Tab A

EXHIBIT D

Instrument Uncertainties for Plant Operating Parameter Inputs to the Westinghouse Revised Thermal Design Procedure

Prairie Island Nuclear Generating Plant, Units 1 & 2

Prepared by / Date:

Brian K. Rogers 2/15/03

Brian K. Rogers

Reviewed by / Date:

2/17/2003

Thomas M. VerBout

Table of Contents

Tab B

Prairie Island Nuclear Generating Plant, Units 1 & 2

Instrument Uncertainties for Plant Operating Parameter Inputs to the Westinghouse Revised Thermal Design Procedure

Introduction

The Nuclear Management Company is in the process of transitioning from internally-generated safety analyses (performed by NMC's Nuclear Analysis Department) to Westinghouse-generated safety analyses. As part of this transition, NMC is making changes in plant operations, including implementation of Relaxed Axial Offset Control (RAOC) of the reactor cores (which replaces Constant Axial Offset Control - CAOC). In making these changes, new safety analyses are required, and Westinghouse will be performing these analyses using their Revised Thermal Design Procedure (RTDP) methodology.

As stated in Westinghouse WCAP-14788, four operating parameter uncertainties are used in the uncertainty analysis of the RTDP. These four operating parameters are:

- Reactor Power
- Reactor Coolant System Flow
- Pressurizer Pressure
- Reactor Coolant System T_{avg}

Reactor power is continuously monitored, and Nuclear Instrumentation System (NIS) Power Range reactor power indication is verified against the plant's computer-based Thermal Power Monitor (TPM; also known as calorimetric reactor power indication) every 24 hours. Uncertainties for the TPM computer calculation, as well as the NIS reactor power indication, are documented in this report.

Reactor coolant system (RCS) flow is monitored by performing a calorimetric RCS flow calculation at the start of each fuel cycle, and the calculation included in this report reflects the uncertainties involved in performing this calculation.

Pressurizer Pressure is a controlled plant parameter, and the uncertainties associated with the pressure control system are documented in this report.

RCS T_{avg} is a controlled plant parameter through the plant's rod control system, and the uncertainty calculation included in this report reflects the uncertainties associated with the T_{avg} input to the rod control system.

Use of the RTDP methodology requires that plant-specific "variances and distributions" for the input parameters be justified. The purpose of the calculations included in this report is to characterize and justify the uncertainties associated with the four primary

RTDP plant operating parameters for Prairie Island Nuclear Generating Plant Units 1 and 2.

The uncertainty calculations included in this report are performed using the NRC approved PINGP Setpoint Methodology documented in PINGP Site Engineering Manual section 3.3.4.1, "Engineering Design Standard for Instrument Setpoint/Uncertainty Calculations". This methodology is based on ISA Standard S67.04-1987, "Setpoints for Nuclear Safety-Related Instrumentation Used in Nuclear Power Plants", and meets the guidance provided in ISA Standard S67.04-1994. Additional information on the Setpoint Methodology is contained in the body of each uncertainty calculation.

Results

The results of the calculations contained in this report are summarized in the table below:

Plant Parameter	Calculated Uncertainty [calculation number]	Uncertainty Used In RTDP Safety Analysis
Pressurizer Pressure	±37.2 psig [SPCRE003]	*
RCS T_{avg}	±3.2 °F (random) -0.5 °F (bias) [SPCRE004]	*
Reactor Power Calorimetric	±1.62 %RTP (random) [SPCNI017] [SPCNI018] (SPCNI018 value is bounding)	*
NIS Indication	±1.44 %RTP (random) [SPCRE005]	*
Calorimetric RCS Flow	±2.5 % nom. flow (random) [SPCRE006]	*

* - bounding uncertainty values for analyses to be determined by Westinghouse

Tab C

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

Calculation Number: SPCRE003

Calculation Rev. No.: 0

Calculation Title: Pressurizer Pressure Control Uncertainty

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

TABLE OF CONTENTS

SECTION PAGE

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 automatic control systems' ability to maintain desired pressurizer pressure during normal, steady state full-power plant operating conditions. The result of this calculation will be used as a design input for Westinghouse-based safety analyses.

Because of the similarities between various channels of pressurizer pressure instrumentation, this calculation is performed for the Unit 1 pressurizer pressure control loop (1P-431), and the result is considered applicable to either Unit's pressurizer pressure control loop.

Pressure Control Loop

1P-431
2P-431

1.2. Results

PRESSURIZER PRESSURE CONTROL PRD

The total Loop Error (TLE) for this instrument string is +4.6465 -4.6465 percent of span.

The results of this calculation show that the uncertainty associated with the plant's automatic control systems' ability to maintain desired pressurizer pressure during normal, steady state full-power plant operating conditions is ±37.172 psig.

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. The normal operating upper and lower limits of pressurizer pressure are both shown as 2235 psig (i.e., same as normal operating pressure) based on section 5.7.13 of Reference 4 which defines "RCS heatup complete" as when RCS (pressurizer) pressure is 2235 psig.

2. Control Room temperature limits are per section 10.3.3.1 of Reference 5.

3. Control Room humidity and radiation values are per section 2.11 of Appendix A to Reference 2.

4. This calculation was performed to determine the uncertainty associated with the plant's automatic control systems' ability to maintain desired pressurizer pressure during normal, steady-state, full-power plant operating conditions. Therefore, accident operating times are not applicable, and for the purposes of this calculation the minimum and maximum accident operating time are both set to zero.

5. The pressurizer pressure transmitters are referenced to containment atmosphere; any containment pressure variation similarily affects pressurizer pressure measurement. Per Technical Specification LCO 3.6.4, "Containment pressure shall be $\leq$ 2.0 psig". For the purposes of this calculation, it is assumed that containment pressure is also maintained at $\geq$ -2.0 psig, and that containment pressure variation is random with respect to pressurizer pressure. Therefore, the effect of variable containment pressure on the reference side of the transmitter is included in this calculation as a random Primary Element Accuracy term of ±2.0 psig (or ±0.25% of span).

6. Ref. 7 provides no vendor accuracy value for Foxboro model 62H controllers. Per Refs. 7 and 28, when pressurizer pressure controller 1PC-431K is found outside deviation meter desired value criteria, various controller subcomponents are calibrated as necessary (per Foxboro instruction 18-536) using a tolerance of ±0.04mA (±0.1% of span for a 10-50 mA device). Because more than one subcomponent might be adjusted each time the device needs to be calibrated, and based on typical Foxboro 60-series component performance specifications, the accuracy for the Foxboro 62HB-5E-0H controller (1PC-431K) is conservatively assumed to be ±1.0% of calibrated span.

4.0 DESIGN INPUT

4.1. Form 1: Loop/Process Data Sheet

Loop ID	1P-431
Configuration No.	1
Loop Description	Pressurizer Pressure Control
Process Span (PS)	1700.0 To 2500.0 PSIG
Analytical/ Process Limit (AL/PL)	2500.0 PSIG
Normal Operation Upper Limit (NOUL)	2235.0 PSIG
Normal Operation Lower Limit (NOLL)	2235.0 PSIG
Process Max Op Pressure (PMOP)	2485.0 PSIG
Process Normal Op Pressure (PNOP)	2235.0 PSIG
Operating Time (Accident)	Min: 0 Hours Max: 0 Hours
Setpoint Direction	I

4.2. Form 2: Instrument Data Sheet

	1
Instrument Tag No.	1PT-429
Function	
Other Tag No.	21146
System	RP
Functional Description	REACTOR COOLANT LOOP PRESSURIZER PRESSURE TRANSMITTER
Rack/Panel No.	
Power Supply Tag No.	1PQ-429
EQ Zone	CNTA1
Elevation	720.00 ft in
Column	11
Row	16
Manuf. Name	ROSEMOUNT
Model Number	1154GP9RC
EQ	Yes
Seismic Category	YES
QA Elec.	X11FM
QA Mech.	2X2PM
Input Span (CS)	1700.0 To 2500.0 PSIG
Output Span (OS)	0.10000 To 0.50000 VDC
Readability (read)	
Surveillance/Calib. Procedure	SP 1002B
Calibration Interval (CI)	24.000 Months
Device Setting Tol. Allowance (st)	0.002
Device M&TE Allowance mte1 : Device M&TE Cal Span mtecs1:	6.0008 PSIG 0 To 3000.0 PSIG
Device M&TE Allowance mte2 : Device M&TE Cal Span mtecs2:	2.8511e-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

	1
Instrument Tag No.	1PM-429A
Function	
Other Tag No.	
System	RP
Functional Description	PRESSURIZER PRESS TO CONTROL ISOL I/I REPEATER
Rack/Panel No.	1R1
Power Supply Tag No.	1PQ-429
EQ Zone	CNLRM
Elevation	735.00 ft 0 in
Column	H.8
Row	8.0
Manuf. Name	FOXBORO
Model Number	66BC-0
EQ	No
Seismic Category	YES
QA Elec.	X11FT
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	SP 1002A
Calibration Interval (CI)	24.000 Months
Device Setting Tol. Allowance (st)	0.002
Device M&TE Allowance mte1 : Device M&TE Cal Span mtecs1:	2.8511e-03 VDC 0 To 3.0000 VDC
Device M&TE Allowance mte2 : Device M&TE Cal Span mtecs2:	2.8511e-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

	1
Instrument Tag No.	1PC-431K
Function	
Other Tag No.	
System	RE
Functional Description	PRESSURIZER PRESSURE CONTROL PRD
Rack/Panel No.	1PLP
Power Supply Tag No.	1PQ-429
EQ Zone	CNLRM
Elevation	735.00 ft 0 in
Column	H.0
Row	7.7
Manuf. Name	FOXBORO
Model Number	62HB-5E-OH CONTROLLER
EQ	No
Seismic Category	NO
QA Elec.	
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	SP 1548
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:	1.0448e-03 VDC 0 To 2.0000 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

4.2.1. Form 3: Make/Model Data Sheet

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}{4500<X,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<=5000000,1%*R}{5000000<X<=55000000,1.5%*R+1.0%*S}
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-0
Range	Min:10.000 Units:MADC Max:50.000
Design Pressure	PSIG
Vendor Accuracy Allowance (va)	0.5%*S
Vendor Drift Allowance (vd)	0.25%*S
Drift Time (DT)	24.000 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	FOXBORO
Model Number	62HB-5E-OH CONTROLLER
Range	Min:0.10000 Units:VDC Max:0.50000
Design Pressure	PSIG
Vendor Accuracy Allowance (va)	1.0%*S
Vendor Drift Allowance (vd)	
Drift Time (DT)	12.000 Months Linear or Non-Linear? L Vendor or Plant-Specific? V
Vendor Temp Effect (vte)	
Vendor Humidity Effect (vhe)	
Vendor Over Pressure Effect (vope)	
Vendor Static Pressure Effect Zero (vspez)	
Vendor Static Pressure Effect Span (vspes)	
Vendor Power Supply Effect (vp)	
Vendor Seismic Effect (vse)	
Vendor Radiation Effect (vre)	
Vendor Steam Press/Temp. Effect (vspt)	
Vendor Post-DBE Effect(vpdbe)	

4.3. 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	1PT-429	
2	1	1PM-429A	
3	1	1PC-431K	

5.1.2. Device Dependency Table

Unit	Instrument	Func	Cal	Pwr	Rad	Seismic	Temp	Humidity
1	1PT-429		A	A	A	A	A	A
1	1PM-429A		B	A	B	B	B	B
1	1PC-431K		C	A	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	1PT-429		0	0
1	1PM-429A		0	0
1	1PC-431K		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
PEA	2.5e-03	R	N			A 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	±4.0000	PSIG
2	±4.0000	PSIG
3	±8.0000	PSIG

* = 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	±4.8000	0	0	PSIG
2	±2.0000	0	0	PSIG
3	±0	0	0	PSIG

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	±8.2780	PSIG
2	±8.0641	PSIG
3	±2.9551	PSIG

* = 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	±14.575	0	0	PSIG
2	±0	0	0	PSIG
3	±0	0	0	PSIG

* = Uncertainty included with plant specific drift for this device

Accident Instrument Temperature Effect (t_A)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PSIG
2	±0	0	0	PSIG
3	±0	0	0	PSIG

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

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PSIG
2	±0	0	0	PSIG
3	±0	0	0	PSIG

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	PSIG
2	±0	0	0	PSIG
3	±0	0	0	PSIG

* = Uncertainty included with plant specific drift for this device

Accident Instrument Humidity Effect (h_A)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PSIG
2	±0	0	0	PSIG
3	±0	0	0	PSIG

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

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PSIG
2	±0	0	0	PSIG
3	±0	0	0	PSIG

5.2.5.1. 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	PSIG
2	±0	0	0	PSIG
3	±0	0	0	PSIG

5.2.6. 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	PSIG
2	±0	0	0	PSIG

3	±0	0	0	PSIG

5.2.7. 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	PSIG
2	±0	0	0	PSIG
3	±0	0	0	PSIG

5.2.8. 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	PSIG
2	±0	0	0	PSIG

3	±0	0	0	PSIG

5.2.9. 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	PSIG
2	±0	0	0	PSIG
3	±0	0	0	PSIG

5.2.10. 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	±30.000	0	0	PSIG
2	±0	0	0	PSIG
3	±0	0	0	PSIG

* = Uncertainty included with plant specific drift for this device

Accident Instrument Radiation Effect (r_A)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	PSIG
2	±0	0	0	PSIG
3	±0	0	0	PSIG

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

Device	Random	+Bias	-Bias	Units
1	±30.000	0	0	PSIG
2	±0	0	0	PSIG
3	±0	0	0	PSIG

5.2.11. 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	PSIG
2	±0	0	0	PSIG
3	±0	0	0	PSIG

5.2.12. 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	PSIG
2	±0	0	0	PSIG
3	±0	0	0	PSIG

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;

$A = \pm \ 96.000 \ (PSIG)^2$

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;

$D_R = \pm \ 27.040 \ (PSIG)^2$

$D_{BP} = 0 \ PSIG$

$D_{BN} = 0 \ PSIG$

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;

$$M = \pm\ 142.29\ (PSIG)^2$$

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;

$T_{NR} = \pm\ 212.43\ (PSIG)^2$

$T_{NBP} = 0\ PSIG$

$T_{NBN} = 0\ PSIG$

$T_{AR} = \pm\ 212.43\ (PSIG)^2$

$T_{ABP} = 0\ PSIG$

$T_{ABN} = 0\ PSIG$

$T_{NSR} = \pm\ 212.43\ (PSIG)^2$

$T_{NSBP} = 0\ PSIG$

T_{NSBN} = 0 PSIG

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;

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

$H_{NBP} = 0 \ PSIG$

$H_{NBN} = 0 \ PSIG$

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

$H_{ABP} = 0 \ PSIG$

$H_{ABN} = 0 \ PSIG$

$H_{NSR} = \pm 0 \ (PSIG)^2$

$H_{NSBP} = 0 \ PSIG$

$H_{NSBN} = 0 \ PSIG$

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;

$OPE_R = \pm 0 \ (PSIG)^2$

OPE_{BP} = 0 PSIG

OPE_{BN} = 0 PSIG

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;

$SPEZ_R$ = ± 0 $(PSIG)^2$

$SPEZ_{BP}$ = 0 PSIG

$SPEZ_{BN}$ = 0 PSIG

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;

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

$SPES_{BP} = 0\ PSIG$

$SPES_{BN} = 0\ PSIG$

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;

$P_R = \pm\ 0\ (PSIG)^2$

$P_{BP} = 0\ PSIG$

$P_{BN} = 0\ PSIG$

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;

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

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

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

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} = ± 900.00 $(PSIG)^2$

R_{NBP} = 0 PSIG

R_{NBN} = 0 PSIG

R_{ANR} = ± 900.00 $(PSIG)^2$

R_{ANBP} = 0 PSIG

R_{ANBN} = 0 PSIG

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;

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

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

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

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;

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

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

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

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:

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

$$READ_R = \pm 0 \text{ (PSIG)}^2$$

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:

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

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

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

$$SRSSN = \pm\ 37.172 \text{ (PSIG)}$$

$$Bias_{pos} = 0 \text{ PSIG}$$

$Bias_{neg}$ = 0 PSIG

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

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

$TLEN_{pos}$ = 37.172 PSIG = 4.6465 % of Process Span

$TLEN_{neg}$ = -37.172 PSIG = -4.6465 % of Process Span

6.0 CONCLUSIONS

The results of this calculation show that the uncertainty associated with the plant's automatic control systems' ability to maintain desired pressurizer pressure during normal, steady state full-power plant operating conditions is ±37.172 psig.

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 Design Basis Document for the Environmental Qualification of Electrical Equipment, DBD-TOP-03.

3. Northern States Power Company Prairie Island Nuclear Generating Plant E.Q. Users Manual Appendix A, EQ Masterlist, H8-A, Rev. 11.

4. Northern States Power Company Prairie Island Nuclear Generating Plant Operations Procedure 1C1.2, "Unit 1 Startup Procedure", Rev. 29.

5. Northern States Power Company Prairie Island Nuclear Generating Plant Updated Safety Analysis Report, Rev. 24.

6. 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).

7. Northern States Power Technical Manual Number X-HIAW 1-1398 -1, Rev. 19, Foxboro Service & Maint Instr, Part B.

8. Northern States Power Technical Manual Number X-HIAW 1-1406, Rev. 10, Foxboro Instrument Documentation Sheets, Vol. I.

9. Northern States Power Company Technical Manual Number NX-20728-1, Rev. 29, Rosemount Composite Manual.

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

11. External Wiring Diagram - Process Protection System Instruments Racks 1R1, 1R2, 1Y1, 1Y2, and 1B1, NF-40294-1, Rev. K.

12. Pressurizer Outline Drawing, X-HIAW 1-10, Rev. 7.

13. Instrument Installation Detail, NL-39776-541(1), Sheet 1 of 2, Rev. R.

14. Westinghouse Electric Corporation Differential Pressure Instruments Specification Sheet No. 4.40, Revised 11-5-70, for Prairie Island Nuclear Generating Plant, Unit No. 1 - Reactor Coolant Sys., Pressurizer Pressure.

15. Westinghouse Electric Corporation Receiver Instruments Specification Sheet No. 4.38, Dated 5-9-69, for Prairie Island Nuclear Generating Plant, Unit No. 1, Reactor Coolant System.

16. Flow Diagram, Unit 1, Reactor Coolant System, X-HIAW-1-7, Rev. AH.

17. Instrument Block Diagram, NSP & NRP, Prairie Island Nuclear Power Plant Unit No. 1 Reactor Protection & Control System, X-HIAW-1-541, Rev. D.

18. Interconnection Wiring Diagram - Rack 1R1/2R1, NSP - NRP, Nuclear Power Plant Unit No. 1 Reactor Protection System X-HIAW-1-561, Rev. C.

19. General Arrangement, Operating Floor East, NF-39206, Rev. P.

20. General Arrangement, Control Room, NF-39750, Rev. W.

21. Rack No. 1R1 Layout, Reactor Protection System, NSP Nuclear Power Plant Unit No. 1, X-HIAW 1-485, Rev. A.

22. Setpoint Study for the Northern States Power Company Units No.1 and No. 2, WCAP-7721, August, 1971.

23. Analog Protection System Calibration, SP 1002A, Rev. 30.

24. Reactor Protection and Control Transmitters, Calibration/Inspection, SP 1002B, Rev. 27.

25. TENERA Calculation 1908-2.2-012, Rev. 0, 12/4/89 for Northern States Power Company, Prairie Island, Pressurizer Pressure.

26. 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.

27. 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.

28. Prairie Island Nuclear Generating Plant Surveillance Procedure SP 1548, Rev. 13.

8.0 ATTACHMENTS

None

Tab D

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

Calculation Number: SPCRE004

Calculation Rev. No.: 0

Calculation Title: RCS T-avg Control Uncertainty

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

TABLE OF CONTENTS

SECTION PAGE

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 automatic control systems' ability to maintain desired RCS T-avg during normal, steady state full-power plant operating conditions. The result of this calculation will be used as a design input for Westinghouse-based safety analyses.

Because of the similarities between the reactor control instrumentation for Prairie Island's two Units, this calculation is performed for the Unit 1 Red Channel RCS T-avg control instruments, up to but not including the Auctioneered High T-avg selector module (1TM-401D). This calculation also includes terms to account for turbine impulse pressure uncertainty and rod control system deadband.

1.2. Results

TAVG TO HI TAVG SELECTOR ISOLATION I/I/ REPEATER

The total Loop Error (TLE) for this instrument string is +3.1897 -3.6897 percent of span.

The results of this calculation show that the RCS T-avg control random uncertainty is ±3.1897°F with additional bias uncertainty of -0.5°F.

Total uncertainty is:
+3.1897°F
-3.6897°F

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 to determine the uncertainty associated with the plant's automatic control systems' ability to maintain desired RCS T-avg during normal, steady-state, full-power plant operating conditions. Therefore, accident environments and accident operating times are not applicable, and for the purposes of this calculation the minimum and maximum accident operating time are both set to zero.

2. The temperature instruments referenced in this calculation are part of the the Unit 1 Red Channel Tavg shown on drawing XH 1-543. Because of the similarities between the various temperature instrument channels on each Unit, the results of this calculation are applicable to both Units.

3. I&C calibration records and a system walkdown show that spare RTD 1TE-405A is currently being used in place of 1TE-401A. The make and model number of the spare RTD placed in service is the same make and model number as the RTD that had been replaced. In addition, calibration records for 1TT-401A show that this device was recalibrated to the 1TE-405A performance curve. Therefore, it is assumed that no additional error is introduced due to exchanging RTDs.

4. The actual calibrated span of 1TE-405A is 31.96 deg F to 649.23 deg F and the actual calibrated span of 1TE-401B is 31.96 deg F to 649.35 deg F. However, the process span for the Tavg loop is only 520 to 620 deg F. Therefore, the calibrated span used for the TE's in the Tavg loop is taken from the calibration data for 1TT-401A and 1TT-401B which are calibrated for 520 to 620 deg F.

5. The hot and cold leg RTDs are mounted in manifolds located in a bypass line. It is assumed that the process temperature at the manifolds is highly representative of the process fluid in the reactor coolant piping, but a (-0.5)°F error is assumed for any temperature differences between the RCS and the RTD bypass loops. This error is included as a bias-negative Process Measurement Accuracy (PMA) term.

6. Per drawing XH-1-543, the signals from the Thot and Tcold Temperature Transmitters are averaged and subtracted by a resistor network to produce two current signals, one proportional to Tavg and the other proportional to ΔT. The Thot and Tcold sections of the loop are identical, each consisting of an RTD and a Temperature Transmitter. Per PINGP's Setpoint Methodology, because these two input channels are averaged to produce the Tavg signal, their resulting uncertainties can be averaged. In this calculation, averaging of the Thot and Tcold

input channel uncertainties is accomplished by including only one RTD and one Temperature Transmitter in the instrument loop

7. Per RDF Corporation, "The actual resistance at a specified temperature must be known to within +/- 0.2 F." This value is, therefore, used as the accuracy value for the RTDs.

8. It is assumed that the vendor data for instrument 1TT-401A (408.39 to 448.79 ohms) also applies to 1TT-401B (408.41 to 448.76 ohms) since there are no errors for either instrument given in terms of the instrument's range. Both devices are Foxboro model 66 R/V Converter Y3000AA.

9. It is assumed that any power supply fluctuations do not cause the instruments' accuracy to exceed the published or assumed values.

10. This calculation applies to all four Unit 1 and all four Unit 2 instrumentation loops that provide signals to the Auctioneered High T-avg selector module in each Unit's reactor control scheme.

11. Calculation SPCRE001 Rev. 0 determined that the total uncertainty associated with the turbine impulse pressure permissive P-2 bistable setpoint is 1.34% of turbine impulse pressure loop span (0-533.psig, equating to 0-100% RTP), and that all of this uncertainty is random. Based on this result, it is conservatively assumed that the total uncertainty associated with the turbine impulse pressure input signal to the rod control system does not exceed 2.5% of pressure loop span. For additional conservatism, this uncertainty is applied directly to the T-avg loop span as ±2.5°F, without scaling relative to 100% RTP (for Tavg loops, 0-100°F equates to 0-150%RTP).

This turbine impulse pressure uncertainty is included in this calculation as an "Other PC" term of ±2.5°F (±2.5% loop span). (See Assumption 13 for additional information.)

12. A ±1.5°F random "Other PC" term has been included to account for rod control system deadband. (See Assumption 13 for additional information.)

13. IISCS assumes that multiple random "Other PC" terms in the same calculation are dependent, and combines these random "Other PC" terms algebraically before including them in the SRSS combination of random, independent uncertainties. To ensure that IISCS handles the two random independent "Other PC" terms (see Assumptions 11 and 12) in this calculation correctly, we need to combine them here using SRSS before including them in IISCS as an "Other PC" term.

PC $= (1.5^2 + 2.5^2)^{1/2}$
$= 2.9155°F$ (or 0.029155 decimal percent of loop span)

4.0 DESIGN INPUT

4.1. Form 1: Loop/Process Data Sheet

Loop ID	1T-401
Configuration No.	2
Loop Description	Tavg - Delta T Red Channel
Process Span (PS)	520.00 To 620.00 DEG F
Analytical/ Process Limit (AL/PL)	0 DEG F
Normal Operation Upper Limit (NOUL)	560.00 DEG F
Normal Operation Lower Limit (NOLL)	547.00 DEG F
Process Max Op Pressure (PMOP)	2485.0 PSIG
Process Normal Op Pressure (PNOP)	2235.0 PSIG
Operating Time (Accident)	Min: 0 Hours Max: 0 Hours
Setpoint Direction	D

4.2. Form 2: Instrument Data Sheet

	1
Instrument Tag No.	1TE-405A
Function	
Other Tag No.	15197
System	RP
Functional Description	RC LOOP B HOT LEG RTD CHANNEL I RED
Rack/Panel No.	
Power Supply Tag No.	
EQ Zone	CNTA1
Elevation	725.00 ft 6.0000 in
Column	34
Row	339
Manuf. Name	RDF
Model Number	21450
EQ	No
Seismic Category	YES
QA Elec.	X11FM
QA Mech.	1X2PM
Input Span (CS)	520.00 To 620.00 DEG F
Output Span (OS)	408.39 To 448.79 OHMS
Readability (read)	
Surveillance/Calib. Procedure	
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.	1TT-401A
Function	
Other Tag No.	
System	RP
Functional Description	RC LOOP B HOT LEG CHAN I RED TEMPERATURE TRANS
Rack/Panel No.	1R1
Power Supply Tag No.	
EQ Zone	CNLRM
Elevation	735.00 ft 0 in
Column	
Row	
Manuf. Name	FOXBORO
Model Number	66 R/V CONVERTER Y3000AA C-011
EQ	No
Seismic Category	YES
QA Elec.	X11FM
QA Mech.	
Input Span (CS)	408.39 To 448.79 OHMS
Output Span (OS)	2.0000 To 10.000 VDC
Readability (read)	
Surveillance/Calib. Procedure	SP1002A
Calibration Interval (CI)	24.000 Months
Device Setting Tol. Allowance (st)	0.04
Device M&TE Allowance mte1 : Device M&TE Cal Span mtecs1:	0.19000 OHMS 0 To 500.00 OHMS
Device M&TE Allowance mte2 : Device M&TE Cal Span mtecs2:	0.01000 VDC 0 To 30.000 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.	1TM-401BB
Function	
Other Tag No.	
System	RP
Functional Description	RC LOOP B T-AVG CHAN I RED LEAD/LAG E/I UNIT
Rack/Panel No.	1R1
Power Supply Tag No.	
EQ Zone	CNLRM
Elevation	735.00 ft 0 in
Column	
Row	
Manuf. Name	FOXBORO
Model Number	66RC-OLA SPECIAL E/I LAG UNIT D-009
EQ	No
Seismic Category	YES
QA Elec.	X11FM
QA Mech.	
Input Span (CS)	2.0000 To 10.000 VDC
Output Span (OS)	10.000 To 50.000 MADC
Readability (read)	
Surveillance/Calib. Procedure	SP1002A
Calibration Interval (CI)	24.000 Months
Device Setting Tol. Allowance (st)	0.20
Device M&TE Allowance mte1 : Device M&TE Cal Span mtecs1:	0.01000 VDC 0 To 30.000 VDC
Device M&TE Allowance mte2 : Device M&TE Cal Span mtecs2:	0.07000 MADC 0 To 100.00 MADC
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.	1TM-401C
Function	
Other Tag No.	
System	RP
Functional Description	TAVG TO CONTROL SYS ISOLATION I/I REPEATER
Rack/Panel No.	1R1
Power Supply Tag No.	
EQ Zone	CNLRM
Elevation	735.00 ft 0 in
Column	H.8
Row	8.0
Manuf. Name	FOXBORO
Model Number	66BC-0
EQ	No
Seismic Category	YES
QA Elec.	X11FT
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	SP 1002A
Calibration Interval (CI)	24.000 Months
Device Setting Tol. Allowance (st)	0.002
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:	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.	1TM-401EE
Function	
Other Tag No.	
System	RE
Functional Description	TAVG TO HI TAVG SELECTOR ISOLATION I/I/ REPEATER
Rack/Panel No.	1SD
Power Supply Tag No.	
EQ Zone	CNLRM
Elevation	735.00 ft 0 in
Column	H.3
Row	7.6
Manuf. Name	FOXBORO
Model Number	66BC-OH
EQ	No
Seismic Category	NO
QA Elec.	
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	SP 1548
Calibration Interval (CI)	24.000 Months
Device Setting Tol. Allowance (st)	0.002
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:	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

4.3. Form 3: Make/Model Data Sheet

Manuf. Name	RDF
Model Number	21450
Range	Min:32.000 Units:DEG F Max:650.00
Design Pressure	PSIG
Vendor Accuracy Allowance (va)	0.2
Vendor Drift Allowance (vd)	0
Drift Time (DT)	12.000 Months Linear or Non-Linear? L Vendor or Plant-Specific? V
Vendor Temp Effect (vte)	
Vendor Humidity Effect (vhe)	
Vendor Over Pressure Effect (vope)	
Vendor Static Pressure Effect Zero (vspez)	
Vendor Static Pressure Effect Span (vspes)	
Vendor Power Supply Effect (vp)	
Vendor Seismic Effect (vse)	
Vendor Radiation Effect (vre)	
Vendor Steam Press/Temp. Effect (vspt)	
Vendor Post-DBE Effect(vpdbe)	

Manuf. Name	FOXBORO
Model Number	66 R/V CONVERTER Y3000AA (C-011)
Range	Min:408.39 Units:OHMS Max:448.79
Design Pressure	PSIG
Vendor Accuracy Allowance (va)	0.2%*S
Vendor Drift Allowance (vd)	
Drift Time (DT)	12.000 Months Linear or Non-Linear? L Vendor or Plant-Specific? V
Vendor Temp Effect (vte)	
Vendor Humidity Effect (vhe)	
Vendor Over Pressure Effect (vope)	
Vendor Static Pressure Effect Zero (vspez)	
Vendor Static Pressure Effect Span (vspes)	
Vendor Power Supply Effect (vp)	
Vendor Seismic Effect (vse)	
Vendor Radiation Effect (vre)	
Vendor Steam Press/Temp. Effect (vspt)	
Vendor Post-DBE Effect(vpdbe)	

Manuf. Name	FOXBORO
Model Number	66RC-OLA SPECIAL E/I LAG UNIT (D-009)
Range	Min:2.0000 Units:VDC Max:10.000
Design Pressure	PSIG
Vendor Accuracy Allowance (va)	0.5%*S
Vendor Drift Allowance (vd)	
Drift Time (DT)	12.000 Months Linear or Non-Linear? L Vendor or Plant-Specific? V
Vendor Temp Effect (vte)	
Vendor Humidity Effect (vhe)	
Vendor Over Pressure Effect (vope)	
Vendor Static Pressure Effect Zero (vspez)	
Vendor Static Pressure Effect Span (vspes)	
Vendor Power Supply Effect (vp)	
Vendor Seismic Effect (vse)	
Vendor Radiation Effect (vre)	
Vendor Steam Press/Temp. Effect (vspt)	
Vendor Post-DBE Effect(vpdbe)	

Manuf. Name	FOXBORO
Model Number	66BC-0
Range	Min:10.000 Units:MADC Max:50.000
Design Pressure	PSIG
Vendor Accuracy Allowance (va)	0.5%*S
Vendor Drift Allowance (vd)	0.25%*S
Drift Time (DT)	24.000 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	FOXBORO
Model Number	66BC-OH
Range	Min:10.000 Units:MADC Max:50.000
Design Pressure	PSIG
Vendor Accuracy Allowance (va)	0.5%*S
Vendor Drift Allowance (vd)	0.125%*S
Drift Time (DT)	24.000 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

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	1TE-405A	
2	1	1TT-401A	
3	1	1TM-401BB	
4	1	1TM-401C	
5	1	1TM-401EE	

5.1.2. Device Dependency Table

Unit	Instrument	Func	Cal	Pwr	Rad	Seismic	Temp	Humidity
1	1TE-405A		A	A	A	A	A	A
1	1TT-401A		B	B	B	B	B	B
1	1TM-401BB		C	B	B	B	B	B
1	1TM-401C		D	B	B	B	B	B
1	1TM-401EE		E	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	1TE-405A		0	0
1	1TT-401A		0	0
1	1TM-401BB		0	0
1	1TM-401C		0	0
1	1TM-401EE		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
PMA	5.0e-03	BN	B			A 5
PC	0.02916	R	N			A 13

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	±0.20000	DEG F
2	±0.50000	DEG F
3	±0.50000	DEG F
4	±0.50000	DEG F
5	±0.50000	DEG F

* = 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	DEG F
2	±0	0	0	DEG F
3	±0	0	0	DEG F
4	±0.25000	0	0	DEG F
5	±0.12500	0	0	DEG F

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	DEG F
2	±0.48663	DEG F
3	±0.21506	DEG F
4	±0.36939	DEG F
5	±0.36939	DEG F

* = 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	DEG F
2	±0	0	0	DEG F
3	±0	0	0	DEG F
4	±0	0	0	DEG F
5	±0	0	0	DEG F

* = Uncertainty included with plant specific drift for this device

Accident Instrument Temperature Effect (t_A)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	DEG F
2	±0	0	0	DEG F
3	±0	0	0	DEG F
4	±0	0	0	DEG F
5	±0	0	0	DEG F

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

Device	Random	+Bias	-Bias	Units
1	±0	0	0	DEG F
2	±0	0	0	DEG F
3	±0	0	0	DEG F
4	±0	0	0	DEG F
5	±0	0	0	DEG F

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	DEG F
2	±0	0	0	DEG F
3	±0	0	0	DEG F
4	±0	0	0	DEG F
5	±0	0	0	DEG F

* = Uncertainty included with plant specific drift for this device

Accident Instrument Humidity Effect (h_A)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	DEG F
2	±0	0	0	DEG F
3	±0	0	0	DEG F
4	±0	0	0	DEG F
5	±0	0	0	DEG F

Loss of non-seismic HVAC during a seismic event

Humidity Effect (h_{NS})

Device	Random	+Bias	-Bias	Units
1	±0	0	0	DEG F
2	±0	0	0	DEG F
3	±0	0	0	DEG F
4	±0	0	0	DEG F
5	±0	0	0	DEG F

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	DEG F
2	±0	0	0	DEG F
3	±0	0	0	DEG F
4	±0	0	0	DEG F
5	±0	0	0	DEG F

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	DEG F
2	±0	0	0	DEG F
3	±0	0	0	DEG F
4	±0	0	0	DEG F
5	±0	0	0	DEG F

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	DEG F
2	±0	0	0	DEG F
3	±0	0	0	DEG F
4	±0	0	0	DEG F

5	±0	0	0	DEG F

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	DEG F
2	±0	0	0	DEG F
3	±0	0	0	DEG F
4	±0	0	0	DEG F
5	±0	0	0	DEG F

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	DEG F
2	±0	0	0	DEG F
3	±0	0	0	DEG F

4	±0	0	0	DEG F
5	±0	0	0	DEG F

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	DEG F
2	±0	0	0	DEG F

3	±0	0	0	DEG F
4	±0	0	0	DEG F
5	±0	0	0	DEG F

* = Uncertainty included with plant specific drift for this device

Accident Instrument Radiation Effect (r_A)

Device	Random	+Bias	-Bias	Units
1	±0	0	0	DEG F
2	±0	0	0	DEG F
3	±0	0	0	DEG F
4	±0	0	0	DEG F
5	±0	0	0	DEG F

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

Device	Random	+Bias	-Bias	Units
1	±0	0	0	DEG F
2	±0	0	0	DEG F
3	±0	0	0	DEG F
4	±0	0	0	DEG F
5	±0	0	0	DEG F

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	DEG F
2	±0	0	0	DEG F
3	±0	0	0	DEG F
4	±0	0	0	DEG F
5	±0	0	0	DEG F

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	DEG F
2	±0	0	0	DEG F
3	±0	0	0	DEG F
4	±0	0	0	DEG F
5	±0	0	0	DEG F

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;

$$A = \pm \ 1.0400 \ (\text{DEG F})^2$$

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;

$$D_R = \pm\ 0.07813\ (\text{DEG F})^2$$

$$D_{BP} = 0\ \text{DEG F}$$

$$D_{BN} = 0\ \text{DEG F}$$

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;

$$M = \pm\ 0.55596\ (\text{DEG F})^2$$

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} = ± 0 (DEG F)^2

T_{NBP} = 0 DEG F

T_{NBN} = 0 DEG F

T_{AR} = ± 0 (DEG F)^2

T_{ABP} = 0 DEG F

T_{ABN} = 0 DEG F

T_{NSR} = ± 0 (DEG F)^2

T_{NSBP} = 0 DEG F

T_{NSBN} = 0 DEG F

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;

$H_{NR} = \pm 0 \text{ (DEG F)}^2$

$H_{NBP} = 0 \text{ DEG F}$

$H_{NBN} = 0 \text{ DEG F}$

$H_{AR} = \pm 0 \text{ (DEG F)}^2$

$H_{ABP} = 0 \text{ DEG F}$

$H_{ABN} = 0 \text{ DEG F}$

$H_{NSR} = \pm 0 \text{ (DEG F)}^2$

$H_{NSBP} = 0 \text{ DEG F}$

$H_{NSBN} = 0 \text{ DEG F}$

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;

$OPE_R = \pm 0 \text{ (DEG F)}^2$

$OPE_{BP} = 0 \text{ DEG F}$

$OPE_{BN} = 0 \text{ DEG F}$

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;

$SPEZ_R = \pm 0 \text{ (DEG F)}^2$

$SPEZ_{BP} = 0 \text{ DEG F}$

$SPEZ_{BN} = 0 \text{ DEG F}$

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;

$SPES_R = \pm\ 0\ (DEG\ F)^2$

$SPES_{BP} = 0\ DEG\ F$

$SPES_{BN} = 0\ DEG\ F$

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;

$P_R = \pm\ 0\ (DEG\ F)^2$

$P_{BP} = 0\ DEG\ F$

P_{BN} = 0 DEG F

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 = ± 0 (DEG F)^2

S_{BP} = 0 DEG F

S_{BN} = 0 DEG F

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;

$$R_{NR} = \pm\ 0\ (\text{DEG F})^2$$

$$R_{NBP} = 0\ \text{DEG F}$$

$$R_{NBN} = 0\ \text{DEG F}$$

$$R_{ANR} = \pm\ 0\ (\text{DEG F})^2$$

$$R_{ANBP} = 0\ \text{DEG F}$$

$$R_{ANBN} = 0\ \text{DEG F}$$

5.3.12. <u>Loop Steam Pressure/Temperature Effect (SPT)</u>

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;

$$SPT_R = \pm \ 0 \ (DEG \ F)^2$$

$$SPT_{BP} = 0 \ DEG \ F$$

$$SPT_{BN} = 0 \ DEG \ F$$

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;

$PDBE_R = \pm\ 0\ (DEG\ F)^2$

$PDBE_{BP} = 0\ DEG\ F$

$PDBE_{BN} = 0\ DEG\ F$

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:

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

$READ_R = \pm\ 0\ (DEG\ F)^2$

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 = ± 3.1897 (DEG F)

$Bias_{pos}$ = 0 DEG F

$Bias_{neg}$ = 0.50000 DEG F

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

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

$TLEN_{pos}$ = 3.1897 DEG F = 3.1897 % of Process Span

$TLEN_{neg}$ = -3.6897 DEG F = -3.6897 % of Process Span

6.0 CONCLUSIONS

The results of this calculation show that the RCS T-avg control random uncertainty is ±3.1897°F with additional bias uncertainty of -0.5°F.

Total uncertainty is:
+3.1897°F
-3.6897°F

7.0 REFERENCES

1. Northern States Power Company Prairie Island Nuclear Generating Plant Updated Safety Analysis Report (USAR), Rev. 24.

2. 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).

3. Northern States Power Company Prairie Island Nuclear Generating Plant Design Basis Document for the Environmental Qualification of Electrical Equipment, DBD-TOP-03, Rev.3.

4. Northern States Power Company Prairie Island Nuclear Generating Plant Design Basis Document for the Reactor Protection System, DBD SYS-08, Rev.2.

5. Prairie Island Nuclear Generating Plant Units 1 and 2 Precautions, Limitations and Set Points for Nuclear Steam Supply Systems, Rev. 6, March 1976.

6. Northern States Power Company Prairie Island Nuclear Generating Plant Operations Manual.

7. Northern States Power Technical Manual Number X-HIAW 1-1398 -1, Foxboro Service & Maint Instr, Part B, Rev. 19.

8. Northern States Power Technical Manual Number X-HIAW 1-1406, Rev. 10, Foxboro Instrument Documentation Sheets, Vol. I.

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

10. Flow Diagram, Reactor Coolant System, X-HIAW 1-7, Rev. AE.

11. Instrument Block Diagram, NSP & NRP, Prairie Island Nuclear Power Plant Unit No. 1 Reactor Protection & Control System, X-HIAW-1-543, Rev. E.

12. Instrument Block Diagram, NSP & NRP, Prairie Island Nuclear Power Plant Unit No. 1 Reactor Protection & Control System, X-HIAW-1-544, Rev. E.

13. Instrument Block Diagram, NSP & NRP, Prairie Island Nuclear Power Plant Unit No. 1 Reactor Protection & Control System, X-HIAW-1-545, Rev. E.

14. Instrument Block Diagram, NSP & NRP, Prairie Island Nuclear Power Plant Unit No. 1 Reactor Protection & Control System, X-HIAW-1-546, Rev. E.

15. Interconnection Wiring Diagram - Rack 1R1/2R1, NSP - NRP, Nuclear Power Plant Unit No. 1 Reactor Protection System X-HIAW-1-560, Rev. B.

16. Interconnection Wiring Diagram - Rack 1R1/2R1, NSP - NRP, Nuclear Power Plant Unit No. 1 Reactor Protection System X-HIAW-1-561, Rev. C.

17. Interconnection Wiring Diagram - Rack 1W1/2W1, NSP - NRP, Nuclear Power Plant Unit No. 1 Reactor Protection System X-HIAW-1-565, Rev. B.

18. Interconnection Wiring Diagram - Rack 1W1/2W1, NSP - NRP, Nuclear Power Plant Unit No. 1 Reactor Protection System X-HIAW-1-566, Rev. C.

19. Interconnection Wiring Diagram - Rack 1B1/2B1, NSP - NRP, Nuclear Power Plant Unit No. 1 Reactor Protection System X-HIAW-1-571, Rev. B.

20. Interconnection Wiring Diagram - Rack 1B1/2B1, NSP - NRP, Nuclear Power Plant Unit No. 1 Reactor Protection System X-HIAW-1-572, Rev. C.

21. Interconnection Wiring Diagram - Rack 1Y1/2Y1, NSP - NRP, Nuclear Power Plant Unit No. 1 Reactor Protection System X-HIAW-1-577, Rev. B.

22. Interconnection Wiring Diagram - Rack 1Y1/2Y1, NSP - NRP, Nuclear Power Plant Unit No. 1 Reactor Protection System X-HIAW-1-578, Rev. B.

23. Northern States Power Co. Prairie Island No. 1 & 2 Logic Diagram, Reactor Trip Signals, X-HIAW-1-236, Rev. C.

24. Northern States Power Co. Prairie Island No. 1 & 2 Logic Diagrams, Primary Coolant System Signals, X-HIAW-1-239, Rev. B.

25. General Arrangement, Operating Floor East, NF-39206, Rev. P.

26. General Arrangement, Control Room, NF-39750, Rev. W.

27. External Wiring Diagram, Process Protection System Rack 1R1 Red Unit 1, NF-40286-1, Rev. H.

28. External Wiring Diagram, Process Protection System Instruments Racks 1R1, 1R2, 1Y1, 1Y2, & 1B1, NF-40294-1, Rev. K.

29. Penetration Cabinets 1136 & 1137 Wiring Diagrams (Penet E5 & E6), NF-40175-2, Rev. J.

30. Rack No. 1R1 Layout, Reactor Protection System, NSP Nuclear Power Plant Unit No. 1, X-HIAW 1-485, Rev. A.

31. Analog Protection System Calibration, SP 1002A, Rev. 30.

32. Reactor Protection and Control Transmitters, Calibration/Inspection, SP 1002B, Rev. 27.

33. Fax from Paul Siemiesz of RDF Corporation to John Harrison of EXCEL Corporation dated 11/21/95 discussing RTD accuracy.

34. Prairie Island Nuclear Generating Plant, Operations Procedure 1C1.4, "Unit 1 Power Operation", Rev. 29.

8.0 ATTACHMENTS

None

Tab

E

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

Calculation Number: SPCNI017

Calculation Rev. No.: 0

Calculation Title: Unit 1 Calorimetric Uncertainty

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: John Harrison **Date:** 07/12/94
Reviewed By: Thomas M. VerBout **Date:** 09/27/95
Approved By: Thomas M. VerBout **Date:** 09/27/95

TABLE OF CONTENTS

SECTION PAGE

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	1FE-466	1F2511A
FEEDWATER TEMP	1TE-15577	1T0418A
STEAM GENERATOR PRESSURE	1PT-468	1P0400A
BLOWDOWN FLOW	27189	1F0409A

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:

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

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

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

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 Seismic conditions (including loss of non-seismic HVAC due to a seismic event):

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

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

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

For Post Accident conditions:

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

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

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

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

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

Where:

AL = Analytical Limit (or Process Limit)

2.3. Calculation of Allowable Value (AV)

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

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

Where:

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

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

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

2.4. Calculation of Rack Allowance (RA)

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. There are no significant differences between the SG loop 11 and SG loop 12 processes and instruments. Therefore, this calculation is based on the processes and instruments for SG loop 11 and considers the process and instrument errors for SG loop 12 to be the same.

6. Per Section III of the Secondary Calorimetry Instrumentation Uncertainties calculation, 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:

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

7. The calibration cards for 1FT-495 and 23116 show 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 Heise model 710A is greatest for the calibrated range of interest and will, therefore, be used in the calculation.

8. The calibration cards for 1PT-468, 1FT-495, 23116 and 1TT-498 show that as many as 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.

9. The calibration card for 1PT-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.

10. The calibration card for 1PM-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.

11. The plant specific drift for the Rochester SC-3372-39 was determined from the maximum difference between the As-Found and previous As-Left values on the calibration card for the two most recent calibrations. (Prior to the two most recent calibrations, new RTD curves were obtained.) The greatest As-found / As-left difference found was 0.0011 Vdc. Converting Vdc to ohms equates to:

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

12. The accuracy for the 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:

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

13. The temperature effects for the 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:

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

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

$$= \frac{0.010237\ \Omega}{°C}$$

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

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

$$= 0.22749$$

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

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

$$= 0.0083760$$

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

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

$$= 0.18613$$

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

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

$$= 0.29393\ \Omega$$

14. The plant specific drift for the Rosemount 1154GP9 was determined from the maximum difference between the As-Found and previous As-Left values on the calibration card for the two most recent calibrations. (Prior to the two most recent calibrations, the initial bench calibration was performed.) The greatest As-found / As-left difference found was 0.0009 Vdc. Converting to percent span:

$$\frac{0.0009Vdc}{0.5Vdc - 0.1Vdc} \times 100 = 0.225\% Span$$

15. The plant specific drift for the Foxboro 66B (1PM-468B) was determined from the maximum difference between the As-Found and previous As-Left values on the calibration card for all calibrations since July, 1986. The greatest As-found / As-left difference found was 0.13 mAdc. Converting to percent span:

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

16. Per the Advanced Digital Feedwater Control System (ADFCS) Block Diagram NX-39767, 1FT-495 is 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.

17. Using the same logic above, 1TT-498 was 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.

18. Since Attachment A to this calculation propagates each process error through each loop device, no process or instrument errors could be considered dependent.

4.0 DESIGN INPUT

4.1. Form 1: Loop/Process Data Sheet

Loop ID	CALORIMETRIC
Configuration No.	1
Loop Description	
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)	764.70 PSIG
Process Normal Op Pressure (PNOP)	764.70 PSIG
Operating Time (Accident)	Min: Hours Max: Hours
Setpoint Direction	I

4.2. Form 2: Instrument Data Sheet

Unit	1
Instrument Tag No.	1FT-495
Function	
Other Tag No.	
System	FW
Functional Description	FEEDWATER FLOW TO SG 11
Rack/Panel No.	
Power Supply Tag No.	
EQ Zone	AXOP1
Elevation	739.00 ft 8.0000 in
Column	H.1
Row	6.2
Manuf. Name	HONEYWELL
Model Number	ST3000STD120
EQ Listed	No
Seismic Functional	NO
QA Elec.	
QA Mech.	
Input Span (CS)	0 To 374.50 INWC
Output Span (OS)	0.10000 To 0.50000 VDC
Readability (read)	
Surveillance/Calib. Procedure	SP1790
Calibration Interval (CI)	18.000 Months
Device Setting Tol. Allowance (st)	0.0004
Device M&TE Allowance mte1 : Device M&TE Cal Span mtecs1:	0.90000 INWC 0 To 600.00 INWC
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	1
Instrument Tag No.	1TT-498
Function	
Other Tag No.	
System	RE
Functional Description	FEEDWATER TEMP TO SG 11
Rack/Panel No.	
Power Supply Tag No.	
EQ Zone	AXOP1
Elevation	735.00 ft 0 in
Column	JA.0
Row	5.0
Manuf. Name	ROCHESTER INSTRUMENT SYSTEMS
Model Number	SC-3372-3P
EQ Listed	No
Seismic Functional	NO
QA Elec.	
QA Mech.	
Input Span (CS)	93.060 To 197.76 OHMS
Output Span (OS)	0.10000 To 0.50000 VDC
Readability (read)	
Surveillance/Calib. Procedure	SP1790
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	1
Instrument Tag No.	1PT-468
Function	
Other Tag No.	21200
System	RP
Functional Description	SG 11 LOOP A PRESSURE
Rack/Panel No.	
Power Supply Tag No.	1PQ-468
EQ Zone	AXMZ1
Elevation	720.00 ft 0 in
Column	P.0
Row	6.0
Manuf. Name	ROSEMOUNT
Model Number	1154GP9
EQ Listed	No
Seismic Functional	YES
QA Elec.	2X2PM
QA Mech.	X11FM
Input Span (CS)	2.0000 To 1402.0 PSIG
Output Span (OS)	0.10000 To 0.50000 VDC
Readability (read)	
Surveillance/Calib. Procedure	SP1790
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	1
Instrument Tag No.	1PM-468B
Function	
Other Tag No.	
System	RP
Functional Description	SG 11 LOOP A PRESSURE SIGNAL I/I ISOLATOR
Rack/Panel No.	1R2
Power Supply Tag No.	1PQ-468
EQ Zone	CNLRM
Elevation	743.00 ft 4.5000 in
Column	H.8
Row	8.0
Manuf. Name	FOXBORO
Model Number	66B
EQ Listed	No
Seismic Functional	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	SP1002A
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	1
Instrument Tag No.	23116
Function	
Other Tag No.	
System	SB
Functional Description	SG 11 BLOWDOWN FLOW TRANSMITTER
Rack/Panel No.	
Power Supply Tag No.	
EQ Zone	AXMZ1
Elevation	720.00 ft 0 in
Column	K.0
Row	6.1
Manuf. Name	FOXBORO
Model Number	823DP-H3S1SL1
EQ Listed	No
Seismic Functional	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 1-019
Calibration Interval (CI)	12.000 Months
Device Setting Tol. Allowance (st)	0.002
Device M&TE Allowance mte1 : Device M&TE Cal Span mtecs1:	0.23000 INWC 0 To 200.00 INWC
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	1
Instrument Tag No.	1F2511A
Function	
Other Tag No.	
System	RE
Functional Description	LOOP A FEEDWATER FLOW ERCS ANALOG INPUT POINT
Rack/Panel No.	RMU123/1PLP
Power Supply Tag No.	
EQ Zone	CNLRM
Elevation	735.00 ft 0 in
Column	H.0
Row	7.5
Manuf. Name	COMPUTER PRODUCTS INC.
Model Number	ERCS ANALOG INPUT POINT 0.0 - 0.640V
EQ Listed	No
Seismic Functional	NO
QA Elec.	
QA Mech.	
Input Span (CS)	0.10000 To 0.50000 VDC
Output Span (OS)	0 To 19.357 INWC
Readability (read)	
Surveillance/Calib. Procedure	
Calibration Interval (CI)	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	1
Instrument Tag No.	1F0409A
Function	
Other Tag No.	
System	SB
Functional Description	LOOP A STM GEN BLOWDOWN FLOW ERCS ANALOG INPUT POINT
Rack/Panel No.	RMU124/1SA
Power Supply Tag No.	
EQ Zone	CNLRM
Elevation	735.00 ft 0 in
Column	H.0
Row	7.4
Manuf. Name	COMPUTER PRODUCTS INC.
Model Number	ERCS ANALOG INPUT POINT 0.0 - 0.640V
EQ Listed	No
Seismic Functional	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)	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	1
Instrument Tag No.	1P0400A
Function	
Other Tag No.	
System	RE
Functional Description	LOOP A SG PRESSURE ERCS ANALOG INPUT POINT
Rack/Panel No.	RMU122/1RSC
Power Supply Tag No.	
EQ Zone	CNLRM
Elevation	735.00 ft 0 in
Column	H.3
Row	7.4
Manuf. Name	COMPUTER PRODUCTS INC.
Model Number	ERCS ANALOG INPUT POINT 0.0 - 0.640V
EQ Listed	No
Seismic Functional	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)	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	1
Instrument Tag No.	1T0418A
Function	
Other Tag No.	
System	RE
Functional Description	LOOP A STM GEN FEEDWATER TEMP ERCS ANALOG INPUT POINT
Rack/Panel No.	RMU122/1RSC
Power Supply Tag No.	
EQ Zone	CNLRM
Elevation	735.00 ft 0 in
Column	H.3
Row	7.4
Manuf. Name	COMPUTER PRODUCTS INC.
Model Number	ERCS ANALOG INPUT POINT 0.0 - 0.640V
EQ Listed	No
Seismic Functional	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)	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	1154GP9
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)	0.5%*S/1000
Vendor Power Supply Effect (vp)	0.005%*S/1
Vendor Seismic Effect (vse)	0.5%*R
Vendor Radiation Effect (vre)	{0<X<55000000,0}{X>=55000000,1.5%*R+1.0%*S}
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	66B
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	823DP-H3S1SL1
Range	Min:0 Units:INWC Max:30.000
Design Pressure	3000.0 PSIG
Vendor Accuracy Allowance (va)	0.522%*S
Vendor Drift Allowance (vd)	0.25
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)	00
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	AXOP1
Room Description	Unit 1 Aux Building Elev 735
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)	2.853e-03 Rads/Hour
Accident Type	NORMAL
Accident Temperature (AT)	0 °F
Accident Humidity (AH)	0 %RH
Accident Radiation (AR)	0 Rads

Eq Zone	AXMZ1
Room Description	Unit 1 Aux Building Elev 715
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)	2.853e-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: 65.000 °F Max: 105.00 °F
Normal Humidity Range (NHMIN & NHMAX)	Min: 20.000 %RH Max: 90.000 %RH
Max. Normal Radiation (NR)	2.853e-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	1FT-495	
2	1	1TT-498	
3	1	1PT-468	
4	1	1PM-468B	
5	1	23116	
6	1	1F2511A	
7	1	1F0409A	
8	1	1P0400A	
9	1	1T0418A	

5.1.2. Device Dependency Table

Unit	Instrument	Func	Cal	Pwr	Rad	Seismic	Temp	Humidity
1	1FT-495		A	A	A	A	A	A
1	1TT-498		B	B	A	B	A	A
1	1PT-468		C	C	B	C	B	B
1	1PM-468B		D	C	C	D	C	C
1	23116		E	D	B	E	B	B
1	1F2511A		F	A	C	F	C	C
1	1F0409A		G	D	C	G	C	C
1	1P0400A		H	C	C	H	C	C
1	1T0418A		I	B	C	H	C	C

Device Dependency Assumptions/References

Calibration: SP 1002A & 1002B

Power Supply: SP 1002A & 1002B

Radiation: SP 1002A & 1002B

Seismic: SP 1002A & 1002B

Temperature: SP 1002A & 1002B

Humidity: SP 1002A & 1002B

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

Unit	Instrument	Function	CSP (PSIG)	PSS (VOLTS)
1	1FT-495		0	2.0000
1	1TT-498		0	2.0000
1	1PT-468		0	4.3000
1	1PM-468B		0	4.3000
1	23116		0	11.800
1	1F2511A		0	2.0000
1	1F0409A		0	11.800
1	1P0400A		0	4.3000
1	1T0418A		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 1002B

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	±0.10681	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	±0.03129	0	0	PCT
2	±0.41251	0	0	PCT
3	±0.25714	0	0	PCT
4	±0.32500	0	0	PCT
5	±0.99443	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	±0.76617	PCT
*2	±0	PCT
3	±0.84435	PCT
*4	±0	PCT
5	±1.1689	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	±0.38235	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

See Attachment A

5.4. Calculation of Total Loop Error (TLE)

See Attachment A

6.0 CONCLUSIONS

Attachment A to this calculation shows that the calorimetric uncertainty is approximately 1.6%.

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-20728-1, Rev. 23, Rosemount Composite Manual.

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

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

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

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

11. Northern States Power Technical Manual Number NX-33977-1, Rev. 0, W & T Test Instrument - Gauges & Calibrators.

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

13. Northern States Power Technical Manual Number NX-33978-4, Rev. 1, Fluke Test

Instrument - Models 8840A & 45 Voltmeter.

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

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

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

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

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

19. Analog Protection System Calibration, SP 1002A, Rev. 17.

8.0 ATTACHMENTS

Attachment A, Mathcad calculation CALM3.MCD

ATTACHMENT A TO CALCULATION SPCNI017

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):

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

$FF := 3541500$

$Hout := 1201.335$

$Hin := 401.659$

$BDF := 22624$

$BDFgpm := 58$

$BDHout := 494.64$

$MCO := 0.2040 \cdot \%$

$Houtstm := 1201.335$

$Houtwtr := 494.64$

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

$SGP := 716 + 7.25$ Steam Generator Pressure measurement correction per Westinghouse

$SGPBD := 716 + 28$ Steam Generator Pressure measurement correction for Blowdown pressure per Westinghouse

$FT := 424$

$Knf := 1.006681$

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

$SGTP = 2.81099 \times 10^{9}$

$NHL := 0.43 \cdot \%$

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)**

$CTPPC = 99.82862$ 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 - 374.5 inwc per Instrument Data Sheet
Flow equivalent to transmitter Output Span = 0 - 4470000 lb/hr per SPCNI017 Rev. 0, Reference 6

$InSpan := 374.5$

$OutSpan := 4470000$

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

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

$FFdp = 231.9677$ inwc

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

$FFdp5 := 0.05 \cdot InSpan + FFdp$

$FFdp5 = 250.6927$ 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:

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

$SGTP = 2.92288 \times 10^9$

$SGTP1 := SGTP$

$SGTP2 := SGTP$

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

$CTPPCff = 103.80223$ Percent Power

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

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

$TPE = 3.98044$ 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:

Based on Westinghouse's input, the steam generator pressure is 7.25 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 + 7.25 psi); and 2) The pressure where the blowdown is measured (716 + 28 psi).

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

$x2 := SGP$

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

$x2 = 723.25$

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

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

$cx2 = 506.73375$

$BDSVtmp := cx2$

$BDSVtmp = 506.73375$

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

$x3 := BDSVtmp$

$y2 := SGPBD$

$y1 := 700 \qquad y2 = 744 \qquad y3 := 750$

$x3 = 506.73375$

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

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

Determine cx3y1:

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

$cx3y1 = 0.02058$

Determine cx3y3:

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

$cx3y3 = 0.02058$

Determine cx3y2:

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

$cx3y2 = 0.02058$

$BDSV := cx3y2$

$BDSV = 0.02058$

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

$BDF5 = 24906.05279$ lb/hr

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

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

$SGTP = 2.80938 \times 10^9$

$SGTP1 := SGTP$

$SGTP2 := SGTP$

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

$CTPPCbdf = 99.77146$ Percent Power

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

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

$TPE = -0.05726$ Percent Thermal Power Error

Since the Blowdown Flow Error:Thermal Power Error ratio is 87:1, 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 = 723.25 psia

Steam Generator Pressure Transmitter Span (SGPS) = 2 - 1402 psig per Instrument Data Sheet

$SGP = 723.25$ psia

$SGPS := 1400$ psig

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

$SGP5 := 0.05 \cdot SGPS + SGP$

$SGP5 = 793.25$ 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):

$x2 := SGP5$

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

$x2 = 793.25$

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

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

$cx2 = 1199.6025$

$Houtsgp := cx2$

$Houtsgp = 1199.6025$

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

$x2 := SGP5$

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

$x2 = 793.25$

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

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

$cx2 = 508.6525$

$Houtsgpwtr := cx2$

$Houtsgpwtr = 508.6525$

Correct Houtsgp for MCO value provided by Westinghouse

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

$Houtsgp = 1198.19296$

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

$y2 := SGP5$

$x2 := FT$

$y1 := 750 \qquad y2 = 793.25 \qquad y3 := 800$

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

$x2 = 424$

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

Determine cx3y2:

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

$cx3y2 = 408.2846$

Determine cx1y2:

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

$cx1y2 = 397.3446$

Determine cx2y2:

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

$cx2y2 = 401.7206$

$Hinsgp := cx2y2$

$Hinsgp = 401.7206$

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:

$x2 := SGP5$

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

$x2 = 793.25$

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

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

$cx2 = 517.23125$

$BDSVtmpsgp := cx2$

$BDSVtmpsgp = 517.23125$

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

$x3 := BDSVtmpsgp$

$y2 := SGP5 + 20.75$ psi difference between steam generator pressure measurement and blowdown pressure per Westinghouse

$y1 := 800$ $\quad y2 = 814$ $\quad y3 := 850$

$x3 = 517.23125$

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

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

Determine cx3y1:

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

$cx3y1 = 0.02082$

Determine cx3y3:

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

$cx3y3 = 0.02082$

Determine cx3y2:

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

$cx3y2 = 0.02082$

$BDSVsgp := cx3y2$

$BDSVsgp = 0.02082$

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

$x3 := BDSVtmpsgp$

$y2 := SGP5 + 20.75$ psi difference between steam generator pressure measurement and blowdown pressure per Westinghouse

$y1 := 800$ $y2 = 814$ $y3 := 850$

$x3 = 517.23125$

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

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

Determine cx3y1:

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

$cx3y1 = 508.48858$

Determine cx3y3:

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

$cx3y3 = 508.43411$

Determine cx3y2:

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

$cx3y2 = 508.47333$

$BDHoutsgp := cx3y2$

$BDHoutsgp = 508.47333$

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

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

$BDFsgp = 22342.87444$ 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
$Hout = 1199.89334$	$Houtsgp = 1198.19296$
$Hin = 401.659$	$Hinsgp = 401.7206$
$BDSV = 0.02058$	$BDSVsgp = 0.02082$
$BDHout = 494.64$	$BDHoutsgp = 508.47333$
$BDF = 22624$	$BDFsgp = 22342.87444$

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

$SGTP = 2.8053 \times 10^9$

$SGTP1 := SGTP$

$SGTP2 := SGTP$

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

$CTPPCsgp = 99.62637$ Percent Power

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

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

$TPE = -0.2026$ 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):

$y2 := SGP$

$x2 := FT5$

$y1 := 700$ $y2 = 723.25$ $y3 := 750$

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

$x2 = 449$

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

Determine cx3y2:

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

$cx3y2 = 430.3893$

Determine cx1y2:

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

$cx1y2 = 419.2586$

Determine cx2y2:

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

$cx2y2 = 429.27623$

$Hinft := cx2y2$

$Hinft = 429.27623$

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
$Hin = 401.659$	$Hinft = 429.27623$

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

$SGTP = 2.71318 \times 10^9$

$SGTP1 := SGTP$

$SGTP2 := SGTP$

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

$CTPPCfwt = 96.355$ Percent Power

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

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

$TPE = -3.47958$ 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 = 0.2040*%

$MCO = 0.00204$

Add 5% error to the baseline MCO value:

$MCO5 := 0.05 \cdot MCO + MCO$

$MCO5 = 0.00214$

Recalculate thermal power based on the new MCO:

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

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

$SGTP = 2.81074 \times 10^9$

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

$SGTP1 := SGTP$

$SGTP2 := SGTP$

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

$CTPPCmco = 99.81961$ Percent Power

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

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

$TPE = -0.00902$ Percent Thermal Power Error

Since the MCO Error:Thermal Power Error ratio is 554:1, 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 SPCNI017 for the Feedwater Flow instruments and then converts each error into inwc (differential pressure) units:

1FE-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):

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

$Fdpfe = 234.2932$ inwc

Subtract baseline flow differential pressure to obtain flow element error:

$afe := Fdpfe - FFdp$

$afe = 2.32548$ inwc

1FT-495

Given:

$Sft := 374.5$ 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

$tft = 0.749$ inwc

Determine Static Pressure Effect, Zero of the FT:

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

$spezft = 0.749$ inwc

Determine Power Supply Effect of the FT:

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

$pft = 0.01873$ 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 - 374.5 inwc and the point of interest is at a differential pressure of 232 inwc):

Solve for voltage at point of interest:

$$vpoi := \sqrt{\frac{232}{374.5}} \cdot (0.5 - 0.1) + 0.1$$

$vpoi = 0.41483$ vdc

Add m&te voltage error:

$vpoi + mftv_2 = 0.41774$

Solve for new differential pressure:

$$mdpft_2 := \left(\frac{0.41774 - 0.1}{0.5 - 0.1}\right)^2 \cdot 374.5$$

$mdpft_2 = 236.30647$ inwc

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

$mft_2 := mdpft_2 - 232$

$mft_2 = 4.30647$ inwc

1F2511A (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 - 374.5 inwc and the point of interest is at a differential pressure of 232 inwc):

Solve for voltage at point of interest:

$$vpoi := \sqrt{\frac{232}{374.5}} \cdot (0.5 - 0.1) + 0.1$$

$vpoi = 0.41483$ vdc

Add ERCS accuracy voltage error:

$vpoi + afercsv = 0.41531$ vdc

Solve for new differential pressure:

$$afercsdpft := \left(\frac{0.41531 - 0.1}{0.5 - 0.1}\right)^2 \cdot 374.5$$

$afercsdpft = 232.70586$ inwc

Subtract baseline flow differential pressure to obtain ERCS accuracy:

$afercs := afercsdpft - 232$

$afercs = 0.70586$ inwc

Determine Temperature Effect of the ERCS point:

$tfercsv := 0.008584 \cdot \% \cdot 2 \cdot Rercs \cdot \frac{15}{1.8}$ vdc per Make/Model Data Sheet for a 15 deg F temp change per Environmental Conditions Data Sheet

$tfercsv = 0.00092$ vdc

Convert vdc to inwc: (0.1 - 0.5 vdc corresponds to 0 - 374.5 inwc and the point of interest is at a differential pressure of 232 inwc):

Solve for voltage at point of interest:

$$vpoi := \sqrt{\frac{232}{374.5}} \cdot (0.5 - 0.1) + 0.1$$

$vpoi = 0.41483$ vdc

Add ERCS temperature effect voltage error:

$vpoi + tfercsv = 0.41575$ vdc

Solve for new differential pressure:

$$tfercsdpft := \left(\frac{0.41575 - 0.1}{0.5 - 0.1}\right)^2 \cdot 374.5$$

$tfercsdpft = 233.35578$ inwc

Subtract baseline flow differential pressure to obtain ERCS temperature effect:

$tfercs := tfercsdpft - 232$

$tfercs = 1.35578$ 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 - 374.5 inwc and the point of interest is at a differential pressure of 232 inwc):

Solve for voltage at point of interest:

$$vpoi := \sqrt{\frac{232}{374.5}} \cdot (0.5 - 0.1) + 0.1$$

$vpoi = 0.41483$ vdc

Add ERCS voltage error:

$vpoi + mfercsv = 0.41515$ vdc

Solve for new differential pressure:

$$mfercsdpft := \left(\frac{0.41515 - 0.1}{0.5 - 0.1}\right)^2 \cdot 374.5$$

$mfercsdpft = 232.46976$ inwc

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

$mfercs := mfercsdpft - 232$

$mfercs = 0.46976$ inwc

Combine all flow errors:

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

$srssf = 5.34946$ inwc

Add this feedwater flow error to the baseline flow differential pressure of 232 inwc to obtain feedwater flow differential pressure max:

$FFdpmax := srssf + FFdp$

$FFdpmax = 237.31716$ inwc

Convert this max dp to max feedwater flow:

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

$FFmax = 3.5821 \times 10^6$ lb/hr

Substitute the new Feedwater flow into equation 1:

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

$SGTP = 2.84315 \times 10^9$

$SGTP1 := SGTP$

$SGTP2 := SGTP$

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

$CTPPCffmax = 100.97057$ Percent Power

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

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

$TPEffmax = 1.14392$ 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 SPCNI017 for the Steam Generator Pressure instruments and then converts each error into psig units:

1PT-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 Static pressure Effect, Span of the PT:

$spespt := 0.5 \cdot \% \cdot Spt \cdot \frac{764.70}{1000}$ psig per Make/Model Data Sheet for a 764.70 psig max operating pressure per Loop/Process Data Sheet

$spespt = 5.3529$ 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 2 - 1402 psig):

$mpt_2 := \frac{1402 - 2}{0.5 - 0.1} \cdot 0.00291$

$mpt_2 = 10.185$ psig

<u>1PM468B</u>

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 2 - 1402 psig):

$dpm := \frac{1402 - 2}{0.5 - 0.1} \cdot 0.0013$

$dpm = 4.55$ psig

1P0400A (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 2 - 1402 psig):

$$apercs := \frac{1402 - 2}{0.5 - 0.1} \cdot 0.00047$$

$apercs = 1.645$ psig

Determine Temperature Effect of the ERCS point:

$tpercsv := 0.008584 \cdot 2 \cdot \% \cdot Rercs \cdot \frac{15}{1.8}$ vdc per Make/Model Data Sheet for a 15 deg F temp change per Environmental Conditions Data Sheet

$tpercsv = 0.00092$ vdc

Convert vdc to psig (0.1 - 0.5 vdc corresponds to 2 - 1402 psig):

$$tpercs := \frac{1402 - 2}{0.5 - 0.1} \cdot 0.00092$$

$tpercs = 3.22$ 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 - 1402 psig):

$$mpercs := \frac{1402 - 2}{0.5 - 0.1} \cdot 0.00031813$$

$mpercs = 1.11346$ psig

Determine Steamline Pressure Correction Error based on Westinghouse input:

$Wpc := 7.25 \cdot 10 \cdot \%$

$Wpc = 0.725$ psig

Combine all pressure errors:

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

$srssp = 19.19559$ psia

Add this steam generator pressure error to the baseline steam generator baseline pressure of 723.25 psia to obtain steam generator pressure max:

$SGPmax := srssp + SGP$

$SGPmax = 742.44559$ 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):

$x2 := SGPmax$

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

$x2 = 742.44559$

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

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

$cx2 = 1200.85109$

$Houtsgpmaxstm := cx2$

$Houtsgpmaxstm = 1200.85109$

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

$x2 := SGPmax$

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

$x2 = 742.44559$

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

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

$cx2 = 499.54021$

$Houtsgpmaxwtr := cx2$

$Houtsgpmaxwtr = 499.54021$

Correct Houtsgp for MCO value provided by Westinghouse

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

$Houtsgpmax = 1199.42041$

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

$y2 := SGPmax$

$x2 := FT$

$y1 := 700 \qquad y2 = 742.44559 \qquad y3 := 750$

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

$x2 = 424$

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

Determine cx3y2:

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

$cx3y2 = 408.24245$

Determine cx1y2:

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

$cx1y2 = 397.30245$

Determine cx2y2:

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

$cx2y2 = 401.67845$

$Hinsgpmax := cx2y2$

$Hinsgpmax = 401.67845$

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

$x2 := SGPmax$

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

$x2 = 742.44559$

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

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

$cx2 = 509.69173$

$BDSVtmpsgp := cx2$

$BDSVtmpsgp = 509.69173$

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

$x3 := BDSVtmpsgp$

$y2 := SGPmax + 20.75$ psi difference between steam generator pressure measurement and blowdown pressure per Westinghouse

$y1 := 750 \qquad y2 = 763.19559 \qquad y3 := 800$

$x3 = 509.69173$

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

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

Determine cx3y1:

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

$cx3y1 = 0.02065$

Determine cx3y3:

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

$cx3y3 = 0.02064$

Determine cx3y2:

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

$cx3y2 = 0.02065$

$BDSVsgpmax := cx3y2$

$BDSVsgpmax = 0.02065$

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

$x3 := BDSVtmpsgp$

$y2 := SGPmax + 20.75$ psi difference between steam generator pressure measurement and blowdown pressure per Westinghouse

$y1 := 750$ $y2 = 763.19559$ $y3 := 800$

$x3 = 509.69173$

$x2 := 500$ $cx2y1 := 487.9$ $cx2y3 := 487.88$

$x1 := 490$ $cx1y1 := 476.11$ $cx1y3 := 476.10$

Determine cx3y1:

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

$cx3y1 = 499.32655$

Determine cx3y3:

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

$cx3y3 = 499.29686$

Determine cx3y2:

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

$cx3y2 = 499.31871$

$BDHoutsgpmax := cx3y2$

$BDHoutsgpmax = 499.31871$

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

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

$BDFsgpmax = 22529.85418$ 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
$Hout = 1199.82126$	$Houtsgpmax = 1199.42041$
$Hin = 401.659$	$Hinsgpmax = 401.67845$
$BDSV = 0.02058$	$BDSVsgpmax = 0.02065$
$BDHout = 494.64$	$BDHoutsgpmax = 499.31871$
$BDF = 22624$	$BDFsgpmax = 22529.85418$

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

$SGTP = 2.80943 \times 10^9$

$SGTP1 := SGTP$

$SGTP2 := SGTP$

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

$CTPPCsgpmax = 99.77317$ Percent Power

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

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

$TPEsgpmax = -0.05554$ 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 SPCNI017 for the Feedwater Temperature instruments and then converts each error into deg F units:

1TE-498

Determine Accuracy of the TE:

Per Calculation SPCNI017, 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 (93.06 ohms corresponds to 0-500 deg F):

$$Reading := \frac{197.76 - 93.06}{500 - 0} \cdot 424 + 93.06 \quad \text{ohms}$$

$$Reading = 181.8456 \quad \text{ohms}$$

Determine accuracy of the TE in ohms:

$$ateo := 0.17293 \cdot \% \cdot Reading$$

$$ateo = 0.31447 \quad \text{ohms}$$

Determine the equivalent accuracy of the TE in deg F:

$$ate := \frac{500 - 0}{197.76 - 93.06} \cdot 0.31447$$

$$ate = 1.50177 \quad \text{deg F}$$

Determine Drift of the TE:

Per Calculation SPCNI017, 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 (93.06 ohms corresponds to 0-500 deg F):

$$Reading := \frac{197.76 - 93.06}{500 - 0} \cdot 424 + 93.06 \quad \text{ohms}$$

$$Reading = 181.8456 \quad \text{ohms}$$

Determine drift of the TE in ohms:

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

$$dteo = 1.53205 \quad \text{ohms}$$

Determine the equivalent drift of the TE in deg F:

$$dte := \frac{500 - 0}{197.76 - 93.06} \cdot 1.53205$$

$dte = 7.31638$ deg F

1TT-498

Given:

$Stt := 197.76 - 93.06$ ohms Span per Instrument Data Sheet

$Stt = 104.7$ 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 (93.06 - 197.76 ohms corresponds to 0 - 500 deg F):

$$dtt := \frac{500 - 0}{197.76 - 93.06} \cdot 0.28793$$

$dtt = 1.37502$ 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 (93.06 - 197.76 ohms corresponds to 0 - 500 deg F):

$$ptt := \frac{500 - 0}{197.76 - 93.06} \cdot 0.00524$$

$ptt = 0.02502$ deg F

1T0418A (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:

$ttercsv := 0.008584 \cdot 2 \cdot \% \cdot Rercs \cdot \frac{15}{1.8}$ vdc per Make/Model Data Sheet for a 15 deg F temp change per Environmental Conditions Data Sheet

$ttercsv = 0.00092$

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:

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

$srsst = 7.71374$ deg F

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

$FTmax := srsst + FT$

$FTmax = 431.71374$ 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):

$y2 := SGP$

$x2 := FTmax$

$y1 := 700$ $y2 = 723.25$ $y3 := 750$

$x3 := 440$ $cx3y1 := 419.24$ $cx3y3 := 419.28$

$x2 = 431.71374$

$x1 := 430$ $cx1y1 := 408.2$ $cx1y3 := 408.25$

Determine cx3y2:

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

$cx3y2 = 419.2586$

Determine cx1y2:

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

$cx1y2 = 408.22325$

Determine cx2y2:

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

$cx2y2 = 410.11443$

$Hinftmax := cx2y2$

$Hinftmax = 410.11443$

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

Original value	New value based on steam tables and interpolations
Hin = 401.659	Hinftmax = 410.11443

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

$$SGTP = 2.78079 \times 10^{9}$$

$$SGTP1 := SGTP$$

$$SGTP2 := SGTP$$

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

$CTPPCftmax = 98.75611$ Percent Power

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

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

$TPEftmax = -1.07435$ 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:

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

$CalUncertainty = 1.57115$ 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 +/- 1.6%