmental Conditions Data Sheet

$tpercsv = 0.00153$ vdc

Convert vdc to psig (0.1 - 0.5 vdc corresponds to 0 - 1400 psig):

$tpercs := \frac{1400 - 0}{0.5 - 0.1} \cdot 0.00153$

$tpercs = 5.355$ psig

Determine M&TE Error of the ERCS point:

$mpercsv := 0.00031813$ vdc per Instrument Data Sheet

Convert vdc to psig (0.1 - 0.5 vdc corresponds to 2 - 1400 psig):

$mpercs := \frac{1400 - 0}{0.5 - 0.1} \cdot 0.00031813$

$mpercs = 1.11346$ psig

Determine Steamline Pressure Correction Error based on Westinghouse input (Ref. 50):

$Wpc := 9.65 \cdot 10 \cdot \%$

$Wpc = 0.965$ psig

Combine all pressure errors:

$$srssp := \sqrt{apt^2 + dpt^2 + tpt^2 + ppt^2 + (mpt_1)^2 + (mpt_2)^2 + dpm^2 + apercs^2 + tpercs^2 + mpercs^2 + Wpc^2}$$

$srssp = 18.9349$ psia

Add this steam generator pressure error to the baseline steam generator baseline pressure of 726.35 psia to obtain steam generator pressure max:

$SGPmax := srssp + SGP$

$SGPmax = 745.2849$ psig

Using the new steam generator pressure value and referring to the steam tables, perform interpolations to determine new Hout, Hin, BDSV and BDHout values:

Determine new Hout value based on the Steam Generator Pressure Change (SGPmax = x2):

$x2 := SGPmax$

$x3 := 750 \qquad cx3 := 1200.7$

$x2 = 745.2849$

$x1 := 740 \qquad cx1 := 1200.9$

$$cx2 := \frac{cx3 - cx1}{x3 - x1} \cdot (x2 - x3) + cx3$$

$cx2 = 1200.7943$

$Houtsgpmaxstm := cx2$

$Houtsgpmaxstm = 1200.7943$

Determine new Houtwtr value based on the Steam Generator Pressure Max (SGPmax = x2):

$x2 := SGPmax$

$x3 := 750 \quad cx3 := 500.9$

$x2 = 745.2849$

$x1 := 740 \quad cx1 := 499.1$

$$cx2 := \frac{cx3 - cx1}{x3 - x1} \cdot (x2 - x3) + cx3$$

$cx2 = 500.05128$

$Houtsgpmaxwtr := cx2$

$Houtsgpmaxwtr = 500.05128$

Correct Houtsgp for MCO value provided by Westinghouse

$Houtsgpmax := (1 - MCO) \cdot Houtsgpmaxstm + MCO \cdot Houtsgpmaxwtr$

$Houtsgpmax = 1199.54137$

Determine new Hin value based on the Steam Generator Pressure Change (FT = x2 and SGPmax = y2):

$y2 := SGPmax$

$x2 := FT$

$y1 := 700 \qquad y2 = 745.2849 \qquad y3 := 750$

$x3 := 430 \quad cx3y1 := 408.20 \qquad cx3y3 := 408.25$

$x2 = 424$

$x1 := 420 \quad cx1y1 := 397.26 \qquad cx1y3 := 397.31$

Determine cx3y2:

$$cx3y2 := \frac{cx3y3 - cx3y1}{y3 - y1} \cdot (y2 - y1) + cx3y1$$

$cx3y2 = 408.24528$

Determine cx1y2:

$$cx1y2 := \frac{cx1y3 - cx1y1}{y3 - y1} \cdot (y2 - y1) + cx1y1$$

$cx1y2 = 397.30528$

Determine cx2y2:

$$cx2y2 := \frac{cx3y2 - cx1y2}{x3 - x1} \cdot (x2 - x1) + cx1y2$$

$cx2y2 = 401.68128$

$Hinsgpmax := cx2y2$

$Hinsgpmax = 401.68128$

Determine the new Blowdown temperature (BDSVtmpsgp) based on saturated conditions:

$x2 := SGPmax$

$x3 := 750 \quad cx3 := 510.84$

$x2 = 745.2849$

$x1 := 740 \quad cx1 := 509.32$

$$cx2 := \frac{cx3 - cx1}{x3 - x1} \cdot (x2 - x3) + cx3$$

$cx2 = 510.1233$

$BDSVtmpsgp := cx2$

$BDSVtmpsgp = 510.1233$

Determine the new Blowdown specific volume (BDSVsgp) based on compressed water conditions:

$x3 := BDSVtmpsgp$

$y2 := SGPmax + 18.35$ psi difference between corrected steam generator pressure and blowdown pressure per Westinghouse (Ref. 50)

$y1 := 750 \quad y2 = 763.6349 \quad y3 := 800$

$x3 = 510.1233$

$x2 := 500 \quad cx2y1 := 0.02042 \quad cx2y3 := 0.02041$

$x1 := 490 \quad cx1y1 := 0.02018 \quad cx1y3 := 0.02017$

Determine cx3y1:

$$cx3y1 := \frac{x3 - x1}{x2 - x1} \cdot (cx2y1 - cx1y1) + cx1y1$$

$cx3y1 = 0.02066$

Determine cx3y3:

$$cx3y3 := \frac{x3 - x1}{x2 - x1} \cdot (cx2y3 - cx1y3) + cx1y3$$

$cx3y3 = 0.02065$

Determine cx3y2:

$$cx3y2 := \frac{cx3y3 - cx3y1}{y3 - y1} \cdot (y2 - y1) + cx3y1$$

$cx3y2 = 0.02066$

$BDSVsgpmax := cx3y2$

$BDSVsgpmax = 0.02066$

Determine the new Blowdown Enthalpy (BDHout) based on compressed water conditions:

$x3 := BDSVtmpsgp$

$y2 := SGPmax + 18.35$ psi difference between corrected steam generator pressure and blowdown pressure per Westinghouse (Ref. 50)

$y1 := 750$ $y2 = 763.6349$ $y3 := 800$

$x3 = 510.1233$

$x2 := 510$ $cx2y1 := 499.88$ $cx2y3 := 499.84$

$x1 := 500$ $cx1y1 := 487.90$ $cx1y3 := 487.88$

Determine cx3y1:

$$cx3y1 := \frac{x3 - x1}{x2 - x1} \cdot (cx2y1 - cx1y1) + cx1y1$$

$cx3y1 = 500.02772$

Determine cx3y3:

$$cx3y3 := \frac{x3 - x1}{x2 - x1} \cdot (cx2y3 - cx1y3) + cx1y3$$

$cx3y3 = 499.98747$

Determine cx3y2:

$$cx3y2 := \frac{cx3y3 - cx3y1}{y3 - y1} \cdot (y2 - y1) + cx3y1$$

$cx3y2 = 500.01674$

$BDHoutsgpmax := cx3y2$

$BDHoutsgpmax = 500.01674$

Use the new Blowdown specific volume (BDSV) to calculate the new Blowdown compensated flow (BDF):

$$BDFsgpmax := BDFgpm \cdot \frac{60}{7.48} \cdot \frac{1}{BDSVsgpmax} \qquad Conversion := \frac{gal}{min} \cdot \frac{60 \cdot min}{hr} \cdot \frac{ft^3}{7.48 \cdot gal} \cdot \frac{lb}{ft^3}$$

$BDFsgpmax = 22518.65489$ lb/hr

Substitute the new values based on the change of steam generator pressure into equation 1:

Original values	New values based on steam tables and interpolations
$Hout = 1199.94994$	$Houtsgpmax = 1199.54137$
$Hin = 401.662$	$Hinsgpmax = 401.68128$
$BDSV = 0.02059$	$BDSVsgpmax = 0.02066$
$BDHout = 496.41$	$BDHoutsgpmax = 500.01674$
$BDF = 22624$	$BDFsgpmax = 22518.65489$

$$SGTP := FF \cdot (Houtsgpmax - Hinsgpmax) - BDFsgpmax \cdot (Houtsgpmax - BDHoutsgpmax)$$

$$SGTP = 2.80987 \times 10^9$$

$$SGTP1 := SGTP$$

$$SGTP2 := SGTP$$

$$CTPPCsgpmax := (SGTP1 + SGTP2) \cdot K - NHL$$

$CTPPCsgpmax = 99.78876$ Percent Power

Therefore, the steam generator pressure signal error results in the following Thermal Power Error (TPE):

$$TPEsgpmax := \frac{CTPPCsgpmax - CTPPC}{CTPPC} \cdot 100$$

$TPEsgpmax = -0.05593$ Percent Thermal Power Error

DETERMINE FEEDWATER TEMPERATURE SIGNAL ERROR BASED ON IISCS CALCULATION

This section considers all the errors identified in Rev. 0 of IISCS calculation SPCNI018 for the Feedwater Temperature instruments and then converts each error into deg F units:

2TE-498

Determine Accuracy of the TE:

Per Calculation SPCNI018, assumption 6, the accuracy of the feedwater temperature RTD is 0.17293% of Reading (ohms).

Determine the Reading at the baseline feedwater temperature value of 424 deg F (92.893-197.474 ohms corresponds to 0-500 deg F):

$$\text{Reading} := \frac{197.474 - 92.893}{500 - 0} \cdot 424 + 92.893 \qquad \text{ohms}$$

$$\text{Reading} = 181.57769 \qquad \text{ohms}$$

Determine accuracy of the TE in ohms:

$$\text{ateo} := 0.17293 \cdot \% \cdot \text{Reading}$$

$$\text{ateo} = 0.314 \qquad \text{ohms}$$

Determine the equivalent accuracy of the TE in deg F:

$$\text{ate} := \frac{500 - 0}{197.474 - 92.893} \cdot 0.314$$

$$\text{ate} = 1.50123 \qquad \text{deg F}$$

Determine Drift of the TE:

Per Calculation SPCNI018, assumption 6, the drift of the feedwater temperature RTD is 0.84250% of Reading (Ω).

Determine the Reading at the baseline feedwater temperature value of 424 deg F ((92.893-197.474 ohms corresponds to 0-500 deg F):):

$$Reading := \frac{197.474 - 92.893}{500 - 0} \cdot 424 + 92.893$$ ohms

$$Reading = 181.57769$$ ohms

Determine drift of the TE in ohms:

$$dteo := 0.84250 \cdot \% \cdot Reading$$

$$dteo = 1.52979$$ ohms

Determine the equivalent drift of the TE in deg F:

$$dte := \frac{500 - 0}{197.474 - 92.893} \cdot 1.52979$$

$$dte = 7.3139$$ deg F

2TT-498

Given:

$Stt := 197.47 - 92.89$ ohms Span per Instrument Data Sheet

$Stt = 104.58$ ohms

Determine Plant Specific Drift of the TT (includes accuracy and temp effects):

$dtto := 0.28793$ ohms per Assumption 11

Convert ohms to deg F (92.89 - 197.47 ohms corresponds to 0 - 500 deg F):

$$dtt := \frac{500 - 0}{197.47 - 92.89} \cdot 0.28793$$

$$dtt = 1.3766$$ deg F

Determine Power Supply Effect of the TT:

$ptto := 0.0025 \cdot \% \cdot Stt \cdot \frac{2}{1}$ ohms per Make/Model Data Sheet for a 2 volt power supply stability (PSS) per section 5.1.3

$ptto = 0.00523$ ohms

Convert ohms to deg F (92.89 - 197.47 ohms corresponds to 0 - 500 deg F):

$$ptt := \frac{500 - 0}{197.47 - 92.89} \cdot 0.00524$$

$ptt = 0.02505$ deg F

2T0418A (ERCS)

Given:

$Rercs := 0.64$ vdc Range per Make/Model Data Sheet

Determine Accuracy of the ERCS point:

$atercsv := 0.03706 \cdot \% \cdot 2 \cdot Rercs$ vdc per Make/Model Data Sheet

$atercsv = 0.00047$ vdc

Convert vdc to deg F (0.1 - 0.5 vdc corresponds to 0 - 500 deg F):

$$atercs := \frac{500 - 0}{0.5 - 0.1} \cdot 0.00047$$

$atercs = 0.5875$ deg F

Determine Temperature Effect of the ERCS point:

$ttercsv := 0.008584 \cdot 2 \cdot \% \cdot Rercs \cdot \frac{25}{1.8}$ vdc per Make/Model Data Sheet for a 25 deg F temp change per Environmental Conditions Data Sheet

$ttercsv = 0.00153$

Convert vdc to deg F (0.1 - 0.5 vdc corresponds to 0 - 500 deg F):

$$ttercs := \frac{500 - 0}{0.5 - 0.1} \cdot 0.00092$$

$ttercs = 1.15$ deg F

Determine M&TE Error of the ERCS point:

$mtercsv := 0.00031813$ vdc per Instrument Data Sheet

Convert vdc to deg F (0.1 - 0.5 vdc corresponds to 0 - 500 deg F):

$$mtercs := \frac{500 - 0}{0.5 - 0.1} \cdot 0.00031813$$

$mtercs = 0.39766$ deg F

Combine all temperature errors:

$$srsst := \sqrt{ate^2 + dte^2 + dtt^2 + ptt^2 + atercs^2 + ttercs^2 + mtercs^2}$$

$srsst = 7.71157$ deg F

Add this feedwater temperature error to the baseline feedwater temperature of 424 deg F to obtain feedwater temp max:

$FTmax := srsst + FT$

$FTmax = 431.71157$ deg F

Using the new feedwater temperature value and referring to the steam tables, perform interpolation to determine new Hin value:

Determine new Hin value (FTmax = x2 and SGP = y2):

$y2 := SGP$

$x2 := FTmax$

	$y1 := 700$	$y2 = 726.35$	$y3 := 750$
$x3 := 440$	$cx3y1 := 419.24$		$cx3y3 := 419.28$
$x2 = 431.71157$			
$x1 := 430$	$cx1y1 := 408.2$		$cx1y3 := 408.25$

Determine cx3y2:

$$cx3y2 := \frac{cx3y3 - cx3y1}{y3 - y1} \cdot (y2 - y1) + cx3y1$$

$cx3y2 = 419.26108$

Determine cx1y2:

$$cx1y2 := \frac{cx1y3 - cx1y1}{y3 - y1} \cdot (y2 - y1) + cx1y1$$

$cx1y2 = 408.22635$

Determine cx2y2:

$$cx2y2 := \frac{cx3y2 - cx1y2}{x3 - x1} \cdot (x2 - x1) + cx1y2$$

$cx2y2 = 410.11502$

$Hinftmax := cx2y2$

$Hinftmax = 410.11502$

Substitute the new value based on the feedwater temperature error into equation 1:

Original value	New value based on steam tables and interpolations
$Hin = 401.662$	$Hinftmax = 410.11502$

$SGTP := FF \cdot (Hout - Hinftmax) - BDF \cdot (Hout - BDHout)$

$SGTP = 2.78128 \times 10^9$

$SGTP1 := SGTP$

$SGTP2 := SGTP$

$CTPPCftmax := (SGTP1 + SGTP2) \cdot K - NHL$

$CTPPCftmax = 98.77354$ Percent Power

Therefore, the feedwater temperature signal error results in the following Thermal Power Error (TPE):

$$TPEftmax := \frac{CTPPCftmax - CTPPC}{CTPPC} \cdot 100$$

$TPEftmax = -1.07274$ Percent Thermal Power Error

DETERMINE NET HEAT INPUT UNCERTAINTY

Per Westinghouse's input, the Net Heat Input Uncertainty is +/- 12% of 7.1 MWt

$NHI := 12 \cdot \% \cdot 7.1$

$NHI = 0.852$ MWt

$TPENHI := \frac{0.852}{1650} \cdot 100$

$TPENHI = 0.05164$ Percent Thermal Power Error

PART 4

Combine all Thermal Power Errors to yield Calorimetric Uncertainty:

$$CalUncertainty := \sqrt{TPEffmax^2 + TPEsgpmax^2 + TPEftmax^2 + TPENHI^2}$$

$CalUncertainty = 1.61818$ Percent of full power

Therefore, the uncertainty of the Calorimetric Calculation, as determined by ERCS, and modified to include Westinghouse's input, would be approximately +/- 1.62%

Tab G

NORTHERN STATES POWER COMPANY
PRAIRIE ISLAND NUCLEAR GENERATING PLANT
CALCULATION COVER SHEET

Calculation Number: SPCRE005

Calculation Rev. No.: 0

Calculation Title: NIS Power Range Indication Uncertainty for control

Calculation Type:

☑ Safety Related — Non-Safety Related (review required)

What if (information only) — Non-Safety Related (review not required)

Plant Conditions:

☑ Normal — Seismic — Post Accident

LOCA — Other

Calculation Verification Method (check one):

☑ Design Review — Alternate Calculation — Qualification Testing

Scope of Revision: original issue

Documentation of Reviews and Approvals:

Originated By: Brian K. Rogers **Date:** 02/10/2003

Reviewed By: Bob Woodling **Date:** 02/11/2003

Approved By: Thomas M. VerBout **Date:** 02/14/2003

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1.0 PURPOSE/RESULTS

1.1. Purpose and Acceptance Criteria

The purpose of this calculation is to determine the uncertainty associated with the plant's NIS Power Range reactor power indication at the NIS racks. The result of this calculation will be used as a design input for Westinghouse-based transient analyses.

Because of the similarities between various NIS Power Range channels, this calculation is performed for channel 1N41 but is applicable to any Unit 1 or Unit 2 NIS Power Range channel.

1.2. Results

POWER RANGE DETECTOR CURRENT METER

The total Loop Error (TLE) for this instrument string is +1.1965 -1.1965 percent of span.

The results of this calculation show that the NIS Power Range indication uncertainty (rack indicator) is ±1.436% RTP.

2.0 METHODOLOGY

The following equations are based on the "Two Loop Group Setpoint Methodology," Revision 0, prepared by TENERA, L.P. for Northern States Power Company, Wisconsin Public Service Corporation, and Wisconsin Electric Power Company. This methodology is based on ISA Standard S67.04-1987, Setpoints for Nuclear Safety-Related Instrumentation Used in Nuclear Power Plants.

2.1. Calculation of Total Loop Error (TLE)

Total Loop Error (TLE) = The Square Root of the Sum of the Squares (SRSS) of the Random terms ± the sum of the Bias terms, or:

TLE_{pos} = SRSS + Bias positive terms
and
TLE_{neg} = - SRSS - Bias negative terms

For normal conditions:

$$SRSS = (A + D_R + M + OPE_R + SPEZ_R + SPES_R + P_R + T_{NR} + R_{NR} + H_{NR} + READ + PEA_{NR}{}^2 + PMA_{NR}{}^2 + PC_{NR}{}^2)^{1/2}$$

$$Bias_{pos} = D_{Bp} + OPE_{Bp} + SPEZ_{Bp} + SPES_{Bp} + P_{Bp} + T_{NBp} + R_{NBp} + H_{NBp} + PEA_{NBp} + PMA_{NBp} + PC_{NBp}$$

$$Bias_{neg} = D_{Bn} + OPE_{Bn} + SPEZ_{Bn} + SPES_{Bn} + P_{Bn} + T_{NBn} + R_{NBn} + H_{NBn} + PEA_{NBn} + PMA_{NBn} + PC_{NBn}$$

For accident conditions:

$$SRSS = (A + D_R + M + OPE_R + SPEZ_R + SPES_R + P_R + T_{AR} + R_{ANR} + H_{AR} + READ + SPT_R + PEA_{AR}{}^2 + PMA_{AR}{}^2 + PC_{AR}{}^2)^{1/2}$$

$$Bias_{pos} = D_{Bp} + OPE_{Bp} + SPEZ_{Bp} + SPES_{Bp} + P_{Bp} + T_{ABp} + R_{ANBp} + H_{ABp} + PEA_{ABp} + PMA_{ABp} + PC_{ABp} + IR_{Bp} + SPT_{Bp}$$

$Bias_{neg} = D_{Bn} + OPE_{Bn} + SPEZ_{Bn} + SPES_{Bn} + P_{Bn} + T_{ABn} + R_{ANBn} + H_{ABn} + PEA_{ABn} + PMA_{ABn} + PC_{ABn} + IR_{Bn} + SPT_{Bn}$

For loss of non-seismic HVAC due to a seismic event:

$SRSS = (A + D_R + M + OPE_R + SPEZ_R + SPES_R + P_R + T_{NSR} + R_{NR} + H_{NSR} + S_R + READ + PEA_{NR}{}^2 + PMA_{NR}{}^2 + PC_{NR}{}^2)^{1/2}$

$Bias_{pos} = D_{Bp} + OPE_{Bp} + SPEZ_{Bp} + SPES_{Bp} + P_{Bp} + T_{NSBp} + R_{NBp} + H_{NSBp} + S_{Bp} + PEA_{NBp} + PMA_{NBp} + PC_{NBp}$

$Bias_{neg} = D_{Bn} + OPE_{Bn} + SPEZ_{Bn} + SPES_{Bn} + P_{Bn} + T_{NSBn} + R_{NBn} + H_{NSBn} + S_{Bn} + PEA_{NBn} + PMA_{NBn} + PC_{NBn}$

For Post Accident conditions:

$SRSS = (A + D_R + M + OPE_R + SPEZ_R + SPES_R + P_R + T_{NR} + R_{NR} + H_{NR} + PDBE_R + READ + PEA_{NR}{}^2 + PMA_{NR}{}^2 + PC_{NR}{}^2)^{1/2}$

$Bias_{pos} = D_{Bp} + OPE_{Bp} + SPEZ_{Bp} + SPES_{Bp} + P_{Bp} + T_{NBp} + R_{NBp} + H_{NBp} + PDBE_{Bp} + PEA_{NBp} + PMA_{NBp} + PC_{NBp}$

$Bias_{neg} = D_{Bn} + OPE_{Bn} + SPEZ_{Bn} + SPES_{Bn} + P_{Bn} + T_{NBn} + R_{NBn} + H_{NBn} + PDBE_{Bn} + PEA_{NBn} + PMA_{NBn} + PC_{NBn}$

Where:

A = The sum of the squares of all of the random device accuracies (a).

D = The sum of the squares of all of the random device drift effects (d).

M = The sum of the squares of all of the random device M&TE effects (m).

OPE = The sum of the squares of all of the random device over pressure effects (ope).

SPEZ = The sum of the squares of all of the random device static pressure zero effects (spez).

SPES = The sum of the squares of all of the random device static pressure span effects (spes).

P = The sum of the squares of all of the random device power supply effects (p).

T = The sum of the squares of all of the random device temperature effects (t).

R = The sum of the squares of all of the random device radiation effects (r).

H = The sum of the squares of all of the random device humidity effects (h).

S = The sum of the squares of all of the random device seismic effects (s).

READ = The square of the indicator readability term (read).

PEA = The primary element accuracy.

PMA = The process measurement accuracy.

PC = The sum of all of the process considerations.

IR = The error introduced by insulation resistance.

PDBE = The sum of the squares of all of the random device post design basis event effects (pdbe).

The subscripts are defined as follows:

A = For accident conditions only.

N = For normal conditions only.

AN = For cumulative accident and normal conditions.

NS = For loss of non-seismic HVAC conditions only.

R = A Random term.

Bp = A Bias positive term.

Bn = A Bias Negative term.

Notes:

1. When a device's setting tolerance is greater than its accuracy, then the setting tolerance is used in place of that device's accuracy.

2. When accident conditions are being evaluated and a Steam Pressure/Temperature (SPT) effect is given on the vendor screen, the SPT effect will automatically be substituted for T_A and H_A.

3. During all conditions, when Plant Specific Drift is entered on the vendor screen, accuracy, M&TE effect, normal temperature effect, normal radiation effect, and normal humidity effect for that device default to zero since they are all considered to be included in the Plant Specific Drift value. During the calculation, the option to override the default for each effect is given.

2.2. Calculation of the Nominal Trip Setpoint (NTSP) for Safety Related Calculations

For an increasing process: $NTSP = AL - TLE_{neg}$

For a decreasing process: $NTSP = AL + TLE_{pos}$

Where:

AL = Analytical Limit

2.3. Calculation of the Nominal Trip Setpoint (NTSP) for Non-Safety Related Calculations

For an increasing process: $NTSP = PL - TLE_{neg}$

For a decreasing process: $NTSP = PL + TLE_{pos}$

Where:

PL = Process Limit

2.4. Calculation of Allowable Value (AV)

The term AV applies to safety related calculations only. Operational Limit (OL) is the equivalent term for non-safety related calculations.

For an increasing process: $AV = NTSP + LD + LD_{Bp}$

For a decreasing process: $AV = NTSP - LD - LD_{Bn}$
Where:

LD (Loop Drift) = $(A + D_R + M + R_{NR})^{1/2}$

$LD_{Bp} = D_{Bp} + R_{Bp}$

$LD_{Bn} = D_{Bn} + R_{Bn}$

2.5. Calculation of Operational Limit (OL)

The term OL applies to non-safety related calculations only.

For an increasing process: $OL = NTSP + LD + LD_{Bp}$

For a decreasing process: $OL = NTSP - LD - LD_{Bn}$
Where:

LD (Loop Drift) = $(A + D_R + M + R_{NR})^{1/2}$

$LD_{Bp} = D_{Bp} + R_{Bp}$

$LD_{Bn} = D_{Bn} + R_{Bn}$

2.6. Calculation of Rack Allowance (RA)

The term RA applies to safety related calculations only. There is no equivalent term for non-safety related calculations.

For an increasing process: $RA = NTSP + RD + RD_{Bp}$

For a decreasing process: $RA = NTSP - RD - RD_{Bn}$

Where:

$RD\,(\text{Rack Drift}) = (A + D_R + M + R_{NR})^{1/2}$

$RD_{Bp} = D_{Bp} + R_{Bp}$

$RD_{Bn} = D_{Bn} + R_{Bn}$

Note: Rack Drift includes the effects from all loop devices except the sensor.

3.0 ASSUMPTIONS

1. This calculation was performed using normal environmental conditions; accident operating times have been set to zero.

2. As described in Section 2.2.4.1 of Reference 5, "The current signals from the two detector sections are summed, then averaged by Summing and Level Amplifier NM310 to produce a single voltage which is proportional to average reactor current.". The two detector sections are identical, each consisting of an upper (or lower) Power Range Detector and a Detector Current Meter. Per PINGP's Setpoint Methodology, because these two input channels are averaged, their resulting uncertainties can be averaged. In this calculation, averaging of the two Summing and Level Amplifier input channel uncertainties is accomplished by including only one Power Range Detector and one Detector Current Meter in the instrument loop.

3. This calculation applies to all eight Unit 1 and Unit 2 Power Range instrumentation loops (i.e., channels N41, N42, N43, and N44).

4. Reference 5 Section 1.4.3.1 states that the summing and level amplifier (Westinghouse model 3359C48G01) has a stability (i.e., drift) of 0.1% per 100 hours. Therefore, the vendor drift time is shown as 100 hours/ 730 hours per month = 0.137 months.

5. For NI-303 , the MCDS input units and tolerance are shown in vdc (rather than mvdc as shown on the calibration cards) in order to match the scale units on the associated M&TE device.

6. Since there are no gain values associated with the 2 inputs from the detector current meters to the summing amplifier (i.e., gain = 1), the summer may be treated as a linear device. Therefore, the standard SRSS method of combining errors is valid for this calculation and the standard ISA summer error propagation equation does not need to be used.

7. The calibration interval for the summing and level amplifier (NM310) is daily in accordance with Surveillance Procedure SP 1005 (Reference 16). Therefore, the MCDS calibration interval is: [(1 day)/(365 days/yr)] x [12 months/yr] = 0.033 months. An additional factor of 2 will be added to allow for the surveillance to be performed up to 48 hours (two days) apart. 2 x 0.033 months = 0.066 months. The setting tolerance is 0.5% (i.e., 0.5% * 10 vdc = 0.05 vdc) per SP 1005, Section 7.6.

8. Per Ref. 5, the input to indicator NI-303 is a 0.0-1.0 mA signal derived from the output of the NI channel's summing and level amplifier. During calibration, the indicator input signal is measured across a precision test point resistor on the meter's printed circuit card, such that 0.0-

120.0 mV measured at the test points corresponds to 0.0-1.0 mA input to the meter circuit, which in turn corresponds to 0-120% RTP on the indicator display. Since 0.0-120.0 mV is used as the input signal for calibration, the MCDS record for NI-303 lists 0.0-120.0 mV as the input span.

4.0 DESIGN INPUT

4.1. Form 1: Loop/Process Data Sheet

Loop ID	1N41
Configuration No.	9
Loop Description	Power Range Neutron Flux
Process Span (PS)	0 To 120.00 PCT
Analytical/ Process Limit (AL/PL)	120.00 PCT
Normal Operation Upper Limit (NOUL)	100.00 PCT
Normal Operation Lower Limit (NOLL)	0 PCT
Process Max Op Pressure (PMOP)	PSIG
Process Normal Op Pressure (PNOP)	PSIG
Operating Time (Accident)	Min: 0 Hours Max: 0 Hours
Setpoint Direction	I

4.2. Form 2: Instrument Data Sheet

	1
Instrument Tag No.	1NE-41
Function	U
Other Tag No.	
System	NI
Functional Description	POWER RANGE UPPER DETECTOR
Rack/Panel No.	
Power Supply Tag No.	1N41-NQ303
EQ Zone	CNTA1
Elevation	ft in
Column	
Row	
Manuf. Name	WESTINGHOUSE
Model Number	WL-23686
EQ	No
Seismic Category	YES
QA Elec.	X11FN
QA Mech.	
Input Span (CS)	0 To 120.00 PCT
Output Span (OS)	0 To 0.40000 VDC
Readability (read)	
Surveillance/Calib. Procedure	SP 1006A, SP 1006B, SP 1006C
Calibration Interval (CI)	24.000 Months
Device Setting Tol. Allowance (st)	1.0*a
Device M&TE Allowance mte1 : Device M&TE Cal Span mtecs1:	To
Device M&TE Allowance mte2 : Device M&TE Cal Span mtecs2:	To
Device M&TE Allowance mte3 : Device M&TE Cal Span mtecs3:	To
Device M&TE Allowance mte4 : Device M&Te Cal Span mtecs4:	To
Device M&TE Allowance mte5 : Device M&TE Cal Span mtecs5:	To

	1
Instrument Tag No.	1N41-NI301
Function	
Other Tag No.	
System	NI
Functional Description	POWER RANGE DETECTOR CURRENT METER
Rack/Panel No.	
Power Supply Tag No.	1N41-NQ301
EQ Zone	CNLRM
Elevation	735.00 ft in
Column	
Row	
Manuf. Name	WESTINGHOUSE
Model Number	8242C46G01
EQ	No
Seismic Category	YES
QA Elec.	XN2FN
QA Mech.	
Input Span (CS)	0 To 0.40000 VDC
Output Span (OS)	0 To 0.40000 VDC
Readability (read)	
Surveillance/Calib. Procedure	SP 1318.3
Calibration Interval (CI)	24.000 Months
Device Setting Tol. Allowance (st)	0.00003
Device M&TE Allowance mte1 : Device M&TE Cal Span mtecs1:	1.0448e-03 VDC 0 To 2.0000 VDC
Device M&TE Allowance mte2 : Device M&TE Cal Span mtecs2:	To
Device M&TE Allowance mte3 : Device M&TE Cal Span mtecs3:	To
Device M&TE Allowance mte4 : Device M&Te Cal Span mtecs4:	To
Device M&TE Allowance mte5 : Device M&TE Cal Span mtecs5:	To

	1
Instrument Tag No.	1N41-NM310
Function	
Other Tag No.	
System	NI
Functional Description	POWER RANGE-SUMMING & LEVEL AMPLIFIER
Rack/Panel No.	
Power Supply Tag No.	1N41-NQ301
EQ Zone	CNLRM
Elevation	735.00 ft in
Column	
Row	
Manuf. Name	WESTINGHOUSE
Model Number	3359C48G01
EQ	No
Seismic Category	YES
QA Elec.	X11FT
QA Mech.	
Input Span (CS)	0 To 0.40000 VDC
Output Span (OS)	0 To 10.000 VDC
Readability (read)	
Surveillance/Calib. Procedure	SP 1318.3, SP 1005
Calibration Interval (CI)	0.06000 Months
Device Setting Tol. Allowance (st)	0.05
Device M&TE Allowance mte1 : Device M&TE Cal Span mtecs1:	0.01240 VDC 0 To 20.000 VDC
Device M&TE Allowance mte2 : Device M&TE Cal Span mtecs2:	1.0448e-03 VDC 0 To 2.0000 VDC
Device M&TE Allowance mte3 : Device M&TE Cal Span mtecs3:	To
Device M&TE Allowance mte4 : Device M&Te Cal Span mtecs4:	To
Device M&TE Allowance mte5 : Device M&TE Cal Span mtecs5:	To

	1
Instrument Tag No.	1N41-NI303
Function	
Other Tag No.	
System	NI
Functional Description	POWER RANGE DETECTOR CURRENT METER
Rack/Panel No.	
Power Supply Tag No.	1N41-NQ301
EQ Zone	CNLRM
Elevation	735.00 ft in
Column	
Row	
Manuf. Name	WESTINGHOUSE
Model Number	8242C46G01
EQ	No
Seismic Category	YES
QA Elec.	XN2FN
QA Mech.	
Input Span (CS)	0 To 0.12000 VDC
Output Span (OS)	0 To 120.00 PCT
Readability (read)	
Surveillance/Calib. Procedure	SP 1318.3
Calibration Interval (CI)	24.000 Months
Device Setting Tol. Allowance (st)	0.00003
Device M&TE Allowance mte1 : Device M&TE Cal Span mtecs1:	1.0448e-03 VDC 0 To 2.0000 VDC
Device M&TE Allowance mte2 : Device M&TE Cal Span mtecs2:	To
Device M&TE Allowance mte3 : Device M&TE Cal Span mtecs3:	To
Device M&TE Allowance mte4 : Device M&Te Cal Span mtecs4:	To
Device M&TE Allowance mte5 : Device M&TE Cal Span mtecs5:	To

4.3. Form 3: Make/Model Data Sheet

Manuf. Name	WESTINGHOUSE
Model Number	WL-23686
Range	Min:0 Units:PCT Max:120.00
Design Pressure	PSIG
Vendor Accuracy Allowance (va)	0.5%*R
Vendor Drift Allowance (vd)	0
Drift Time (DT)	1.0000 Months Linear or Non-Linear? L Vendor or Plant-Specific? V
Vendor Temp Effect (vte)	0
Vendor Humidity Effect (vhe)	0
Vendor Over Pressure Effect (vope)	0
Vendor Static Pressure Effect Zero (vspez)	0
Vendor Static Pressure Effect Span (vspes)	0
Vendor Power Supply Effect (vp)	0
Vendor Seismic Effect (vse)	0
Vendor Radiation Effect (vre)	0
Vendor Steam Press/Temp. Effect (vspt)	0
Vendor Post-DBE Effect(vpdbe)	0

Manuf. Name	WESTINGHOUSE
Model Number	8242C46G01
Range	Min:0 Units:VDC Max:0.40000
Design Pressure	PSIG
Vendor Accuracy Allowance (va)	0.1%*S
Vendor Drift Allowance (vd)	0
Drift Time (DT)	1.0000 Months Linear or Non-Linear? L Vendor or Plant-Specific? V
Vendor Temp Effect (vte)	0
Vendor Humidity Effect (vhe)	0
Vendor Over Pressure Effect (vope)	0
Vendor Static Pressure Effect Zero (vspez)	0
Vendor Static Pressure Effect Span (vspes)	0
Vendor Power Supply Effect (vp)	0
Vendor Seismic Effect (vse)	0
Vendor Radiation Effect (vre)	0
Vendor Steam Press/Temp. Effect (vspt)	0
Vendor Post-DBE Effect(vpdbe)	0

Manuf. Name	WESTINGHOUSE
Model Number	3359C48G01
Range	Min:0 Units:VDC Max:0.40000
Design Pressure	PSIG
Vendor Accuracy Allowance (va)	0.2%*R
Vendor Drift Allowance (vd)	0.1%*R
Drift Time (DT)	0.14000 Months Linear or Non-Linear? L Vendor or Plant-Specific? V
Vendor Temp Effect (vte)	0
Vendor Humidity Effect (vhe)	0
Vendor Over Pressure Effect (vope)	0
Vendor Static Pressure Effect Zero (vspez)	0
Vendor Static Pressure Effect Span (vspes)	0
Vendor Power Supply Effect (vp)	0
Vendor Seismic Effect (vse)	0
Vendor Radiation Effect (vre)	0
Vendor Steam Press/Temp. Effect (vspt)	0
Vendor Post-DBE Effect(vpdbe)	0

4.4. Form 4: Environmental Conditions Data Sheet

Eq Zone	CNTA1
Room Description	Unit 1 Containment (Elev 706 and above)
Normal Temperature Range (NTMIN & NTMAX)	Min: 65.000 °F Max: 120.00 °F
Normal Humidity Range (NHMIN & NHMAX)	Min: 30.000 %RH Max: 90.000 %RH
Max. Normal Radiation (NR)	2.85e-03 Rads/Hour
Accident Type	NORMAL
Accident Temperature (AT)	0 °F
Accident Humidity (AH)	0 %RH
Accident Radiation (AR)	0 Rads

Eq Zone	CNLRM
Room Description	Unit 1 & 2 Control Room
Normal Temperature Range (NTMIN & NTMAX)	Min: 60.000 °F Max: 85.000 °F
Normal Humidity Range (NHMIN & NHMAX)	Min: 50.000 %RH Max: 50.000 %RH
Max. Normal Radiation (NR)	1.0e-03 Rads/Hour
Accident Type	NORMAL
Accident Temperature (AT)	0 °F
Accident Humidity (AH)	0 %RH
Accident Radiation (AR)	0 Rads

5.0 ERROR ANALYSIS AND SETPOINT DETERMINATION

5.1. Given Conditions

5.1.1. Loop Instrument List

Device	Unit	Instrument Tag	Function
1	1	1NE-41	U
2	1	1N41-NI301	
3	1	1N41-NM310	
4	1	1N41-NI303	

5.1.2. Device Dependency Table

Unit	Instrument	Func	Cal	Pwr	Rad	Seismic	Temp	Humidity
1	1NE-41	U	A	A	A	A	A	A
1	1N41-NI301		B	B	B	B	B	B
1	1N41-NM310		C	B	B	B	B	B
1	1N41-NI303		D	B	B	B	B	B

Device Dependency Assumptions/References

Calibration:

Power Supply:

Radiation:

Seismic:

Temperature:

Humidity:

5.1.3. Calibration Static Pressure(CSP), Power Supply Stability(PSS)

Unit	Instrument	Function	CSP (PSIG)	PSS (VOLTS)
1	1NE-41	U	0	0
1	1N41-NI301		0	0
1	1N41-NM310		0	0
1	1N41-NI303		0	0

Note: PSS values are only considered for devices with a Vendor Power Supply Effect which is expressed per volt.

CSP and PSS Assumptions/References

CSP:

PSS:

5.1.4. Insulation Resistance (IR), Primary Element Accuracy (PEA), Process Measurement Accuracy (PMA) and other Process Considerations (PC)

Type	Magnitude (decimal%)	Sign	Acc/ Norm	Dependent Device	Dependent Uncertainty	PC/IR Assumptions/ References

Note: Magnitude is expressed in decimal percent of span, e.g. 0.02 equals 2% of span. IR value per specific Loop Configuration IR calculation.

5.2. Calculation of Instrument Uncertainties

5.2.1. Instrument Accuracy (a_n)

$$a_n = (va_n)(PS/CS_n)$$

Where n = the number of the loop device
va = vendor's accuracy expression

Note: If the Device Setting Tolerance (st), per Form 2, is greater than the Instrument Accuracy (a) for a specific device, then (st) will be used in lieu of (a) in the equation shown above.

Instrument Accuracy(a)

Device	Random	Units
1	±0.60000	PCT
2	±0.12000	PCT
3	±0.60000	PCT
4	±0.12000	PCT

* = Uncertainty included with plant specific drift for this device

5.2.2. Instrument Drift (d_n)

d = (CI/DT)(vd)(PS/CS)

Where vd = vendor's drift expression

Note: The factor (CI/DT) is included in the above equation if Drift is linear over time. If Drift is non-linear over time, the factor is replaced by:

$(CI/DT)^{1/2}$

Instrument Drift(d)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PCT
2	±0	0	0	PCT
3	±0.05143	0	0	PCT
4	±0	0	0	PCT

5.2.3. Instrument Measurement and Test Equipment Allowance (m_n)

$$mte_x = [(mtea_x + mtestd_x)^2 + (mtet_x)^2 + (mteread_x)^2]^{1/2}$$

$$m_n = [(mte_1/mtecs_1)^2 + (mte_2/mtecs_2)^2 + (mte_3/mtecs_3)^2 + (mte_4/mtecs_4)^2 + (mte_5/mtecs_5)^2]^{1/2} * PS$$

Where:

mte_x = the Measurement and Test Equipment allowance for one M&TE device.

$mtea_x$ = the accuracy of the M&TE device.

$mtet_x$ = the temperature effect of the M&TE device.

$mteread_x$ = the readability of the M&TE device.

$mtestd_x$ = the accuracy of the standard used to calibrate the M&TE device.

m_n = the Measurement and Test Equipment allowance for one loop device.

mtecs = the calibrated span of the M&TE device.

Instrument M&TE(m)

Device	Random	Units
1	±0	PCT
2	±0.31344	PCT
3	±0.34697	PCT
4	±1.0448	PCT

* = Uncertainty included with plant specific drift for this device

5.2.4. Instrument Temperature Effect (t_N, t_A & t_{NS})

Normal: t_N = (NTMAX - NTMIN)(vte)(PS/CS)

Accident: t_A = [(AT - NTMIN)(vte)(PS/CS)] - t_N

Loss of non-seismic HVAC during a seismic event:

t_{NS} = [(NST - NTMIN)(vte)(PS/CS)] - t_N

Where vte = vendor's temperature effect expression

Notes: The factors (NTMAX - NTMIN), (AT - NTMIN) and (NST - NTMIN) are included in the equations shown above only if the Vendor's Temperature Effect (vte) for a specific device is expressed per degree. This is indicated by the character "/" in the Vendor's Temperature Effect equation shown on Form 3.

If the Vendor's Temperature Effect equation is expressed as a step function, then the values of NTMAX, AT and NST will be used to determine the value of "X" in the step function.

Normal Instrument Temperature Effect (t_N)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PCT
2	±0	0	0	PCT
3	±0	0	0	PCT
4	±0	0	0	PCT

* = Uncertainty included with plant specific drift for this device

Accident Instrument Temperature Effect (t_A)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PCT
2	±0	0	0	PCT
3	±0	0	0	PCT
4	±0	0	0	PCT

Loss of non-seismic HVAC during a seismic event
Temperature Effect (t_{NS})

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PCT
2	±0	0	0	PCT
3	±0	0	0	PCT
4	±0	0	0	PCT

5.2.5. Instrument Humidity Effect (h_N, h_A & h_{NS})

Normal: h_N = (NHMAX - NHMIN)(vhe)(PS/CS)

Accident: h_A = [(AH - NHMIN)(vhe)(PS/CS)] - h_N

Loss of non-seismic HVAC during a seismic event:

h_{NS} = [(NSH - NHMIN)(vhe)(PS/CS)] - h_N

Where vhe = vendor's humidity effect expression

Notes: The factors (NHMAX - NHMIN), (AH - NHMIN) and (NSH - NHMIN) are included in the equations shown above only if the Vendor's Humidity Effect (vhe) for a specific device is expressed per degree. This is indicated by the character "/" in the Vendor's Humidity Effect equation shown on Form 3.

If the Vendor's Humidity Effect equation is expressed as a step function, then the values of NHMAX, AH and NSH will be used to determine the value of "X" in the step function.

Normal Instrument Humidity Effect (h_N)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PCT
2	±0	0	0	PCT
3	±0	0	0	PCT
4	±0	0	0	PCT

* = Uncertainty included with plant specific drift for this device

Accident Instrument Humidity Effect (h_A)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PCT
2	±0	0	0	PCT
3	±0	0	0	PCT
4	±0	0	0	PCT

Loss of non-seismic HVAC during a seismic event
Humidity Effect (h_{NS})

Device	Random	+Bias	-Bias	Units

1	±0	0	0	PCT
2	±0	0	0	PCT
3	±0	0	0	PCT
4	±0	0	0	PCT

5.2.6. Instrument Over Pressure Effect (ope)

ope = (PMOP - DP)(vope)(PS/CS)

Where vope = vendor's over pressure effect expression

Notes: The factor (PMOP -DP) is included in the equation shown above only if the Vendor's Over Pressure Effect (vope) for a specific device is expressed per PSI. This is indicated by the character "/" in the Vendor's Over Pressure Effect equation shown on Form 3.

If the Design Pressure for a specific device (DP) is greater than or equal to the Process Maximum Operating Pressure (PMOP), then the Over Pressure Effect (ope) is equal to zero.

Instrument Over Pressure Effect (ope)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PCT
2	±0	0	0	PCT
3	±0	0	0	PCT
4	±0	0	0	PCT

5.2.7. Instrument Static Pressure Effect Zero (spez)

spez = (PMOP - CSP)(vspez)(PS/CS)

Where vspez = vendor's static pressure zero effect expression

Note: The factor (PMOP - CSP) is included in the equation shown above only if the Vendor's Static Pressure Effect Zero (vspez) for a specific device is linear for the given

pressure change defined. This is indicated by the character " / " in the Vendor's Static Pressure Effect Zero equation shown on Form 3.

Instrument Static Pressure Effect Zero (spez)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PCT
2	±0	0	0	PCT
3	±0	0	0	PCT
4	±0	0	0	PCT

5.2.8. Instrument Static Pressure Effect Span (spes)

spes = (PMOP - CSP)(vspes)(PS/CS)

Where vspes = vendor's static pressure span effect expression
Note: The factor (PMOP - CSP) is included in the equation shown above only if the Vendor's Static Pressure Effect Span (vspes) for a specific device is linear for the given pressure change defined. This is indicated by the character " / " in the Vendor's Static Pressure Effect Span equation shown on Form 3.

Instrument Static Pressure Effect Span (spes)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PCT
2	±0	0	0	PCT
3	±0	0	0	PCT
4	±0	0	0	PCT

5.2.9. Instrument Power Supply Effect (p)

p = ((PSS)(vp)(PS/CS)

Where p = vendor's power supply effect expression

Note: The factor (PSS) is included in the equation shown above only if the Vendor's Power Supply Effect (vp) for a specific device is expressed per volt. This is indicated by the character " / " in the Vendor's Power Supply Effect equation shown on Form 3.

Instrument Power Supply Effect (p)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PCT
2	±0	0	0	PCT
3	±0	0	0	PCT
4	±0	0	0	PCT

5.2.10. Instrument Seismic Effect (s)

s = (vse)(PS/CS)
Where vse = vendor's seismic effect expression

Instrument Seismic Effect (s)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PCT
2	±0	0	0	PCT
3	±0	0	0	PCT
4	±0	0	0	PCT

5.2.11. Instrument Radiation Effect (r_N, r_A & r_{AN})

Normal: r_N = (NTID)(vre)(PS/CS)

Accident: r_A = (ATID)(vre)(PS/CS)

Accident: r_{AN} = (ANTID)(vre)(PS/CS)

Where vre = vendor's radiation effect expression

NTID = total integrated dose for normal conditions

ATID = total integrated dose for accident conditions

ANTID = total integrated dose for accident plus normal conditions

Notes: The factors (NTID)(ATID) and (ANTID) are included in the equations only if the Vendor Radiation Effect (vre) for a specific device is expressed per Rad. This is indicated by the character " / " in the Radiation Effect equation shown on Form 3.

If the Radiation Effect equation is expressed as a step function, then the values NTID, ATID and ANTID will be used to determine the value of "X" in the step function.

If plant specific drift is entered for a loop device that is subject to accident radiation, r_A is used in place or r_{AN} if the user does not change the plant specific drift default value of 0 for the normal radiation effect.

Normal Instrument Radiation Effect (r_N)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PCT
2	±0	0	0	PCT
3	±0	0	0	PCT
4	±0	0	0	PCT

* = Uncertainty included with plant specific drift for this device

Accident Instrument Radiation Effect (r_A)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PCT
2	±0	0	0	PCT
3	±0	0	0	PCT
4	±0	0	0	PCT

Accident and Normal Instrument Radiation Effect (r_{AN})

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PCT
2	±0	0	0	PCT
3	±0	0	0	PCT
4	±0	0	0	PCT

5.2.12. Instrument Steam Pressure/Temperature Effect (spt)

spt = (vspt)(PS/CS)

Where vspt = vendor's steam pressure/temperature effect expression

Instrument Steam Pressure/Temperature Effect (spt)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PCT
2	±0	0	0	PCT
3	±0	0	0	PCT
4	±0	0	0	PCT

5.2.13. Instrument Post-DBE Effect (pdbe)

pdbe = (vpdbe)(PS/CS)

Where vpdbe = vendor's Post-DBE effect expression

Instrument Post-DBE Effect (pdbe)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PCT
2	±0	0	0	PCT
3	±0	0	0	PCT
4	±0	0	0	PCT

5.3. Calculation of Combined Loop Effects

5.3.1. Loop Accuracy (A)

Accuracy contains only random terms. Since the individual device Accuracies are considered independent, they may be combined as follows:

$$A = (a_1)^2 + (a_2)^2 + ... + (a_n)^2$$

Using the equations for Instrument Accuracy and combining the results in accordance with the method described above;

$$A = \pm \quad 0.74880 \ (PCT)^2$$

5.3.2. Loop Drift (D)

Drift may contain random and bias terms. The individual device drifts which are random are combined according to device calibration dependency groups.

For example, consider a loop which contains devices 1, 2, and 3 which each have random, bias positive, and bias negative terms. If device 1 is calibrated alone (e.g. Calibration Group "A") and devices 2 and 3 are calibrated together (e.g. Calibration Group "B") then:

$$D_R = (d_{1R})^2 + (d_{2R} + d_{3R})^2$$

$D_{BP} = (d_{1BP} + d_{2BP} + d_{3BP})$

$D_{BN} = (d_{1BN} + d_{2BN} + d_{3BN})$

Combining the results of Instrument Drift calculated in section 5.2.2 in accordance with the method described above;

$D_R = \pm$ 2.6449e-03 $(PCT)^2$

$D_{BP} =$ 0 PCT

$D_{BN} =$ 0 PCT

5.3.3. Loop Measurement & Test Equipment Allowance (M)

The M&TE Allowance contains a random term only. The individual device M&TE Allowances are combined according to device calibration dependency groups.

For example, consider a loop which contains devices 1, 2, and 3. If device 1 is calibrated alone (e.g. Calibration Group "A") and devices 2 and 3 are calibrated together (e.g. Calibration Group "B") then:

$M = (m_1)^2 + (m_2 + m_3)^2$

Combining the results of Instrument M&TE Allowance calculated in section 5.2.3 in accordance with the method described above;

$M = \pm$ 1.3102 $(PCT)^2$

5.3.4. Loop Temperature Effect (T_N, T_A and T_{NS})

The Temperature Effect (Normal, Accident and Loss of non-seismic HVAC during a seismic event) contains a random term and bias terms. The individual device Temperature Effects which are random are combined according to device temperature dependency

groups. Process Considerations that are considered to be temperature-related are also combined with the associated device Temperature Effect.

For example, consider a loop which contains devices 1, 2, and 3 which each have a random, bias positive, and bias negative terms. The devices also have the following temperature-related process considerations (PC):

PCA_{1R} = Device 1 Accident Random PC

PCN_{1R} = Device 1 Normal Random PC

PCA_{2BP} = Device 2 Accident Bias Positive PC

PCN_{3BN} = Device 3 Normal Bias Negative PC

If device 1 is located in one temperature environment (e.g. Temperature Group "A") and devices 2 and 3 are located in another temperature environment (e.g. Temperature Group "B") then:

Normal:

$$T_{NR} = (t_{N1R} + PCN_{1R})^2 + (t_{N2R} + t_{N3R})^2$$

$$T_{NBP} = (t_{N1BP} + t_{N2BP} + t_{N3BP})$$

$$T_{NBN} = (t_{N1BN} + t_{N2BN} + t_{N3BN} + PCN_{3BN})$$

Accident:

$$T_{AR} = (t_{N1R} + t_{A1R} + PCA_{1R})^2 + (t_{N2R} + t_{A2R} + t_{N3R} + t_{A3R})^2$$

$$T_{ABP} = (t_{N1BP} + t_{A1BP} + t_{N2BP} + t_{A2BP} + t_{N3BP} + t_{A3BP} + PCA_{2BP})$$

$$T_{ABN} = (t_{N1BN} + t_{A1BN} + t_{N2BN} + t_{A2BN} + t_{N3BN} + t_{A3BN})$$

Loss of non-seismic HVAC during a seismic event:

$$T_{NSR} = (t_{N1R} + t_{NS1R} + PCA_{1R})^2 + (t_{N2R} + t_{NS2R} + t_{N3R} + t_{NS3R})^2$$

$$T_{NSBP} = (t_{N1BP} + t_{NS1BP} + t_{N2BP} + t_{NS2BP} + t_{N3BP} + t_{NS3BP} + PCA_{2BP})$$

$$T_{NSBN} = (t_{N1BN} + t_{NS1BN} + t_{N2BN} + t_{NS2BN} + t_{N3BN} + t_{NS3BN})$$

Combining the results of Instrument Temperature Effects calculated in Section 5.2.4 along with the appropriate temperature dependent process considerations in accordance with the method described above;

$T_{NR} = \pm\ 0\ (PCT)^2$

$T_{NBP} = 0\ PCT$

$T_{NBN} = 0\ PCT$

$T_{AR} = \pm\ 0\ (PCT)^2$

$T_{ABP} = 0\ PCT$

$T_{ABN} = 0\ PCT$

$T_{NSR} = \pm\ 0\ (PCT)^2$

$T_{NSBP} = 0\ PCT$

$T_{NSBN} = 0\ PCT$

5.3.5. Loop Humidity Effect (H_N, H_A and H_{NS})

The Humidity Effect (Normal, Accident and Loss of non-seismic HVAC during a seismic event) contains a random term and bias terms. The individual device Humidity Effects which are random are combined according to device humidity dependency groups.

If device 1 is located in one humidity environment (e.g. Humidity Group "A") and devices 2 and 3 are located in another humidity environment (e.g. Humidity Group "B") then:

Normal:

$$H_{NR} = (h_{N1R})^2 + (h_{N2R} + h_{N3R})^2$$

$$H_{NBP} = (h_{N1BP} + h_{N2BP} + h_{N3BP})$$

$$H_{NBN} = (h_{N1BN} + h_{N2BN} + h_{N3BN})$$

Accident:

$$H_{AR} = (h_{N1R} + h_{A1R})^2 + (h_{N2R} + h_{A2R} + h_{N3R} + h_{A3R})^2$$

$$H_{ABP} = (h_{N1BP} + h_{A1BP} + h_{N2BP} + h_{A2BP} + h_{N3BP} + h_{A3BP})$$

$$H_{ABN} = (h_{N1BN} + h_{A1BN} + h_{N2BN} + h_{A2BN} + h_{N3BN} + h_{A3BN})$$

Loss of non-seismic HVAC during a seismic event:

$$H_{NSR} = (h_{N1R} + h_{NS1R})^2 + (h_{N2R} + h_{NS2R} + h_{N3R} + h_{NS3R})^2$$

$$H_{NSBP} = (h_{N1BP} + h_{NS1BP} + h_{N2BP} + h_{NS2BP} + h_{N3BP} + h_{NS3BP})$$

$$H_{NSBN} = (h_{N1BN} + h_{NS1BN} + h_{N2BN} + h_{NS2BN} + h_{N3BN} + h_{NS3BN})$$

Combining the results of Instrument Humidity Effects calculated in Section 5.2.5 in accordance with the method described above;

$$H_{NR} = \pm\ 0\ (PCT)^2$$

$$H_{NBP} = 0\ PCT$$

$$H_{NBN} = 0\ PCT$$

$$H_{AR} = \pm\ 0\ (PCT)^2$$

$$H_{ABP} = 0\ PCT$$

$$H_{ABN} = 0\ PCT$$

$H_{NSR} = \pm 0 \ (PCT)^2$

$H_{NSBP} = 0 \ PCT$

$H_{NSBN} = 0 \ PCT$

5.3.6. Loop Over Pressure Effect (OPE)

The Over Pressure Effect contains a random term and bias terms. Since the individual device Over Pressure Effects are considered independent, the random terms may be combined by the sum of the squares. The random and bias terms will be combined as follows:

$$OPE_R = (ope_{1R})^2 + (ope_{2R})^2 + ... + (ope_{nR})^2$$

$$OPE_{BP} = (ope_{1BP} + ope_{2BP} + ... + ope_{nBP})$$

$$OPE_{BN} = (ope_{1BN} + ope_{2BN} + ... + ope_{nBN})$$

Combining the results of Instrument Over Pressure Effects calculated in Section 5.2.6 in accordance with the method described above;

$OPE_R = \pm 0 \ (PCT)^2$

$OPE_{BP} = 0 \ PCT$

$OPE_{BN} = 0 \ PCT$

5.3.7. Loop Static Pressure Effect Zero (SPEZ)

The Static Pressure Zero Effect contains a random term and bias terms. Since the individual device Static Pressure Zero Effects are considered independent, the random terms may be combined by the sum of the squares. The random and bias terms will be combined as follows:

$$SPEZ_R = (spez_{1R})^2 + (spez_{2R})^2 + ... + (spez_{nR})^2$$

$$SPEZ_{BP} = (spez_{1BP} + spez_{2BP} + ... + spez_{nBP})$$

$$SPEZ_{BN} = (spez_{1BN} + spez_{2BN} + ... + spez_{nBN})$$

Combining the results of Instrument Static Pressure Zero Effects calculated in Section 5.2.7 in accordance with the method described above;

$$SPEZ_R = \pm\ 0\ (PCT)^2$$

$$SPEZ_{BP} = 0\ PCT$$

$$SPEZ_{BN} = 0\ PCT$$

5.3.8. Loop Static Pressure Effect Span (SPES)

The Static Pressure Span Effect contains a random term and bias terms. Since the individual device Static Pressure Span Effects are considered independent, the random terms may be combined by the sum of the squares. The random and bias terms will be combined as follows:

$$SPES_R = (spes_{1R})^2 + (spes_{2R})^2 + ... + (spes_{nR})^2$$

$$SPES_{BP} = (spes_{1BP} + spes_{2BP} + ... + spes_{nBP})$$

$$SPES_{BN} = (spes_{1BN} + spes_{2BN} + ... + spes_{nBN})$$

Combining the results of Instrument Static Pressure Span Effects calculated in Section 5.2.8 in accordance with the method described above;

$$SPES_R = \pm\ 0\ (PCT)^2$$

$$SPES_{BP} = 0\ PCT$$

$$SPES_{BN} = 0\ PCT$$

5.3.9. Loop Power Supply Effect (P)

The Power Supply Effect contains a random term and bias terms. The individual device Power Supply Effects which are random are combined according to device power dependency groups.

For example, consider a loop which contains devices 1, 2, and 3 which each have random, bias positive, and bias negative terms. If device 1 is powered by one power supply (e.g. Power Supply Group "A") and devices 2 and 3 are powered by another Power Supply (e.g. Power Supply Group "B") then:

$$P_R = (p_{1R})^2 + (p_{2R} + p_{3R})^2$$

$$P_{BP} = (p_{1BP} + p_{2BP} + p_{3BP})$$

$$P_{BN} = (p_{1BN} + p_{2BN} + p_{3BN})$$

Combining the results of Instrument Power Supply Effects calculated in Section 5.2.9 in accordance with the method described above;

$$P_R = \pm\ 0\ (PCT)^2$$

$$P_{BP} = 0\ PCT$$

$$P_{BN} = 0\ PCT$$

5.3.10. Loop Seismic Effect (S)

The Seismic Effect contains a random term and bias terms. The individual device Seismic Effects which are random are combined according to device seismic dependency groups.

For example, consider a loop which contains devices 1, 2, and 3 which each have random, bias positive, and bias negative terms. If device 1 is located in one seismic environment (e.g. Seismic Group "A") and devices 2 and 3 are located in another seismic environment (e.g. Seismic Group "B") then:

$$S_R = (s_{1R})^2 + (s_{2R} + s_{3R})^2$$

$$S_{BP} = (s_{1BP} + s_{2BP} + s_{3BP})$$

$$S_{BN} = (s_{1BN} + s_{2BN} + s_{3BN})$$

Combining the results of Instrument Seismic Effects calculated in Section 5.2.10 in accordance with the method described above;

$$S_R = \pm\ 0\ (PCT)^2$$

$$S_{BP} = 0\ PCT$$

$$S_{BN} = 0\ PCT$$

5.3.11. Loop Radiation Effect (R_N & R_{AN})

The Radiation Effect contains a random term and bias terms. The individual device Radiation Effects which are random are combined according to device radiation dependency groups.

For example, consider a loop which contains devices 1, 2, and 3 which each have random, bias positive, and bias negative terms. If device 1 is located in one radiation environment (e.g. Radiation Group "A") and devices 2 and 3 are located in another radiation environment (e.g. Radiation Group "B") then:

Normal:

$$R_{NR} = (r_{N1R})^2 + (r_{N2R} + r_{N3R})^2$$

$$R_{NBP} = (r_{N1BP} + r_{N2BP} + r_{N3BP})$$

$$R_{NBN} = (r_{N1BN} + r_{N2BN} + r_{N3BN})$$

Accident:

$$R_{ANR} = (r_{AN1R})^2 + (r_{AN2R} + r_{AN3R})^2$$

$$R_{ANBP} = (r_{AN1BP} + r_{AN2BP} + r_{AN3BP})$$

$$R_{ANBN} = (r_{AN1BN} + r_{AN2BN} + r_{AN3BN})$$

Combining the results of Instrument Radiation Effects calculated in Section 5.2.11 in accordance with the method described above;

$$R_{NR} = \pm\ 0\ (PCT)^2$$

$$R_{NBP} = 0\ PCT$$

$$R_{NBN} = 0\ PCT$$

$$R_{ANR} = \pm\ 0\ (PCT)^2$$

$$R_{ANBP} = 0\ PCT$$

$$R_{ANBN} = 0\ PCT$$

5.3.12. Loop Steam Pressure/Temperature Effect (SPT)

The Steam Pressure/Temperature Effect contains a random term and bias terms. Since the individual device Steam Pressure/Temperature Effects are considered independent, the random terms may be combined by the sum of the squares. The random and bias terms will be combined as follows:

$$SPT_R = (spt_{1R})^2 + (spt_{2R})^2 + ... + (spt_{nR})^2$$

$$SPT_{BP} = (spt_{1BP} + spt_{2BP} + ... + spt_{nBP})$$

$$SPT_{BN} = (spt_{1BN} + spt_{2BN} + ... + spt_{nBN})$$

Combining the results of Instrument Steam Pressure/Temperature Effects calculated in Section 5.2.12 in accordance with the method described above;

$SPT_R = \pm\ 0\ (PCT)^2$

$SPT_{BP} = 0\ PCT$

$SPT_{BN} = 0\ PCT$

5.3.13. Loop Post-DBE Effect (PDBE)

The Post-DBE Effect contains a random term and bias terms. Since the individual device Post-DBE Effects are considered independent, the random terms may be combined by the sum of the squares. The random and bias terms will be combined as follows:

$PDBE_R = (pdbe_{1R})^2 + (pdbe_{2R})^2 + ... + (pdbe_{nR})^2$

$PDBE_{BP} = (pdbe_{1BP} + pdbe_{2BP} + ... + pdbe_{nBP})$

$PDBE_{BN} = (pdbe_{1BN} + pdbe_{2BN} + ... + pdbe_{nBN})$

Combining the results of Instrument Post-DBE Effects calculated in Section 5.2.13 in accordance with the method described above;

$PDBE_R = \pm\ 0\ (PCT)^2$

$PDBE_{BP} = 0\ PCT$

$PDBE_{BN} = 0\ PCT$

5.3.14. Loop Readability Effect (READ)

The Readability Effect contains a random term only and is the square of the Readability term given on the MCDS table for the loop's indicator, if applicable. The Readability effect is is determined as follows:

$READ_R = (read_{nR})^2$

$READ_R = \pm 0\ (PCT)^2$

5.4. Calculation of Total Loop Error (TLE)

Total Loop Error (TLE) = The Square Root of the Sum of the Squares (SRSS) of the Random terms ± the Bias terms

or

TLE_{pos} = SRSS + Bias positive terms

and

TLE_{neg} = - SRSS - Bias negative terms

For normal conditions:

$$SRSSN = (A + D_R + M + OPE_R + SPEZ_R + SPES_R + P_R + T_{NR} + R_{NR} + H_{NR} + READ + PEA_{NR}{}^2 + PMA_{NR}{}^2 + PC_{NR}{}^2)^{1/2}$$

$$Bias_{pos} = D_{Bp} + OPE_{Bp} + SPEZ_{Bp} + SPES_{Bp} + P_{Bp} + T_{NBp} + R_{NBp} + H_{NBp} + PEA_{NBp} + PMA_{NBp} + PC_{NBp} + IR_{Bp}$$

$$Bias_{neg} = D_{Bn} + OPE_{Bn} + SPEZ_{Bn} + SPES_{Bn} + P_{Bn} + T_{NBn} + R_{NBn} + H_{NBn} + PEA_{NBn} + PMA_{NBn} + PC_{NBn} + IR_{Bn}$$

$SRSSN = \pm\ 1.4359\ (PCT)$

$Bias_{pos} = 0\ PCT$

$Bias_{neg} = 0\ PCT$

$TLEN_{pos} = SRSSN + Bias_{pos}$

$TLEN_{neg} = -SRSSN - Bias_{neg}$

$TLEN_{pos} = 1.4359\ PCT = 1.1965\ \%$ of Process Span

$TLEN_{neg}$ = -1.4359 PCT = -1.1965 % of Process Span

6.0 CONCLUSIONS

The results of this calculation show that the NIS Power Range indication uncertainty (rack indicator) is ±1.436% RTP.

7.0 REFERENCES

1. Northern States Power Company Prairie Island Nuclear Generating Plant Design Basis Document WCAP-13123, Rev. 0, 12/91.

2. Northern States Power Company Prairie Island Nuclear Generating Plant Updated Safety Analysis Report, Rev. 24.

3. Technical Specifications, Appendix A to Facility Operating License DPR-42 and Facility Operating
License DPR-60 for Prairie Island Nuclear Generating Plant Units 1 and 2, Northern States Power
Company Docket Nos. 50-282 and 50-306, Amendments 158 (Unit 1) and 149 (Unit 2).

4. Northern States Power Company Prairie Island Nuclear Generating Plant Design Basis Document for the Environmental Qualification of Electrical Equipment, DBD-TOP-03.

5. Northern States Power Technical Manual Number XH-1-1931, Rev. 2, Nuclear Instrumentation System.

6. Northern States Power Company, Prairie Island Nuclear Generating Plant, Design Basis Document for the Reactor Protection System, DBD-SYS-08, Revision 0.

7. General Arrangement, Operating Floor East, NF-39206, Rev. P.

8. General Arrangement, Control Room, NF-39750, Rev. W.

9. Setpoint Study for the Northern States Power Company Units No.1 and No. 2, WCAP-7721, August, 1971.

10. Seismic Testing of Electrical and Control Equipment, WCAP-7817, December, 1971.

11. Surveillance Procedure, NIS Power Range Channel Calibration, SP 1318.3, Rev. 9.

12. Surveillance Procedure, NIS Power Range Axial Offset Calibration Power Greater Than 50%, SP 1006B, Rev. 37.

13. Section Work Instruction, Test Instrument Calibration Control, I&C-TI-1, Rev. 14.

14. Functional Block Diagram, Nuclear Instrumentation System, Power Range N-41, X-HIAW-1001-170, Rev. 8.

15. Northern States Power Technical Manual Number XH-1-1838, Rev. 0, Power Range Ionization Chambers.

16. Surveillance Procedure, NIS Power Range Daily Calibration, SP 1005, Rev. 31.

17. Northern States Power Company, Prairie Island Nuclear Generating Plant Engineering Manual, Section 3.3.4.1, Engineering Design Standard for Instrument Setpoint/Uncertainty Calculations. Rev. 0.

8.0 ATTACHMENTS

None

Tab H

NORTHERN STATES POWER COMPANY

PRAIRIE ISLAND NUCLEAR GENERATING PLANT

CALCULATION COVER SHEET

Calculation Number: SPCRE006

Calculation Rev. No.: 0 Addenda No.:

Calculation Title: PINGP Calorimetric RCS Flow Uncertainty

Safety Related?: YES

Calculation Verification Method (Check One):

☒ Design Review ☐ Alternate Calculation ☐ Qualification Testing

Scope of Revision:

original issue

Documentation of Reviews and Approvals:

Originated By: Brian Rogers Brian K. Rogers Date: 2/13/03

Checked By: PE # 24391 Date: 2/14/03

Verified By: Printed Name: KEVIN HOLMSTROM Date: 2/14/03

Approved By: Date: 2/14/03

PINGP Calorimetric RCS Flow Uncertainty

Calculation SPCRE006
Rev. 0

1.0 Purpose

The purpose of this calculation is to determine the uncertainty associated with calculation of Calorimetric RCS Flow at PINGP.

Per PINGP Technical Specification SR 3.4.1.3, within 72 hours of reaching/exceeding 90% RTP, the plant is required to "Verify RCS total flow rate is within the limit specified in the COLR". This requirement is satisfied through performance of a secondary side power-based calorimetric flow verfication in SP 1169 and SP 2169, "Reactor Coolant System Flow Verfication". SP 1169 (or SP 2169) is perfomed at the beginning of each fuel cycle near full power operation.

Per SP 1169 Rev. 11, Calorimetric RCS flow is calculated as follows:

$$RCSFlow := \frac{Calorimetric_Power}{Cp \cdot \Delta T_{avg}}$$

Where Cp is the specific heat of water at 2250 psia and 560°F (nominal RCS 100% RTP conditions), and ΔT_{avg} is the core average expected ΔT at 100% RTP.

This calculation will use previously calculated uncertainties for calorimetric power indication and ΔT_{avg}, in conjunction with other uncertainties, to determine the total uncertainty associated with calculation of Calorimetric RCS Flow.

2.0 Methodology

This calculation is performed in accordance with the guidance provided in Reference 6.1, which is based on ISA Standard S67.04-1987, "Setpoints for Nuclear Safety-Related Instrumentation Used in Nuclear Power Plants".

As stated above, previously calculated values for Calorimetric Power uncertainty and ΔT uncertainty, in conjunction with other uncertainties, will be combined in accordance with the methods described in Reference 6.1 and the assumptions in section 3 of this calculation, to calculate Calorimetric RCS Flow uncertainty.

3.0 Assumptions/Design Inputs

3.1 PINGP calculation SPCNI017 Rev. 0 determined Unit 1 Calorimetric Power indication uncertainty to be ±1.6% RTP. PINGP calculation SPCNI018 Rev. 0 determined Unit 2 Calorimetric Power indication uncertainty to be ±1.62% RTP. This calculation will use the more conservative Unit 2 Calorimetric Power indication uncertainty value in calculating Calorimeteric RCS Flow uncertainty.

3.2 For the purposes of this calculation, Calorimetric Power indication uncertainty is assumed to be random, independent and normally distributed.

3.3 PINGP calculation SPCRP064 Rev. 0 determined that the uncertainty associated with the ΔT input to the OTΔT trip setpoint function is ±1.28°F. (PINGP calculation SPCRP068 Rev. 0 produced a similar result for the ΔT input to the OPΔT setpoint function.) The following ΔT loop instruments (typical for each channel) were included in computing this result:

1TE-405A	Hot leg RTD
1TE-401B	Cold Leg RTD
1TT-401A	Hot leg R/E module
1TT-401B	Cold leg R/E module
1TM-405R	Delta-T Lead/Lag unit
1TC-405C/D	Rod Stop/OTΔT trip bistable

Per SP 1169 (SP 2169) and SP 1722, "Unit 1 Loop Delta T Check" (SP 2722), the Delta-T Lead/Lag Unit output values for each RCS ΔT channel (two per RCS loop) are used to calculate a core average 100% ΔT value, and this core average 100% ΔT value is used in calculation of the Calorimetric RCS Flow. For this calculation, we will conservatively utilize the ΔT uncertainty calculated in SPCRP064 and SPCRP068, despite the fact that those calculations include uncertainty for a component (Rod Stop/OTΔT trip bistable) that is not part of the loop signal used in calculating Calorimetric RCS Flow.

Per the guidance in Ref. 1, because four RCS ΔT loops are used to calculate a single core average ΔT for use in calculating Calorimetric RCS Flow, we are permitted to reduce the uncertainty by dividing by the number of loops used to compute the average. However, for conservatism, in this calculation we will divide the single-loop ΔT uncertainty by two rather than four. Thus, the RCS ΔT uncertainty value for this calculation is ±1.28/2 = ±0.64°F.

3.4 For the purposes of this calculation, RCS ΔT uncertainty is assumed to be random, independent and normally distributed.

3.5 A 0.5 % RCS flow allowance for uncertainties in the computation of enthalpy and specific volume parameters in the calorimetric RCS flow equation is included as $U_{COMP_R\%F}$. This uncertainty is assumed to be random, independent and normally distributed.

3.6 A 0.5 % RCS flow allowance to account for uncertainties associated with RCS pressure variance during calorimetric RCS flow surveillance performance (i.e. during time alloted for SP 1172 and SP 1169) has been included as $U_{RCSP_R\%F}$. This uncertainty is assumed to be random, independent and normally distributed.

3.7 A 0.5 % RCS flow allowance to account for uncertainties associated with RCS temperature variance during calorimetric RCS flow surveillance performance (i.e. during time alloted for SP 1172 and SP 1169) has been included as $U_{RCST_R\%F}$. This uncertainty is assumed to be random, independent and normally distributed.

4.0 Analysis

Per Assumption 3.1, Calorimetric Power indication uncertainty is ±1.62% RTP:

$U_{CALM_R\%RTP} := 1.62$ %RTP

A study of the calorimetric RCS flow equation in SP 1169 (ignoring the 0.9845 "calorimetric correction" term, which is used to compensate for calorimetric power uncertainty) reveals that the RCS flow sensitivity to changes in calorimetric power is 1.12 %flow/%RTP. Thus, the calorimetric power uncertainty in terms of RCS flow is:

$U_{CALM_R\%F} := 1.12 \cdot U_{CALM_R\%RTP}$

$U_{CALM_R\%F} = 1.814$ % RCS flow

Per Assumption 3.3, core average ΔT uncertainty is ±0.64°F

$U_{\Delta T_R°F} := 0.64$ °F

A study of the calorimetric RCS flow equation in SP 1169 (again ignoring the 0.9845 "calorimetric correction" term) reveals that the maximum RCS flow sensitivity to changes in core average ΔT in the ΔT range of is 55-65°F is approximately 2.2%flow/°F. Thus, the core average ΔT uncertainty in terms of RCS flow is:

$U_{\Delta T_R\%F} := 2.2 U_{\Delta T_R°F}$

$U_{\Delta T_R\%F} = 1.408$ % RCS flow

Per Assumption 3.5, computational uncertainty is 0.5 %RCS flow:

$U_{COMP_R\%F} := 0.5$ % RCS flow

Per Assumption 3.6, the uncertainty due to RCS pressure test period variance is 0.5 % RCS flow:

$U_{RCSP_R\%F} := 0.5$ % RCS flow

Per Assumption 3.7, the uncertainty due to RCS temperature test period variance is 0.5 % RCS flow:

$U_{RCST_R\%F} := 0.5$ % RCS flow

Since these uncertainties are all random, independent and normally distributed, we can use SRSS to combine them (per Ref. 1):

$$U_{CRF_R\%} := \sqrt{U_{CALM_R\%F}^2 + U_{\Delta T_R\%F}^2 + U_{COMP_R\%F}^2 + U_{RCSP_R\%F}^2 + U_{RCST_R\%F}^2}$$

$U_{CRF_R\%} = 2.454$ % RCS flow

5.0 Conclusions

This calculation shows that the uncertainty associated with calculation of the Calorimetric RCS Flow (as performed in SP 1169/SP 2169) is ±2.454 % nominal RCS flow.

6.0 References

6.1 Northern States Power Company, Prairie Island Nuclear Generating Plant Engineering Manual, Section 3.3.4.1, "Engineering Design Standard for Instrument Setpoint/Uncertainty Calculations", Rev. 0.

6.2 Northern States Power Company Prairie Island Nuclear Generating Plant Design Basis Document for the Environmental Qualification of Electrical Equipment, DBD-TOP-03.

6.3 Northern States Power Company Prairie Island Nuclear Generating Plant Operations Procedure 1C1.2, "Unit 1 Startup Procedure", Rev. 29.

6.4 Northern States Power Company Prairie Island Nuclear Generating Plant Updated Safety Analysis Report, Rev. 24.

6.5 Technical Specifications, Appendix A to Facility Operating License DPR-42 and Facility Operating License DPR-60 for Prairie Island Nuclear Generating Plant Units 1 and 2, Northern States Power Company Docket Nos. 50-282 and 50-306, Amendments 158 (Unit 1) and 149 (Unit 2).

6.6 Flow Diagram, Unit 1, Reactor Coolant System, X-HIAW-1-7, Rev. AH.

6.7 Instrument Block Diagram, NSP & NRP, Prairie Island Nuclear Power Plant Unit No. 1 Reactor Protection & Control System, X-HIAW-1-543, Rev. E.

6.8 PINGP SP 1169, "Reactor Coolant System Flow Verification", Rev. 11.

6.9 PINGP SP 2169, "Reactor Coolant System Flow Verification", Rev. 12.

6.10 PINGP SP 1722, "Unit 1 Loop Delta T Check", Rev. 16.

6.11 PINGP SP 2722, "Unit 2 Loop Delta T Check", Rev. 16.

6.12 Westinghouse Electric Corporation, "Channel Accuracies, Overall Channel Accuracies and Setpoint Tolerances for W NES Process I&C Reactor Protection and Control Systems, Prairie Island Nuclear Power Plants Unit Nos 1 & 2", May 1973.

6.13 Westinghouse WCAP-14788, "Westinghouse Revised Thermal Design Procedure Instrument Uncertainty methodology for Wisconsin Electric Power Company Point Beach Units 1 & 2 (Fuel Upgrade & Uprate to 1656 Mwt - NSSS Power)", April 1999.

6.14 PINGP calculation SPCRP064, "Delta T signal error contribution to OTDT trip", Rev. 0.

6.15 PINGP calculation SPCRP068, "Delta T signal error contribution to OPDT trip", Rev. 0.

6.16 PINGP calculation SPCNI017, "Unit 1 Calorimetric Uncertainty", Rev. 0.

6.17 PINGP calculation SPCNI018, "Unit 2 Calorimetric Uncertainty", Rev. 0.