Attachment 7

L-PI-04-002

Pressurizer Pressure – Low Setpoint Calculations

1. SPCRP021 Rev. 1, "Unit 1 Pressurizer Low Pressure Reactor Trip - for SBLOCA event"
2. SPCRP022 Rev. 1, "Unit 2 Pressurizer Low Pressure Reactor Trip - for SBLOCA event"
3. SPCRP082 Rev. 0, "Unit 1 Pressurizer Low Pressure Reactor Trip - for non-SBLOCA events"
4. SPCRP083 Rev. 0, "Unit 2 Pressurizer Low Pressure Reactor Trip - for non-SBLOCA events"

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

Calculation Number: SPCRP021

Calculation Rev. No.: 1

Calculation Title: Unit 1 Pressurizer Low Pressure Reactor Trip - for SBLOCA event

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: Revised assumptions and other text. In support of Westinghouse transient analyses, the scope of SPCRP021 Rev. 0 has been split into two calculations; SPCRP021 Rev. 1 and SPCRP082 Rev. 0.

Documentation of Reviews and Approvals:

Originated By: Brian K. Rogers **Date:** 02/10/2003
Reviewed By: Kevin J. Holmstrom **Date:** 02/12/2003
Approved By: Thomas M. VerBout **Date:** 02/14/2003

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1.0 PURPOSE/RESULTS

1.1. Purpose and Acceptance Criteria

The purpose of this calculation is to determine the Nominal Trip Setpoint and Allowable Value for the Unit 1 Pressurizer Low Pressure Reactor Trip bistables, 1PC-429E, 1PC-430H, 1PC-431J, and 1PC-449A, for a Small Break LOCA (SBLOCA) event, given the assumed Analytical Limit of 1700 psia proposed in Ref. 32.

As the Westinghouse transient analyses supporting this assumed Analytical Limit are not yet complete, this calculation SHALL not be implemented on actual plant equipment until the assumed Analytical Limit has been verified through review of completed and approved Westinghouse transient analyses.

Per the Prairie Island Nuclear Generating Plant Design Basis Document, Reference 1, the pressurizer low pressure instrumentation loop trips the reactor on two out of four coincident low pressure signals to protect against excessive boiling in the core and to limit the pressure range in which the core DNB protection is required from the thermal overtemperature deltaT reactor trip.

PINGP setpoint calculation SPCRP082 Rev. 0 has been developed to determine the Nominal Trip Setpoint and Allowable Value for these same Pressurizer Low Pressure Reactor Trip bistables for all events other than a SBLOCA.

When utilizing the results of this calculation, or developing a revision of this calculation, consideration should also be given to calculation SPCRP082 Rev. 0.

The following is a list of all PINGP reactor protection system setpoint calculations for the Pressurizer Pressure Low RX Trip function:

SPCRP021 Rev. 1:	Unit 1, SBLOCA event
SPCRP022 Rev. 1:	Unit 2, SBLOCA event
SPCRP082 Rev. 0:	Unit 1, non-SBLOCA events
SPCRP083 Rev. 0:	Unit 2, non-SBLOCA events

1.2. Results

LOW PRESSURE REACTOR TRIP SINGLE ALARM

PARAMETER	VALUE (PSIG)	VALUE (VDC)
Analytical Limit (AL)	1685.0	-
Allowable Value (AV)	1754.2	0.12708
Rack Allowable (RA)	1775.8	0.13788
Nominal Trip Setpoint (NTSP)	1788.3	0.14414
Actual Plant Setting (APS)	1900.0	-
Normal Operation Upper Limit (NOUL)	2235.0	-
Normal Operation Lower Limit (NOLL)	2235.0	-

The results of this calculation show that there is a 111.7 psig margin between the Actual Plant Setting and the calculated Nominal Trip Setpoint.

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 (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. Per Ref. 32, it is assumed that the Analytical Limit for the Pressurizer Low Pressure Reactor Trip function for the SBLOCA event is 1685 psig (1700 psia - 15 psi = 1685 psig). This is an unverfied assumption, as the supporting Westinghouse transient analyses are not yet complete.

2. Since current plant transient analyses demonstrate that a LOCA event results in more adverse conrtainment environmental conditions than a seismic event, this calculation is being performed using LOCA environmental conditions.

3. Based on a review of the calibration data for the M&TE test equipment used to calibrate the Fluke Model 45 (0-3 vdc scale), the accuracy of the M&TE standard has been determined to be +/- (0.002% of span + 0.1 mv).

4. The plant specific drift for the Foxboro model 63U-AC-0HAA-F bistable was determined specifically for 2FC-411 based on the calibrations that occurred from 9/26/90 through 5/8/92. The drift value of 0.275% of span is based on the as-found setting of 38.26 mA on 5/8/92 and the as-left setting of 38.37 mA on 3/8/91 (i.e., ((38.37 - 38.26)/40) * 100). This drift value is conservatively used as a vendor drift uncertainty for the Foxboro bistable.

5. The normal operating upper and lower limits of the pressurizer pressure are both shown as 2235 psig (i.e., same as normal operating pressure) based on section 4.2 of section B-4A of Reference 4 which states that "pressure is maintained at or near 2235 psig".

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

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

8. The plant specific drift for the Foxboro model 66RC-0LA lead/lag unit was determined specifically for 1PM-429B based on the calibrations that occurred from 4/16/86 through4/12/94. The drift value of 0.175% of span is based on the as-found setting of 39.95 mA on 4/22/92 and the as-left setting of 40.02 mA on 6/8/91 (i.e., ((40.02 - 39.95)/40) * 100). This drift value is conservatively used as a vendor drift uncertainty for the Foxboro Lead/Lag module.

9. This calculation applies to all four Unit 1 Pressurizer Low Pressure Reactor Trip instrumentation loops.

10. The control room and containment HVAC are seismically qualified. Therefore, neither the transmitter nor rack devices are subject to increased temperature or humidity due to a loss of non-seismic HVAC as a result of a seismic event.

11. Per the EQ DBD (Reference 2), Table 4-2 shows that the Pressurizer Pressure function required operating time after an accident is considered "Intermediate Term". Table 4-2 shows that the Reactor Trip function required operating time after an accident is considered "Short Term". Section 4.7 of Reference 2 defines "Intermediate Term" as 20 minutes to 24 hours, and "Short Term" as 0 to 20 minutes. It is assumed that the Pressurizer Pressure function shown in Table 4-2 is based on the loop indication (i.e., not trip) function. Therefore, since this calculation is for a reactor trip function, it is assumed that the loop operating time is 0 to 20 minutes after an accident.

12. For calculation of the Insulation Resistance (IR) error (see Attachment 1), only the cable and components exposed to harsh environmental conditions (i.e., inside containment) will be considered. IR error due to cables and components outside containment will be assumed to be negligible.

13. For transmitter loops, the IR error increases as the device output current decreases. Therefore, the transmitter IR errors calculated in Attachment 1 will be based on a device output span of 4 - 20 milliamps at a point of interest of 4 milliamps, i.e., Imin = 4 madc, Imax = 20 madc, and It = 4 madc.

14. For transmitter loops, the IR error increases as the source voltage increases. Per Reference 7, the loop power supply can vary from 36 to 50 vdc. Therefore a source voltage (Vs) of 50 vdc will be used for calculation of the IR error in Attachment 1.

15. For transmitter loops, the IR error increases as the load impedance decreases. Per Reference 30, the loop load is 1150 ohms. Therefore an input load impedance (Re) of 1150 ohms will be used for calculation of the IR error in Attachment 1.

16. The vendor IR values for the seal assembly, splices, cable, and penetration provided in References 29 and 30 will be assumed as the input values used in the IR error calculation per Attachment 1.

17. The Pressurizer Pressure Transmitters are referenced to containment atmosphere. The effect of increased containment pressure on the reference side of the transmitter is not considered in this calculation because the effect would conservatively increase the pressure at which the low pressurizer pressure reactor trip would occur.

4.0 DESIGN INPUT

4.1. Form 1: Loop/Process Data Sheet

Loop ID	1P-429
Configuration No.	2
Loop Description	PRESSURIZER PRESSURE
Process Span (PS)	1700.0 To 2500.0 PSIG
Analytical/ Process Limit (AL/PL)	1685.0 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: 0.33000 Hours
Setpoint Direction	D

4.2. Form 2: Instrument Data Sheet

Unit	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

Unit	1
Instrument Tag No.	1PM-429B
Function	
Other Tag No.	
System	RP
Functional Description	PRESSURIZER PRESSURE COMPENSATION LEAD/LAG UNIT
Rack/Panel No.	1R1
Power Supply Tag No.	1PQ-429
EQ Zone	CNLRM
Elevation	737.00 ft 6.5000 in
Column	H.7
Row	8.0
Manuf. Name	FOXBORO
Model Number	66RC-OLA W-DRIFT
EQ	NO
Seismic Category	YES
QA Elec.	X11FM
QA Mech.	
Input Span (CS)	0.10000 To 0.50000 VDC
Output Span (OS)	0.10000 To 0.50000 VDC
Readability (read)	
Surveillance/Calib. Procedure	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

Unit	1
Instrument Tag No.	1PC-429E
Function	
Other Tag No.	
System	RP
Functional Description	LOW PRESSURE REACTOR TRIP SINGLE ALARM
Rack/Panel No.	1R1
Power Supply Tag No.	1PQ-429
EQ Zone	CNLRM
Elevation	737.00 ft 6.5000 in
Column	H.7
Row	8.0
Manuf. Name	FOXBORO
Model Number	63U-AC-OHAA-F W-DRIFT
EQ	No
Seismic Category	YES
QA Elec.	X11FM
QA Mech.	
Input Span (CS)	0.10000 To 0.50000 VDC
Output Span (OS)	0.10000 To 0.50000 ON / OFF
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:	 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	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	66RC-OLA W-DRIFT
Range	Min:0.10000 Units:VDC Max:0.50000
Design Pressure	PSIG
Vendor Accuracy Allowance (va)	0.5%*S
Vendor Drift Allowance (vd)	0.175%*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

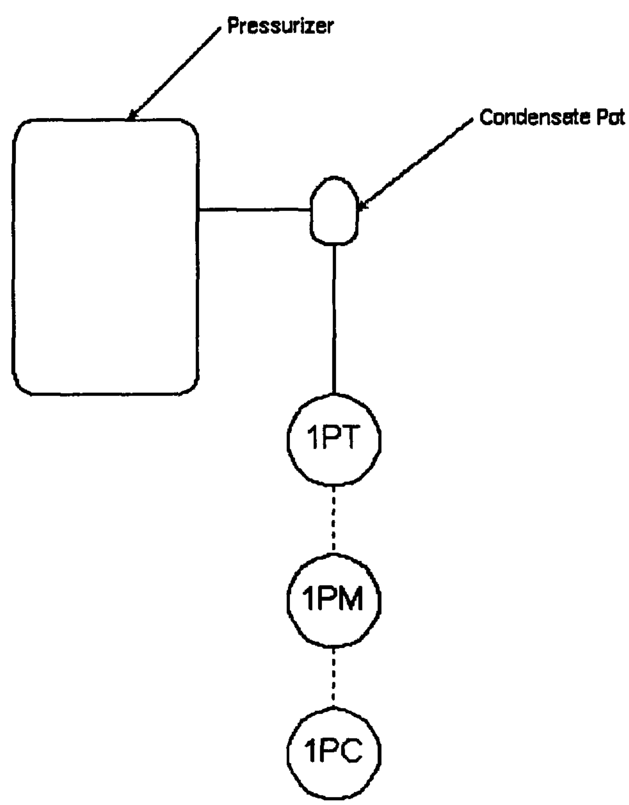
Manuf. Name	FOXBORO
Model Number	63U-AC-OHAA-F W-DRIFT
Range	Min:0.10000 Units:VDC Max:0.50000
Design Pressure	PSIG
Vendor Accuracy Allowance (va)	0.5%*S
Vendor Drift Allowance (vd)	0.275%*S
Drift Time (DT)	12.000 Months Linear or Non-Linear? L Vendor or Plant-Specific? P
Vendor Temp Effect (vte)	0
Vendor 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

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	LOCA
Accident Temperature (AT)	275.00 °F
Accident Humidity (AH)	100.00 %RH
Accident Radiation (AR)	1.6e{+}06 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	LOCA
Accident Temperature (AT)	82.500 °F
Accident Humidity (AH)	50.000 %RH
Accident Radiation (AR)	1.0000 Rads

PRESSURIZER LOW PRESSURE REACTOR TRIP
INSTRUMENT LOOP CONFIGURATION



Channel I: 1PT-429, 1PM-429B, 1PC-429E

Channel II: 1PT-430, 1PM-430C, 1PC-430H

Channel III: 1PT-431, 1PM-431C, 1PC-431J

Channel IV: 1PT-449, 1PM-449B, 1PC-449A

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-429B	
3	1	1PC-429E	

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-429B		B	A	B	B	B	B
1	1PC-429E		C	A	B	B	B	B

Device Dependency Assumptions/References

Calibration: References 27 & 28

Power Supply: Reference 17

Radiation: Reference 2

Seismic: Reference 2

Temperature: Reference 2

Humidity: Reference 2

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

Unit	Instrument	Function	CSP (PSIG)	PSS (VOLTS)
1	1PT-429		0	7.0000
1	1PM-429B		0	0
1	1PC-429E		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: Reference 28

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
IR	0.02000	BP				Att. 1

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	±4.0000	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	±2.8000	0	0	PSIG
3	±4.4000	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	±5.7022	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. <u>Instrument Humidity Effect (h_N, h_A & h_{NS})</u>

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

5.2.6. 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	PSIG
2	±0	0	0	PSIG
3	±0	0	0	PSIG

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	$\pm$0	0	0	PSIG
2	$\pm$0	0	0	PSIG
3	$\pm$0	0	0	PSIG

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	$\pm$0	0	0	PSIG
2	$\pm$0	0	0	PSIG
3	$\pm$0	0	0	PSIG

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	±0.28000	0	0	PSIG
2	±0	0	0	PSIG
3	±0	0	0	PSIG

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	PSIG
2	±0	0	0	PSIG
3	±0	0	0	PSIG

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	±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	±30.000	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

5.2.12. 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	'±79.000	0	0	PSIG
2	±0	0	0	PSIG
3	±0	0	0	PSIG

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	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;

$$A = \pm\ 48.000\ (PSIG)^2$$

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;

$$D_R = \pm\ 50.240\ (PSIG)^2$$

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

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

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;

$$M = \pm 166.07 \text{ (PSIG)}^2$$

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} = ± 212.43 (PSIG)^2

T_{ABP} = 0 PSIG

T_{ABN} = 0 PSIG

T_{NSR} = ± 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 combined as follows:

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

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

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

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

OPE_R = ± 0 $(PSIG)^2$

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;

$SPES_R$ = ± 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;

$P_R = \pm$ 0.07840 (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 = ± 6241.0 $(PSIG)^2$

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:

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

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

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 = ± 37.106 (PSIG)

$Bias_{pos}$ = 0 PSIG

$Bias_{neg}$ = 0 PSIG

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

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

$TLEN_{pos}$ = 37.106 PSIG = 4.6382 % of Process Span

$TLEN_{neg}$ = -37.106 PSIG = -4.6382 % of Process Span

For accident conditions:

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

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

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

SRSSA = ± 87.280 (PSIG)

$Bias_{pos}$ = 16.000 PSIG

$Bias_{neg}$ = 0 PSIG

$TLEA_{pos}$ = $SRSSA + Bias_{pos}$

$TLEA_{neg}$ = $- SRSSA - Bias_{neg}$

$TLEA_{pos}$ = 103.28 PSIG = 12.910 % of Process Span

$TLEA_{neg}$ = -87.280 PSIG = -10.910 % of Process Span

5.5. Calculation of NTSP

The following equations are used to determine the Nominal Trip Setpoint (NTSP) For Normal Conditions:

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

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

Setpoint Direction (Per Form 1): D

AL = 1685.0 PSIG
(Per Form 1)

NTSP = 1788.3 PSIG

5.6. Calculation of Allowable Value (AV)

The following equations are used to determine the Allowable Value (AV):

For an increasing process: $AV = NTSP + LD_R + LD_{BP}$

For a decreasing process: $AV = NTSP - LD_R - LD_{BN}$

Where:

LD_R (Loop Drift, random component) $= (A + D_R + M + R_{NR})^{1/2}$

LD_{BP} (Loop Drift, bias pos component) $= D_{BP} + R_{NBP}$

LD_{BN} (Loop Drift, bias neg component) $= D_{BN} + R_{NBN}$

LD_R = 34.122 PSIG

LD_{BP} = 0 PSIG

LD_{BN} = 0 PSIG

AV = 1754.2 PSIG

5.7. Calculation of Rack Allowance (RA)

The following equations are used to determine the Rack Allowance (RA):

For an increasing process: $RA = NTSP + RD_R + RD_{BP}$

For a decreasing process: $RA = NTSP - RD_R - RD_{BN}$

Where:

RD_R (Rack Drift, random component) $= (A + D_R + M + R_{NR})^{1/2}$

RD_{BP} (Rack Drift, bias pos component) $= D_{BP} + R_{NBP}$

RD_{BN} (Rack Drift, bias neg component) $= D_{BN} + R_{NBN}$

RD_R = 12.520 PSIG

RD_{BP} = 0 PSIG

RD_{BN} = 0 PSIG

RA = 1775.8 PSIG

6.0 CONCLUSIONS

The results of this calculation show that there is a 111.7 psig margin between the Actual Plant Setting and the calculated Nominal Trip Setpoint.

7.0 REFERENCES

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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. 12.

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

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.

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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. Northern States Power Co, Prairie Island No. 1, Reactor Protection System, Reactor Trip Matrices, X-HIAW-1-933, Rev. H.

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

21. Northern States Power Co. Prairie Island No. 1 & 2 Logic Diagrams, Pressurizer Trip Signals, X-HIAW-1-240, Rev. B.

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

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

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

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

26. Seismic Testing of Electrical and Control Equipment, WCAP-7817, December, 1971.

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

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

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

30. Northern States Power Company Prarie Island Calculation No. ENG-EE-040, Rev. 2, Pressurizer Pressure DBE Channel Uncertainties.

31. 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.

32. Westinghouse letter NSP-03-13/LTR-IPES-03-28, dated 7 February 2003, from Steve Swigart of Westinghouse to David Rothrock of NMC, "Nuclear Management Company, Prairie Island Units 1 & 2, Safety Analysis Transition Program, Pressurizer Pressure Low Safety Analysis Limit".

8.0 ATTACHMENTS

Subject		Originator	Rick Ennis	
		Date	1994-11-28	
Project		Checker	John Harrison	
		Date	1994-11-28	
Calc No. SPCRP021	Rev.			

Attachment 1 to Calculation SPCRP021

1.0 PURPOSE

1.1 Introduction

The purpose of this analysis is to determine the IR error created by the parallel resistance paths or current leakage paths in the associated instrument loop. These resistance paths provide leakage current that can adversely affect the performance of instrument current loops. These resistance paths are defined by the insulation resistance (IR) as provided by the manufacturer of the current carrying components in the instrument loop.

1.2 Scope

The scope of this analysis is limited to those current leakage paths which contribute significantly to the overall error. These current leakage paths are limited to the instrument loop cable and, where applicable, the containment penetration, splice(s) and seal assembly(s) through which the signal current passes. This analysis covers instrument loops that are located in a harsh environment. If any portion of the instrument loop cable is located in a mild environment, the mild environment cable portion is also included in the analysis.

1.3 DEFINITIONS

1.3.1 Device Output Current - the current output (at a given point of interest) from the sensor.

1.3.2 Device Span - the difference between the device maximum and minimum output current values.

1.3.3 Insulation Resistance - the conductor to conductor resistance through the insulating material of any electrical device or component.

1.3.4 IR Error - the directional error caused by the effects of leakage current, through individual component resistance paths, on the instrument loop's accuracy.

1.3.5 Load Impedance - the effective resistance created by the load device(s).

1.3.6 Source Voltage - the voltage at the terminals of the power source to the instrument loop.

1.4 Abbreviations

1.4.1 Environment Codes and Leakage Path Codes

Environments are classified as:

H = Harsh
R = Radiation only
T = High temperature
M = Mild

Leakage paths are classified as:

C = Cable
P = Penetration
S = Splice
T = Terminal block
A = Seal assembly

2.0 ASSUMPTIONS

2.1 The total IR error is only affected in a substantial manner by the contribution from the instrument circuit cable and the electrical penetration assembly, terminal blocks, splices, and seal assemblies through which the circuit current flows.

2.2 The IR values provided by the manufacturer are valid for use in determining the instrument loop IR error contribution.

2.3 The loop transmitter is a constant current device.

2.4 The loop power source is a constant voltage source.

2.5 For conservative purposes, cables which are partially routed through non-harsh environments will assume 50% of their respective lengths is routed through a harsh environment and 50% is routed through a mild environment.

3.0 CALCULATION

3.1 Formulae

The IR error at the temperature of interest is determined by the following formula:

$$e_1 = \frac{V_s - [R_e*(I_t/1000)]}{(I_t/1000)*[R_c+R_e]}*100$$

where:

e_1 = IR error at output current of interest (percent)

V_s = Source voltage in volts

R_e = Input load impedance in ohms

I_t = Device output current at point of interest in milliamperes

R_c = Leakage resistance defined by:

$$R_c = \frac{1}{(1/R_{cab1}+\ldots 1/R_{cabn})+(1/R_{non-c1}+\ldots+1/R_{non-cn})}$$

where:

$$R_{cab} = IR_c*\frac{L_{ir}}{L_c}(cable) \text{ and } R_{non-c} = IR_c(non-cable)$$

where:

IR_c = Leakage path insulation resistance (ohms)

L_{ir} = Cable IR test length as specified by manufacturer (feet)

L_c = Installed cable length (feet)

The IR error in terms of percent of device span is determined by the following formula:

$$e_2 = \frac{e_1 * (I_l / 1000)}{|I_{max} - I_{min}| / 1000}$$

where:

e_2 =	IR error in terms of device span (percent)
I_{max} =	Device maximum output current in milliamperes
I_{min} =	Device minimum output current in milliamperes

3.2 Leakage Path Data

3.2.1 Cable Leakage Paths

Code	Env	Vendor IR Value	Test Length	Installed Length	Equivalent IR Value
CAB-01	H	1.400e+04	1000.0	99.0	1.414e+05

3.2.2 Other Leakage paths

Code	Env	Type	Vendor IR Value	Qty
SA-01	H	A	4.700e+10	1
SPL-01	H	S	8.160e+06	2
PEN-01	H	P	1.000e+07	1

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Project		Checker	John Harrison	
		Date	1994-11-28	
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4.0 RESULTS

$$R_c = \frac{1}{1/4.700e{+}10 + 2/8.160e{+}06 + 1/1.414e{+}05 + 1/1.000e{+}07}$$

$R_c =$ 134800.000 ohms

$$e_1 = \frac{50.000 - (1150.000 * 4.000 / 1000)}{4.000 / 1000 * (134800.000 + 1150.000)} * 100$$

$e_1 =$ 8.349 %

$$e_2 = \frac{8.349 * (4.000 / 1000)}{|20.000 - 4.000| / 1000}$$

$e_2 =$ 2.087 %

5.0 REFERENCES

5.1 NUREG/CR-3691, "An Assessment of Terminal Blocks in the Nuclear Power Industry"

5.2 TENERA Project Instruction 63331-001, "Methodology to Determine Systematic Error for Leakage Currents"

5.3 Instrument Society of America Standard RP67.04 - Part II, "Methodologies for the Determination of Setpoints for Nuclear Safety-related Instrumentation", Appendix D, "Insulation Resistance Effects" (Committee Draft 8, dated January, 1991)

5.4 EQ Report No. ENG-EE-040, REV 2
ROSEMOUNT, TRANSMITTER SEAL ASSEMBLY (Code SA-01)

5.5 EQ Report No. 1908-2.2-012, REV 0
RAYCHEM, CABLE SPLICE (Code SPL-01)

5.6 EQ Report No. 1908-2.2-012, REV 0
, 2/C - 16AWG STP (Code CAB-01)

5.7 EQ Report No. 1908-2.2-012, REV 0
, PENETRATION (Code PEN-01)