DOCUMENT APPROVAL COVER SHEET

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DOCUMENT NUMBER: PBNP-IC-25

DOCUMENT TITLE: Steam Generator Narrow Range Level Instrument Uncertainty and Setpoint Calculation

CLIENT: WISCONSIN ELECTRIC POWER COMPANY

PROJECT: PBNP Setpoint Verification Program

PROJECT NUMBER: V03333

SUMMARY DESCRIPTION:

This calculation determines the total loop errors for the Steam Generator Narrow Range Water Level instrumentation and evaluates the Steam Generator Narrow Range Water Level Low-Low and Low Reactor Trip setpoints following the Unit 2 Steam Generator Replacement and Unit 1 Steam Generator Tap Relocation.

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1.0. OBJECTIVE OF CALCULATION

This calculation is applicable to Unit 2 following the Steam Generator Replacement and Unit 1 following the Steam Generator Tap Relocation. The first objective of this calculation is to determine the device uncertainties and total loop errors of the Steam Generator Narrow Range Level instrumentation channels associated with the Low-Low Steam Generator Level Reactor Trip setpoint and the Low Steam Generator Level Reactor Trip setpoint (coincident with Steam Flow/Feedwater Flow Mismatch). The second objective of this calculation is to evaluate the acceptability of the Low-Low and Low Steam Generator Level setpoints.

2.0. ACCEPTANCE CRITERIA

This calculation will be considered acceptable if the total loop errors and setpoints are calculated in accordance with the methodology in Ref. G.1. and the results are compared to the applicable plant documents.

3.0. ABBREVIATIONS

3.1.	AL	Analytical Limit
3.2.	ATSP	Existing Actual Trip Setpoint
3.3.	AV	Allowable Value
3.4.	DBE	Design Basis Event
3.5.	dP	Differential Pressure
3.6.	EQ	Environmental Qualification
3.7.	ESF	Engineered Safety Features
3.8.	FSAR	Final Safety Analysis Report
3.9.	Lvl	Level
3.10.	M&TE	Measurement and Test Equipment
3.11.	OBE	Operating Basis Earthquake
3.12.	PBNP	Point Beach Nuclear Plant
3.13.	PPCS	Plant Process Computer System
3.14.	RAD	Radiation Absorbed Dose
3.15.	RAF	Rack Acceptable As-Found
3.16.	RAL	Rack Acceptable As-Left
3.17.	RCS	Reactor Coolant System
3.18.	RE	Rack Error
3.19.	RPS	Reactor Protection System
3.20.	RSG	Replacement Steam Generator
3.21.	RTP	Rated Thermal Power
3.22.	SAF	Sensor Acceptable As-Found
3.23.	SAL	Sensor Acceptable As-Left
3.24.	SG	Steam Generator
3.25.	SSE	Safe Shutdown Earthquake
3.26.	SRSS	Square Root of the Sum of the Squares
3.27.	Tech Spec	Technical Specifications
3.28.	TID	Total Integrated Dose
3.29.	TLE	Total Loop Error
3.31.	TS	Technical Specifications
3.32.	USL	Upper Span Limit
3.33.	Xmtr	Transmitter

4.0. REFERENCES

Please note that it is the responsibility of the individual revising any of the references listed below to evaluate if the change being made affects this calculation.

4.1. General

G.1. Point Beach Nuclear Plant Design Guideline DG-I01, Instrument Setpoint Methodology, Rev. 1

G.2. Modification Request 95-058 Steam Generator Replacement Design Package T Instrumentation Changes, prepared by Gene Gross of Wisconsin Electric, dated 8/27/96

G.3. Wisconsin Electric Letter No. VPNPD-96-051 to US NRC, Dockets 50-266 and 50-301, Supplement to Technical Specifications Change Requests 188 and 189, Point Beach Nuclear Plants, Units 1 and 2, dated 8/5/96

G.4. Summary of RPS and ESFAS Functions Actuated, pages 54 and 55 of SECL 95-064, Revision 0, Fax from Rick Kohrt of Wisconsin Electric, dated 7/3/96 (Attachment A)

G.5. Point Beach Final Safety Analysis Report, Section 7.2.3, dated 6/92

G.6. Reactor Protection ESF Activation Analytical Limit Verification Information Revision, Westinghouse Letter WEP-94-525, dated 1/28/94

G.7. PBNP Setpoint Document, STPT 1.6, Unit 2 Low-Low Steam Generator Water Level Reactor Trip and Coincident Low Level and Steam/Feedwater Flow Mismatch, Rev. 1

G.8. PBNP Setpoint Document, STPT 5.2, Major Control Systems Setpoints: Steam Dump Control, Rev. 4

G.9. PBNP Setpoint Document, STPT 5.3, Pressurizer Pressure and Level Control, Rev. 5

G.10. PBNP Equipment Qualification Summary Sheets: 7.4.A dated 1/20/91, 7.4.B dated 1/20/91, 7.4.C dated 8/16/91, 7.4.D dated 1/20/91, 7.4.E dated 1/20/91, and 7.4.F dated 1/20/91

G.11. PBNP Condition Report CR 95-109 Evaluation

G.12. PBNP Unit 2 Steam Generator Replacement Project, Steam Generator Replacement Report, Draft Rev. 0, 12/22/95 (Attachment B)

G.13. ASME Boiler and Pressure Vessel Code, Section II Specification for Pressure Vessel Plates, Alloy Steel, Quenched and Tempered, Manganese-Molybdenum and Manganese-Molybdenum-Nickel (SA-533/SA-533M); and Section III Division I, 1989, Appendix I, Table I-5.0, Mean coefficient of thermal expansion

G.14. ASME Steam Tables, Fourth Edition, 1979 Tables 1, 2, and 3

G.15. Reactor Protection System Design Basis Document, Wisconsin Electric PBNP DBD-27, Rev. 0

4.2. Drawings

D.1. BD8, Foxboro Job No. 10668, Instrument Block Diagram RPS Loop A, Unit 1, Rev. 5

D.2. BD8, Foxboro Job No. 10665, Instrument Block Diagram RPS Loop A, Unit 2, Rev. 4

D.3. BD9, Foxboro Job No. 10668, Instrument Block Diagram RPS Loop B, Unit 1, Rev. 5

D.4. BD9, Foxboro Job No. 10665, Instrument Block Diagram RPS Loop B, Unit 2, Rev. 3

D.5. BD18, Foxboro Job No. 10668, Instrument Block Diagram RPS Loop A, Unit 1, Rev. 8

D.6. BD18, Foxboro Job No. 10665, Instrument Block Diagram RPS Loop A, Unit 2, Rev. 6

D.7. BD19, Foxboro Job No. 10668, Instrument Block Diagram RPS Loop B, Unit 1, Rev. 7

D.8. BD19, Foxboro Job No. 10665, Instrument Block Diagram RPS Loop B, Unit 2, Rev. 6

D.9. CD-3, Sheet 1 of 3, Foxboro Job 10668, Connection Diagram Rack 1R2 (1C112), Unit 1, Rev. 10

D.10. CD-3, Sheet 1 of 3, Foxboro Job 10665, Connection Diagram Rack 2R2 (2C112), Unit 2, Rev. 7

D.11. CD-3, Sheet 2 of 3, Foxboro Job 10668, Connection Diagram Rack 1R2 (1C112), Unit 1, Rev. 8

D.12. CD-3, Sheet 2 of 3, Foxboro Job 10665, Connection Diagram Rack 2R2 (2C112), Unit 2, Rev. 6

D.13. CD-5, Sheet 2 of 3, Foxboro Job 10668, Connection Diagram Rack 1W2 (1C114), Unit 1, Rev. 8

D.14. CD-5, Sheet 3 of 3, Foxboro Job 10668, Connection Diagram Rack 1W2 (1C114), Unit 1, Rev. 4

D.15. CD-5, Sheet 2 of 3, Foxboro Job 10665, Connection Diagram Rack 2W2 (2C114), Unit 2, Rev. 8

D.16. CD-5, Sheet 3 of 3, Foxboro Job 10665, Connection Diagram Rack 2W2 (2C114), Unit 2, Rev. 3

D.17. CD-7, Sheet 2 of 3, Foxboro Job 10668, Connection Diagram Rack 1B2 (1C115), Unit 1, Rev. 7

D.18. CD-7, Sheet 2 of 3, Foxboro Job 10665, Connection Diagram Rack 2B2 (2C115), Unit 2, Rev. 5

D.19. CD-7, Sheet 3 of 3, Foxboro Job 10668, Connection Diagram Rack 1B2 (1C115), Unit 1, Rev. 5

D.20. CD-7, Sheet 3 of 3, Foxboro Job 10665, Connection Diagram Rack 2B2 (2C115), Unit 2, Rev. 2

D.21. CD-9, Sheet 2 of 3, Foxboro Job 10668, Connection Diagram Rack 1Y2 (1C117), Unit 1, Rev. 7

D.22. CD-9, Sheet 3 of 3, Foxboro Job 10668, Connection Diagram Rack 1Y2 (1C117), Unit 1, Rev. 3

D.23. CD-9, Sheet 2 of 3, Foxboro Job 10665, Connection Diagram Rack 2Y2 (2C117), Unit 2, Rev. 5

4.3. Procedures

P.1. 1ICP-02.001, Rev. 1, "Reactor Protection and Emergency Safety Features Analog Quarterly Surveillance Test"

P.2. 1ICP-02.001BL-1, Rev. 7, "Reactor Protection and Emergency Safety Features Blue Channel Analog Quarterly Surveillance Test"

P.3. 1ICP-02.001RD-1, Rev. 6, "Reactor Protection and Emergency Safety Features Red Channel Analog Quarterly Surveillance Test"

P.4. 1ICP-02.001WH-1, Rev. 7, "Reactor Protection and Emergency Safety Features White Channel Analog Quarterly Surveillance Test"

P.5. 1ICP-02.001YL-1, Rev. 5, "Reactor Protection and Emergency Safety Features Yellow Channel Analog Quarterly Surveillance Test"

P.6. 2ICP-02.001, Rev. 1, "Reactor Protection and Emergency Safety Features Analog Quarterly Surveillance Test"

P.7. 2ICP-02.001BL-1, Rev. 7, "Reactor Protection and Emergency Safety Features Blue Channel Analog Quarterly Surveillance Test"

P.8. 2ICP-02.001RD-1, Rev. 6, "Reactor Protection and Emergency Safety Features Red Channel Analog Quarterly Surveillance Test"

P.9. 2ICP-02.001WH-1, Rev. 5, "Reactor Protection and Emergency Safety Features White Channel Analog Quarterly Surveillance Test"

P.10. 2ICP-02.001YL-1, Rev. 5, "Reactor Protection and Emergency Safety Features Yellow Channel Analog Quarterly Surveillance Test"

P.11. 1ICP-02.020, Rev. 1, "Post-Refuel Pre-Startup RPS and ESF Analog Surveillance Test"

P.12. 1ICP-02.020BL-1, Rev. 4, "Post-Refuel Pre-Startup RPS and ESF Analog Blue Channel Surveillance Test"

P.13. 1ICP-02.020RD-1, Rev. 3, "Post-Refuel Pre-Startup RPS and ESF Analog Red Channel Surveillance Test"

P.14. 1ICP-02.020WH-1, Rev. 4, "Post-Refuel Pre-Startup RPS and ESF Analog White Channel Surveillance Test"

P.15. 1ICP-02.020YL-1, Rev. 4, "Post-Refuel Pre-Startup RPS and ESF Analog Yellow Channel Surveillance Test"

P.16. 2ICP-02.020, Rev. 0, "Post-Refuel Pre-Startup RPS and ESF Analog Surveillance Test"

P.17. 2ICP-02.020BL-1, Rev. 3, "Post-Refuel Pre-Startup RPS and ESF Analog Blue Channel Surveillance Test"

P.18. 2ICP-02.020RD-1, Rev. 2, "Post-Refuel Pre-Startup RPS and ESF Analog Red Channel Surveillance Test"

P.19. 2ICP-02.020WH-1, Rev. 3, "Post-Refuel Pre-Startup RPS and ESF Analog White Channel Surveillance Test"

P.20. 2ICP-02.020YL-1, Rev. 2, "Post-Refuel Pre-Startup RPS and ESF Analog Yellow Channel Surveillance Test"

P.21. ICP 4.1I U1, Rev. 2, "Reactor Protection and Safeguards Analog Racks Steam Generator Level"

P.22. ICP 4.1I U2, Rev. 1, "Reactor Protection and Safeguards Analog Racks Steam Generator Level"

P.23. 1ICP-04.003-2, Rev. 1, "Steam Generator Level Transmitters Outage Calibration"

P.24. 2ICP-04.003-2, Rev. 1, "Steam Generator Level Transmitters Outage Calibration"

4.4. Vendor

V.1. Foxboro Composite Books, PBNP Control No. 00623A, Book 1, Rev. 12 and Book 4, Rev. 9

V.2. Foxboro EQ Transmitters Manual, PBNP Control No. 00432, Rev. 16

V.3. Fax from Foxboro, Re: Calculation Information Regarding N-E11 and N-E13 Transmitters, dated 5/5/94 (Attachment C)

V.4. Fax from Gene Gross of Wisconsin Electric, dated 8/27/96, Preliminary Westinghouse Process Measurement Errors for PBNP U2 Replacement Steam Generators (Attachment D)

4.5. Calculations

C.1. Foxboro 63U-BC Bistable Drift Calculation, VECTRA Calculation No. PBNP-IC-06, Rev. 0

C.2. Foxboro 63U-AC Bistable Drift Calculation, VECTRA Calculation No. PBNP-IC-11, Rev. 0

C.3. Foxboro N-E13DM Transmitter Drift Calculation, Wisconsin Electric Calculation N94-154, Rev. 0

C.4. Steam Generator Narrow Range Level Scaling Calculation, Duke Engineering & Services Calculation PBNP-IC-26, Rev. 0

5.0 ASSUMPTIONS

5.1. From the PBNP Setpoint Methodology (Ref. G.1.), the statistically derived as-found/as-left drift value includes the effects of M&TE used in past calibrations. To maintain the validity of this value, it is

assumed the M&TE used to perform future calibrations will be of equivalent accuracy to the M&TE used in the past calibrations on which the as-found/as-left drift data is based.

5.2. Based on the transmitter calibration information provided in the SG Level transmitter scaling calculation (Ref. C.4.), it is assumed that the containment ambient temperature at the time of transmitter calibration is approximately 68°F, and the normal containment ambient temperature is 100°F during normal operation. The minimum temperature in containment during plant operation is assumed to be no less than 60°F.

5.3. According to the PBNP Setpoint Methodology (Ref. G.1.), only mechanical devices experience a permanent output shift due to a seismic event. Ref. G.1. states that the environmental allowance used will be the uncertainty due to the larger of either the post accident harsh environment or the seismic effects on the loop devices since the events are considered to be independent of one another. Since this calculation only addresses Reactor Trips and not post accident conditions, the seismic effect will not be considered. Ref. G.1. also states that seismic events do not cause safety systems to fail and assumes that for seismic events greater than an Operating Basis Earthquake, instrumentation will be recalibrated prior to any subsequent accident; thus, negating any permanent shift that may have occurred due to the seismic event.

5.4. From Ref. G.11., the results of testing performed at PBNP has shown that changing the Plant Process Computer from normal to standby condition causes a change in the instrument bus inverter output voltage. The testing has shown that the voltage change has an effect only on the Foxboro H-Line current to current converters; therefore, it is assumed the inverter output voltage variations do not affect the other H-Line modules, (i.e., bistables).

5.5. The values shown in this calculation are linked to a Microsoft Excel spreadsheet file in which the calculated values are determined. The cells are linked such that successively calculated values are dependent on the previously calculated cells, which may cause intermediate values to appear incorrectly rounded. However, the final results are correct with respect to the initial input values.

6.0 DESIGN INPUTS

6.1. Loop Definitions

The loop components addressed in this calculation were identified in References D.1. through D.23., P.1. through P.24., and C.1. through C.3., and are shown on Figure 1 of Section 7.1. The table in Section 7.2 lists the devices that compose each loop.

6.2. Steam Generator Narrow Range Level Low-Low Water Level Reactor Trip Basis

From Section 15.2.3 of Ref. G.4., the Steam Generator Low-Low Water Level Reactor Trip is credited in the Accident Analysis for the following accidents: Loss of Load, Loss of Normal Feedwater, and Loss of AC Power. Based on the most limiting Analytical Limit provided in Ref. G.4., the Reactor Trip is implemented as a percent of span as follows (Ref. G.2.):

Actual Trip Setpoint (ATSP)	$\geq$25 % span
Technical Specification Limit (TS)	$\geq$ 20 % span
Analytical Limit (AL)	$\geq$10 % span

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The above values are applicable to Unit 2 following steam generator replacement and Unit 1 following steam generator lower tap relocation.

6.3. Steam Generator Narrow Range Low Water Level Trip Basis

The Steam Generator Narrow Range Low Water Level signal is used in conjunction with the Steam Flow/Feedwater Flow Mismatch to generate a Reactor Trip. The steam generator low water level trip occurs when the water level falls to 30 % of the narrow range span (Ref. G.2.). There is no Technical Specification Limit for this portion of the trip signal. This trip is not simulated in the Westinghouse accident analysis and there is no defined Analytical Limit. This setpoint is applicable to Unit 2 following steam generator replacement and Unit 1 following the Steam Generator lower tap relocation.

7.0. METHOD AND EQUATION SUMMARY

7.1. Block Diagrams

The block diagram shown below in Figure 1 represents the components associated with the Low-Low and Low Steam Generator Narrow Range Water Level Reactor Trips (instrument loops L-461, 462, 463, 471, 472, and 473) for Unit 1 and Unit 2.

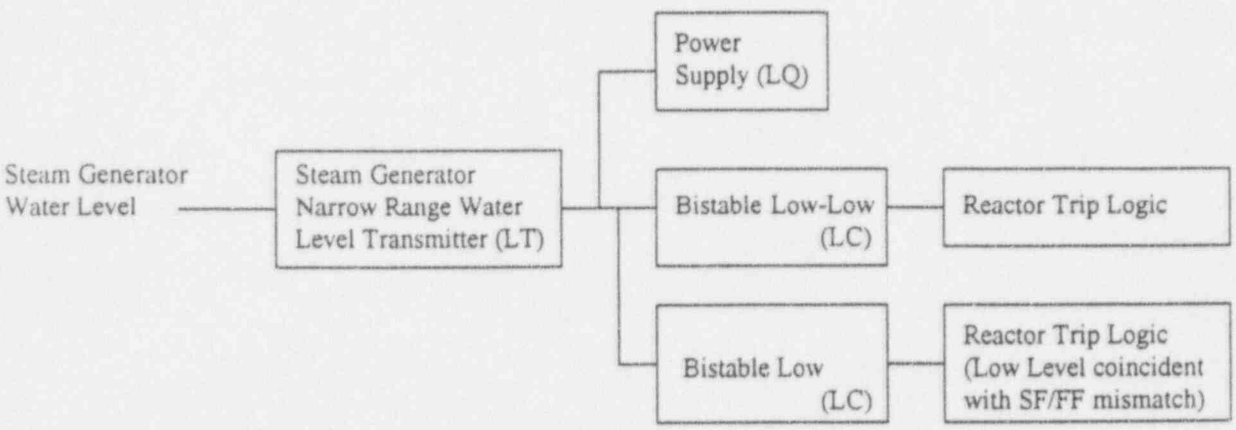

Figure 1. Steam Generator Narrow Range Water Level Instrument Loops

7.2. Loop Component Information

The following table lists the component, manufacturer and model, and instrument number for the Steam Generator Narrow Range Water Level Instrument loops shown in Figure 1. The information presented is applicable to Unit 1 and Unit 2.

Component	Manufacturer/model	Instrument Number
SG Level Transmitter	Foxboro / N-E13DM	Loop A : LT-461, 462, 463 Loop B : LT-471, 472, 473
Power Supply	Foxboro / 610AC-0	Loop A : LQ-461, 462, 463 Loop B : LQ-471, 472, 473
Bistable - Low	Foxboro / 63U-AC-0HBA-F (Note 1)	Loop A : LC-462C, 463E Loop B : LC-472C, 473E
Bistable - Low-Low	Foxboro / 63U-BC-0HEA-F	Loop A : LC-461B, 462A, 463C Loop B : LC-471B, 472A, 473C

Note 1. The model numbers shown for the bistables listed in CHAMPS and on the Block Diagrams, Ref. D.1. through D.8. (63U-AC-0HAA-F) reflect the setting (alarm High or alarm Low) of the bistables at the time they were received from the vendor. Per Ref. C.2., if necessary, the bistables were rewired to perform the trip/alarm function required for the specific application and the bistable model number assumed for this application is 63U-AC-0HBA-F.

7.3. Environment

The maximum ambient temperature in containment during normal operation is 105°F (Ref. G.5., Section 7.2.3). From Assumption 5.2., the containment ambient temperature during calibration is considered to be 68°F and the minimum temperature during normal operation is considered to be 60°F.

From Section 6.2. of this calculation, the Low-Low SG NR Level Reactor Trip is credited for Loss of Load, Loss of Normal Feedwater, and Loss of AC Power accidents. Per Ref. G.15., none of these accidents would cause a harsh environment in containment prior to the reactor trip actuations.

From Section 6.3. of this calculation, the Low SG NR Level Reactor Trip is not credited in any Accident Analysis and therefore, does not need to take adverse conditions into account.

The rack components are located in the control room, which is maintained at 75 ± 10°F and is subject to a mild environment under all plant conditions (Ref. G.5., Section 7.2.3).

7.4. Sources of Uncertainty

The drift values were calculated using as-found/as-left values from plant calibration data, as described in Ref. G.1., which states that the drift values calculated from as-found/as-left string calibration data include the error effects under normal conditions of drift, accuracy, power supply, plant vibration, calibration temperature, normal radiation, normal humidity, M&TE used for calibration, and instrument readability. Therefore, these error effects will not be considered separately when a drift value is determined from as-found/as-left calibration data. The as-found/as-left data is taken from the surveillance procedures performing static verification of the loops and the calculation of uncertainties will be performed with the loops in steady-state condition. The device uncertainties to be considered for normal conditions include the following (Ref. G.1.):

Sensor Accuracy	(sa)
Sensor Drift	(sd)
Sensor M&TE	(sm)
Sensor Setting Tolerance	(sv)
Sensor Power Supply Effect	(sp)
Sensor Temperature Effect	(st_n)
Sensor Humidity Effect	(sh_n)
Sensor Radiation Effect	(sr_n)
Sensor Seismic Effect	(ss_n)
Sensor Static Pressure Effect	(spe_n)
Sensor Overpressure Effect	(ope_n)
Bistable Accuracy	($bist_{AC}$ a & $bist_{BC}$ a)
Bistable Drift	($bist_{AC}$ d & $bist_{BC}$ d)
Bistable M&TE	($bist_{AC}$ m & $bist_{BC}$ m)
Bistable Setting Tolerance	($bist_{AC}$ v & $bist_{BC}$ v)
Bistable Power Supply Effect	($bist_{AC}$ p & $bist_{BC}$ p)
Bistable Temperature Effect	($bist_{AC}$ t & $bist_{BC}$ t)
Bistable Humidity Effect	($bist_{AC}$ h & $bist_{BC}$ h)
Bistable Radiation Effect	($bist_{AC}$ r & $bist_{BC}$ r)
Bistable Seismic Effect	($bist_{AC}$ s & $bist_{BC}$ s)
Normal Process Considerations (random, independent)	(pc n)
Normal Process Considerations (positive bias)	(pc pos n)
Normal Process Considerations (negative bias)	(pc neg n)

7.5. Equation Summary

The total loop error for setpoints and indication is determined in accordance with the requirements of Ref. G.1. This methodology uses the square root of the sum of the squares (SRSS) method to combine random and independent errors, and algebraic addition of non-random or bias errors. From Ref. G.1., the general equation for combining errors to calculate total loop error is:

$$TLE = \pm \sqrt{A^2 + B^2 + (C + D)^2} \pm \sum |X| + \sum Y - \sum Z$$

where:
- A, B = Random and independent uncertainty terms
- C, D = Random and dependent uncertainty terms
- X = Non-random (unknown direction)
- Y = Non-random (positive biases)
- Z = Non-random (negative biases)

The general equation for total instrument loop error is (Ref. G.1.):

$$TLE = \pm \sqrt{A + D + M + V + P + T + H + R + S + SPE + OPE + PC} + B^{+} - B^{-}$$

A	=	Accuracy Allowance	=	$(a_1^2 + a_2^2 \ldots + a_n^2)$
D	=	Drift Allowance	=	$(d_1^2 + d_2^2 \ldots + d_n^2)$
M	=	M&TE Allowance	=	$(m_1^2 + m_2^2 \ldots + m_n^2)$
V	=	Setting Tolerance Allowance	=	$(v_1^2 + v_2^2 \ldots + v_n^2)$
P	=	Power Supply Allowance	=	$(p_1^2 + p_2^2 \ldots + p_n^2)$
T	=	Temperature Allowance	=	$(t_1^2 + t_2^2 \ldots + t_n^2)$
H	=	Humidity Allowance	=	$(h_1^2 + h_2^2 \ldots + h_n^2)$
R	=	Radiation Allowance	=	$(r_1^2 + r_2^2 \ldots + r_n^2)$
S	=	Seismic Allowance	=	$(s_1^2 + s_2^2 \ldots + s_n^2)$
SPE	=	Static Pressure Allowance	=	$(spe_1^2 + spe_2^2 \ldots + spe_n^2)$
OPE	=	Over Pressure Allowance	=	$(ope_1^2 + ope_2^2 \ldots + ope_n^2)$
PC	=	Random Process Considerations	=	$(pc_1^2 + pc_2^2 \ldots + pc_n^2)$
B^{+}	=	Positive Bias Errors	=	$+ (pc_{pos1}^2 + pc_{pos2}^2 \ldots + pc_{pos\,n}^2)$
B^{-}	=	Negative Bias Errors	=	$- (pc_{neg1}^2 + pc_{neg2}^2 \ldots + pc_{neg\,n}^2)$

8.0 BODY OF CALCULATION

8.1. Device Uncertainties

Parameter		Uncertainty (% span)
Sensor Accuracy		See Note 1.
	(sa)	± 0.141 % span
Sensor Drift		See Note 2.
	(sd)	± 0.877 % span
Sensor M&TE		See Note 3.
Sensor Setting Tolerance		See Note 4.
	(sv)	± 0.500 % span
Sensor Power Supply Effect		See Note 5.
Sensor Temperature Effect		See Note 6.
	(st_n)	± 1.018 % span
Sensor Humidity Effect		See Note 7.
Sensor Radiation Effect		See Note 8.
Sensor Seismic Effect		See Note 9.
Sensor Static Pressure Effect		See Note 10.
Sensor Overpressure Effect		See Note 11.
Bistable Accuracy		See Note 12.
Bistable Drift		See Note 13.
	($bist_{AC}$ d)	± 0.222 % span
	($bist_{BC}$ d)	± 0.212 % span
Bistable M&TE		See Note 14.
Bistable Setting Tolerance		See Note 15.
Bistable Power Supply Effect		See Note 16.

Parameter	Uncertainty (% span)	
Bistable Temperature Effect	See Note 17.	
Bistable Humidity Effect	See Note 18.	
Bistable Radiation Effect	See Note 19.	
Bistable Seismic Effect	See Note 20.	
Process Considerations	See Note 21.	
Combined downcomer subcooling & fluid velocity effects		
	pc n 1 (25%)	-0.7925 %
	pc n 1 (30%)	-0.7235 %
Process pressure variation effects		
	pc n 2 (25%)	0.000 %
	pc n 2 (30%)	-0.233 %
Reference leg temperature effects (60°F)		
	pc n 3 (25%)	-0.673 %
	pc n 3 (30%)	-0.681 %
Reference leg temperature effects (105°F)		
	pc n 4 (25%)	0.341%
	pc n 4 (30%)	0.333%

8.2. Device Uncertainty Notes

Note 1. - Sensor Accuracy

The repeatability and hysteresis effects of the Foxboro N-E13DM, Sensor Code M differential pressure transmitter will be included as separate accuracy terms that are not necessarily included in the as-found/as-left drift analysis results. Vendor information (Ref. V.2.) provides the following specifications:

s rep = ± 0.100 % span
s hyst = ± 0.100 % span

Following the PBNP Setpoint Methodology (Ref. G.1.), repeatability and hysteresis effects are combined as random and independent terms using the SRSS method as follows:

$$sa = \pm [(s\ rep)^2 + (s\ hyst)^2\ ]^{1/2}$$
$$sa = \pm [(0.100)^2 + (0.100)^2\ ]^{1/2}$$
$$sa = \pm 0.141\ \%\ span$$

Note 2. - Sensor Drift

To be conservative, the largest recommended drift value for the level transmitters calculated in Ref. C.3. will be used.

sd = $\pm$ 0.877 % span

Note 3. - Sensor M&TE

From the PBNP Setpoint Methodology (Ref. G.1.), the M&TE effect is included in the as-found/as-left drift data and is therefore included in the statistical drift value for the level transmitters calculated in Ref. C.3. Therefore, the M&TE error for the transmitters is considered to be zero.

sm = $\pm$ 0.000 % span

Note 4. - Sensor Setting Tolerance

The setting tolerance for the Steam Generator Narrow Range Level transmitters from the calibration procedures (Refs. P.23. and P.24.) is:

sv = $\pm$ (xmtr cal tol / instr span)* 100%
= $\pm$ (0.200 mA / 40 mA)* 100%
= $\pm$ 0.500 % span

Note 5. - Sensor Power Supply Effect

From Ref. V.1., the AC supply voltage regulation requirement for the Foxboro 610-AC-O loop power supply is $\pm$ 10%. Per Ref. G.11., the instrument bus voltage varied by no more than 2.5 Vrms during instrument bus load testing. This variation is within the $\pm$ 10% voltage variation requirement for the loop power supply. In addition, this voltage variation was proven to only have an effect on the current to current converters (see Assumption 5.4.).

Vendor information for the N-E13DM differential pressure transmitters (Ref. V.2.) shows that the 10 to 50 mA output model can accept a supply voltage between 60 and 95 Vdc for non-LOCA/HELB applications; however, a power supply effect is not specified. Vendor information for the Foxboro 610A loop power supply (Ref. V.1.) states that the power supply is designed for force-balance transmitters and shows the nominal 80 Vdc output can vary from 84 Vdc $\pm$ 2 Vdc at 10 mA to 76 Vdc $\pm$ 2 Vdc at 50 mA. For normal conditions, the voltage supply requirement of the transmitter is met and the sensor power supply effect is negligible.

sp = $\pm$ 0.000 % span

Note 6. - Sensor Temperature Effects

The Steam Generator Narrow Range Level transmitters are Foxboro N-E13DM transmitters, Sensor Code M, with an upper span limit of 205 inwc (Refs. G.10. and V.2.). From Ref. C.4., the calibration range is 152.422 inwc, which is 74.35% of the upper span limit of 205 inwc. The transmitters have a vendor specified temperature effect that must be considered. From information provided by Foxboro (Ref. V.3.), transmitters calibrated between 50% and 80% of the upper span limit may have a zero shift of ± 1.500 % of span per 100°F for an operating ambient temperature range of 32 °F to 180 °F. The span effect, regardless of span setting or temperature range is ± 1.250 % of span per 100°F change. The zero shift and span change effects are conservatively considered to be dependent random errors, and per the methodology in Ref. G.1., will be added algebraically (straight sum) to determine the overall normal operating temperature effect on the transmitters.

For normal operating conditions, only the temperature change from calibration conditions needs to be considered. From Assumption 5.2., the containment ambient temperature at the time of transmitter calibration is approximately 68°F, the normal containment ambient temperature is 100°F during normal operation, and the minimum temperature in containment during plant operation is assumed to be no less than 60°F. The temperature effect on the transmitter at the high end of the normal operating temperature range (105°F per Ref. G.5.) is calculated using the maximum normal temperature variation of 37°F from calibration (68°F to 105°F).

xmtr t zero n	=	± (50-80% effect n)(temp change n/100°F)
	=	± (1.500 % span)(37°F /100°F)
	=	± 0.555 % span
xmtr t span n	=	± (span shift)(temp change n/100°F)
	=	± (1.250 % span)(37°F /100°F)
	=	± 0.463 % span
st_n	=	± (xmtr t zero + xmtr t span)
	=	± (0.555 % span + 0.463 % span)
	=	± 1.018 % span

Note 7. - Sensor Humidity Effects

The normal operating conditions specified by the manufacturer for the transmitters show there is no operating limit for relative humidity (Ref. V.2.). Information from the manufacturer (Ref. V.3.) also states that humidity effects are negligible since the transmitters are sealed and are rated for accident conditions.

sh_n	=	± 0.000 % span

Note 8. - Sensor Radiation Effect

The as-found/as-left drift value for the N-E13DM transmitters calculated in Ref. C.3. includes the cumulative effect of exposure to radiation. Although the transmitters are qualified for adverse environmental conditions, there is a normal radiation effect specified for the Foxboro transmitters. However, according to vendor supplied information (Ref. V.3.), this radiation effect "can be zero and span adjusted to return to the normal accuracy specification," or in other words, is corrected by calibration.

sr_n = ± 0.000 % span

Note 9. - Sensor Seismic Effect

From vendor information (Ref. V.2.), for seismic events less than an Operating Basis Earthquake, no permanent shift in the instrument input/output relationship occurs.

ss_n = ± 0.000 % span

From Assumption 5.3., seismic events do not cause safety systems to fail and assumes that for seismic events greater than an OBE, instrumentation will be recalibrated prior to any subsequent accident; thus, negating any permanent shift that may have occurred due to the seismic event.

ss_s = ± 0.000 % span

Note 10. - Sensor Static Pressure Effect

Static pressure effects due to process pressure apply to differential pressure instruments in direct contact with the process. Foxboro N-E13DM, Sensor Code M differential pressure transmitters are rated for a maximum static pressure of 2000 psia. The Atmospheric Steam Dump Control setpoint is set for 1050 psig (Ref. G.8.) and the normal operating pressure is 820 psia. Therefore, since the transmitters will not be subjected to a static pressure beyond the rating of 2000 psia, the static pressure effect due to process pressure is negligible. From Section 7.3., the accidents in the Accident Analyses that take credit for the Low-Low SG NR Level Reactor Trip would not cause adverse conditions in containment and the Low SG NR Level Reactor Trip is not credited for any accidents. Therefore, only normal conditions are applicable and would not result in a static pressure effect on the transmitter due to ambient pressure.

spe_n = ± 0.000 % span

Note 11. - Sensor Overpressure Effect

Foxboro N-E13DM, Sensor Code M differential pressure transmitters are rated for a maximum static pressure of 2000 psia. The design steam pressure for the new Steam Generators is 1085 psig (Ref. G.3.); therefore, since the transmitters will not be subjected to overpressurization, the overpressure effect is negligible.

ope_n = ± 0.000 % span

Note 12. - Bistable Accuracy

From the PBNP Setpoint Methodology (Ref. G.1.), when drift error values are derived from as-found/as-left calibration data, the resultant drift term includes the effects of accuracy. Linearity, which is a contributor to accuracy, is included in the bistable as-found/as-left drift values calculated in Refs. C.1. and C.2. Also from Ref. G.1., when as-found/as-left drift values are used, repeatability and hysteresis are considered to be negligible for rack components unless vendor or other industry experience indicates otherwise.

$bist_{AC}\ a = \pm 0.000$ % span

$bist_{BC}\ a = \pm 0.000$ % span

Note 13. - Bistable Drift

The drift values are based on the method of calibration performed. The drift analysis results for the bistables shown below are taken from Refs. C.1. and C.2. and are for quarterly surveillance intervals, including the ± 25% extension allowed by the Technical Specifications.

$bist_{AC}\ d = \pm 0.222$ % span

$bist_{BC}\ d = \pm 0.212$ % span

Note 14. - Bistable M&TE Effects

From the PBNP Setpoint Methodology (Ref. G.1.), the M&TE effect is included in the as-found/as-left drift data and is therefore included in the statistical drift values for the bistables calculated in Refs. C.1. and C.2.

$bist_{AC}\ m = \pm 0.000$ % span

$bist_{BC}\ m = \pm 0.000$ % span

Note 15. - Bistable Setting Tolerances

From Refs. P.1. through P.22., the bistables for the Low and Low-Low Narrow Range Steam Generator Level setpoints have one-sided setting tolerances in the conservative direction. For the purposes of evaluating the setpoints, the bistable setting tolerances are considered to be equal to zero. Therefore, the power supply effect on the bistables is considered to be negligible.

$bist_{AC}\ v = \pm 0.000$ % span

$bist_{BC}\ v = \pm 0.000$ % span

Note 16. - Bistable Power Supply Effect

From Ref. V.1., the AC supply voltage regulation requirement for the Foxboro 610-AC-O loop power supply is ± 10%. Per Ref. G.11., the instrument bus voltage varied by no more than 2.5 Vrms during instrument bus load testing. This variation is within the ± 10% voltage variation requirement for the loop power supply. In addition, this voltage variation was proven to only have an effect on the current to current converters (see Assumption 5.4.).

$bist_{AC}\ p$ = ± 0.000 % span

$bist_{BC}\ p$ = ± 0.000 % span

Note 17. - Bistable Temperature Effects

Section 7.2.3 of Ref. G.5. states that the control room is maintained at 75 ± 10°F and the protective equipment inside the room is designed to operate within design tolerance over this temperature range and will perform its protective function in an ambient of 110°F. Therefore, there is no temperature effect associated with the bistables.

$bist_{AC}\ t$ = ± 0.000 % span

$bist_{BC}\ t$ = ± 0.000 % span

Note 18. - Bistable Humidity Effect

The bistables are located in the control room, which is subject to a mild environment under all plant conditions. Therefore, the humidity effect for the bistables is considered to be negligible.

$bist_{AC}\ h$ = ± 0.000 % span

$bist_{BC}\ h$ = ± 0.000 % span

Note 19. - Bistable Radiation Effect

The bistables are located in the control room, which is subject to a mild environment under all plant conditions and is not a radiologically controlled area. Therefore, the radiation effect for the bistables is considered to be negligible. In addition, the as-found/as-left drift values calculated in Refs. C.1. and C.2. would include any cumulative effects of exposure to radiation.

$bist_{AC}\ r$ = ± 0.000 % span

$bist_{BC}\ r$ = ± 0.000 % span

Note 20. - Bistable Seismic Effect

From the PBNP Setpoint Methodology (Ref. G.1.), seismic or vibration effects on non-mechanical instrumentation (i.e., electronic rack equipment) are considered to be zero unless vendor or other industry experience indicates otherwise. The rack equipment is seismically qualified; therefore, would not be expected to experience any vibration effects under normal conditions. Ref. G.1. also assumes that for seismic events greater than an Operating Basis Earthquake, instrumentation will be recalibrated prior to any subsequent accident, thus, negating any permanent shift that may have occurred due to the seismic event (Assumption 5.3.).

$bist_{AC}\ s \quad = \quad \pm 0.000$ % span

$bist_{BC}\ s \quad = \quad \pm 0.000$ % span

Note 21. - Process Considerations

The uncertainties due to process considerations take into account fluid velocity effects, downcomer subcooling effects, process pressure variations, and reference leg temperature variations.

The fluid velocity and downcomer subcooling effects shown below were calculated by Westinghouse (Ref. V.4.) for the Unit 1 Steam Generator Tap Relocation and the Unit 2 Replacement Steam Generators for uprated power conditions (which bound the errors for current power level operation). The worst case error is for the Unit 1 scenario, which will be used to also bound the Unit 2 case.

	Low-Low Setpoint = 25% Level	Low Setpoint = 30% Level
Combined Velocity and Subcooling Effects	-0.7925 % level	-0.7235 % level

The errors due to process pressure variations are determined for the density variations due to load changes. From Ref. C.4., the transmitters are calibrated for full load conditions at 100% Rated Thermal Power (820 psia, 521°F). From Ref. G.9., no load Tavg is 547°F, which corresponds to a saturation pressure of approximately 1020 psia (Ref. G.14.) and is equivalent to the Steam Dump Header Pressure Control setpoint of 1005 psig (1020 psia) for normal power operation (Ref. G.8.).

From Ref. C.4., the transmitter calibration values take into account the thermal expansion of the tap to tap distance of the Steam Generators at normal operating temperature (521°F), and the reference leg pressure side of the transmitter under normal operating conditions in containment (100°F, 820 psia). The specific volume values of water and steam for the applicable conditions shown in the table below are taken from Refs. C.4. and G.14.

Process Parameter	Specific Volume (ft3/lbm)	Density (den) (lbm/ft3)	Specific Gravity (G)	Notes
water (68F, 14.7 psia)	0.016046	62.3208	1.0000	reference condition
steam (820 psia, 521F)	0.55441	1.8037	0.0289	vessel steam 100% RTP (cal)
water (820 psia, 521F)	0.02094	47.7555	0.7663	vessel water 100% RTP (cal)
steam (1020 psia, 547F)	0.43620	2.29253	0.0368	vessel steam 0% RTP
water (1020 psia, 547F)	0.02166	46.1681	0.7408	vessel water 0% RTP
water (820 psia, 100F)	0.01609	62.1504	0.9973	reference leg cal value
water (1020 psia, 100F)	0.01608	62.1891	0.9979	reference leg 0% RTP
water (820 psia, 60F)	0.01599	62.5391	1.0035	reference leg cool down
water (820 psia, 105F)	0.01611	62.0732	0.9960	reference leg heat up

Process Pressure Variation Errors

For the Low and Low-Low setpoints, the process pressure variation errors are determined by comparing the 100% RTP values (transmitter calibration) against the no load values. Based on the scaling calculations from Ref. C.4., the transmitter calibration values for the points of interest are calculated as follows:

dP_cal_pct = [(% level*40 mA +10 mA) - 62.530 mA] / (-0.262 mA/inwc)

The higher pressure at 0% RTP conditions (1020 psia) as opposed to 100% RTP conditions (820 psia) results in a slightly different tap to tap distance than used for the transmitter calibration values.

D_hot_0%RTP = tap to tap distance for 0% RTP at 1020 psia, 547°F
= (206 in)*[1+(7.77E-06 in/in/°F) * (547°F - 70°F)]
= 206.76 inches

The actual differential pressure measured by the transmitter at 0% RTP conditions for a given % level:

dP_pct = WC_rl - WC_pct

where:

WC_rl = pressure of reference leg at 0% RTP (water at 100F, 1020 psia)
= G_rl_0%RTP * D_hot_0%RTP
= (0.9979)*(206.76 inches)
= 206.32 inwc

WC_ pct = pressure of variable leg for 0% RTP at desired % level
= (D_hot_0%RTP)*{[(G_wtr_0%RTP)*(%_lvl)]+[(G_stm_0%RTP)*(1-%_lvl)]}

where:

D_hot_0%RTP = 206.76 inches
G_wtr_0%RTP = specific gravity of water in SG at 0% RTP (1020 psia, 547°F)
%_level = desired % level
G_stm_0%RTP = specific gravity of steam in SG at 0% RTP (1020 psia, 547°F)

The error due to the pressure variation between 100% RTP and 0% RTP for a given % level is calculated as a % of calibrated span and accounts for the reverse acting configuration of the transmitter (lower dP results in an indicated level higher than actual):

dP_pct_error = [(dP_cal_pct) - (dP_ pct)]/(xmtr_cal_span)

Using the equations described above, the error due to varying process pressure for the points of interest (Low-Low and Low SG NR Level setpoints) are summarized below:

	dP_cal_pct (inwc)	dP_pct (inwc)	dP_pct_error (% cal span)
Low-Low Setpoint = 25%	162.328	162.326	0.000 %
Low Setpoint = 30%	154.695	155.048	-0.233 %

Reference Leg Temperature Variation Errors

From Ref. C.4., the transmitter calibration values take into account the thermal expansion of the tap to tap distance of the Steam Generators at normal operating temperature (521°F), and the reference leg pressure side of the transmitter under normal operating conditions in containment (100°F, 820 psia). From Section 7.3. of this calculation, the maximum ambient temperature in containment during normal operation is 105°F (Ref. G.5., Section 7.2.3.) and the minimum temperature during normal operation is assumed to be 60°F (Assumption 5.2.).

Following the scaling calculation steps in Ref. C.4., the pressure exerted by the reference leg at a given ambient containment temperature during normal operation at full power (820 psia) is as follows:

WC_rl = G_rl * D_hot

where:

G_rl = specific gravity of compressed water in the reference leg at given temperature
D_hot = length of reference leg used for transmitter calibration values
= 206.718 inches

The actual differential pressure measured by the transmitter at 100% RTP conditions for a given % level and a given ambient temperature in containment:

dP_pct = WC_rl - WC_pct

where:

WC_rl = pressure of reference leg at 100% RTP (water at given temperature, 820 psia)
= G_rl * D_hot
WC_ pct = pressure of variable leg for 100% RTP at desired % level
= (D_hot)*[(G_wtr_100%RTP) *(%_lvl) + (G_stm_100%RTP)*(1-%_lvl)]

where:

D_hot = length of reference leg used for transmitter calibration values
= 206.718 inches
G_wtr_100%RTP = specific gravity of water at 100% RTP (820 psia, 521°F)
%_level = desired % level
G_stm_100%RTP = specific gravity of steam at 100% RTP (820 psia, 521°F)

The error due to the reference leg temperature variations for a given % level is calculated as a % of calibrated span and accounts for the reverse acting configuration of the transmitter (lower dP results in an indicated level higher than actual):

dP_pct_error = [(dP_ cal_pct) - (dP_ pct)]/(xmtr_cal_span)

Using the equations described above, the error due to varying reference leg temperatures (60°F and 105°F) for the points of interest (Low-Low and Low SG NR setpoints) are summarized below:

Reference Leg Temperature = 60°F	dP_cal_pct (inwc)	dP_pct (inwc)	dP_pct_error (% cal span)
Low-Low Setpoint = 25%	162.328	163.354	-0.673%
Low Setpoint = 30%	154.695	155.732	-0.681%

Reference Leg Temperature = 105°F	dP_cal_pct (inwc)	dP_pct (inwc)	dP_pct_error (% cal span)
Low-Low Setpoint = 25%	162.328	161.808	0.341%
Low Setpoint = 30%	154.695	154.187	0.333%

Summarizing the process consideration errors:

Process Considerations	Low-Low Setpoint (25%)	Low Setpoint (30%)
Subcooling & velocity effects:	pc n 1 (25%) = -0.7925 %	pc n 1 (30%) = -0.7235 %
Process pressure variation effects:	pc n 2 (25%) = 0.000 %	pc n 2 (30%) = -0.233 %
Reference leg temperature = 60°F:	pc n 3 (25%) = -0.673 %	pc n 3 (30%) = -0.681 %
Reference leg temperature = 105°F:	pc n 4 (25%) = 0.341%	pc n 4 (30%) = 0.333%

8.3. Total Loop Error - Normal Conditions

8.3.1. Low-Low SG NR Level Reactor Trip Uncertainty Allowances

The device uncertainty terms determined in Section 8.1 applicable to Low-Low SG NR Level Reactor Trip are combined into the following Uncertainty Allowances for normal conditions:

$$\text{Lo-Lo A} = (sa)^2 = (\pm 0.141\%)^2 = 0.020$$

$$\text{Lo-Lo D} = (sd)^2 + (bist_{BC}\ d)^2$$
$$= (\pm 0.877\%)^2 + (\pm 0.212\%)^2 = 0.814$$

$$\text{Lo-Lo V} = (sv)^2 = (\pm 0.500\%)^2 = 0.250$$

$$\text{Lo-Lo T} = (st_n)^2 = (\pm 1.018\%)^2 = 1.035$$

$$\text{Lo-Lo PC pos} = pc_n\ 4\ (25\%) = 0.341\%$$

$$\text{Lo-Lo PC neg} = pc_n\ 1\ (25\%) + pc_n\ 3\ (25\%)$$
$$= (-0.7925\ \%) + (-0.673\%) = -1.465\ \%$$

8.3.2. Low-Low SG NR Level Reactor Trip Total Loop Error

The Total Loop Error is determined from the Loop Uncertainty Allowances in Section 8.3.1. Combining the random and bias allowances, the TLE equation for the to Low-Low SG NR Level Reactor Trip under normal conditions becomes:

$$\text{Lo-Lo } TLE_n \text{ pos} = +(A + D + V + T)^{1/2} + PC\ pos$$

$$= +(0.020 + 0.814 + 0.250 + 1.035)^{1/2} + (0.341\ \%)$$

$$= +1.797\ \%\ \text{level}$$

$$\text{Lo-Lo } TLE_n \text{ neg} = -(A + D + V + T)^{1/2} + PC\ neg$$

$$= -(0.020 + 0.814 + 0.250 + 1.035)^{1/2} + (-1.465\%)$$

$$= -2.921\ \%\ \text{level}$$

8.3.3. Low SG NR Level (w/ Steam Flow/Feed Flow Mismatch) Reactor Trip Uncertainty Allowances

The device uncertainty terms determined in Section 8.1 applicable to Low SG NR Level (coincident with Steam Flow/Feed Flow Mismatch) Reactor Trip are combined into the following Uncertainty Allowances for normal conditions:

Lo A = $(sa)^2$ = $(\pm 0.141\%)^2$ = 0.020

Lo D = $(sd)^2 + (bist_{AC}\, d)^2$

= $(\pm 0.877\%)^2 + (\pm 0.222\%)^2$ = 0.818

Lo V = $(sv)^2$ = $(\pm 0.500\%)^2$ = 0.250

Lo T = $(st_n)^2$ = $(\pm 1.018\%)^2$ = 1.035

Lo PC pos = $pc_n\ 4\ (30\%)$ = + 0.333 %

Lo PC neg = $pc_n\ 1\ 30\% + pc_n\ 2\ 30\% + pc_n\ 3\ 30\%$

= (-0.7235%) + (-0.233%) + (-0.681) = - 1.637 %

8.3.4. Low SG NR Level (w/ Steam Flow/Feed Flow Mismatch) Reactor Trip Total Loop Error

The Total Loop Error is determined from the Loop Uncertainty Allowances in Section 8.3.3. Combining the random and bias allowances, the TLE equation for the to Low SG NR Level (with Steam Flow/Feed Flow Mismatch) Reactor Trip under normal conditions becomes:

Lo TLE_n pos = $+(A + D + V + T)^{1/2} + PC\ pos$

= $+(0.020 + 0.818 + 0.250 + 1.035)^{1/2} + (0.333\ \%)$

= + 1.790 % level

Lo TLE_n neg = $-(A + D + V + T)^{1/2} + PC\ neg$

= $-(0.020 + 0.818 + 0.250 + 1.035)^{1/2} + (-1.637\ \%)$

= - 3.095 % level

8.4. Low-Low SG NR Level Reactor Trip Setpoint Evaluation

Following the Unit 2 Steam Generator replacement and the Unit 1 Steam Generator Tap Relocation, the Low-Low SG NR Level Reactor Trip Analytical Limit (AL) is 10% level, the proposed Technical Specification (TS) value is 20% level, and the proposed Actual Plant Setpoint (ATSP) is 25% level (Ref. G.2.). As demonstrated below, the proposed plant setpoint is proven to provide adequate margin with respect to the AL. The Total Loop Error calculated in Section 8.3 of this calculation is added to the AL to determine the Nominal Trip Setpoint (NTSP). The margin between the calculated NTSP and proposed ATSP is referred to as Setpoint Margin.

Lo-Lo NTSP = $AL + TLE_n$ = 10% + 1.797% = 11.797%

Lo-Lo Setpt Margin = ATSP - NTSP = 25% - 11.797% = 13.203%

The allowance from the proposed ATSP to the proposed Tech Spec value is shown below:

Lo-Lo Rxr Trip TS to ATSP Allowance = ATSP - TS = 25% - 20% = 5%

The required margin between the ATSP and TS value is determined by the Allowable Value (AV), which is defined as the value that the trip setpoint can have when tested periodically. If exceeded, the instrument channel operability is suspect and further evaluation is required. The AV is calculated by subtracting the applicable Rack Error (RE) from the ATSP.

Lo-Lo RE = $bist_{BC}$ d = 0.212%

Lo-Lo AV = ATSP - RE = 25% - 0.212% = 24.788%

The AV is compared to the proposed Tech Spec value to ensure that the AV is conservative with respect to the TS, the difference being referred to as margin.

Lo-Lo TS to AV Margin = AV - TS = 24.788% - 20% = 4.788%

The AV is established to ensure that sufficient margin exists between the ATSP and the AL to account for instrument uncertainties that are not present or measured during periodic testing. This provides assurance that the AL will not be exceeded as long as the AV is satisfied and provides a means to determine unacceptable instrument performance.

The first check calculation performed adds the positive Sensor and Process Errors (S/PE) to the AL, to account for portions of the loop not validated by surveillance testing of the rack components.

Lo-Lo S/PE $= + \{[(sa)^2 + (sd)^2 + (sv)^2 + (st_n)^2]^{1/2}$ + Lo-Lo PCn pos

$= + \{[(0.141\%)^2 + (0.877\%)^2 + (0.500\%)^2 + (1.018\%)^2]^{1/2} + (0.341\%)$

$= + 1.781\ \%$

Lo-Lo Check Limit 1 = AL + S/PE = 10% + 1.781 % = 11.781%

Lo-Lo Chk Limit 1 Margin = AV - Chk Limit 1 = 24.788% - 11.781% = 13.007%

The second check calculation compares the AV to the limit determined by subtracting the Rack Error (RE) from the calculated NTSP to determine if the AV is conservative with respect to the second check limit.

Lo-Lo Check Limit 2 = NTSP - RE = 11.797% - 0.212% = 11.585%

Lo-Lo Chk Limit 2 Margin = AV - Chk Limit 2 = 24.788% - 11.585% = 13.203%

Since both check calculations resulted in positive margin to the Allowable Value, the AV is considered to be acceptable. The AV is also conservative with respect to the Tech Spec value of 20%.

8.5. Low SG NR Level Reactor Trip Setpoint Evaluation

Following the Unit 2 Steam Generator replacement and the Unit 1 Steam Generator Tap Relocation, the Low SG NR Level Reactor proposed Actual Plant Setpoint (ATSP) is 30% level; however, there is no Technical Specification limit or Analytical Limit for this setpoint (Ref. G.2.). As stated in Ref. G.2., the setpoint is at 20% with the present Steam Generators. Although the setpoint will be 10% of span higher for the new Steam Generators, the actual water level will be slightly less than for the old setpoint of 20% level. This trip is not simulated in the Accident Analysis and does not require a setpoint evaluation.

9.0 CONCLUSIONS

The results of this calculation are intended to be used following the Unit 2 Steam Generator Replacement and the Unit 1 Steam Generator Tap Relocation. The results of the instrument uncertainty calculations and setpoint evaluations performed in Section 8.0 of this calculation indicate the proposed Technical Specification and the plant setpoint for the Low-Low Steam Generator Narrow Range Level Reactor Trip provides adequate margin from the Analytical Limit (10% level) to the proposed plant setpoint (25% level), and from the proposed plant setpoint to the proposed Tech Spec value (20% level). The proposed plant setpoint of 30% level for Low Steam Generator Narrow Range Level Reactor Trip (coincident with Steam Flow/ Feedwater Flow) does not have a Technical Specification value or Analytical Limit and was found to correlate to a slightly lower water level in the replacement Steam Generators as compared to the 20% level setpoint for the old Steam Generators (Ref. G.2.).

10.0 IMPACT ON PLANT DOCUMENTS

The following plant documents are to be reviewed to determine if they are affected by this calculation:

Licensing Documents:
- Point Beach FSAR
- Point Beach Technical Specifications

Design Basis Documents:
- Point Beach Reactor Protection System DBD

Plant Documents:

PBNP Setpoint Document
PBNP EOPSTPT

Calculations:

PBNP I&C Calculation Book

Procedures:

PBNP ICP Procedures
PBNP RESP Procedures

Other:

EQ Summary Sheets

11.0 ATTACHMENTS

9.1.	Attachment A	-	Ref. G.4. (2 pages)
9.2.	Attachment B	-	Ref. G.12.(3 pages)
9.3.	Attachment C	-	Ref. V.3. (3 pages)
9.4.	Attachment D	-	Ref. V.4.(3 pages)

WESTINGHOUSE NON-PROPRIETARY CLASS 3

SETPOINT METHODOLOGY FOR OVERTEMPERATURE - ΔT AND OVERPOWER - ΔT REACTOR PROTECTION SETPOINTS FOR POINT BEACH UNITS 1 & 2

MARCH 1996

Prepared by:

C.F. Ciocca

TABLE 1b

POINT BEACH 1/2 REPLACEMENT STEAM GENERATORS
OVERTEMPERATURE ΔT (CORE BURNDOWN EFFECTS)
(Foxboro N-E11GM transmitter for Pressurizer Pressure)
Assumes conservative normalization of ΔT_o
P' = 2000 PSIA

Parameter	Allowance*
Process Measurement Accuracy	[ ]+a,c
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	
Primary Element Accuracy	
Sensor Calibration Accuracy	
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	
Sensor Reference Accuracy	
[ ]+a,c	
[ ]+a,c	
Measurement & Test Equipment Accuracy	
[ ]+a,c	
[ ]+a,c	
Sensor Temperature Effects	
[ ]+a,c	
Sensor Drift	
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	
Environmental Allowance	
Rack Calibration Accuracy	
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	

TABLE 1a (continued)

POINT BEACH 1/2 REPLACEMENT STEAM GENERATORS
OVERTEMPERATURE ΔT (CORE BURNDOWN EFFECTS)
(Foxboro N-E11GM transmitter for Pressurizer Pressure)
Assumes conservative normalization of ΔT_o
P' = 2000 PSIA

Parameter	Allowance*
Measurement & Test Equipment Accuracy	[ ]+a,c
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	
Comparator (Included in string calibration)	
Rack Temperature Effect	
Rack Drift	
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	

Tag Numbers - TE401A, TE401B, PT429, N41
TE402A, TE402B, PT430, N42
TE403A, TE403B, PT431, N43
TE404A, TE404B, PT432, N44

* [ ]+a,c

Channel Statistical Allowance =

[ ]+a,c

TABLE 1b

POINT BEACH 1/2 REPLACEMENT STEAM GENERATORS
OVERTEMPERATURE ΔT (CORE BURNDOWN EFFECTS)
(Foxboro N-E11GM transmitter for Pressurizer Pressure)
Assumes conservative normalization of ΔT_o
P' = 2250 PSIA

Parameter	Allowance*
Process Measurement Accuracy	[ ]+a,c
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	
Primary Element Accuracy	
Sensor Calibration Accuracy	
[+a,c	
[ ]+a,c	
[ ]+a,c	
Sensor Reference Accuracy	
[+a,c	
[ ]+a,c	
Measurement & Test Equipment Accuracy	
[ ]+a,c	
[ ]+a,c	
Sensor Temperature Effects	
[ ]+a,c	
Sensor Drift	
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	
Environmental Allowance	
Rack Calibration Accuracy	
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	

TABLE 1b (continued)

POINT BEACH 1/2 REPLACEMENT STEAM GENERATORS
OVERTEMPERATURE ΔT (CORE BURNDOWN EFFECTS)
(Foxboro N-E11GM transmitter for Pressurizer Pressure)
Assumes conservative normalization of ΔT_o
P' = 2250 PSIA

Parameter	Allowance*
Measurement & Test Equipment Accuracy	[ ]+a,c
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	
Comparator (Included in string calibration)	
Rack Temperature Effect	
Rack Drift	
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	
[ ]+a,c	

Tag Numbers - TE401A, TE401B, PT429, N41
TE402A, TE402B, PT430, N42
TE403A, TE403B, PT431, N43
TE404A, TE404B, PT432, N44

* [ ]+a,c

Channel Statistical Allowance =

[ ]+a,c

TABLE 2

POINT BEACH 1/2 REPLACEMENT STEAM GENERATORS
OVERPOWER ΔT (CORE BURNDOWN EFFECTS)
Assumes conservative normalization of ΔT_o
P' = 2000 PSIA or 2250 PSIA

Parameter **Allowance***

[ ]+a,c

Process Measurement Accuracy
[ ]+a,c
[ ]+a,c
[ ]+a,c
[ ]+a,c
[ ]+a,c
[ ]+a,c

Primary Element Accuracy

Sensor Calibration Accuracy
[ ]+a,c
[ ]+a,c

Sensor Reference Accuracy
[ ]+a,c

Measurement & Test Equipment Accuracy
[ ]+a,c

Sensor Temperature Effects

Sensor Drift
[ ]+a,c
[ ]+a,c

Environmental Allowance

Rack Calibration Accuracy
[ ]+a,c
[ ]+a,c
[ ]+a,c

Measurement & Test Equipment Accuracy
[ ]+a,c
[ ]+a,c
[ ]+a,c

Comparator
(Included in string calibration)

Rack Temperature Effect

Rack Drift
[ ]+a,c
[ ]+a,c

TABLE 2 (continued)

POINT BEACH 1/2 REPLACEMENT STEAM GENERATORS
OVERPOWER ΔT (CORE BURNDOWN EFFECTS)
Assumes conservative normalization of ΔT_o
P' = 2000 PSIA or 2250 PSIA

Tag Numbers - TE401A, TE401B,
TE402A, TE402B,
TE403A, TE403B,
TE404A, TE404B,

---

* [ ]+a,c

Channel Statistical Allowance =

[ ]+a,c

TABLE 3a

OVERTEMPERATURE ΔT CALCULATIONS
(Foxboro N-E11GM Transmitter for Pressurizer Pressure)
Assumes conservative normalization of ΔT_o
P' = 2000 PSIA

- The equation for Overtemperature ΔT:

$$\Delta T \left(\frac{1}{1+\tau_3 S}\right) \le \Delta T_0 \left\{K_1 - K_2 \frac{(1+\tau_1 S)}{(1+\tau_2 S)} \left(T\left(\frac{1}{1+\tau_4 S}\right) - T'\right) + K_3 (P - P') - f(\Delta I)\right\}$$

K_1 (nominal) = 1.14 Technical Specification value
K_1 (max) = [ ]+a,c
K_2 = 0.022/°F
K_3 = 0.001/psi
Vessel ΔT = 58.2 °F
ΔI gain = 2.0% RTP/% ΔI
P' = 2000 PSIA
557.0°F < full power Tavg < 573.9°F

- Full power ΔT calculation:

ΔT span = [ ]+a,c

=> [ ]+a,c

- Process Measurement Accuracy Calculations:

[ ]+a,c

[ ]+a,c

[ ]+a,c

* [ ]+a,c

TABLE 3a (continued)

OVERTEMPERATURE ΔT CALCULATIONS
(Foxboro N-E11GM Transmitter for Pressurizer Pressure)
Assumes conservative normalization of ΔT_o
P' = 2000 PSIA

ΔI - Incore / Excore Mismatch

[ ] +a,c

ΔI - Incore Map Delta-I

[ ] +a,c

- Pressure Channel Uncertainties

Gain = [ ] +a,c

SCA =

SRA =

SMTE =

STE =

SD =

[ ] +a,c

RCA =

RMTE =

RD =

[ ] +a,c

TABLE 3a (continued)

OVERTEMPERATURE ΔT CALCULATIONS
(Foxboro N-E11GM Transmitter for Pressurizer Pressure)
Assumes conservative normalization of ΔT_o
P' = 2000 PSIA

- Tavg Channel Uncertainties

Gain = [ ] +a,c

SCA =
SRA =
SMTE =
SD =
[ ] +a,c

- ΔI Channel Uncertainties

Gain = [ ] +a,c

RCA =
RMTE =
RD =
[ ] +a,c

- Total Allowance

[ ] +a,c

- Margin

Margin = [ ] +a,c

TABLE 3b

OVERTEMPERATURE ΔT CALCULATIONS
(Foxboro N-E11GM Transmitter for Pressurizer Pressure)
Assumes conservative normalization of ΔT_o
P' = 2250 PSIA

- The equation for Overtemperature ΔT:

$$\Delta T \left(\frac{1}{1 + \tau_3 S}\right) \leq \Delta T_0 \left\{K_1 - K_2 \frac{(1 + \tau_1 S)}{(1 + \tau_2 S)} \left(T \left(\frac{1}{1 + \tau_4 S}\right) - T'\right) + K_3 (P - P') - f(\Delta I)\right\}$$

K_1 (nominal)	=	1.26 Technical Specification value
K_1 (max)	=	[ ]+a,c
K_2	=	0.025/°F
K_3	=	0.0013/psi
Vessel ΔT	=	58.2 °F
ΔI gain	=	2.0% RTP/% ΔI
P'	=	2250 PSIA

557.0°F < full power Tavg < 573.9°F

- Full power ΔT calculation:

  ΔT span = [ ]+a,c

  => [ ]+a,c

- Process Measurement Accuracy Calculations:

  [ ]+a,c

  [ ]+a,c

  [ ]+a,c

- [ ]+a,c

TABLE 3b (continued)

OVERTEMPERATURE ΔT CALCULATIONS
(Foxboro N-E11GM Transmitter for Pressurizer Pressure)
Assumes conservative normalization of ΔT_o
P' = 2250 PSIA

ΔI - Incore / Excore Mismatch

[ ] +a,c

ΔI - Incore Map Delta-I

[ ] +a,c

- Pressure Channel Uncertainties

Gain = [ ] +a,c

SCA =
SRA =
SMTE =
STE =
SD =
[ ] +a,c

RCA =
RMTE =
RD =
[ ] +a,c

TABLE 3b (continued)

OVERTEMPERATURE ΔT CALCULATIONS
(Foxboro N-E11GM Transmitter for Pressurizer Pressure)
Assumes conservative normalization of ΔT_o
P' = 2250 PSIA

- Tavg Channel Uncertainties

Gain = [ ] +a,c

SCA =
SRA =
SMTE =
SD =
[ ] +a,c

- ΔI Channel Uncertainties

Gain = [ ] +a,c

RCA =
RMTE =
RD =
[ ] +a,c

- Total Allowance

[ ] +a,c

- Margin

Margin = [ ] +a,c

TABLE 4a
OVERPOWER ΔT CALCULATIONS
Assumes conservative normalization of ΔT_o
P' = 2000 PSIA

- The equation for Overpower ΔT:

$$\Delta T \left(\frac{1}{1 + \tau_3 S}\right) \leq \Delta T_0 \{K_4 - K_5\left(\frac{\tau_5 S}{(1 + \tau_5 S)}\right)\left(\frac{1}{1 + \tau_4 S}\right) T - K_6 [T(\frac{1}{1 + \tau_4 S}) - T']\}$$

K_4 (nominal) = 1.09 Technical Specification value
K_4 (max) = [ ]+a,c
K_5 = 0 for decreasing average temperature
K_5 = 0.0262 for increasing average temperature (1/°F)
K_6 = 0.00123/°F for average temperature ≥ T'
K_6 = 0 for average temperature < T'
Vessel ΔT = 58.2 °F
557.0°F < full power Tavg < 573.9°F

- Full power ΔT calculation:

ΔT span = [ ]+a,c
=> [ ]+a,c

- Process Measurement Accuracy Calculations:

[ ]+a,c
[ ]+a,c
[ ]+a,c

* [
]+a,c

TABLE 4a (Continued)

OVERPOWER ΔT CALCULATIONS
Assumes conservative normalization of ΔT_o
P' = 2000 PSIA

- Tavg Channel Uncertainties

Gain = [ ]+a,c

SCA =
SRA =
SMTE =
SD =
[ ]+a,c

- Total Allowance

[ ]+a,c

- Margin

Margin = [ ]+a,c

TABLE 4b

OVERPOWER ΔT CALCULATIONS
Assumes conservative normalization of ΔT_o
P' = 2250 PSIA

- The equation for Overpower ΔT:

$$\Delta T\left(\frac{1}{1+\tau_3 S}\right) \le \Delta T_0 \left\{K_4 - K_5\left(\frac{\tau_5 S}{(1+\tau_5 S)}\right)\left(\frac{1}{1+\tau_4 S}\right)T - K_6\left[T\left(\frac{1}{1+\tau_4 S}\right) - T'\right]\right\}$$

K_4 (nominal) = 1.09 Technical Specification value
K_4 (max) = [ ]$^{+a,c}$
K_5 = 0 for decreasing average temperature
K_5 = 0.0262 for increasing average temperature (1/°F)
K_6 = 0.00123/°F for average temperature ≥ T'
K_6 = 0 for average temperature < T'
Vessel ΔT = 58.2 °F
557.0°F < full power Tavg < 573.9°F

- Full power ΔT calculation:

ΔT span = [ ]$^{+a,c}$
=> [ ]$^{+a,c}$

- Process Measurement Accuracy Calculations:

[ ]$^{+a,c}$
[ ]$^{+a,c}$
[ ]$^{+a,c}$

* [
]$^{+a,c}$

TABLE 4b (Continued)

OVERPOWER ΔT CALCULATIONS
Assumes conservative normalization of ΔT_c
P' = 2250 PSIA

- Tavg Channel Uncertainties

Gain = [ ]+a,c

SCA =
SRA =
SMTE =
SD =
[ ]+a,c

- Total Allowance

[ ]+a,c

- Margin

Margin = [ ]+a,c