Attachment 4 To

W3F1-2004-0073

Additional Information Regarding
EPU Steam Generator Pressure – Low Setpoint Development

CALCULATION COVER PAGE

☐ Calculation
☒ DRN

DRN No. 04-1235 Pages _____

Init. Doc.: ER-W3-2003-0353-000

☐ DRN Superseded: 03-551
☐ DRNs Voided:
☐ Calculation Superseded/Voided:
☐ As-Built/No ICN Required
☒ Pending/ICN Required (verify current status in IDEAS)

Reason For Pending Status: (ER, T.S., Change, etc.)
ER-W3-2003-0353-000

Calculation No: ECI92-019 **Revision:** 3

Title: Plant Protection System Indicating and Recording Instrumentation Loop Uncertainty Calculation

System: PPS

Component/Equipment Identifier: N/A

Safety Code:
☒ Yes
☐ No
☐ Quality

Calc Code: (ANO/GGNS Only)

Study Calc:
☐ Yes ☒ No

10CFR50.59 Review
☒ Addressed in: ER-W3-2003-0353-000
☐ Attached
☐ No LBD Impact

Structure:
Bldg. _____ Elev. _____
Room _____ Wall _____
Coordinates: _____

R-Type: B13.16

Org. Code: (ANO/GGNS/RBS Only)

Keywords: None

Topical Codes: (ANO Only)

REVIEWS

Robin Smith 8/4/2004 (Name/Signature/Date) **Responsible Engineer**	Dave Tolman 8/4/2004 (Name/Signature/Date) ☒ Design Verifier ☐ Reviewer ☐ Checker (Only As-Built DRNs included in Revision) ☐ Comments Attached	RALPH F. SCHWARTZBECK 8/4/04 (Name/Signature/Date) **Supervisor/Approval** ☐ Comments Attached

CALCULATION REFERENCE SHEET	CALCULATION NO: ECI92-019 REVISION: 0

I. DRNs INCORPORATED:

II. RELATIONSHIPS:

Document No.	Sht	Rev	Input Doc	Output Doc	Impact Y/N	DRN/Tracking No.
ECI01-006, DRN 03-1409		0	☒	☐	N	
MI-005-463			☐	☒	Y	ER-W3-2003-0353-000
FSAR			☐	☒	Y	DRN 04-363
Tech. Specifications			☐	☒	Y	ER-W3-2001-1149-000
Passport CDB			☐	☒	Y	ER-W3-2003-0353-000
DBD-12			☐	☒	Y	ER-W3-2003-0353-000
SD-PPS			☐	☒	Y	ER-W3-2003-0353-000
OP-903-107			☐	☒	Y	ER-W3-2003-0353-000
OP-500-009			☐	☒	Y	ER-W3-2003-0353-000
OP-009-007			☐	☒	Y	ER-W3-2003-0353-000
			☐	☐		
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			☐	☐		
			☐	☐		

III. CROSS REFERENCES:

1.

IV. SOFTWARE USED:

Title: N/A Version/Release: _____ Disk/CD No. _____

DISK/CDS INCLUDED:

Title: N/A Version/Release: _____ Disk/CD No. _____

V. OTHER CHANGES:

Revision No.	Record Of Revision	Affected Pages
DRN 04-1235	Revised Low Pressure setpoint, allowable value and alarm, based on revised analysis limit. The Low SG Pressure Variable Setpoint Step value is also revised. Corrected error in calculating SG Low Press PTE. Ref.: CR-WF3-2004-02388 Supersedes DRN 03-551.	2, 4, 6, 8, 15, 22, 28, 120, 121, 122, 125, 126, 127

DESIGN VERIFICATION RECORD

Document Number ECI92-019 Revision 3

METHOD

Verification methods to be used:

X	Design Review
	Qualification Testing
	Alternate Calculations

DOCUMENT(S) REVIEWED: (Attach Additional Sheet(s), if needed)

Document Number	Revision	Document Title
ECI92-019	DRN 04-1235	PPS Setpoint Uncertainty

SUMMARY OF REVIEW: (Attach Additional Sheet(s), if needed)

Design Verification Completed By D.M. TOLMAN Date: 8/5/04

Comment Resolutions Accepted By N/A Date:

Engineering Supervisor RALPH K. SCHWARTZBECK Date: 8/5/04

DESIGN VERIFICATION RECORD

Document Number ECI92-019 Revision 3

CMNT NO.	COMMENT	RESOLUTION	ACPT Y/N	INIT/DATE
	None	All comments and questions were resolved without requiring documentation.		

2.0 CONCLUSION

TABLE 2.0 CONCLUSIONS SUMMARY

PARAMETER			ENG. UNITS	VDC
S/G LEVEL	LOW TRIP		27.40 %	2.096
	ALLOWABLE VALUE		26.48 %	2.059
	PRE-TRIP ALARM		29.70 %	2.188
	HIGH TRIP		87.70 %	4.508
	ALLOWABLE VALUE		88.62 %	4.545
	PRE-TRIP ALARM		85.40 %	4.416
RCS FLOW	LOW TRIP		19.00 PSID	3.800
	ALLOWABLE VALUE		18.47 PSID	3.694
	PRE-TRIP ALARM		N/A	N/A
PZR. PRESS.(NR)	HIGH TRIP		2350.0 PSIA	4.400
	ALLOWABLE VALUE		2359.2 PSIA	4.437
	PRE-TRIP ALARM		2310.0 PSIA	4.240
PZR. PRESS. (WR)	LOW TRIP		1684.0 PSIA	3.245
	ALLOWABLE VALUE		1649.7 PSIA	3.200
	PRE-TRIP ALARM		1788.0 PSIA	3.384
CONT. PRESS.(NR)	HIGH TRIP		17.1 PSIA	3.280
	ALLOWABLE VALUE		17.4 PSIA	3.317
	PRE-TRIP ALARM		16.4 PSIA	3.187
CONT. PRESS. (WR)	HIGH TRIP		17.7 PSIA	3.360
	ALLOWABLE VALUE		18.0 PSIA	3.397
	PRE-TRIP ALARM		18.8 PSIA	3.240
S/G PRESSURE	LOW TRIP		662.0 PSIA	3.207
	ALLOWABLE VALUE		648.4 PSIA	3.162
	PRE-TRIP ALARM		720.0 PSIA	3.400
S/G D/P	HIGH TRIP		123.00 PSID	0.410
	ALLOWABLE VALUE		134.02 PSID	0.447
	PRE-TRIP ALARM		98.64 PSID	0.329
LINEAR POWER	HIGH TRIP		108.00 %	5.400
	ALLOWABLE VALUE		108.76 %	5.438
	PRE-TRIP ALARM		103.00 %	5.150
LOG POWER	HIGH TRIP		0.257 %	7.109
	ALLOWABLE VALUE		0.280 %	7.147
	PRE-TRIP ALARM		0.001 %	4.699
RWSP LEVEL	LOW TRIP		10.00 %	1.400
	ALLOWABLE VALUE		09.08 %	1.363
	PRE-TRIP ALARM		15.00 %	1.600

2.1.6 WIDE RANGE CONTAINMENT PRESSURE

59.00 % SPAN
3.360 VOLTS DC
17.7 PSIA

2.1.7 LOW STEAM GENERATOR PRESSURE

55.17 % SPAN
3.207 VOLTS DC
662.0 PSIA

2.1.8 STEAM GENERATOR DIFFERENTIAL PRESSURE

10.25 % SPAN
0.410 VOLTS DC
123.0 PSID

2.1.9 LINEAR POWER

54.00 % SPAN
5.400 VOLTS DC
108.0 % POWER

2.1.10 LOG POWER

71.09 % SPAN
7.109 VOLTS DC
-0.590 LOG % POWER
0.257 % POWER

2.1.11 REFUELING WATER STORAGE POOL LEVEL

10.00 % SPAN
1.400 VOLTS DC
10.00% LEVEL

2.2.6 WIDE RANGE CONTAINMENT PRESSURE

59.92 % SPAN
3.397 VOLTS DC
18.0 PSIA

2.2.7 LOW STEAM GENERATOR PRESSURE

54.03 % SPAN
3.162 VOLTS DC
648.4 PSIA

2.2.8 STEAM GENERATOR DIFFERENTIAL PRESSURE

11.17 % SPAN
0.447 VOLTS DC
134.0 PSID

2.2.9 LINEAR POWER

54.38 % SPAN
5.438 VOLTS DC
108.76 % POWER

2.2.10 LOG POWER

71.47 % SPAN
7.147 VOLTS DC
-0.552 LOG % POWER
0.280 % POWER

2.2.11 REFUELING WATER STORAGE POOL LEVEL

9.08 % SPAN
1.363 VOLTS DC
9.08 % LEVEL

2.3.6 WIDE RANGE CONTAINMENT PRESSURE

56.00 % SPAN
3.240 VOLTS DC
16.8 PSIA

2.3.7 LOW STEAM GENERATOR PRESSURE

60.00 % SPAN
3.400 VOLTS DC
720.0 PSIA

2.3.8 STEAM GENERATOR DIFFERENTIAL PRESSURE

8.22 % SPAN
0.329 VOLTS DC
98.6 PSID

2.3.9 LINEAR POWER

51.50 % SPAN
5.150 VOLTS DC
103.00 % POWER

2.3.10 LOG POWER

46.99 % SPAN
4.699 VOLTS DC
-3.000 LOG % POWER
0.001 % POWER

2.3.11 REFUELING WATER STORAGE POOL LEVEL

15.00 % SPAN
1.600 VOLTS DC
15.0 % LEVEL

2.4 CHANNEL SUMMARY (continued)

2.4.7 LOW STEAM GENERATOR PRESSURE

SUMMARY					
PPS Input Range	:	1.000	to	5.000	vDC
Loop Span	:	0.00	to	100	% SPAN
Transmitter Span	:			1200.0	PSIA

The loop errors for Steam Generator Pressure Loops A, B, C and D are as follows:

REF PPSo	=	±	1.28	% SPAN
NOR PPSo	=	+	1.85	% SPAN
		–	1.78	% SPAN
ACC PPSo	=	+	6.44	% SPAN
		–	5.82	% SPAN

The setpoints for these instrument loops are:

	VALUE % SPAN	VOLTS (VDC)	EU PSIA
Trip/Actuation Setpoint	55.17	3.207	662.0

The allowable values for these instrument loops are:

	VALUE % SPAN	VOLTS (VDC)	EU PSIA
Allowable Value	54.03	3.162	648.4

The pretrip setpoint for these instrument loops are:

	VALUE % SPAN	VOLTS (VDC)	EU PSIA
Pretrip Setpoint	60.00	3.400	720.0

2.6 ANALYSIS SETPOINT SUMMARY

PARAMETER	LIMITING ACCIDENT	ANALYSIS SETPOINT
Low S/G Level	MSLB	5% Level
High S/G Level	N/A	90% Level
Low Reactor Coolant Flow	MSLB with LOOP	70% Flow
High Pressurizer Pressure	FWLB	2422 PSIA
Low Pressurizer Pressure	LOCA, CEA Ejection	1560 PSIA
High Containment Pressure	MSLB	19.7 PSIA
High-High Cont. Pressure	MSLB, LOCA	19.7 PSIA
Low S/G Pressure	MSLB, FWLB	576 PSIA
High S/G Delta Pressure	MSLB	230 PSID
High Linear Power Level	MSLB	115% Power
High Logarithmic Power	CEA Withdrawal	0.760% Power [5.20]
Low RWSP Level	LOCA	7.00% Level [4.17]

3.0 REFERENCES (continued)

3.39 Letter C. Sweeney (EBASCO) to W. Mawhinney (CE), LW3-1434-77, dated 7/22/77 "LOUISIANA POWER & LIGHT COMPANY WATERFORD SES UNIT NO. 3 CONTAINMENT OVER-PRESSURE ANALYSIS".

3.40 CE Interoffice Correspondence M. F. Strollo to R. O. Allen, C-PSAE-82-020, dated July 22, 1982, "Steam Generator Low Level Setpoint Used In Waterford-3 FSAR".

3.41 CE Interoffice Correspondence M. F. Strollo to R. O. Allen, C-PSAE-82-016, dated June 30, 1982, "Setpoint and Response Time Used in the Chapter 15 Analysis for Waterford-3 FSAR".

3.42 CE Interoffice Correspondence C. R. Lehmann to R. O. Allen, C-TM-034, dated November 4, 1981, "Analysis Setpoints and Response Times".

3.43 CE Interoffice Correspondence M F. Strollo to R. O. Allen, C-PSS-81-020, dated November 10, 1981, "Setpoints and Operability Time Requirements used in Chapter 15 Analysis for Waterford-3 FSAR".

3.44 CE Interoffice Correspondence F. K. Chiang to R. O. Allen, C-LOCA-81-017, dated November 9, 1981, "Waterford Unit 3 ECCSA'S Data Response for Setpoint Analysis".

3.45 CE Interoffice Correspondence R. L. Kim to E. Anavim, C-PSAE-82-040, dated November 18, 1982, "Revised Waterford Unit 3 RPS Requirements for SLB and FWLB Events".

3.46 CE Interoffice Correspondence W. G. Dove to R. O. Allen, C-PSA-261, dated March 28, 1983, "Waterford Plant: MSLB Containment Temperatures @ 6.5 psig (512962)".

3.47 Louisiana Power & Light Co. Waterford SES Unit No. 3 drawing LOU-5817, 075A, "Line List Document Revision 19 Page 172".

3.48 ENTERGY Inter-Office Correspondence J. B. Holman to R. H. O'Donnell, W3C1-93-0024, dated July 15, 1993, "Post-MSLB Reference Leg Water Temperature".

3.49 ABB/CE Calculation 9270-ICE-36182, Rev. 2, PPS Setpoint Analysis

3.50 ECI01-006, Rev. 0, Determination of Secondary Systems Measurement Channels Functional Safety Significance.

3.51 Letter PO-95-281 from ABB/CE to J.P. Johnson dated May 19, 1995 "ESR 95-004, Design Basis for RAS Response Time and Setpoint"

3.52 Calculation EC-M91-011 Revision 0 "NPSH for Safeguard Pumps in Recirculation Mode with Valve SI-106A(B) Failed Open"

7.7 STEAM GENERATOR PRESSURE (continued)

The output uncertainty terms for the bistable (PPSo) and the variable setpoint card after the transmitter and the PAC are given as follows.

REF PPSo = ± (PACo^2 + ePPS^2 + ePPV^2)^0.5
= ± 1.28 % SPAN

NOR PPSos = ± (PACo^2 + ePPS^2 + ePPV^2)^0.5
= ± 1.63 % SPAN

NOR PPSo = ± PPSos + ePPSb + ePPVb
= ± 1.63 % SPAN + 0.07 % SPAN

ACC PPSos = ± (PACos^2 + ePPS^2 + ePPV^2)^0.5
= ± 5.82 % SPAN

ACC PPSo = ± ACC PPSos + IRb + ACC ePPSb + ACC ePPVb
= ± 5.82 % SPAN + 0.63 % SPAN

The periodic test error includes the bistable card uncertainties and the variable setpoint card uncertainties.

PERIODIC TEST ERROR = ± (PPS(RA) ^2 + PPS(MTE)^2 + PPS(DR)^2+ PPV(RA)^2 + PPV(MTE)^2 + PPV(DR)^2)^0.5

PTE = ± 1.14 % SPAN

7.7 STEAM GENERATOR PRESSURE (continued)

7.7.3 Calculated Trip Setpoint and Allowable Value

The purpose of the low steam generator pressure function is to provide a reactor trip to assist the ESF system in a Steam Line Break event.

The reactor trip and main steam isolation functions are credited with limiting the consequences of the Steam line break, feedwater line break with or without loss of AC, and Steam Bypass Malfunction event.

The limiting analysis setpoint of 576 psia (48.00% span) from Reference 3.50 is used as the basis for the following setpoint determinations.

The low S/G pressure setpoint is a variable setpoint. This means that the setpoint is automatically set to a certain step value below actual S/G pressure. As S/G pressure increases, the variable trip setpoint is increased to maintain the adjusted step difference up to a calibrated maximum setpoint. At this point, further increases in S/G pressure do not affect the trip / actuation setpoint. This maximum trip setpoint is the value that is calculated / determined below.

7.7.3.1 Trip/Actuation Setpoint

To determine the most conservative uncertainty, the positive bias error is added to the highest analysis low setpoint:

PPS Trip/Actuation Setpoint = PPS/ESFAS Analysis Setpoint + ACC PPSo
= 48.00 % SPAN + 6.44 % SPAN
= 54.44 % SPAN

The PPS Trip/Actuation Setpoint for Low S/G Pressure must therefore be set at a value greater than or equal to 653.28 PSIA (54.44%). The setpoint is set at 662 psia (55.17%).

PPS Trip/Actuation Setpoint = 55.17 % SPAN

7.7 STEAM GENERATOR PRESSURE (continued)

7.7.3.2 Allowable Value

PPS Allowable Value	= Trip/Actuation Setpoint - PPS PTE				
	=	55.17	% SPAN	- 1.14	% SPAN
	=	54.03	% SPAN		

7.7.3.3 Alarm Setpoints

There are no safety analysis requirements for the pretrip (alarm) setpoints. The following value may be changed as required, provided that Section 7.7.5 (below) is considered in the change process. The pretrip (alarm) setpoint is chosen to retain the original offset of 58 psi from the trip setpoint provided by Reference 3.49.

PPS Alarm Value	= Trip/Actuation Setpoint + 58 PSI				
	=	55.17	% SPAN	+4.84	% SPAN
	=	60.00	% SPAN		

7.7.4 Voltage Equivalents for Setpoints and Allowable Values

The PPS Cabinet input ranges from	1.000	to	5.000	vDC
Equivalent process range	0.00	to	100	% SPAN

Based on these end points the following equation is derived:

$$V = (\%\ SPAN / 25.00) + 1.00$$

	Value		Voltage	
PPS Trip/Actuation Setpoint	55.17	%	3.207	volts
Allowable Values	54.03	%	3.162	volts
Pretrip Setpoint	60.00	%	3.400	volts

7.7.5 Basis for Variable Setpoint Step Value

There are four design considerations that need to be accommodated in the selection of the Low S/G Pressure Variable Setpoint Step Value. These considerations are discussed below, then the overall design basis for the selected step value is presented.

7.7 STEAM GENERATOR PRESSURE (continued)

variations during both startup and normal operations. Since the existing step value of 184 PSIA reflects the current field setting, the years of operating history show that a step value of 184 PSIA is within the range of adjustment of the equipment. Therefore, a step value of 184 PSIA satisfies the requirements of DC1 and DC4.

In simulator runs and drills, operators have been trained to respond to Design Basis Accidents, including SGTR events. During recovery from an SGTR, operators are alerted to manually reduce the Low S/G Pressure setpoint upon actuation of the Pretrip alarm, which first actuates at 720 PSIA. At this time, S/G pressure is at 720 PSIA, so the trip setpoint is reduced to a value 184 PSIA below the existing S/G pressure, or 536 PSIA. Coincident with the setpoint reduction, the pretrip value is also reduced to 594 PSIA maintaining the normal differential between the pretrip setpoint and the trip setpoint of 58 PSIA. As the rapid cooldown (to below 500°F) continues, eventually the reduced pretrip setpoint (594 PSIA) will be reached, and its actuation will again prompt the operator to manually reduce the variable setpoint. At this point the reduced trip setpoint will be 410 PSIA and the reduced pretrip setpoint will be 468 PSIA. The saturation temperature for 468 PSIA is approximately 460°F so the operator can cooldown to 460°F with only two setpoint reductions and without constant attention (due to the prompting by the pretrip alarm). Since this is the limiting scenario, the preceding discussion illustrates that the existing step value satisfies the requirements of DC3.

In summary, the existing step value (184 PSI) satisfies the requirements of DC1, DC3, and DC4, while administrative controls are in place to minimize the significance of DC2. In addition, the existing step value is consistent with the value stated in Technical Specification Table 2.2-1, ≤ 200 PSI. Therefore, the existing step value of 184 PSIA is appropriately chosen.

7.7.6 Basis for Variable Setpoint Minimum Trip Setting

Accident analyses credit the MSIS ESFAS function throughout the range of S/G pressures (from 0 to 1200 PSIA and from 1200 to 0 PSIA). Therefore, the minimum trip setpoint is set outside the range, i.e. less than 0 PSIA. Setting the minimum trip value less than 0 PSIA ensures that the minimum trip setting will not affect operation of the MSIS function at any time. Therefore the existing minimum trip value of "less than zero" PSIA is appropriately chosen.

7.7 STEAM GENERATOR PRESSURE (continued)

7.7.7 Basis for "Variable Setpoint Low" Annunciator Setpoint

Since the Low S/G Pressure Trip / Actuation Setpoint is a variable setpoint that is automatically increased as S/G pressure increases, an annunciator has been provided to alert the operator if the tracking function should fail. This avoids the need for constant operator attention to the setpoint indicators to ensure that the setpoint is tracking properly. Note that the setpoint is a differential setpoint that is actuated by an adjusted deviation between S/G pressure and the Low S/G Pressure Trip / Actuation setting. Three design considerations form the basis for the setting of the "Variable Setpoint Low" annunciator. These are described below as DC1 and DC2, and DC3.

Design Consideration 1 (DC1):

The trip setting tracks the increasing S/G pressure by an amount equal to the step value (184 PSIA) plus or minus some variation due to equipment uncertainty. To prevent operation of the Low Setpoint Annunciator when there is no equipment malfunction, the step value provides the basis for the minimum annunciator setting. That is, the annunciator setpoint should be set greater than 184 PSIA deviation.

Design Consideration 2 (DC2):

The minimum annunciator setting is also based on avoiding annunciator actuation during startup or normal operations. The maximum setting of the Low S/G Pressure Trip Bistable is 662 PSIA (Reference Section 7.7.3.1 above). The maximum S/G pressure during startup or normal operations is approximately 1000 PSIA (Reference 3.58). To avoid annunciator actuation at 1000 PSIA, the Low Setpoint Annunciator setting must be greater than the difference between 1000 PSIA and the maximum trip setpoint (662 PSIA). Therefore the annunciator setpoint must be greater than 338 PSIA deviation.

7.7 STEAM GENERATOR PRESSURE (continued)

Design Consideration 3 (DC3):

The Low Annunciator Setpoint should be low enough that a faulty tracking function is detected before the deviaiton between the trip setpoint and S/G pressure becomes large enough to compromise the protective actions.

Basis Summary:

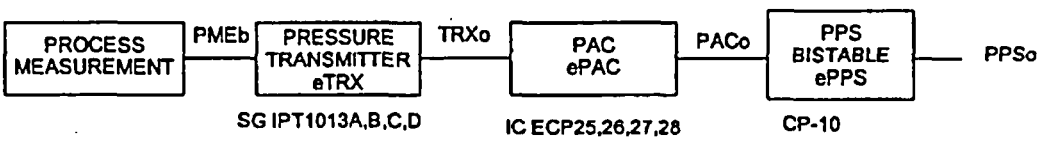
Based on DC1, DC2, and DC3, the Low Annunciator setpoint should meet the following criteria:

- Setpoint must be >184 PSI deviation (from DC1).
- Setpoint must be >338 PSI deviation (from DC2).
- Setpoint should be small enough that a malfunction is detected in a timely manner to ensure continuous protection (from DC3).

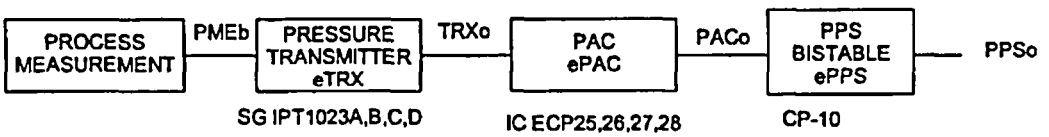
Evaluating the existing Low Annunciator setting (301 PSIA deviation between S/G pressure and the current setting of the trip / actuation setpoint) against the design considerations shows that DC1 is satisfied but DC2 is not. Therefore, the existing Low Annunciator setting of 301 PSI deviation is not adequate. The setpoint should be changed to 345 PSI deviation to satisfy DC1, DC2 and DC3.

Section 7.7 of Calculation EC-I92-019, Revision 3

7.7 STEAM GENERATOR PRESSURE



BLOCK DIAGRAM
STEAM GENERATOR No. 1 PRESSURE LOOPS A, B, C, and D



BLOCK DIAGRAM
STEAM GENERATOR No. 2 PRESSURE LOOPS A, B, C, and D

7.7 STEAM GENERATOR PRESSURE (continued)

7.7.1 Functional Description

The Steam Generator Pressure function of the Plant Protection System (PPS) provides a reactor trip on Low Steam Generator Pressure.

During plant cooldown the Low Steam Generator Pressure trip setpoint can be manually decreased to 200 PSI below the existing pressure. During plant startup the setpoint is automatically increased and remains 200 PSI below steam generator pressure.

The Steam Generator Pressure transmitter is calibrated from 0 to 1200 PSIA and outputs a 4 to 20 maDC signal proportional to the process variable. A 250 ohm resistor develops a 1 to 5 vDC signal for input to the PPS bistable.

The most limiting accident condition (ACC) for a low steam generator pressure trip is a Steam Line Break (SLB).

7.7 STEAM GENERATOR PRESSURE (continued)

7.7.2 Process Measurement Errors and Instrument Uncertainties

7.7.2.1 Process Measurement Error

The process measurement error is attributed to the vertical section of the water-filled sensing line between the process tap and the pressure transmitter. The transmitters are located below the process taps. Reference 3.24 calculates the transmitter calibration based on the sensing line head above the transmitter at a temperature of 120 °F. A change in ambient temperature causes a change in sensing line temperature and density.

The process measurement error is calculated for transmitter SGIPT1013B & D which has the largest vertical distance between tap and transmitter. This will result in the most conservative error. The density of water in the sensing line during accident conditions is at the temperatures indicated and a pressure corresponding to an analytical setpoint of 675 PSIA.

SPAN	:	1200.00	PSI	[3.11]
SENSING LINE HEIGHT	:	38.1	FEET	[3.24]
CALIBRATION TEMPERATURE	:	120.00	deg F	[3.24]
S.G. @ CAL TEMP	:	0.9901		[3.24]
DENSITY @ CAL TEMP (Dc)	:	61.73	Lbm/Ft^3	[4.16]
NORMAL TEMPERATURE	:	120.00	deg F	[3.24]
ACC TEMP (SLB)	:	350.00	deg F	[4.20]
DENSITY @ NOR TEMP (Dn)	:	61.73	Lbm/Ft^3	
DENSITY @ SLB TEMP (Da)	:	55.74	Lbm/Ft^3	[3.9]
STATIC HEAD (h)	:	16.35	PSI	[3.24]
TEMPERATURE EFFECT	:	h(Da-Dc)/Dc	PSI	[3.1]
NOR TEMP EFF (TE)	:	0.00	PSI	
ACC TEMP EFF-SLB (ATE)	:	- 1.58	PSI	

7.7 STEAM GENERATOR PRESSURE (continued)

The process measurement errors during accident temperatures are as follows:

ACC SLB PMEb = (ATE/SPAN)*100%
= - 0.13 % SPAN

Since the Trip/Actuation Setpoint is a "low" setpoint, only the positive errors are applicable. Therefore, ACC PME will have no effect upon the Trip/Actuation setpoint and need not be considered.

TRANSMITTER

TAG NUMBER	:	SG IPT1013A, B, C, D SG IPT1023A, B, C, D		[3.2, 3.10]
MANUFACTURER	:	ROSEMOUNT		[3.2]
MODEL NUMBER	:	1154SH9		[3.2]
UPPER RANGE LIMIT (URL)	:	3000.00	PSIA	[3.3b]
SPAN	:	1200.00	PSIA	[3.10]
AMB CAL TEMPERATURE	:	65.00	deg F	[3.6]
AMB NOR TEMPERATURE	:	120.00	deg F	[3.8]
AMB ACC (SLB) TEMP	:	350.00	deg F	[4.20]
REF ACCURACY (RA)	:±	0.25	%	[3.3b]
DRIFT (DR)	:±	0.20	% URL	[3.3c]
DR (for 22.5 mo.)	:±	0.50	%	[4.4]
CALIBRATION EFF (CAL)	:±	0.25	%	[3.24]
M&TE EFFECT (MTE)	:±	0.14	%	[4.13]
NOR TEMP EFF (TE)	:±	(0.15%URL+0.35%SPAN)/50 °F		[3.3b]
TE	:±	0.80	%	
ACC TEMP EFF (ATE)	:±	(2.0%URL+0.5%SPAN)		[3.3b]
ATE	:±	5.50	%	
POWER SUPPLY EFF (PS)	:±	N/A		[5.3]
POST-SEISMIC (PSE)	:±	0.50	% URL	[3.3b]
PSE	:±	1.25	%	
ACC RAD EFF (ARE)	:±	(0.5%URL+1.0%SPAN)		[3.3b]
ARE	:±	N/A		[5.11]

7.7 STEAM GENERATOR PRESSURE (continued)

The transmitter uncertainties (eTRX) for Reference (REF), Normal (NOR) and Accident (ACC) conditions are given as follows:

REF eTRX = ± (CAL + MTE) = ± 0.39 % SPAN

NOR eTRX = ± ((CAL + MTE)^2 + DR^2 + TE^2)^0.5
= ± 1.02 % SPAN

ACC eTRX = ± ((CAL + MTE)^2 + DR^2 + ATE^2 + PSE^2)^0.5
= ± 5.68 % SPAN

The output uncertainty terms for the Transmitter (TRXo) for Reference (REF), Normal (NOR) and Accident (ACC) are as follows:

REF TRXo = ± REF eTRX = ± 0.39 % SPAN

NOR TRXo = ± NOR eTRX = ± 1.02 % SPAN

ACC TRXo = ± ACC eTRX = ± 5.68 % SPAN

INSULATION RESISTANCE

The transmitter is located within the containment building, and as such, the effects of harsh environment on loop signal cabling must be considered. The accident environment effect is considered for cabling from the transmitter through the containment electrical penetrations. The most conservative of the loops (P1013D) is used in determining the IR effects.

CABLE LENGTH/MFG	:	220	FT/SAMUEL MOORE	[3.5]
IRb	: +	0.51	% SPAN	[3.4]

7.7 STEAM GENERATOR PRESSURE (continued)

PAC CABINET

TAG NUMBER	:	SG IPCI1013A,B, C, D SG IPCI1023A,B, C, D		[3.10]
MANUFACTURER	:	WESTINGHOUSE		
MODEL	:	2837A86G03		
DESCRIPTION	:	250.00	ohm RESISTOR	
AMB CAL TEMP (AMB)	:	70.00	deg F	[5.2]
MAX NOR TEMP (NOR)	:	110.00	deg F	[5.2]
MAX ACC TEMP (ACC)	:	110.00	deg F	[5.2]
DT (NOR-AMB)	:	40.00	deg F	
REFERENCE ACCURACY (RA)	: +	0.075	OHMS	[3.16.a]
RA	: +	0.0375	% SPAN (NEGLIGIBLE)	
TEMP COEFF (TE)	: ±	3.00	ppm/deg C	[5.8]
TE	: ±	0.0083	% SPAN (NEGLIGIBLE)	[4.18]
STABILITY (DRIFT)	: ±	35.00	ppm/year	[5.8]
DR (for 22.5 mo.)	: ±	0.0082	% SPAN (NEGLIGIBLE)	[4.19]
M & TE (MTE)	: ±	0.072	% SPAN	[4.7]

RA, TE and DR for PAC are < 0.05% and considered negligible per ASSUMPTION 5.1. The total PAC uncertainty (ePAC) consists of MTE.

REF ePAC = ± (RA + MTE) = ± 0.072 % SPAN

NOR ePAC = ± ((RA + MTE)^2 + DR^2 + TE^2)^0.5
= ± 0.072 % SPAN

ACC ePAC = ± ((RA + MTE)^2 + DR^2 + TE^2)^0.5
= ± 0.072 % SPAN

7.7 STEAM GENERATOR PRESSURE (continued)

The output uncertainty terms for the PAC (PACo) after the transmitter is given as follows:

REF PACo = ± ((REF TRXo)^2 + (REF ePAC)^2)^0.5
= ± 0.39 % SPAN

NOR PACo = ± ((NOR TRXo)^2 + (NOR ePAC)^2)^0.5
= ± 1.02 % SPAN

ACC PACos = ± ((ACC TRXos)^2 + (ACC ePAC)^2)^0.5
= ± 5.68 % SPAN

ACC PACo = ± ACC PACos + IRb
= ± 5.68 % SPAN + 0.51 % SPAN

7.7 STEAM GENERATOR PRESSURE (continued)

LOW STEAM GENERATOR PRESSURE TRIP BISTABLE

MODEL NUMBER		26440			[3.17]
FULL RANGE	0.00	to	10.00	vDC	[3.17]
INPUT RANGE	1.00	to	5.00	vDC	
SPAN		4.00	vDC		
LINEARITY (LA)	: ±	25.00	mV		[3.17]
LA	: ±	0.63	% SPAN		
REPEATABILITY (RP)	: ±	0.25	% FULL SCALE		[3.17]
RP	: ±	0.63	% SPAN		
RESOLUTION (RL)	: ±	1.00	mV		[3.17]
RL	: ±	0.03	% SPAN (NEGLIGIBLE)		
M & TE EFFECT(MTE)	: ±	0.10	% SPAN		[5.9]
DRIFT (DR):	: ±	9.1	mV / 39 days		[3.17]
(105 DAYS)	: ±	0.23	% SPAN		[4.4]

REFERENCE ACCURACY (RA) = ± (LA^2 + RP^2 + RL^2)^0.5

RA	= ±	0.88	% SPAN	

WORST CASE NORMAL TEMPERATURE EFFECT (± TE + TEb):

(for a temperature shift of 20 deg F)				[5.10]
TE	= ±	2.81	mV	[3.17]
	= ±	0.070	% SPAN	
TEb	= +	0.84	mV	[3.17]
	= +	0.02	% SPAN	

The Bistable Comparator Card uncertainties (ePPS) for the Reference (Ref), Normal (Nor), and Accidents (ACC) conditions are as follows:

REF ePPS = ± (RA + MTE)	= ±	0.98	% SPAN
NOR ePPS = ± ((RA + MTE)^2 + DR^2 +TE^2)^0.5			
	= ±	1.01	% SPAN
NOR ePPSb = + TEb	= +	0.02	% SPAN
ACC ePPS = ± ((RA + MTE)^2 + DR^2 +TE^2)^0.5			
	= ±	1.01	% SPAN
ACC ePPSb = + TEb	= +	0.02	% SPAN

7.7 STEAM GENERATOR PRESSURE (continued)

LOW STEAM GENERATOR PRESSURE VARIABLE SETPOINT CARD

MODEL NUMBER		26480			[3.17]
FULL RANGE	0.00	to	10.00	vDC	[3.17]
INPUT RANGE	1.00	to	5.00	vDC	
SPAN		4.00	vDC		
ACCURACY (AC)	: ±	25.00	mV		[3.17]
AC	: ±	0.63	% SPAN		
RESOLUTION (RL)	: ±	2.00	mV		[3.17]
RL	: ±	0.05	% SPAN		
M & TE EFFECT(MTE)	: ±	0.10	% SPAN		[5.9]
DRIFT (DR):	: ±	9.1	mV / 39 days		[3.17]
(105 DAYS)	: ±	0.23	% SPAN		[4.4]

REFERENCE ACCURACY (RA) = ± (AC^2 + RL^2)^0.5

RA	= ±	0.63	% SPAN

WORST CASE NORMAL TEMPERATURE EFFECT (± TE + TEb):

(for a temperature shift of 20 deg F)				[5.10]
TE	= ±	3.23	mV	[3.17]
	= ±	0.08	% SPAN	
TEb	= +	1.88	mV	[3.17]
	= +	0.05	% SPAN	

The Variable Setpoint Card uncertainties (ePPV) for the Reference (Ref), Normal (Nor), and Accidents (ACC) conditions are as follows:

REF ePPV = ± (RA + MTE)	= ±	0.73	% SPAN
NOR ePPV = ± ((RA + MTE)^2 + DR^2 +TE^2)^0.5			
	= ±	0.77	% SPAN
NOR ePPVb = + TEb	= +	0.05	% SPAN
ACC ePPV = ± ((RA + MTE)^2 + DR^2 +TE^2)^0.5			
	= ±	0.77	% SPAN
ACC ePPVb = + TEb	= +	0.05	% SPAN

7.7 STEAM GENERATOR PRESSURE (continued)

The output uncertainty terms for the bistable (PPSo) and the variable setpoint card after the transmitter and the PAC are given as follows.

REF PPSo = ± (PACo^2 + ePPS^2 + ePPV^2)^0.5
= ± 1.28 % SPAN

NOR PPSos = ± (PACo^2 + ePPS^2 + ePPV^2)^0.5
= ± 1.63 % SPAN

NOR PPSo = ± PPSos + ePPSb + ePPVb
= ± 1.63 % SPAN + 0.07 % SPAN

ACC PPSos = ± (PACos^2 + ePPS^2 + ePPV^2)^0.5
= ± 5.82 % SPAN

ACC PPSo = ± ACC PPSos + IRb + ACC ePPSb + ACC ePPVb
= ± 5.82 % SPAN + 0.63 % SPAN

The periodic test error includes the bistable card uncertainties and the variable setpoint card uncertainties.

PERIODIC TEST ERROR = ± (PPS(RA) ^2 + PPS(MTE)^2 + PPS(DR)^2+ PPV(RA)^2 + PPV(MTE)^2 + PPV(DR)^2)^0.5
PTE = ± 1.18 % SPAN

7.7 STEAM GENERATOR PRESSURE (continued)

7.7.3 Calculated Trip Setpoint and Allowable Value

The purpose of the low steam generator pressure function is to provide a reactor trip to assist the ESF system in a Steam Line Break event.

The reactor trip and main steam isolation functions are credited with limiting the consequences of the Steam line break, feedwater line break with or without loss of AC, and Steam Bypass Malfunction event.

The limiting FSAR Chapter 15 safety analysis setpoints for the Low Steam Generator Pressure are: a reactor trip and ESFAS actuation at 675 PSIA (56.25% SPAN) for Steam Line Break with or without Loss of Offsite AC and ESFAS at 675 PSIA (56.25% SPAN) for Feedwater Line Break. FSAR Chapter 6 Mass and Energy Release Analysis (for peak containment pressure) for Postulated Secondary System Pipe Ruptures Inside Containment uses an analysis setpoint of 678 PSIA. As this is the most limiting analysis setpoint, 678 PSIA is used as the basis for the following setpoint determinations. These setpoints are taken from References 3.43 and 3.50.

The low S/G pressure setpoint is a variable setpoint. This means that the setpoint is automatically set to a certain step value below actual S/G pressure. As S/G pressure increases, the variable trip setpoint is increased to maintain the adjusted step difference up to a calibrated maximum setpoint. At this point, further increases in S/G pressure do not affect the trip / actuation setpoint. This maximum trip setpoint is the value that is calculated / determined below.

7.7.3.1 Trip/Actuation Setpoint

To determine the most conservative uncertainty, the positive bias error is added to the highest analysis low setpoint:

PPS Trip/Actuation Setpoint = PPS/ESFAS Analysis Setpoint + ACC PPSo
= 56.50 % SPAN + 6.44 % SPAN
= 62.94 % SPAN

The PPS Trip/Actuation Setpoint for Low S/G Pressure must therefor be set at a value greater than or equal to 755.28 PSIA (62.94%). The setpoint is set at 764 PSIA (63.67%) Decreasing to retain the existing Technical Specification Setpoint.

PPS Trip/Actuation Setpoint = 63.67 % SPAN

7.7 STEAM GENERATOR PRESSURE (continued)

7.7.3.2 Allowable Value

PPS Allowable Value	= Trip/Actuation Setpoint - PPS PTE				
	=	63.67	% SPAN	- 1.18	% SPAN
	=	62.49	% SPAN		

7.7.3.3 Alarm Setpoints

There are no safety analysis requirements for the pretrip (alarm) setpoints. The following value may be changed as required, provided that Section 7.7.5 (below) is considered in the change process. The pretrip (alarm) setpoint is chosen to reflect current field settings, originally provided by Reference 3.49.

Alarm Setpoint	=	68.50	% SPAN

7.7.4 Voltage Equivalents for Setpoints and Allowable Values

The PPS Cabinet input ranges from	1.000	to	5.000	vDC
Equivalent process range	0.00	to	100	% SPAN

Based on these end points the following equation is derived:

$$V = (\%\ SPAN / 25.00) + 1.00$$

	Value		Voltage	
PPS Trip/Actuation Setpoint	63.67	%	3.547	volts
Allowable Values	62.49	%	3.500	volts
Pretrip Setpoint	68.50	%	3.740	volts

7.7.5 Basis for Variable Setpoint Step Value

There are four design considerations that need to be accommodated in the selection of the Low S/G Pressure Variable Setpoint Step Value. These considerations are discussed below, then the overall design basis for the selected step value is presented.

7.7 STEAM GENERATOR PRESSURE (continued)

Design Consideration 1 (DC1):

It is imperative that the step value be large enough that normal (expected) S/G pressure variations (decreases) during either startup or normal operations will not cause unnecessary protective system alarms, trips, or actuations.

Design Consideration 2 (DC2):

It is desirable that the step value magnitude be limited such that the trip setpoint would not be reduced below the Tech Spec Allowable Value, if the Reset button were depressed during Normal Operating Conditions.

Design Consideration 3 (DC3):

The design of the variable setpoint is such that the setpoint is automatically increased as S/G pressure increases up to a maximum adjustable setpoint. However, when S/G pressure is decreasing, the setpoint must be manually reset. This is accomplished by manually depressing a Reset button which reduces the variable trip setpoint to a value equal to the current S/G pressure minus the magnitude of the adjusted step value. This action can be repeated as necessary to preserve MSIS protection while decreasing S/G pressure during a shutdown. The magnitude of the step value determines how often (how many times) the setpoint must be manually reset during shutdown / depressurization. The impact of this required action on operators must be considered when choosing the step value.

Design Consideration 4 (DC4):

The selected step value must be within the adjustment range of the equipment.

Overall Design Basis:

A review of the four design considerations listed above indicates that DC1 and DC4 must be fully accommodated in the selected step value, while DC2 and DC3 require further evaluation.

DC2 is desirable, but not mandatory, since administrative controls are in place to ensure that inadvertent lowering of the Low S/G pressure setpoint (by depressing the Reset button) is detected / avoided. These administrative controls include procedure steps and channel checks of the trip setpoint

7.7 STEAM GENERATOR PRESSURE (continued)

indicators. Procedural steps in both Operations and Maintenance surveillance procedures return the variable trip setpoint to its maximum value following performance of these procedures. It is generally agreed that the procedural controls will prevent inadvertent operation with reduced setpoints. This is further assured by performance of channel checks of the setpoint indicators, which would clearly indicate if reduced setpoints were in effect during normal operation. Based on this discussion, the significance of DC2 is minor.

DC3 is most significant during EOP situations, namely following a Steam Generator Tube Rupture (SGTR) accident. After the affected S/G is identified and isolated, only one S/G is available as a heat sink for RCS cooldown / depressurization. It is critical that this heat sink be available to allow the optimum cooldown method. A MSIS at this time would require a less desirable cooldown method / scenario. Therefore, as the unaffected S/G pressure decreases (as a result of the RCS cooldown), the Low S/G Pressure setpoint must be manually reduced by depressing the Reset button. As the RCS continues to cooldown (rapidly) to ≈ 500 °F (Reference 3.59), the setpoint may have to be reduced again and again to avoid MSIS actuation. Because of the demands on operator attention that would exist in the control room following any accident, the number of times the Operators must perform this setpoint reduction should be minimized. Therefore the step value should be large enough to avoid the need for constant attention and action by the operators in this, or any similar circumstances. Proper selection of the step value in conjunction with the selected pretrip value can accommodate these objectives and trigger operator action to manually reduce the Low S/G Pressure setpoint, thus avoiding the need for continuous operator attention. The trigger is the actuation of the pretrip alarm (see below).

Basis Summary

Since DC2 would dictate a very small step value and DC3 would be better served with a larger step value, some balance must be reached. Since DC2 has been evaluated to have only minor significance, DC3 considerations should prevail. The existing step value of 184 PSIA shall be evaluated in light of DC1, DC3, and DC4.

Years of operating experience have shown that the existing step value (184 PSIA) is large enough to avoid unwanted protective actions due to pressure

7.7 STEAM GENERATOR PRESSURE (continued)

variations during both startup and normal operations. Since the existing step value of 184 PSIA reflects the current field setting, the years of operating history show that a step value of 184 PSIA is within the range of adjustment of the equipment. Therefore, a step value of 184 PSIA satisfies the requirements of DC1 and DC4.

In simulator runs and drills, operators have been trained to respond to Design Basis Accidents, including SGTR events. During recovery from an SGTR, operators are alerted to manually reduce the Low S/G Pressure setpoint upon actuation of the Pretrip alarm, which first actuates at 822 PSIA. At this time, S/G pressure is at 822 PSIA, so the trip setpoint is reduced to a value 184 PSIA below the existing S/G pressure, or 638 PSIA. Coincident with the setpoint reduction, the pretrip value is also reduced to **!Undefined Bookmark, RT** PSIA maintaining the normal differential between the pretrip setpoint and the trip setpoint of 58 PSIA. As the rapid cooldown (to below 500°F) continues, eventually the reduced pretrip setpoint (696 PSIA) will be reached, and its actuation will again prompt the operator to manually reduce the variable setpoint. At this point the reduced trip setpoint will be 512 PSIA and the reduced pretrip setpoint will be 570 PSIA. The saturation temperature for 570 PSIA is approximately 480°F, so the operator can cooldown to 480°F with only two setpoint reductions and without constant attention (due to the prompting by the pretrip alarm). Since this is the limiting scenario, the preceding discussion illustrates that the existing step value satisfies the requirements of DC3.

In summary, the existing step value (184 PSI) satisfies the requirements of DC1, DC3, and DC4, while administrative controls are in place to minimize the significance of DC2. In addition, the existing step value is consistent with the value stated in Technical Specification Table 2.2-1, ≤ 200 PSI. Therefore, the existing step value of 184 PSIA is appropriately chosen.

7.7.6 Basis for Variable Setpoint Minimum Trip Setting

Accident analyses credit the MSIS ESFAS function throughout the range of S/G pressures (from 0 to 1200 PSIA and from 1200 to 0 PSIA). Therefore, the minimum trip setpoint is set outside the range, i.e. less than 0 PSIA. Setting the minimum trip value less than 0 PSIA ensures that the minimum trip setting will not affect operation of the MSIS function at any time. Therefore the existing minimum trip value of "less than zero" PSIA is appropriately chosen.

7.7 STEAM GENERATOR PRESSURE (continued)

7.7.7 Basis for "Variable Setpoint Low" Annunciator Setpoint

Since the Low S/G Pressure Trip / Actuation Setpoint is a variable setpoint that is automatically increased as S/G pressure increases, an annunciator has been provided to alert the operator if the tracking function should fail. This avoids the need for constant operator attention to the setpoint indicators to ensure that the setpoint is tracking properly. Note that the setpoint is a differential setpoint that is actuated by an adjusted deviation between S/G pressure and the Low S/G Pressure Trip / Actuation setting. Three design considerations form the basis for the setting of the "Variable Setpoint Low" annunciator. These are described below as DC1 and DC2, and DC3.

Design Consideration 1 (DC1):

The trip setting tracks the increasing S/G pressure by an amount equal to the step value (184 PSIA) plus or minus some variation due to equipment uncertainty. To prevent operation of the Low Setpoint Annunciator when there is no equipment malfunction, the step value provides the basis for the minimum annunciator setting. That is, the annunciator setpoint should be set greater than 184 PSIA deviation.

Design Consideration 2 (DC2):

The minimum annunciator setting is also based on avoiding annunciator actuation during startup or normal operations. The maximum setting of the Low S/G Pressure Trip Bistable is 764 PSIA (Reference Section 7.7.3.1 above). The maximum S/G pressure during startup or normal operations is approximately 1050 PSIA (Reference 3.58). To avoid annunciator actuation at 1050 PSIA, the Low Setpoint Annunciator setting must be greater than the difference between 1050 PSIA and the maximum trip setpoint (764 PSIA). Therefore the annunciator setpoint must be greater than 286 PSIA deviation.

7.7 STEAM GENERATOR PRESSURE (continued)

Design Consideration 3 (DC3):

The Low Annunciator Setpoint should be low enough that a faulty tracking function is detected before the deviaiton between the trip setpoint and S/G pressure becomes large enough to compromise the protective actions.

Basis Summary:

Based on DC1, DC2, and DC3, the Low Annunciator setpoint should meet the following criteria:

- Setpoint must be >184 PSIA deviation (from DC1).
- Setpoint must be >286 PSIA deviation (from DC2).
- Setpoint should be small enough that a malfunction is detected in a timely manner to ensure continuous protection (from DC3).

Evaluating the existing Low Annunciator setting (301 PSIA deviation between S/G pressure and the current setting of the trip / actuation setpoint) against the design considerations shows that DC1 and DC2 are satisfied. DC3 is satisfied since the existing setpoint is very near the minimum setting allowed by DC2 (>286 PSIA). Therefore, the existing Low Annunciator setting of 301 PSIA deviation is appropriately chosen.