CALCULATION COVER PAGE

☐ CALCULATION
☒ DRN

(1) DRN No. 05-3577 Page(s) 83
(2) Initiating Doc.: ER-ANO-2005-0871-000 ERCN 1
☒ DRN Superseded: DRN 05-3546
☐ DRNs Voided:
☐ Calculation Superseded/Voided:
☐ As-Built/No ICN Required
☒ Pending/ICN Required (Verify current status in IDEAS.)

(3) Reason For Pending Status: (ER, T.S., Change, etc.)
ER-ANO-2005-0871-000 ERCN #1 RAA 1/3/06

(4) Calculation No: 80-D-1083C-01
(5) Revision: 7

(6) Title: EFIC System Loop Error and Setpoint Analysis

(7) System(s): EFIC

(8) Component/Equipment Identifier:
C37-1-TDB-A25 C37-1-TDB-A35
C37-2-TDB-B25 C37-2-TDB-B35
C37-3-TDB-C45 C37-3-TDB-C55
C37-4-TDB-D45 C37-4-TDB-D55

(9) Safety Code:
☒ Yes
☐ Quality
☐ No

(10) Calc Code:
(ANO/GGNS Only)
IC

(20) Study Calc
☐ YES ☒ NO

(11) 10CFR50.59 Review:
☒ Addressed in ER-ANO-2005-0871-000 ERCN 1
☐ Attached
☐ No LBD Impact

(12) Structure: (Optional)
Bldg. NA Elev. NA
Room NA Wall NA
Coordinates: NA

(13) R-Type: TDCALC

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

(15) Keywords: EFIC, EFW, low level initiate, time delay

(19) Topical Codes: (ANO Only) INUN, SETC

REVIEWS

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Responsible Engineer	☒ Design Verifier ☐ Reviewer ☐ Checker (Only As-Built DRNs included in Revision) ☒ Comments Attached	Supervisor/Approval ☐ Comments Attached

CALCULATION REFERENCE SHEET	CALCULATION NO: CALC-80-D-1083C-01 REVISION: 7 (DRN 05-3577)

I. **DRNs INCORPORATED:**

1.NA

II Relationships:	Sht	Rev	Input Doc	Output Doc	Impact Y/N	DRN/ Tracking No.
1. ER-ANO-2005-0871-000 ERCN #1	ALL	0	☐	☒	Y	NA
2. CALC-A1-NE-2004-002	ALL	2	☐	☒	Y	NA
3. CALC-86-D-1101-01	ALL	2	☒	☒	Y	DRN 05-3578
4. CALC-A1-NE-2005-005	All	0	☒	☐		NA
5. OP-1304.098	All	016-0-0	☒	☒	Y	NA
6. OP-1304.099	All	017-0-0	☒	☒	Y	NA
7. OP-1304.100	All	015-0-0	☒	☒	Y	NA
8. OP-1304.101	All	015-0-0	☒	☒	Y	NA
9. OP-1304-145	All	028-0-0	☒	☒	Y	NA
10. OP-1304-146	All	028-0-0	☒	☒	Y	NA
11. OP-1304-147	All	027-0-0	☒	☒	Y	NA
12. OP-1304-148	All	029-0-0	☒	☒	Y	NA

III. **CROSS REFERENCES:**

1.CR-ANO-1-2005-3075

IV. **SOFTWARE USED:**

Title: Microsoft Excel Version/Release: 2002 Disk/CD No. NA

DISK/CDS INCLUDED:

Title: 80D1083C01 DRN 05-3577.xls Version/Release 0 Disk/CD No. NA

V. **OTHER CHANGES:**

ATTACHMENT 9.4 **RECORD OF REVISION**

Sheet 1 of 1

Revision	Record of Revision
0	Initial issue.
DRN 05-3577	To support ER-ANO-2005-0871-000, ERCN1, which was developed to address spurious EFIC actuations, DRN 05-3577 was issued to change CALC-80-D-1083C-01, Rev 7, to reflect an EFIC low level initiate in plant setpoint of 11.0 inches (previously 13.5 inches). In addition, the EFIC low level bistable time delay setpoint was increased from 2.0 +/- 0.5 second time delay to 9.9 +/- 0.5 seconds. The specific sections of the calculation that were affected and attached to this DRN are as follows: 5.2.0 Page 173-Changed the In-plant setpoint. 5.3.0 Page 177 and 178-Changed Assumption and Given Conditions 5.3.20, 5.3.28, 5.3.29, and 5.3.31. 5.4 Page 200-Changed the Setting Tolerance, Change to Table 5.4.4.10 (Pg. 202), Table 5.4.4.11 (Pg. 203), Table 5.4.4.13 (Pg. 204), Table 5.4.4.15 and Table 5.4.4.16 (Pg. 205), 5.4.6-Changed Time Delay (Pg. 219). 5.5.0 Page 220 and 221- Error values changed and on Page 221 the Setpont Evaluation changes to reflect the new calculated setpoint (10.42 inches), Test Error (1.08 inches), Allowable Value (9.34) inches, and the In-Plant Setpoint (11.0 inches ± 0.975 inches). 5.6.0 Pages 222 thru Page 224-Changed references 5.6.8, 5.6.11, 5.6.22, 5.6.23, 5.6.38, 5.6.39, 5.6.40, and 5.6.41. In addition, References 5.6.44 and 5.6.45 were added. Attachment 5-1- Page 225-Corrected typographical errors. 6.2.0 Page 229- In-plant setpoint change. 6.3.0 Page 232-Changed Assumption and Given Conditions 6.3.17, 6.3.20, 6.3.21, and 6.3.22. 6.4 Page 250-Changed the Setting Tolerance, Change to Table 6.4.4.10 (Pg. 252), Table 6.4.4.11 (Pg. 253), Table 6.4.4.13 (Pg. 254), Table 6.4.4.15 and Table 6.4.4.16 (Pg. 255), 6.4.5-Changed Time Delay (Pg. 256). 6.5.0 Page 257 and 258 -Error values changed and the Setpoint Evaluation changes to reflect the new calculated setpoint (9.53 inches), Test Error (1.08 inches), Allowable Value (8.45 inches) and the In-Plant Setpont (11.0 inches ± 0.975 inches). 6.6.0 Pages 259 and 260-Changed references 6.6.8, 6.6.11, 6.6.22, 6.6.23, 6.6.32, 6.6.33, 6.6.34, and 6.6.35. In addition, References 6.6.39, and 6.6.40 were added. Attachment 6.1- Page 261-Corrected typographical errors. 7.0 Page 262-Changed the discussion write up.

5.0 EFIC SYSTEM CHANNELS A & B LOW RANGE LEVEL

5.1.0 PURPOSE/SCOPE

5.1.1 PURPOSE

The purpose of this section of this calculation is to determine the accuracy of the level loops associated with the ANO-1 Emergency Feedwater Initiate and Control (EFIC) System, Channels A & B. The specific loops of interest are:

1) the SG Low Level Initiate; and
2) the Low Range Level Control.

See Figure 1 for the block diagram.

5.1.2 SCOPE

This Section is applicable to the following instrument loops:

Unit	Instrument Loop No.	Service
1	LT-2618	SGA Level
1	LT-2667	SGB Level
1	LT-2622	SGA Level
1	LT-2671	SGB Level

The errors will be calculated for the Reference, Abnormal and Accident Conditions.

The loop output error is calculated for the following output devices:

Instrument Device	Function
EFIC Channel A: C37-1-TDB-A25	SG A Low Level Initiate
EFIC Channel A: C37-1-TDB-A35	SG B Low Level Initiate
EFIC Channel B: C37-2-TDB-B25	SG A Low Level Initiate
EFIC Channel B: C37-2-TDB-B35	SG B Low Level Initiate
EFIC Channel A: C37-1-CT-A513	SG A Low Range Level
EFIC Channel A: C37-1-CT-A613	SG B Low Range Level
EFIC Channel B: C37-2-CT-B513	SG A Low Range Level
EFIC Channel B: C37-2-CT-B613	SG B Low Range Level

5.2.0 INTRODUCTION

The ANO-1 Emergency Feedwater Initiation and Control (EFIC) System is an instrumentation system that monitors selected plant conditions and automatically initiates the Emergency Feedwater (EFW) System upon detection of abnormal conditions. The EFW System is required for the accident analysis of Loss of Feedwater for EFW Sizing (Ref. 5.6.16), Main Steam Line Break, Small Break LOCAs and Loss of All Unit AC Power (Ref. 5.6.14).

The SG level signals are corrected for process density changes relative to the calibration density values. As depicted in the block diagram (Figure 1), the inputs into the compensation module consist of a level signal and a pressure signal. Per Reference 5.6.10, these signals are combined using the equations below to produce the output signals that represent the compensated level signals.

1) $v_o = 1 + \frac{23.91*(\Delta P_L - 2.5) - 4.0*\rho_{st}}{\rho_w - \rho_{st}}$ where v_o is the output voltage fed to the Bistables.

2) $v_o = \frac{18.150*(\Delta P_L - 2.5) - 3.036*\rho_{st}}{\rho_w - \rho_{st}}$ where v_o is the output voltage for the Low Range Level Control.

In the equations above,

ΔP_L is the level signal corresponding to the SG level transmitter signal prior to density compensation (volts)

ρ_w is the density of water corresponding to the SG pressure transmitter signal. The density values are stored in EPROM and are retrieved based on the pressure signal. (lb/ft^3)

ρ_{st} is the density of steam corresponding to the SG pressure transmitter signal. The density values are stored in EPROM and are retrieved based on the pressure signal. (lb/ft^3)

All errors are converted to units of volts for a consistent analysis throughout the EFIC System modules. The equations above are used to determine the expected output voltage and the output voltage with maximum errors included. The output voltage with maximum errors is compared to the expected output voltage to determine the loop uncertainty. The resulting uncertainty is then combined with the manufacturers specifications for the EFIC System.

SG LOW LEVEL INITIATE

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The Low SG Level Initiate setpoint for EFIC determines the level at which emergency feedwater (EFW) is initiated during Loss of Main Feedwater (LOFW) events. The in-plant setpoint evaluated per Reference 5.6.44 is 11.00 inches above the lower tube sheet (5.00 inches above the lower tap). This setpoint will be evaluated with respect to the instrument uncertainty in the Conclusions Section.

SG LEVEL CONTROL

This is a control level setpoint designed to be selected following initiation of EFW if one or more reactor coolant pumps (RCPs) are providing forced circulation. The current setpoint, per References 5.6.22 and 5.6.23, is 31 inches. This setpoint will be evaluated with respect to the instrument uncertainty in the Conclusions Section.

The statistical method of the Square Root of the Sum of Squares (SRSS) is used to determine the random error on a component level and for the loop. Non-random errors are combined via simple addition with the random error term to establish the total error.

This calculation is done with the guidelines set forth in the Instrument Loop Error Analysis and Setpoint Methodology Manual (Ref. 5.6.1).

All percentages are expressed in terms of span unless otherwise noted.

All terms are considered random error terms unless noted by a lower case "b" suffix to indicate a bias or non-random error term or "t" suffix to indicate a total of bias and random terms.

5.3.0 ASSUMPTIONS AND GIVEN CONDITIONS

7 5.3.1 The minimum and maximum temperatures expected for the transmitter reference leg fluid, during normal operation, are 104°F and 118°F, respectively. These values are conservative per Reference 5.6.43, Table 1, for Elev. 336'.

5.3.2 The maximum temperature expected for the transmitter reference leg fluid, during accident conditions, is 285°F. This value is found in Reference 5.6.2, Appendix A. For the calculation of the process measurement error, it is assumed that the reference leg fluid does not flash. Therefore, the density is taken from Reference 6.3 for 285°F and 54 psia (P_{SAT}).

5.3.3 The operating pressure range is assumed to be limited by the pressure inputs from the pressure loops (Ref. 5.6.7). Therefore, the operating pressure range is 0 to 1200 psig.

5.3.4 Per Reference 5.6.8, the static pressure zero and static pressure span errors are correctable during calibration. Per Attachment 5-1 and References 5.6.22 and 5.6.23, the transmitter is calibrated based on a static pressure of 900 psig. The minimum and maximum operating static pressures are 0 psig and 1200 psig, respectively. Since the transmitters are corrected for a static pressure of 900 psig (Pcor), the static pressure uncertainties will be computed using the maximum deviation from 900 psig, or 900 psi (900 - 0 psig). In addition, to maximize the static pressure span error, the maximum reading of 100% will be used.

5.3.5 Per Reference 5.6.8, static pressure causes a systematic span shift of -0.75% of input per 1000 psi increase which is correctable by applying a correction factor during calibration. Per Attachment 1 and References 5.6.22 and 5.6.23, a correction factor is applied during calibration based on a static pressure of 900 psig. A bias error is introduced when the actual operating static pressure deviates from the calibration pressure of 900 psig. A negative bias occurs for a deviation above 900 psig and a positive bias occurs for a deviation below 900 psig. The deviations are based on the minimum and maximum operating pressures (0 psig and 1200 psig). In addition, the maximum DP input (100%) is used in that it yields the maximum, i.e. the most conservative, error.

5.3.6 Individual error terms less than 0.05%Span are considered negligible (Ref. 5.6.1). Where a note to this effect has been provided, the error is not provided in the calculations. However, where error terms less than 0.05%Span exist in error analyses, they are used in calculations though the impact is negligible.

5.3.7 The measurement and test equipment (M&TE) used at ANO is controlled by a program to ensure traceability is maintained. In accordance with Reference 5.6.9, M&TE specified for use in calibration of instrumentation should have an accuracy at least two times that of the instrument being calibrated unless authorized by responsible management. Unless otherwise noted, the Calibration Error Effect for all devices is based upon using M&TE which is twice as accurate as the devices being calibrated. The calibration uncertainty assumes there are calibration devices on the input and output of the device being calibrated.

5.3.8 For purposes of determining Temperature Effect (TE) for the differential pressure transmitter, a variation of 50°F is used. This assumes a calibration temperature of 60°F and an Abnormal Temperature of 110°F (Ref. 5.6.2). For accident conditions, a variation of 225°F is used. This assumes the maximum temperature in an accident of 285°F (Ref. 5.6.2).

5.3.9 Unless otherwise noted, the line voltage is assumed to be 120 VAC with a variance of ±10 VAC and the DC power supplies are assumed to have a variance of ±10% rated voltage. These variances are assumed to be conservative per Reference 5.6.1.

5.3.10 Per Reference 5.6.8, the Rosemount transmitter drift is 0.20%URL over a 30 month period. References 5.6.22 and 5.6.23 indicate that the transmitters are calibrated every 72 weeks or 18 months. Tech Specs (Ref. 5.6.11) allow a 25% extension, making the calibration interval 22.5 months. Since the calibration interval is within the vendor supplied drift specification, the 0.20%URL will be used as a bounding drift error.

5.3.11 Per Reference 5.6.12, the normal error specifications for the transmitter, given by the vendor, are accurate to three sigma. All other specifications are two sigma values, therefore, the normal transmitter specifications will be multiplied by 2/3 to convert them to two sigma values before combining them with other two sigma values.

5.3.12 The power for the I/V converters and the V/I converters is supplied from the internal power supply in the Foxboro nest (Ref. 5.6.25 - 5.6.26). This ± 15 VDC power supply is regulated to 0.2% output voltage change for a ± 10% change from nominal line voltage (Ref. 5.6.13). Since the power supply line voltage remains within the 10% criteria (5.3.9) the power supply error will be limited to 0.2 %. The power supply is also affected by temperature and has an ambient temperature effect of 0.5% for a 45 °F change within 40 - 120 °F. Since the power supply temperature effect envelopes the Auxiliary Building temperature range (5.3.13) the power supply temperature effect will be limited to 0.5%. The two power supply error terms will be combined using the SRSS method, since the two terms are random and independent, to provide a total power supply error.

$$\text{Power Supply Error} = \pm [(0.2)^2 + (0.5)^2]^{1/2}$$
$$= \pm 0.539\ \%$$

5.3.13 The maximum normal temperature extremes for the Auxiliary Building is listed as 60 to 105 °F (Ref. 5.6.2). This calculation will use 60 °F as the calibration temperature for the Foxboro components which are located in the Auxiliary Building in the Electrical Equipment Rooms.

5.3.14 The vendor for the I/V converters, Foxboro, supplied a reference accuracy (RA) specification of ±0.2% of span. Per References 5.6.22 and 5.6.23, the converters are calibrated to ±0.5%Span. Therefore, a setting tolerance (ST) of ±0.3%Span will be added to RA to make the adjusted device tolerance (Dtol) ±0.5%Span. The error calculation for the I/V converters will use Dtol in lieu of RA.

5.3.15 The MTE used to calibrate the signal converters is much more accurate than one-half the accuracy of the devices being calibrated (Ref. 5.6.22 and 5.6.23). Therefore, in lieu of using RA/2 for the MTE accuracy (5.3.7), the actual accuracy of the DMM (±0.125%) and DVM (±0.005%) will be used.

5.3.16 The vendor for the I/V and V/I converters, Foxboro, did not supply a drift (DR) error specification. It is assumed that DR will not be worse than the reference accuracy (RA) or device tolerance (Dtol) of the device, whichever is greater. 7

5.3.17 All Foxboro normal performance specifications are considered 3 sigma specifications (Ref. 5.6.17). Therefore, the data must be converted to 2 sigma before being combined with other 2 sigma data.

5.3.18 The vendor specifies that the 625-ohm input resistor is a precision resistor (Ref. 5.6.10). Per Reference 5.6.24, the resistor tolerance is ±0.01%. The maximum error will result from maximum input, or 20 mADC and is determined as follows:

[625 + (.01% * 625)] * .02 A = 12.501 volts

The maximum voltage (without error) would be 12.5 volts. Therefore, the error in percent span is (12.501-12.5)/span*100%= 0.0125 %Span. The error will be considered negligible per Assumption 5.3.6.

5.3.19 Per Reference 5.6.19, the Control Room temperature is 75°F with a temperature variance of ±9°F for the Abnormal and Accident Conditions.

5.3.20 The vendor for the EFIC system did not provide any drift data for the components. Given the reference accuracy of the combination of the EFIC compensation module and bistable is 0.539 %span per 5.3.25 below, a drift allowance of approximately half of RA or 0.250 % is considered reasonable. This drift allowance will be increased to 0.258 % span by increasing it by a factor of 31/30 to account for the former 30 day vs. 31 day test frequency presently required by Technical Specifications.

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5.3.21 The vendor did not supply a temperature effect or power supply effect error specification for the EFIC modules. Based on the small deviations in both the Control Room temperature and the power supply voltage, and based on similar devices in the Control Room, it is assumed that these deviations will have a negligible effect on the loop error.

5.3.22 The MTE used to calibrate the EFIC Modules is much more accurate than one-half the accuracy of the devices being calibrated (Ref. 5.6.22 and 5.6.23). Therefore, in lieu of using RA/2 for the MTE accuracy (5.3.7), the actual accuracy of the MTE (±0.125%) will be used.

5.3.23 The radiation effect for the transmitters is given in Reference 5.6.35 as ±1.0%URL for doses less than 1 MRad/ hr and a TID less than 5 MRads. Reference 5.6.36 gives a dose of 2.1 MRads over a 3 year period for a Small Break LOCA. Although the dose given in Reference 5.6.36 may not bound all SBLOCA cases, it is assumed that doses will remain lower than 5MRads.

5.3.24 Foxboro specifies a separate accuracy and repeatability error term for the V/I converter. Therefore, this calculation will combine both the accuracy and the repeatability by SRSS and use the resultant as the overall Reference Accuracy (Ref. 5.6.1):

Accuracy (A)	= ±	0.50	%SPAN
Repeatability (R)	= ±	0.10	%SPAN
Reference Accuracy	= ±	$[A^2+R^2]^{1/2}$	
RA	= ±	0.51	%SPAN

5.3.25 Per Reference 5.6.20, each component within the EFIC Compensation Module has an accuracy of 0.25%SPAN and the EFIC Bistable Module has an accuracy of 0.20%SPAN. The SG Low Level Initiate Bistable loop uses four components in the Compensation Module along with the Bistable (Refs. 5.6.29 and 5.6.30). Therefore, the reference accuracy for SU1 is assumed to be the SRSS of the accuracies for four Compensation Module components and the Bistable Module, or 0.539%SPAN.

5.3.26 Per Reference 5.6.20, each component within the EFIC Compensation Module has an accuracy of 0.25%SPAN and the EFIC Control Module has an accuracy of 0.35%SPAN. The SG Low-Range Level Control loop uses five components in the Compensation Module along with the Control Module (Refs. 5.6.29 and 5.6.30). Therefore, the reference accuracy for FRL is assumed to be the SRSS of the accuracies for five Compensation Module components and the Control Module, or 0.660%SPAN.

5.3.27 The vendor did not supply the time response for the voltage-to-current converter. It is assumed that the time response for the voltage-to-current converter is not worse than the time response for the current-to-voltage converter. Therefore, a time response of 0.1 second is assumed for the converter.

5.3.28 The SG Low Level Initiate Bistable has a 9.900 second time delay (Ref. 5.6.44). The DRN 05-3577 bistables are tested and assumed to be acceptable with a ±0.5 second tolerance (Refs. 5.6.22 and 5.6.23). Therefore, the time response analysis will assume a 10.400 second delay.

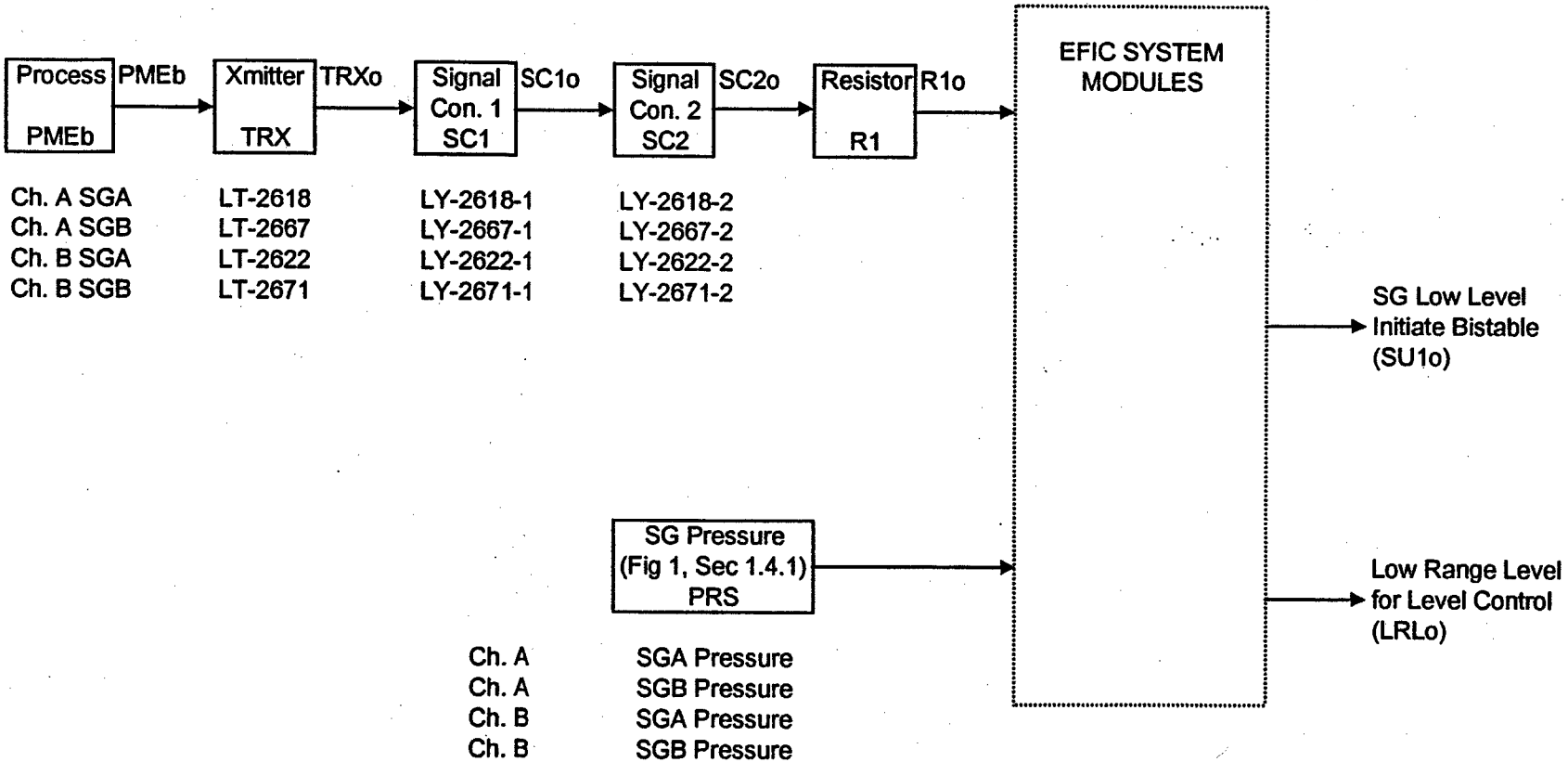
5.3.29 The calibration procedures state that the Low SG Level Initiate Bistable is calibrated to 0.650%SPAN. This is slightly greater than the reference accuracy (RA) of 0.539% Span DRN listed in Section 5.4.4.2 and less than the former tolerance of 1.0% Span. Therefore, a 05-3577 setting tolerance (ST) will be added to the reference accuracy (RA) to obtain a device tolerance (Dtol) of 0.650% SPAN.

7 5.3.30 Note that the SG Low-Range Level Control bistables evaluated in this section are not associated with any Allowable Values in the Technical Specifications (Ref. 5.6.11). The drift terms will be revised to account for the slight decrease in frequency of Channel Functional test requirements required per Technical Specifications, however no additional evaluation of the impact to Allowable Values is required in section 5.5.

5.3.31 EFIC initiates on a low level of 11 inches above the lower tube sheet or 5 inches of calibrated span (3.3 % span, rounded), this is equivalent to an uncompensated voltage level of DRN approximately 2.833 volts or 2.84 volts (rounded). This trip is credited for a Loss of Feedwater 05-3577 (LOFW) event which does not assume a main steam or main feedwater line break. For LOFW the actual SG pressure would be expected to remain the same or increase above normal operating pressure at the the time of trip intitiation. Table 5.4.4.15 shows that for the range of bistable voltages from 2.5 - 6.0 vdc and for pressures equal to or greater than 900 psia the abnormal low level initiate bistable uncertainty (ABN SU1ot) is bounded by +2.62 / -2.54% Span.

5.4.0 ANALYSIS

5.4.1 FIGURE 1: BLOCK DIAGRAM--EFIC CHANNELS A & B [5.6.25, 5.6.26, 5.6.27, 5.6.28, 5.6.29, 5.6.30]



5.4.2 SG PRESSURE (PRS)

The Steam Generator pressure signals for EFIC Channels A and B come from the following pressure transmitters:

PT-2618A
PT-2618B
PT-2667A
PT-2667B

The loop error analysis for the above pressure transmitter loops is calculated in Section 1.0. The following errors ("R1o" from Sect. 1.0) for the Reference, Abnormal and Accident conditions are the errors associated with the pressure signal that is input to the EFIC density compensation module:

REF PRSo	=	±	REF R1o (from Sect. 1.0)						
REF PRSo	=	±	0.99	%Span	=	±	11.9	psi	[Sect. 1.0]
ABN PRSo	=	±	ABN R1o (from Sect. 1.0)						
7 ABN PRSo	=	±	1.35	%Span	=	±	16.2	psi	[Sect. 1.0]
ACC PRSo	=	±	ACC R1o (from Sect. 1.0)						
7 ACC PRSo	=	±	1.35	%Span	=	±	16.2	psi	[Sect. 1.0]
ACC PRSob	=		ACC R1ob (from Sect. 1.0)						
ACC PRSob	=	+	0.00	%Span	=	+	0.0	psi	[Sect. 1.0]
ACC PRSob	=	-	0.07	%Span	=	-	0.8	psi	[Sect. 1.0]

Note: The errors are converted from %Span to units of psi since the density computation error (Sections 5.4.4 and 5.4.5) is based on variations from actual SG pressure.

5.4.3 SG LEVEL (LVL)

The Steam Generator level signals for EFIC Channels A and B come from the following level transmitters:

LT-2618
LT-2667
LT-2622
LT-2671

The loop error analysis for the above level transmitter loops is calculated in Sections 5.4.3.1 through 5.4.3.6 of this calculation. The errors ("R1o" of Section 5.4.3.6) for the Reference, Abnormal and Accident conditions are summarized as follows:

	REF LVLo	=	±	REF R1o (from 5.4.3.6)					
7	REF LVLo	=	±	0.988	%Span	=	±	0.099 volts	[Sect. 5.4.3.6]
	ABN LVLo	=	±	ABN R1o (from 5.4.3.6)					
7	ABN LVLo	=	±	1.300	%Span	=	±	0.130 volts	[Sect. 5.4.3.6]
	ACC LVLo	=	±	ACC R1o (from 5.4.3.6)					
7	ACC LVLo	=	±	3.497	%Span	=	±	0.350 volts	[Sect. 5.4.3.6]
	ABN LVLob	=		ABN R1ob (from 5.4.3.6)					
7	ABN LVLob	=	+	0.675	%Span	=	+	0.068 volts	[Sect. 5.4.3.6]
	ABN LVLob	=	-	0.622	%Span	=	-	0.062 volts	[Sect. 5.4.3.6]
	ACC LVLob	=		ACC R1ob (from 5.4.3.6)					
7	ACC LVLob	=	+	7.983	%Span	=	+	0.798 volts	[Sect. 5.4.3.6]
	ACC LVLob	=	-	0.225	%Span	=	-	0.023 volts	[Sect. 5.4.3.6]

Note: The errors have been converted from %Span to units of volts since the loop errors within the EFIC System Modules will be calculated in volts. The input resistor, R1 from Section 5.4.3.6, is 625 Ω which makes the span 10 volts.

5.4.3.1 PROCESS MEASUREMENT ERROR (PME)

The process measurement error (PME) for this closed level loop is caused by density changes in the reference leg fluid due to ambient temperature variations. Since the loop is pressure compensated (Ref. 5.6.10), the density changes due to system pressure variations do not cause a process measurement error.

As the reference leg fluid temperature varies from the temperature assumed during calibration, the density of the reference leg fluid changes, causing the transmitter to sense a different differential pressure than expected, thus causing a bias process measurement error. The error will be positive when the reference leg temperature is greater than that assumed during calibration, and negative when the reference leg temperature is less than that assumed during calibration.

The assumed calibration conditions are given as follows: [Att. 5-1]

Span	=	143.98	"H_2O	(span of transmitter)
H_R	=	150	inches	(height of reference leg)

Reference Leg Fluid:

T_{CAL}	=	120 °F		(temperature assumed at calibration)
SV_{CAL}	=	0.016204	ft^3/lbm	(specific volume H_2O @ 120°F)
ρ_{CAL}	=	61.7132	lbm/ft^3	(density assumed at calibration)
ρ_{CAL}	=	0.0357	lbm/in^3	(density assumed at calibration)

The error introduced by variations in the reference leg fluid density is calculated for the abnormal and accident conditions as follows:

ABNORMAL CONDITIONS

Reference Leg Fluid: [5.3.1]

T_{MIN}	=	104 °F		(minimum temperature)	
SV_{MIN}	=	0.016142	ft^3/lbm	(specific volume H_2O @ 104°F)	[5.6.3]
ρ_{MAX}	=	61.9502	lbm/ft^3	(density at T_{MIN})	
ρ_{MAX}	=	0.0359	lbm/in^3	(density at T_{MIN})	
T_{MAX}	=	118 °F		(maximum temperature)	
SV_{MAX}	=	0.016192	ft^3/lbm	(specific volume H_2O @ 118°F)	[5.6.3]
ρ_{MIN}	=	61.7589	lbm/ft^3	(density at T_{MAX})	
ρ_{MIN}	=	0.0357	lbm/in^3	(density at T_{MAX})	

$eDP(-) = H_R * (\rho_{CAL} - \rho_{MAX})$ [5.6.1]

$= -0.02058$ psi

$= -0.571$ "H_2O $= -0.397$ %Span

$eDP(+) = H_R * (\rho_{CAL} - \rho_{MIN})$ [5.6.1]

$= -0.00397$ psi

$= -0.110$ "H_2O $= -0.077$ %Span

ACCIDENT CONDITIONS

Reference Leg Fluid: [5.3.2]

T_{MAX}	=	285 °F		(maximum temperature)
SV_{MAX}	=	0.01726	ft^3/lbm	(specific volume H_2O @ 285°F) [5.6.3]
ρ_{MIN}	=	57.9374	lbm/ft^3	(density at T_{MAX})
ρ_{MIN}	=	0.0335	lbm/in^3	(density at T_{MAX})

$eDP(+) = H_R * (\rho_{CAL} - \rho_{MIN})$ [5.6.1]

= 0.32775 psi

= 9.096 $"H_2O$ = 6.318 %Span

SUMMARY OF PROCESS MEASUREMENT ERROR (PMEb):

ABN PMEb	=	+	N/A	%Span
	=	-	0.397	%Span
ACC PMEb	=	+	6.318	%Span

5.4.3.2 LEVEL TRANSMITTER (TRX)

COMPONENT ID

Tag Number(s)	:		LT-2618, LT-2667 LT-2622, LT-2671		[5.6.28]
Manufacturer	:		Rosemount		[5.6.5]
Model Number	:		1154DP4RB		[5.6.5]
Upper Range Limit (URL)	:		150 "H_2O		[5.6.8]
Calibrated Range	:		-4.58 to -148.56 "H_2O		[Att. 5-1]
Calibrated Span	:		143.98 "H_2O		[Att. 5-1]
Turn Down Factor (TDF)	:		1.0418		

ENVIRONMENTAL CONDITIONS

Location	:		Reactor Building		[5.6.5]
Static Pressure Corr (Pcor)	:		900 psig		[Att. 5-1]
Operating Press Range	:		0 to 1200 psig		[5.3.3]
Pdiff(-)	:		-900 psi		[5.3.4, 5.3.5]
Pdiff(+)	:		300 psi		[5.3.5]
Calibration Temp (Tcal)	:		60 °F		[5.3.8]
Abnormal Temp (Tabn)	:		110 °F		[5.3.8]
DT (Tabn-Tcal)	:		50 °F		[5.3.8]
Accident Temp (Tacc)	:		285 °F		[5.3.8]
ADT (Tcal-Tacc)	:		225 °F		[5.3.8]
Power Supply Voltage	:		30 VDC		[5.6.10]
Power Supply Variance	:	±	10 %		[5.3.9]
Power Supply Variance (DV)	:	±	3 VDC		

ERROR SUMMARY

Reference Accuracy (RA)	=	±	0.250 %Span		[5.6.8]
Calibration (CAL)	=	±	$[(RA/2)^2+(RA/2)^2]^{1/2}$		[5.3.7]
Calibration (CAL)	=	±	0.177 %Span		
Drift (DR)	=	±	0.2%URL / 30 months		[5.3.10]
Drift (DR)	=	±	(0.2)*(TDF)		
Drift (DR)	=	±	0.208 %Span		
Power Supply Effect (PS)	=	±	0.005 % per Volt		[5.6.8]
Power Supply Effect (PS)	=	±	(0.005)*(DV)		
Power Supply Effect (PS)	=	±	0.015 %Span	(negligible)	[5.3.6]
Power Supply Effect (PS)	=	±	0.000 %Span		
Temperature Effect (TE)	=	±	0.75%URL + 0.5%Span per 100°F change		[5.6.8]
Temperature Effect (TE)	=	±	[(0.75)*(TDF)+(0.5)]*DT/100		
Temperature Effect (TE)	=	±	0.641 %Span		

Acc Temperature Effect (ATE)	=	±	2.5%URL + 0.5%Span	[5.6.8]
Acc Temperature Effect (ATE)	=	±	(2.5)*(TDF)+(0.5) %Span	
Acc Temperature Effect (ATE)	=	±	3.105 %Span	
Acc Radiation Effect (ARE)	=	±	1.0%URL	[5.3.23]
Acc Radiation Effect (ARE)	=	±	(1.0)*(TDF) %Span	
Acc Radiation Effect (ARE)	=	±	1.042 %Span	
Static Pressure Zero (SPZ)	=	±	0.2%URL per 1000 psi	[5.6.8, 5.3.4]
Static Pressure Zero (SPZ)	=	±	(0.2)*(TDF)*(Pdiff)/1000	
Static Pressure Zero (SPZ)	=	±	0.188 %Span	
Static Pressure Span (SPS)	=	±	0.5%RDG per 1000 psi	[5.6.8, 5.3.4]
Static Pressure Span (SPS)	=	±	(0.5)*(1)*(Pdiff)/1000	
Static Pressure Span (SPS)	=	±	0.450 %Span	
Stat Press Span Bias (SPSb)	=	-	0.75 % Input/1000 psi	[5.6.8, 5.3.5]
SPSb(+)	=		(-0.75)*[Pdiff(-)]/1000 %DP Input	
SPSb(+)	=	+	0.675 %DP Input	
SPSb(-)	=		(-0.75)*[Pdiff(+)]/1000 %DP Input	
SPSb(-)	=	-	0.225 %DP Input	
SPSb(+)	=	+	0.675 %Span	[5.3.5]
SPSb(-)	=	-	0.225 %Span	

The transmitter error (eTRX) for the Reference, Abnormal and Accident conditions is given as follows:

REF eTRX	=	±	RA + CAL	
REF eTRX	=	±	0.427 %Span	
ABN eTRX	=	±	$[(RA+CAL)^2+(2DR/3)^2+(2PS/3)^2+(2TE/3)^2+(2SPZ/3)^2+(2SPS/3)^2]^{1/2}$	[5.3.11]
ABN eTRX	=	±	0.700 %Span	
ACC eTRX	=	±	$[(RA+CAL)^2+(2DR/3)^2+(2PS/3)^2+ATE^2+ARE^2+(2SPZ/3)^2+(2SPS/3)^2]^{1/2}$	
ACC eTRX	=	±	3.321 %Span	[5.3.11]
ABN eTRXb	=		SPSb	
ABN eTRXb	=	+	0.675 %Span	
ABN eTRXb	=	-	0.225 %Span	
ACC eTRXb	=		SPSb	
ACC eTRXb	=	+	0.675 %Span	
ACC eTRXb	=	-	0.225 %Span	

The output error terms for the transmitter (TRXo) are given as follows:

REF TRXo	=	±	REF eTRX
REF TRXo	=	±	0.427 %Span
ABN TRXo	=	±	ABN eTRX
ABN TRXo	=	±	0.700 %Span
ACC TRXo	=	±	ACC eTRX
ACC TRXo	=	±	3.321 %Span
ABN TRXob	=		ABN PMEb + ABN eTRXb
ABN TRXob	=	+	0.675 %Span
ABN TRXob	=	-	0.622 %Span
ACC TRXob	=		ACC PMEb + ACC eTRXb
ACC TRXob	=	+	6.993 %Span
ACC TRXob	=	-	0.225 %Span

5.4.3.3 INSULATION RESISTANCE (IR)

The transmitters are located inside the containment building and as such, the effects of harsh environment on loop signal cabling must be considered. The accident environment effects are considered for cabling from the transmitter through the containment electrical penetrations. The IR effect was calculated in Reference 5.6.4 and is quoted below.

ACC IRb = + 0.990 %Span [5.6.4]

5.4.3.4 SIGNAL CONVERTER 1 (SC1)

COMPONENT ID

Tag Number(s)	:		LY-2618-1, LY-2667-1 LY-2622-1, LY-2671-1		[5.6.28]
Manufacturer	:		Foxboro		[5.6.5]
Model Number	:		N-2AI-I2V		[5.6.5]

ENVIRONMENTAL CONDITIONS

Location	:		Auxiliary Building Rooms 104 and 112		[5.6.5]
Calibration Temp (Tcal)	:		60	°F	[5.3.13]
Abnormal/Accident Temp (Ta)	:		105	°F	[5.3.13]
DT (Ta-Tcal)	:		45	°F	
Power Supply Voltage	:	±	15	VDC	[5.6.13]
Power Supply Variance (DV)	:	±	0.539	%	[5.3.12]

ERROR SUMMARY

Reference Accuracy (RA)	=	±	0.200	%Span	[5.6.15]
Setting Tolerance (ST)	=	±	0.300	%Span	[5.3.14]
Device Tolerance (Dtol)	=	±	0.500	%Span	[5.3.14]
Calibration (CAL)	=	±	$[0.125^2+0.005^2]^{1/2}$		[5.3.15]
Calibration (CAL)	=	±	0.125	%Span	
Drift (DR)	=	±	Dtol		[5.3.16]
Drift (DR)	=	±	0.500	%Span	
Power Supply Effect (PS)	=	±	0.200	%span / 5% change in supply * DV	[5.6.16]
Power Supply Effect (PS)	=	±	0.022	%Span	
Power Supply Effect (PS)	=	±	0.000	%Span (negligible)	[5.3.6]
Temperature Effect (TE)	=	±	0.500	%span / 50°F change * DT	[5.6.15]
Temperature Effect (TE)	=	±	0.450	%Span	

The errors for the I/V converter (eSC1) for the Reference, Abnormal and Accident conditions are given as follows:

REF eSC1 = ± Dtol + CAL
REF eSC1 = ± 0.625 %Span

ABN eSC1 = ± $[(Dtol+CAL)^2+(2DR/3)^2+(2PS/3)^2+(2TE/3)^2]^{1/2}$ [5.3.17]
ABN eSC1 = ± 0.769 %Span

ACC eSC1 = ± $[(Dtol+CAL)^2+(2DR/3)^2+(2PS/3)^2+(2TE/3)^2]^{1/2}$ [5.3.17]
ACC eSC1 = ± 0.769 %Span

The output error terms for the I/V converters (SC1o) are given as follows:

REF SC1o = ± $[(REF\ TRXo)^2+(REF\ eSC1)^2]^{1/2}$
REF SC1o = ± 0.757 %Span

ABN SC1o = ± $[(ABN\ TRXo)^2+(ABN\ eSC1)^2]^{1/2}$
ABN SC1o = ± 1.040 %Span

ACC SC1o = ± $[(ACC\ TRXo)^2+(ACC\ eSC1)^2]^{1/2}$
ACC SC1o = ± 3.409 %Span

ABN SC1ob = ABN TRXob
ABN SC1ob = + 0.675 %Span
ABN SC1ob = - 0.622 %Span

ACC SC1ob = ACC TRXob + ACC IRb
ACC SC1ob = + 7.983 %Span
ACC SC1ob = - 0.225 %Span

5.4.3.5 SIGNAL CONVERTER 2 (SC2)

COMPONENT ID

Tag Number(s)	:		LY-2618-2, LY-2667-2 LY-2622-2, LY-2671-2		[5.6.28]
Manufacturer	:		Foxboro		[5.6.5]
Model Number	:		N-2AO-V2I		[5.6.5]

ENVIRONMENTAL CONDITIONS

Location	:		Auxiliary Building Rooms 104 and 112		[5.6.5]
Calibration Temp (Tcal)	:		60	°F	[5.3.13]
Abnormal/Accident Temp (Ta)	:		105	°F	[5.3.13]
DT (Ta-Tcal)	:		45	°F	
Power Supply Voltage	:	±	15	VDC	[5.6.13]
Power Supply Variance (DV)	:	±	0.539	%	[5.3.12]

ERROR SUMMARY

Reference Accuracy (RA)	=	±	0.510	%Span		[5.3.24]
Calibration (CAL)	=	±	$[0.005^2+0.125^2]^{1/2}$			[5.3.15]
Calibration (CAL)	=	±	0.125	%Span		
Drift (DR)	=	±	RA			[5.3.16]
Drift (DR)	=	±	0.510	%Span		
Power Supply Effect (PS)	=	±	0.200	%span / 5% change in supply * DV		[5.6.18]
Power Supply Effect (PS)	=	±	0.022	%Span		
Power Supply Effect (PS)	=	±	0.000	%Span	(negligible)	[5.3.6]
Temperature Effect (TE)	=	±	0.500	%span / 50°F change * DT		[5.6.18]
Temperature Effect (TE)	=	±	0.450	%Span		

The errors for the V/I converter (eSC2) for the Reference, Abnormal and Accident conditions are given as follows:

REF eSC2 = ± RA + CAL
REF eSC2 = ± 0.635 %Span

ABN eSC2 = ± $[(RA+CAL)^2+(2DR/3)^2+(2PS/3)^2+(2TE/3)^2]^{1/2}$ [5.3.17]
ABN eSC2 = ± 0.780 %Span

ACC eSC2 = ± $[(RA+CAL)^2+(2DR/3)^2+(2PS/3)^2+(2TE/3)^2]^{1/2}$ [5.3.17]
ACC eSC2 = ± 0.780 %Span

The output error terms for the V/I converters (SC2o) are given as follows:

REF SC2o = ± $[(REF\ SC1o)^2+(REF\ eSC2)^2]^{1/2}$
REF SC2o = ± 0.988 %Span

ABN SC2o = ± $[(ABN\ SC1o)^2+(ABN\ eSC2)^2]^{1/2}$
ABN SC2o = ± 1.300 %Span

ACC SC2o = ± $[(ACC\ SC1o)^2+(ACC\ eSC2)^2]^{1/2}$
ACC SC2o = ± 3.497 %Span

ABN SC2ob = ABN SC1ob
ABN SC2ob = + 0.675 %Span
ABN SC2ob = - 0.622 %Span

ACC SC2ob = ACC SC1ob
ACC SC2ob = + 7.983 %Span
ACC SC2ob = - 0.225 %Span

5.4.3.6 RESISTOR (R1)

COMPONENT ID

Type	:	625	ohms			[5.6.29, 30]
Input Range	:	4	to	20	ma	[5.6.10]
Output Range	:	2.5	to	12.5	VDC	[5.6.10]
Span	:	10	VDC			

ENVIRONMENTAL CONDITIONS

Location	:	Aux. Bldg.-Control Room		[5.6.5]
Calibration Temperature	:	75	°F	[5.3.19]
Temp Variance	:	± 9	°F	[5.3.19]

ERROR SUMMARY

Reference Accuracy (RA)	=	±	0.000	%Span	(negligible) [5.3.18]

The errors for the resistor (eR1) are given as follows:

REF eR1	=	±	RA
REF eR1	=	±	0.000 %Span
ABN eR1	=	±	RA
ABN eR1	=	±	0.000 %Span
ACC eR1	=	±	RA
ACC eR1	=	±	0.000 %Span

The output error terms for the resistor (R1o) are given as follows:

REF R1o	=	±	$[(\text{REF SC2o})^2+(\text{REF eR1})^2]^{1/2}$
REF R1o	=	±	0.988 %Span
ABN R1o	=	±	$[(\text{ABN SC2o})^2+(\text{ABN eR1})^2]^{1/2}$
ABN R1o	=	±	1.300 %Span
ACC R1o	=	±	$[(\text{ACC SC2o})^2+(\text{ACC eR1})^2]^{1/2}$
ACC R1o	=	±	3.497 %Span
ABN R1ob	=		ABN SC2ob
ABN R1ob	=	+	0.675 %Span
ABN R1ob	=	-	0.622 %Span
ACC R1ob	=		ACC SC2ob
ACC R1ob	=	+	7.983 %Span
ACC R1ob	=	-	0.225 %Span

5.4.4 SG LOW LEVEL INITIATE

5.4.4.1 EFIC ALGORITHM 1

Table 5.4.4.1 determines the errors in density expected based upon the error associated with the pressure signal (Section 5.4.2). Per Reference 5.6.10, the densities are stored in EPROM based on the ASME Steam Tables. Table 5.4.4.1 compares what the density is at the actual SG pressure with the density at the SG pressure with the uncertainty included. This methodology conservatively assumes that no interpolation is performed.

Table 5.4.4.2 determines the minimum and maximum input voltages for the uncompensated level signal based upon the error associated with the level signal (Section 5.4.3).

Table 5.4.4.3 computes the expected output voltages without errors. The equation used for the expected output voltages (Section 5.2.0) is as follows:

$$v_o = 1 + \frac{23.91*(\Delta P_L - 2.5) - 4.0*\rho_{st}}{\rho_w - \rho_{st}}$$

where v_o is the output voltage fed to the Bistables.

Tables 5.4.4.4, 5.4.4.5 and 5.4.4.6 compute the output error due to the error in the uncompensated level signal for the reference, abnormal and accident conditions, respectively. The equation used is as follows:

$$V1o = 1 + \frac{23.91*[(\Delta P_L \pm LVLo) - 2.5)] - 4.0*\rho_{st}}{\rho_w - \rho_{st}} - v_o$$

Table 5.4.4.7 computes the output error due to the error in the pressure signal for the reference, abnormal and accident conditions. This error is minimal compared to other errors in the loop. Therefore, for simplicity, only the accident error is considered for the pressure signal. The equation used is as follows:

$$V2o = 1 + \frac{23.91*(\Delta P_L - 2.5) - 4.0*\rho_{st}}{\rho_w - \rho_{st}} - v_o$$

with the densities based upon the pressure signal with error PRSo

Tables 5.4.4.8 and 5.4.4.9 compute the bias output error based upon the bias error in the uncompensated level signal for the abnormal and accident conditions, respectively. The equation used is as follows:

$$Vob = 1 + \frac{23.91*[(\Delta P_L \pm LVLob) - 2.5)] - 4.0*\rho_{st}}{\rho_w - \rho_{st}} - v_o$$

TABLE 5.4.4.1

SG PRESSURE (psia)		DENSITY-SATURATED CONDITIONS (lbm/ft ^{3})					
		Expected	w/ Error	Expected	w/ Error	Expected	w/ Error
Actual	w/ Error	ρ_w	ρ_w	ρ_{st}	ρ_{st}	ρ_w-ρ_{st}	ρ_w-ρ_{st}
14.7	14.7	59.8122	59.8122	0.0373	0.0373	59.7749	59.7749
	30.8		58.7406		0.0750		58.6656
50.0	33.9	57.8905	58.5857	0.1175	0.0818	57.7730	58.5039
	66.1		57.3296		0.1525		57.1771
100.0	83.9	56.3698	56.7924	0.2257	0.1914	56.1441	56.6010
	116.1		55.9910		0.2598		55.7313
150.0	133.9	55.2792	55.5864	0.3318	0.2980	54.9474	55.2885
	166.1		54.9753		0.3656		54.6097
300.0	283.9	52.9381	53.1350	0.6482	0.6165	52.2899	52.5185
	316.1		52.7426		0.6800		52.0626
450.0	433.9	51.1771	51.3875	0.9692	0.9259	50.2079	50.4615
	466.1		50.9424		1.0126		49.9298
600.0	583.9	49.6771	49.8504	1.2991	1.2545	48.3780	48.5959
	616.1		49.4805		1.3439		48.1365
750.0	733.9	48.3325	48.5201	1.6407	1.5944	46.6918	46.9257
	766.1		48.1696		1.6873		46.4823
900.0	883.9	47.1032	47.2590	1.9964	1.9481	45.1068	45.3109
	916.1		46.9484		2.0449		44.9034
1050.0	1033.9	45.9348	46.0829	2.3683	2.3177	43.5665	43.7652
	1066.1		45.7875		2.4193		43.3683
1214.7	1198.6	44.7227	44.8029	2.7857	2.7590	41.9370	42.0439
	1214.7		44.7227		2.7857		41.9370

DENSITY OF H_2O (WATER AND STEAM) ERRORS

TABLE 5.4.4.2

SG LEVEL (volts)										
	w/ REF LVLo		w/ ABN LVLo		w/ ABN LVLob		w/ ACC LVLo		w/ ACC LVLob	
Actual	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)
2.5	2.401	2.599	2.370	2.630	2.438	2.568	2.150	2.850	2.478	3.298
3.0	2.901	3.099	2.870	3.130	2.938	3.068	2.650	3.350	2.978	3.798
4.0	3.901	4.099	3.870	4.130	3.938	4.068	3.650	4.350	3.978	4.798
6.0	5.901	6.099	5.870	6.130	5.938	6.068	5.650	6.350	5.978	6.798
8.0	7.901	8.099	7.870	8.130	7.938	8.068	7.650	8.350	7.978	8.798
10.0	9.901	10.099	9.870	10.130	9.938	10.068	9.650	10.350	9.978	10.798
11.0	10.901	11.099	10.870	11.130	10.938	11.068	10.650	11.350	10.978	11.798
12.0	11.901	12.099	11.870	12.130	11.938	12.068	11.650	12.350	11.978	12.798
12.5	12.401	12.599	12.370	12.630	12.438	12.568	12.150	12.850	12.478	13.298

UNCOMPENSATED LEVEL ERRORS (volts)

TABLE 5.4.4.3

EXPECTED V_O									
PRESS. (psia)	SG LEVEL (volts)								
	2.5	3.0	4.0	6.0	8.0	10.0	11.0	12.0	12.5
14.7	0.998	1.198	1.598	2.398	3.198	3.998	4.398	4.798	4.998
50.0	0.992	1.199	1.613	2.440	3.268	4.096	4.510	4.924	5.130
100.0	0.984	1.197	1.623	2.474	3.326	4.178	4.604	5.030	5.243
150.0	0.976	1.193	1.629	2.499	3.369	4.239	4.675	5.110	5.327
300.0	0.950	1.179	1.636	2.551	3.465	4.380	4.837	5.294	5.523
450.0	0.923	1.161	1.637	2.590	3.542	4.494	4.971	5.447	5.685
600.0	0.893	1.140	1.634	2.622	3.611	4.599	5.094	5.588	5.835
750.0	0.859	1.115	1.628	2.652	3.676	4.700	5.212	5.724	5.980
900.0	0.823	1.088	1.618	2.678	3.738	4.799	5.329	5.859	6.124
1050.0	0.783	1.057	1.606	2.703	3.801	4.899	5.447	5.996	6.271
1214.7	0.734	1.019	1.590	2.730	3.870	5.010	5.580	6.151	6.436

EXPECTED OUTPUT VOLTAGE

TABLE 5.4.4.4

REF V1o																	
PRESS	LEVEL w/Error (volts)																
(psia)	2.401	2.599	2.901	3.099	3.901	4.099	5.901	6.099	7.901	8.099	9.901	10.099	10.901	11.099	11.901	12.099	12.401	12.599
14.7	-0.040	0.040	-0.040	0.040	-0.040	0.040	-0.040	0.040	-0.040	0.040	-0.040	0.040	-0.040	0.040	-0.040	0.040	-0.040	0.040
50.0	-0.041	0.041	-0.041	0.041	-0.041	0.041	-0.041	0.041	-0.041	0.041	-0.041	0.041	-0.041	0.041	-0.041	0.041	-0.041	0.041
100.0	-0.042	0.042	-0.042	0.042	-0.042	0.042	-0.042	0.042	-0.042	0.042	-0.042	0.042	-0.042	0.042	-0.042	0.042	-0.042	0.042
150.0	-0.043	0.043	-0.043	0.043	-0.043	0.043	-0.043	0.043	-0.043	0.043	-0.043	0.043	-0.043	0.043	-0.043	0.043	-0.043	0.043
300.0	-0.045	0.045	-0.045	0.045	-0.045	0.045	-0.045	0.045	-0.045	0.045	-0.045	0.045	-0.045	0.045	-0.045	0.045	-0.045	0.045
450.0	-0.047	0.047	-0.047	0.047	-0.047	0.047	-0.047	0.047	-0.047	0.047	-0.047	0.047	-0.047	0.047	-0.047	0.047	-0.047	0.047
600.0	-0.049	0.049	-0.049	0.049	-0.049	0.049	-0.049	0.049	-0.049	0.049	-0.049	0.049	-0.049	0.049	-0.049	0.049	-0.049	0.049
750.0	-0.051	0.051	-0.051	0.051	-0.051	0.051	-0.051	0.051	-0.051	0.051	-0.051	0.051	-0.051	0.051	-0.051	0.051	-0.051	0.051
900.0	-0.052	0.052	-0.052	0.052	-0.052	0.052	-0.052	0.052	-0.052	0.052	-0.052	0.052	-0.052	0.052	-0.052	0.052	-0.052	0.052
1050.0	-0.054	0.054	-0.054	0.054	-0.054	0.054	-0.054	0.054	-0.054	0.054	-0.054	0.054	-0.054	0.054	-0.054	0.054	-0.054	0.054
1214.7	-0.056	0.056	-0.056	0.056	-0.056	0.056	-0.056	0.056	-0.056	0.056	-0.056	0.056	-0.056	0.056	-0.056	0.056	-0.056	0.056

REF V1o (random output error due to uncompensated level signal error)

TABLE 5.4.4.5

ABN V1o																	
PRESS	LEVEL w/Error (volts)																
(psia)	2.370	2.630	2.870	3.130	3.870	4.130	5.870	6.130	7.870	8.130	9.870	10.130	10.870	11.130	11.870	12.130	12.370	12.630
14.7	-0.040	0.040	-0.040	0.040	-0.040	0.040	-0.040	0.040	-0.040	0.040	-0.040	0.040	-0.040	0.040	-0.040	0.040	-0.040	0.040
50.0	-0.041	0.041	-0.041	0.041	-0.041	0.041	-0.041	0.041	-0.041	0.041	-0.041	0.041	-0.041	0.041	-0.041	0.041	-0.041	0.041
100.0	-0.042	0.042	-0.042	0.042	-0.042	0.042	-0.042	0.042	-0.042	0.042	-0.042	0.042	-0.042	0.042	-0.042	0.042	-0.042	0.042
150.0	-0.043	0.043	-0.043	0.043	-0.043	0.043	-0.043	0.043	-0.043	0.043	-0.043	0.043	-0.043	0.043	-0.043	0.043	-0.043	0.043
300.0	-0.045	0.045	-0.045	0.045	-0.045	0.045	-0.045	0.045	-0.045	0.045	-0.045	0.045	-0.045	0.045	-0.045	0.045	-0.045	0.045
450.0	-0.047	0.047	-0.047	0.047	-0.047	0.047	-0.047	0.047	-0.047	0.047	-0.047	0.047	-0.047	0.047	-0.047	0.047	-0.047	0.047
600.0	-0.049	0.049	-0.049	0.049	-0.049	0.049	-0.049	0.049	-0.049	0.049	-0.049	0.049	-0.049	0.049	-0.049	0.049	-0.049	0.049
750.0	-0.051	0.051	-0.051	0.051	-0.051	0.051	-0.051	0.051	-0.051	0.051	-0.051	0.051	-0.051	0.051	-0.051	0.051	-0.051	0.051
900.0	-0.052	0.052	-0.052	0.052	-0.052	0.052	-0.052	0.052	-0.052	0.052	-0.052	0.052	-0.052	0.052	-0.052	0.052	-0.052	0.052
1050.0	-0.054	0.054	-0.054	0.054	-0.054	0.054	-0.054	0.054	-0.054	0.054	-0.054	0.054	-0.054	0.054	-0.054	0.054	-0.054	0.054
1214.7	-0.056	0.056	-0.056	0.056	-0.056	0.056	-0.056	0.056	-0.056	0.056	-0.056	0.056	-0.056	0.056	-0.056	0.056	-0.056	0.056

ABN V1o (random output error due to uncompensated level signal error)

TABLE 5.4.4.6

ACC V1o																	
PRESS	LEVEL w/Error (volts)																
(psia)	2.150	2.850	2.650	3.350	3.650	4.350	5.650	6.350	7.650	8.350	9.650	10.350	10.650	11.350	11.650	12.350	12.150	12.850
14.7	-0.140	0.140	-0.140	0.140	-0.140	0.140	-0.140	0.140	-0.140	0.140	-0.140	0.140	-0.140	0.140	-0.140	0.140	-0.140	0.140
50.0	-0.145	0.145	-0.145	0.145	-0.145	0.145	-0.145	0.145	-0.145	0.145	-0.145	0.145	-0.145	0.145	-0.145	0.145	-0.145	0.145
100.0	-0.149	0.149	-0.149	0.149	-0.149	0.149	-0.149	0.149	-0.149	0.149	-0.149	0.149	-0.149	0.149	-0.149	0.149	-0.149	0.149
150.0	-0.152	0.152	-0.152	0.152	-0.152	0.152	-0.152	0.152	-0.152	0.152	-0.152	0.152	-0.152	0.152	-0.152	0.152	-0.152	0.152
300.0	-0.160	0.160	-0.160	0.160	-0.160	0.160	-0.160	0.160	-0.160	0.160	-0.160	0.160	-0.160	0.160	-0.160	0.160	-0.160	0.160
450.0	-0.167	0.167	-0.167	0.167	-0.167	0.167	-0.167	0.167	-0.167	0.167	-0.167	0.167	-0.167	0.167	-0.167	0.167	-0.167	0.167
600.0	-0.173	0.173	-0.173	0.173	-0.173	0.173	-0.173	0.173	-0.173	0.173	-0.173	0.173	-0.173	0.173	-0.173	0.173	-0.173	0.173
750.0	-0.179	0.179	-0.179	0.179	-0.179	0.179	-0.179	0.179	-0.179	0.179	-0.179	0.179	-0.179	0.179	-0.179	0.179	-0.179	0.179
900.0	-0.185	0.185	-0.185	0.185	-0.185	0.185	-0.185	0.185	-0.185	0.185	-0.185	0.185	-0.185	0.185	-0.185	0.185	-0.185	0.185
1050.0	-0.192	0.192	-0.192	0.192	-0.192	0.192	-0.192	0.192	-0.192	0.192	-0.192	0.192	-0.192	0.192	-0.192	0.192	-0.192	0.192
1214.7	-0.199	0.199	-0.199	0.199	-0.199	0.199	-0.199	0.199	-0.199	0.199	-0.199	0.199	-0.199	0.199	-0.199	0.199	-0.199	0.199

ACC V1o (random output error due to uncompensated level signal error)

TABLE 5.4.4.7

REF, ABN, ACC V2o																		
LEVEL	PRESSURE w/Error (psia)																	
(volts)	14.7	30.8	33.9	66.1	83.9	116.1	133.9	166.1	283.9	316.1	433.9	466.1	583.9	616.1	733.9	766.1	883.9	916.1
2.5	0.000	-0.003	0.003	-0.003	0.003	-0.003	0.003	-0.003	0.003	-0.003	0.004	-0.004	0.004	-0.004	0.005	-0.005	0.005	-0.005
3.0	0.000	0.001	0.000	0.000	0.001	-0.001	0.001	-0.001	0.002	-0.002	0.003	-0.003	0.003	-0.003	0.003	-0.003	0.004	-0.004
4.0	0.000	0.009	-0.005	0.004	-0.003	0.002	-0.001	0.001	0.000	0.000	0.000	0.000	0.001	-0.001	0.001	-0.001	0.001	-0.002
6.0	0.000	0.024	-0.016	0.013	-0.009	0.008	-0.007	0.007	-0.004	0.004	-0.005	0.005	-0.004	0.004	-0.004	0.003	-0.003	0.003
8.0	0.000	0.039	-0.026	0.021	-0.016	0.015	-0.012	0.012	-0.008	0.008	-0.009	0.011	-0.008	0.009	-0.009	0.008	-0.008	0.008
10.0	0.000	0.054	-0.036	0.030	-0.023	0.021	-0.018	0.018	-0.012	0.012	-0.014	0.016	-0.012	0.014	-0.014	0.013	-0.013	0.013
11.0	0.000	0.062	-0.041	0.034	-0.027	0.024	-0.020	0.020	-0.014	0.014	-0.017	0.019	-0.015	0.017	-0.017	0.015	-0.015	0.015
12.0	0.000	0.069	-0.047	0.038	-0.030	0.027	-0.023	0.023	-0.016	0.016	-0.019	0.021	-0.017	0.019	-0.020	0.017	-0.018	0.018
12.5	0.000	0.073	-0.049	0.041	-0.032	0.029	-0.024	0.024	-0.017	0.017	-0.020	0.023	-0.018	0.021	-0.021	0.018	-0.019	0.019

REF, ABN, ACC V2o				
LEVEL	PRESSURE w/Error (psia)			
(volts)	1033.9	1066.1	1198.6	1214.7
2.5	0.006	-0.006	0.003	0.000
3.0	0.004	-0.004	0.002	0.000
4.0	0.002	-0.002	0.001	0.000
6.0	-0.003	0.003	-0.002	0.000
8.0	-0.008	0.008	-0.005	0.000
10.0	-0.013	0.013	-0.008	0.000
11.0	-0.016	0.016	-0.009	0.000
12.0	-0.018	0.018	-0.011	0.000
12.5	-0.019	0.019	-0.011	0.000

REF, ABN, ACC V2o (output error due to the pressure signal error)

TABLE 5.4.4.8

ABN Vob																	
PRESS	LEVEL w/Error (volts)																
(psia)	2.438	2.568	2.938	3.068	3.938	4.068	5.938	6.068	7.938	8.068	9.938	10.068	10.938	11.068	11.938	12.068	12.438	12.568
14.7	-0.025	0.027	-0.025	0.027	-0.025	0.027	-0.025	0.027	-0.025	0.027	-0.025	0.027	-0.025	0.027	-0.025	0.027	-0.025	0.027
50.0	-0.026	0.028	-0.026	0.028	-0.026	0.028	-0.026	0.028	-0.026	0.028	-0.026	0.028	-0.026	0.028	-0.026	0.028	-0.026	0.028
100.0	-0.026	0.029	-0.026	0.029	-0.026	0.029	-0.026	0.029	-0.026	0.029	-0.026	0.029	-0.026	0.029	-0.026	0.029	-0.026	0.029
150.0	-0.027	0.029	-0.027	0.029	-0.027	0.029	-0.027	0.029	-0.027	0.029	-0.027	0.029	-0.027	0.029	-0.027	0.029	-0.027	0.029
300.0	-0.028	0.031	-0.028	0.031	-0.028	0.031	-0.028	0.031	-0.028	0.031	-0.028	0.031	-0.028	0.031	-0.028	0.031	-0.028	0.031
450.0	-0.030	0.032	-0.030	0.032	-0.030	0.032	-0.030	0.032	-0.030	0.032	-0.030	0.032	-0.030	0.032	-0.030	0.032	-0.030	0.032
600.0	-0.031	0.033	-0.031	0.033	-0.031	0.033	-0.031	0.033	-0.031	0.033	-0.031	0.033	-0.031	0.033	-0.031	0.033	-0.031	0.033
750.0	-0.032	0.035	-0.032	0.035	-0.032	0.035	-0.032	0.035	-0.032	0.035	-0.032	0.035	-0.032	0.035	-0.032	0.035	-0.032	0.035
900.0	-0.033	0.036	-0.033	0.036	-0.033	0.036	-0.033	0.036	-0.033	0.036	-0.033	0.036	-0.033	0.036	-0.033	0.036	-0.033	0.036
1050.0	-0.034	0.037	-0.034	0.037	-0.034	0.037	-0.034	0.037	-0.034	0.037	-0.034	0.037	-0.034	0.037	-0.034	0.037	-0.034	0.037
1214.7	-0.035	0.038	-0.035	0.038	-0.035	0.038	-0.035	0.038	-0.035	0.038	-0.035	0.038	-0.035	0.038	-0.035	0.038	-0.035	0.038

ABN Vob (bias output error due to uncompensated level signal error)

TABLE 5.4.4.9

ACC Vob																	
PRESS	LEVEL w/Error (volts)																
(psia)	2.478	3.298	2.978	3.798	3.978	4.798	5.978	6.798	7.978	8.798	9.978	10.798	10.978	11.798	11.978	12.798	12.478	13.298
14.7	-0.009	0.319	-0.009	0.319	-0.009	0.319	-0.009	0.319	-0.009	0.319	-0.009	0.319	-0.009	0.319	-0.009	0.319	-0.009	0.319
50.0	-0.009	0.330	-0.009	0.330	-0.009	0.330	-0.009	0.330	-0.009	0.330	-0.009	0.330	-0.009	0.330	-0.009	0.330	-0.009	0.330
100.0	-0.010	0.340	-0.010	0.340	-0.010	0.340	-0.010	0.340	-0.010	0.340	-0.010	0.340	-0.010	0.340	-0.010	0.340	-0.010	0.340
150.0	-0.010	0.347	-0.010	0.347	-0.010	0.347	-0.010	0.347	-0.010	0.347	-0.010	0.347	-0.010	0.347	-0.010	0.347	-0.010	0.347
300.0	-0.010	0.365	-0.010	0.365	-0.010	0.365	-0.010	0.365	-0.010	0.365	-0.010	0.365	-0.010	0.365	-0.010	0.365	-0.010	0.365
450.0	-0.011	0.380	-0.011	0.380	-0.011	0.380	-0.011	0.380	-0.011	0.380	-0.011	0.380	-0.011	0.380	-0.011	0.380	-0.011	0.380
600.0	-0.011	0.395	-0.011	0.395	-0.011	0.395	-0.011	0.395	-0.011	0.395	-0.011	0.395	-0.011	0.395	-0.011	0.395	-0.011	0.395
750.0	-0.012	0.409	-0.012	0.409	-0.012	0.409	-0.012	0.409	-0.012	0.409	-0.012	0.409	-0.012	0.409	-0.012	0.409	-0.012	0.409
900.0	-0.012	0.423	-0.012	0.423	-0.012	0.423	-0.012	0.423	-0.012	0.423	-0.012	0.423	-0.012	0.423	-0.012	0.423	-0.012	0.423
1050.0	-0.012	0.438	-0.012	0.438	-0.012	0.438	-0.012	0.438	-0.012	0.438	-0.012	0.438	-0.012	0.438	-0.012	0.438	-0.012	0.438
1214.7	-0.013	0.455	-0.013	0.455	-0.013	0.455	-0.013	0.455	-0.013	0.455	-0.013	0.455	-0.013	0.455	-0.013	0.455	-0.013	0.455

ACC Vob (bias output error due to uncompensated level signal error)

5.4.4.2 EFIC1--Level Initiate Bistables (SU1)

			COMPONENT ID			
	Tag Number(s)		C37-1-TDB-A25, -A35 C37-2-TDB-B25, -B35			[5.6.5]
	Manufacturer		Vitro Engineering Corp.			[5.6.5]
	Model Number		3801-3034			[5.6.5]
			ENVIRONMENTAL CONDITIONS			
	Location		Aux. Bldg.-Control Room			[5.6.5]
	Calibration Temperature		75	°F		[5.3.19]
	Temp Variance		± 9	°F		[5.3.19]
			ERROR SUMMARY			
DRN 05-3577	Reference Accuracy (RA)	=	± 0.539	%Span		[5.3.25]
	Setting Tolerance (ST)	=	± 0.111	%Span		[5.3.29]
	Device Tolerance (Dtol)	=	± 0.650	%Span		[5.3.29]
	Calibration (CAL)	=	± $[(0.125)^2+(0.125)^2]^{1/2}$			[5.3.22]
	Calibration (CAL)	=	± 0.177	%Span		
7	Drift (DR)	=	± 0.258	%Span		[5.3.20]
	Power Supply Effect (PS)	=	± 0.000	%Span		[5.3.21]
	Temperature Effect (TE)	=	± 0.000	%Span		[5.3.21]

The errors for the Low Range Level Signal (eSU1) are given as follows:

REF eSU1	=	± (Dtol + CAL)	
REF eSU1	=	± 0.827 %Span	DRN 05-3577
ABN eSU1	=	± $[(Dtol+CAL)^2+DR^2+PS^2+TE^2]^{1/2}$	
ABN eSU1	=	± 0.866 %Span	DRN 05-3577
ACC eSU1	=	± $[(Dtol+CAL)^2+DR^2+PS^2+TE^2]^{1/2}$	
ACC eSU1	=	± 0.866 %Span	DRN 05-3577

The output error for the Bistables (SU1o) are given based on the following equations:

REF SU1o = ± $[(\text{REF eSU1})^2+(\text{REF V1o})^2+(\text{REF V2o})^2]^{1/2}$
REF SU1o = ± $[(\text{REF eSU1})^2+(\text{Table 5.4.4.4})^2+(\text{Table 5.4.4.7})^2]^{1/2}$
REF SU1o = ± Table 5.4.4.10

ABN SU1o = ± $[(\text{ABN eSU1})^2+(\text{ABN V1o})^2+(\text{ABN V2o})^2]^{1/2}$
ABN SU1o = ± $[(\text{ABN eSU1})^2+(\text{Table 5.4.4.5})^2+(\text{Table 5.4.4.7})^2]^{1/2}$
ABN SU1o = ± Table 5.4.4.11

ACC SU1o = ± $[(\text{ACC eSU1})^2+(\text{ACC V1o})^2+(\text{ACC V2o})^2]^{1/2}$
ACC SU1o = ± $[(\text{ABN eSU1})^2+(\text{Table 5.4.4.6})^2+(\text{Table 5.4.4.7})^2]^{1/2}$
ACC SU1o = ± Table 5.4.4.13

ABN SU1ob = ABN Vob
ABN SU1ob = (Table 5.4.4.8)
ABN SU1ob = Table 5.4.4.12

ACC SU1ob = ACC Vob
ACC SU1ob = (Table 5.4.4.9)
ACC SU1ob = Table 5.4.4.14

Note: Errors in volts are converted to %Span prior to combining with the EFIC error (eSU1).

The total otput error for the reference condition is given in Table 5.4.4.10 since there is no bias error.

The total output error for the abnormal condition is the algebraic sum of the random and bias terms:
ABN SU1ot = ABN SU1o + ABN SU1ob
ABN SU1ot = (Table 5.4.4.11)+(Table 5.4.4.12)
ABN SU1ot = Table 5.4.4.15

The total output error for the accident condition is the algebraic sum of the random and bias terms:
ACC SU1ot = ACC SU1o + ACC SU1ob
ACC SU1ot = (Table 5.4.4.13)+(Table 5.4.4.14)
ACC SU1ot = Table 5.4.4.16

TABLE 5.4.4.10

REF SU1o (%Span)									
PRESS	LEVEL (volts)								
(psia)	2.5	3.0	4.0	6.0	8.0	10.0	11.0	12.0	12.5
14.7	1.29	1.29	1.31	1.42	1.62	1.87	2.01	2.16	2.23
50.0	1.32	1.31	1.32	1.37	1.47	1.60	1.67	1.76	1.80
100.0	1.34	1.34	1.34	1.36	1.40	1.46	1.49	1.54	1.56
150.0	1.36	1.36	1.36	1.37	1.39	1.43	1.45	1.47	1.49
300.0	1.40	1.40	1.40	1.40	1.42	1.43	1.44	1.46	1.46
450.0	1.44	1.44	1.44	1.44	1.46	1.49	1.51	1.53	1.54
600.0	1.48	1.48	1.47	1.48	1.49	1.52	1.53	1.55	1.56
750.0	1.52	1.51	1.51	1.51	1.53	1.55	1.57	1.59	1.60
900.0	1.55	1.55	1.55	1.55	1.56	1.58	1.59	1.61	1.62
1050.0	1.59	1.59	1.59	1.59	1.60	1.62	1.64	1.65	1.66
1214.7	1.64	1.63	1.63	1.63	1.64	1.64	1.65	1.65	1.66

REF SU1o--OUTPUT LOOP ERROR (%Span)

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TABLE 5.4.4.11

ABN SU1o (%Span)									
PRESS	LEVEL (volts)								
(psia)	2.5	3.0	4.0	6.0	8.0	10.0	11.0	12.0	12.5
14.7	1.32	1.31	1.33	1.44	1.64	1.89	2.03	2.17	2.25
50.0	1.34	1.34	1.35	1.40	1.49	1.62	1.69	1.78	1.82
100.0	1.36	1.36	1.36	1.38	1.42	1.48	1.52	1.56	1.58
150.0	1.38	1.38	1.38	1.39	1.41	1.45	1.47	1.49	1.51
300.0	1.42	1.42	1.42	1.43	1.44	1.46	1.47	1.48	1.49
450.0	1.46	1.46	1.46	1.47	1.49	1.51	1.53	1.55	1.57
600.0	1.50	1.50	1.50	1.50	1.52	1.54	1.55	1.57	1.58
750.0	1.54	1.54	1.53	1.54	1.55	1.58	1.59	1.61	1.62
900.0	1.58	1.57	1.57	1.57	1.58	1.60	1.62	1.63	1.64
1050.0	1.62	1.61	1.61	1.61	1.62	1.64	1.66	1.67	1.68
1214.7	1.66	1.65	1.65	1.65	1.66	1.66	1.67	1.67	1.68

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ABN SU1o--OUTPUT LOOP ERROR (%Span)

TABLE 5.4.4.12

ABN SU1ob (%Span)																		
	LEVEL (volts)																	
PRESS	2.5		3.0		4.0		6.0		8.0		10.0		11.0		12.0		12.5	
(psia)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)
14.7	-0.62	0.68	-0.62	0.68	-0.62	0.68	-0.62	0.68	-0.62	0.68	-0.62	0.68	-0.62	0.68	-0.62	0.68	-0.62	0.68
50.0	-0.64	0.70	-0.64	0.70	-0.64	0.70	-0.64	0.70	-0.64	0.70	-0.64	0.70	-0.64	0.70	-0.64	0.70	-0.64	0.70
100.0	-0.66	0.72	-0.66	0.72	-0.66	0.72	-0.66	0.72	-0.66	0.72	-0.66	0.72	-0.66	0.72	-0.66	0.72	-0.66	0.72
150.0	-0.68	0.73	-0.68	0.73	-0.68	0.73	-0.68	0.73	-0.68	0.73	-0.68	0.73	-0.68	0.73	-0.68	0.73	-0.68	0.73
300.0	-0.71	0.77	-0.71	0.77	-0.71	0.77	-0.71	0.77	-0.71	0.77	-0.71	0.77	-0.71	0.77	-0.71	0.77	-0.71	0.77
450.0	-0.74	0.80	-0.74	0.80	-0.74	0.80	-0.74	0.80	-0.74	0.80	-0.74	0.80	-0.74	0.80	-0.74	0.80	-0.74	0.80
600.0	-0.77	0.83	-0.77	0.83	-0.77	0.83	-0.77	0.83	-0.77	0.83	-0.77	0.83	-0.77	0.83	-0.77	0.83	-0.77	0.83
750.0	-0.80	0.86	-0.80	0.86	-0.80	0.86	-0.80	0.86	-0.80	0.86	-0.80	0.86	-0.80	0.86	-0.80	0.86	-0.80	0.86
900.0	-0.82	0.89	-0.82	0.89	-0.82	0.89	-0.82	0.89	-0.82	0.89	-0.82	0.89	-0.82	0.89	-0.82	0.89	-0.82	0.89
1050.0	-0.85	0.93	-0.85	0.93	-0.85	0.93	-0.85	0.93	-0.85	0.93	-0.85	0.93	-0.85	0.93	-0.85	0.93	-0.85	0.93
1214.7	-0.89	0.96	-0.89	0.96	-0.89	0.96	-0.89	0.96	-0.89	0.96	-0.89	0.96	-0.89	0.96	-0.89	0.96	-0.89	0.96

ABN SU1ob--OUTPUT LOOP ERROR (%Span)

TABLE 5.4.4.13

ACC SU1o (%Span)									
PRESS	LEVEL (volts)								
(psia)	2.5	3.0	4.0	6.0	8.0	10.0	11.0	12.0	12.5
14.7	3.60	3.60	3.61	3.65	3.73	3.85	3.92	4.00	4.04
50.0	3.72	3.72	3.72	3.74	3.78	3.83	3.86	3.90	3.92
100.0	3.82	3.82	3.82	3.83	3.84	3.87	3.88	3.90	3.90
150.0	3.90	3.90	3.90	3.91	3.91	3.93	3.93	3.94	3.95
300.0	4.09	4.09	4.09	4.09	4.10	4.10	4.11	4.11	4.11
450.0	4.25	4.25	4.25	4.26	4.26	4.27	4.28	4.29	4.29
600.0	4.41	4.41	4.41	4.41	4.41	4.42	4.43	4.43	4.44
750.0	4.56	4.56	4.56	4.56	4.57	4.57	4.58	4.59	4.59
900.0	4.72	4.72	4.72	4.72	4.72	4.73	4.73	4.74	4.74
1050.0	4.88	4.88	4.88	4.88	4.88	4.89	4.89	4.90	4.90
1214.7	5.06	5.06	5.06	5.06	5.06	5.06	5.06	5.07	5.07

ACC SU1o--OUTPUT LOOP ERROR (%Span)

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TABLE 5.4.4.14

ACC SU1ob (%Span)																		
PRESS	LEVEL (volts)																	
	2.5		3.0		4.0		6.0		8.0		10.0		11.0		12.0		12.5	
(psia)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)
14.7	-0.23	7.98	-0.23	7.98	-0.23	7.98	-0.23	7.98	-0.23	7.98	-0.23	7.98	-0.23	7.98	-0.23	7.98	-0.23	7.98
50.0	-0.23	8.26	-0.23	8.26	-0.23	8.26	-0.23	8.26	-0.23	8.26	-0.23	8.26	-0.23	8.26	-0.23	8.26	-0.23	8.26
100.0	-0.24	8.50	-0.24	8.50	-0.24	8.50	-0.24	8.50	-0.24	8.50	-0.24	8.50	-0.24	8.50	-0.24	8.50	-0.24	8.50
150.0	-0.24	8.68	-0.24	8.68	-0.24	8.68	-0.24	8.68	-0.24	8.68	-0.24	8.68	-0.24	8.68	-0.24	8.68	-0.24	8.68
300.0	-0.26	9.13	-0.26	9.13	-0.26	9.13	-0.26	9.13	-0.26	9.13	-0.26	9.13	-0.26	9.13	-0.26	9.13	-0.26	9.13
450.0	-0.27	9.50	-0.27	9.50	-0.27	9.50	-0.27	9.50	-0.27	9.50	-0.27	9.50	-0.27	9.50	-0.27	9.50	-0.27	9.50
600.0	-0.28	9.86	-0.28	9.86	-0.28	9.86	-0.28	9.86	-0.28	9.86	-0.28	9.86	-0.28	9.86	-0.28	9.86	-0.28	9.86
750.0	-0.29	10.22	-0.29	10.22	-0.29	10.22	-0.29	10.22	-0.29	10.22	-0.29	10.22	-0.29	10.22	-0.29	10.22	-0.29	10.22
900.0	-0.30	10.58	-0.30	10.58	-0.30	10.58	-0.30	10.58	-0.30	10.58	-0.30	10.58	-0.30	10.58	-0.30	10.58	-0.30	10.58
1050.0	-0.31	10.95	-0.31	10.95	-0.31	10.95	-0.31	10.95	-0.31	10.95	-0.31	10.95	-0.31	10.95	-0.31	10.95	-0.31	10.95
1214.7	-0.32	11.38	-0.32	11.38	-0.32	11.38	-0.32	11.38	-0.32	11.38	-0.32	11.38	-0.32	11.38	-0.32	11.38	-0.32	11.38

ACC SU1ob--OUTPUT LOOP ERROR (%Span)

TABLE 5.4.4.15

ABN SU1ot (%Span)																		
	LEVEL (volts)																	
PRESS	2.5		3.0		4.0		6.0		8.0		10.0		11.0		12.0		12.5	
(psia)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)
14.7	1.94	1.99	1.94	1.99	1.95	2.01	2.06	2.12	2.26	2.31	2.51	2.56	2.65	2.70	2.79	2.85	2.87	2.92
50.0	1.98	2.04	1.98	2.04	1.99	2.04	2.04	2.09	2.13	2.19	2.26	2.32	2.34	2.39	2.42	2.47	2.46	2.52
100.0	2.03	2.08	2.02	2.08	2.03	2.08	2.04	2.10	2.08	2.14	2.14	2.20	2.18	2.24	2.22	2.28	2.24	2.30
150.0	2.06	2.12	2.06	2.12	2.06	2.12	2.07	2.13	2.09	2.15	2.12	2.18	2.15	2.20	2.17	2.23	2.18	2.24
300.0	2.14	2.20	2.13	2.20	2.13	2.20	2.14	2.20	2.15	2.21	2.17	2.23	2.18	2.24	2.19	2.25	2.20	2.26
450.0	2.20	2.27	2.20	2.27	2.20	2.26	2.21	2.27	2.23	2.29	2.25	2.32	2.27	2.34	2.29	2.36	2.31	2.37
600.0	2.27	2.33	2.27	2.33	2.27	2.33	2.27	2.33	2.28	2.35	2.31	2.37	2.32	2.39	2.34	2.41	2.35	2.42
750.0	2.33	2.40	2.33	2.40	2.33	2.40	2.33	2.40	2.35	2.42	2.37	2.44	2.39	2.46	2.41	2.47	2.42	2.48
900.0	2.40	2.47	2.40	2.47	2.39	2.46	2.40	2.47	2.41	2.48	2.43	2.50	2.44	2.51	2.45	2.53	2.46	2.53
1050.0	2.47	2.54	2.47	2.54	2.46	2.54	2.46	2.54	2.47	2.55	2.49	2.57	2.51	2.58	2.52	2.60	2.53	2.61
1214.7	2.54	2.62	2.54	2.62	2.54	2.62	2.54	2.62	2.54	2.62	2.55	2.63	2.55	2.63	2.56	2.64	2.56	2.64

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ABN SU1ot--TOTAL OUTPUT LOOP ERROR (%Span)

TABLE 5.4.4.16

ACC SU1ot (%Span)																		
	LEVEL (volts)																	
PRESS	2.5		3.0		4.0		6.0		8.0		10.0		11.0		12.0		12.5	
(psia)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)
14.7	3.83	11.59	3.83	11.59	3.83	11.59	3.88	11.63	3.96	11.72	4.07	11.83	4.14	11.90	4.22	11.98	4.26	12.02
50.0	3.95	11.98	3.95	11.98	3.96	11.98	3.97	12.00	4.01	12.04	4.06	12.09	4.09	12.12	4.13	12.16	4.15	12.18
100.0	4.06	12.32	4.06	12.32	4.06	12.32	4.07	12.33	4.08	12.34	4.11	12.37	4.12	12.38	4.14	12.40	4.14	12.40
150.0	4.15	12.59	4.15	12.59	4.15	12.59	4.15	12.59	4.16	12.60	4.17	12.61	4.18	12.62	4.19	12.63	4.19	12.63
300.0	4.35	13.22	4.35	13.22	4.35	13.22	4.35	13.22	4.35	13.22	4.36	13.23	4.36	13.23	4.37	13.24	4.37	13.24
450.0	4.52	13.76	4.52	13.76	4.52	13.76	4.52	13.76	4.53	13.76	4.54	13.78	4.55	13.78	4.55	13.79	4.56	13.79
600.0	4.69	14.27	4.69	14.27	4.69	14.27	4.69	14.27	4.69	14.28	4.70	14.28	4.71	14.29	4.71	14.30	4.71	14.30
750.0	4.85	14.78	4.85	14.78	4.85	14.78	4.85	14.78	4.85	14.79	4.86	14.79	4.87	14.80	4.87	14.81	4.88	14.81
900.0	5.01	15.30	5.01	15.29	5.01	15.29	5.01	15.29	5.02	15.30	5.02	15.30	5.03	15.31	5.03	15.31	5.04	15.32
1050.0	5.19	15.83	5.19	15.83	5.18	15.83	5.19	15.83	5.19	15.83	5.20	15.84	5.20	15.84	5.21	15.85	5.21	15.85
1214.7	5.38	16.44	5.38	16.44	5.38	16.44	5.38	16.44	5.38	16.44	5.38	16.44	5.39	16.44	5.39	16.44	5.39	16.45

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ACC SU1ot--TOTAL OUTPUT LOOP ERROR (%Span)

5.4.6 TIME RESPONSE FOR TRIP FUNCTIONS

COMPONENT	TIME			
Transmitter	0.500	Sec.		[5.6.8]
I/V Converter	0.100	Sec.		[5.6.15]
V/I Converter	0.100	Sec.		[5.3.27]
EFIC Time Delay Bistable	10.400	Sec.	DRN 05-3577	[5.3.28]
Trip Interface Equipment (TIE)	0.025	Sec.		[5.6.42]
Total Time Response	11.125	Sec.	DRN 05-3577	

5.5.0 CONCLUSIONS

The instrument uncertainty for the ANO-1 EFIC Channel A & B level bistable, SG Low Level Initiate (SU1o) is calculated below:

SG Low Level Initiate (SU1o)

The output error for each of these bistables is the output error determined at the output of the EFIC Bistable Modules.

REF SU1o[1]	=	±	2.23	%SPAN		=	±	3.35	inches
ABN SU1ot[2]	=	+	2.62	%SPAN	DRN	=	+	3.92	inches
ABN SU1ot[2]	=	-	2.54	%SPAN	05-3577	=	-	3.81	inches
ACC SU1ot[1]	=	+	16.45	%SPAN		=	+	24.67	inches
ACC SU1ot[1]	=	-	5.39	%SPAN		=	-	8.08	inches

Note: 1. These results are the worst cases (i.e. greatest possible errors) found in Tables 5.4.4.10, and 5.4.4.16.
DRN 05-3577 2. These values reflect Assumption & Given Condition 5.3.31.

Reference these tables if uncertainties are required at specific levels/pressures.

The instrument uncertainty for the ANO-1 EFIC Channel A & B Low Range Level Control (LRLo) is calculated below:

SG Low Range Level Control (LRLo)

The output error for Low Range Level Control is the output determined at the output of the EFIC Control Modules.

REF LRLo	=	±	1.05	%SPAN		=	±	1.57	inches
7 ABN LRLo	=	+	1.27	%SPAN		=	+	1.91	inches
	=	-	1.27	%SPAN		=	-	1.90	inches
7 ACC LRLo	=	+	5.21	%SPAN		=	+	7.81	inches
	=	-	1.85	%SPAN		=	-	2.77	inches

7 Note: These results are the worst cases found in Tables 5.4.5.10, 5.4.5.15, and 5.4.5.16. Reference these tables if uncertainties are required at specific levels/pressures.

SETPOINT EVALUATION

7 SG Low Level Initiate (SU1)

Credit is only taken for the initiation of EFW using this setpoint under the conditions of normal reactor building environment. Therefore, the uncertainties for the Abnormal Condition will be used in setpoint evaluation. Per Reference 5.6.45, the process limit for SG Low Level Initiate is 6 inches above the lower tubesheet (LTS). Since this trip provides protection for a decreasing level, the bistable positive abnormal error terms will be used. DRN 05-3577

Calc. Setpoint = Analytical Limit + Total Loop Error + Margin to Lower Tap
= 6.0 + ABN SU1ot(+) + 0.5
= 6 + 3.92 + 0.5
= 10.42 inches (above LTS)

Note also that the Technical Specifications provide an Allowable Value of 9.34 inches (Ref. 5.6.11). The calculated Allowable Value using guidance provided in Reference 5.6.43 is shown below.

Test Error = $((RA^2 + CAL^2 + DR^2)^{1/2})$%SPAN
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Note: Dtol will be used in place of RA where applicable (Dtol = 0.650 % SPAN or 0.975 inches)

DRN 05-3577 = 0.721 %SPAN
= 1.08 inches

Allowable Value = Calc. Setpoint - Test Error
= 9.34 inches

The in-plant setpoint of 5.0 inches above the lower tap (11.0 ± 0.975 inches above the LTS) is conservative with respect to the Allowable Value. Note that the Total Loop Error, Test Error and the as-left bistable tolerance (see Dtol above) support the Technical Specification Allowable Value (Ref. 5.6.11) of 9.34 inches. DRN 05-3577

SG Low-Range Level Control (LRL)

This setpoint is used when adequate subcooling margin exists (at least one RC pump is operating). Since any inventory in the generator will be adequate to remove core decay heat, the process limit should correspond to to the lower tap elevation, 6 inches above the LTS. The low-range level setpoint is currently 31 inches above the LTS. Since this setpoint provides protection for a decreasing level, the bistable positive accident error terms will be used.

Setpoint = Analytical Limit + Total Loop Error
= 6 + ACC LRLot(+)
= 6 + 7.81
= 13.81 inches (above LTS)

The present setpoint of 31 inches (above the LTS) is conservative with respect to this calculation.

5.6.0 REFERENCES

5.6.1 Design Guide IDG-001-0, Instrument Loop Error Analysis and Setpoint Methodology Manual.

5.6.2 ANO Engineering Standard NES-13, Rev. 1, Environmental Qualification -Environmental Service Conditions.

5.6.3 ASME Steam Tables, Sixth Edition.

5.6.4 Calculation No. 92-EQ-0003-01, Rev. 5, Specific IR Effects Calculation.

5.6.5 SIMS, As of the calculation origination date.

5.6.6 ANO-1 System Training Manual, STM 1-66, Rev. 5, Emergency Feedwater Initiation and Control System.

5.6.7 Procedure No. 1304.206, Rev. 4, Unit 1 EFIC Channel B Monthly Test, SG Pressure Greater Than 750 PSIG.

5.6.8 TM R370.0010 Rev. 23, TD R370.0160, Rev. 5, Rosemount Pressure Transmitters for Nuclear Service Model 1154 Alphaline. DRN 05-3577

5.6.9 Conduct of Maintenance Procedure 1025.003, Rev. 43-01.

5.6.10 TM B015.0580, Rev. 5, Technical Manual For Unit 1 Emergency Feedwater and Initiation and Control System.

5.6.11 ANO-1 Technical Specifications Submittal 1CAN010601. DRN 05-3577

5.6.12 ANO Document No. MISC-96-022, Letter from Neil P. Lien (Rosemount) to Bob McCain (Entergy Operations) dated September 20, 1990 Regarding Rosemount transmitter specifications.

5.6.13 TM F180.9080, Rev. 0, Instruction Book 3252 For Foxboro Single Nest Power Supply 2AX + PS9 Series.

5.6.14 ULD-1-SYS-12, Rev. 3, ANO-1 Emergency Feedwater System.

5.6.15 TD F180.3250, Rev. 2, Instruction Current to Voltage Converter Models 4 to 20 mA, Isolated, Styles A and B.

5.6.16 Document No. 1CAN038104.

5.6.17 ANO-97-00107, Foxboro Fax, dated February 17, 1997.

5.6.18 TD F180.3380, Rev. 1, Technical Information Voltage to Current Converter Model 2AO-V2I, Isolated 4 to 20 mADC.

5.6.19 ANO Engineering Report, 95-R-0013-01, Rev. 0; Control Room Post Accident Requirements.

5.6.20 B & W Document Identifier 51-1142173-00, EFIC System Accuracies.

5.6.21 ANO-1 Calculation No. 92-R-1023-01, Rev. 0.

5.6.22 Procedure No. 1304.098, Rev. 016-00-0, Unit 1 EFIC Channel A Calibration.
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5.6.23 Procedure No. 1304.099, Rev. 017-00-0, Unit 1 EFIC Channel B Calibration.

5.6.24 Vendor Drawing No. 58526-022-1, Rev. 1, B&W Emergency Feedwater Initiation and Control System Assembly.

5.6.25 ANO-1 Drawing No. E-258, sheet 1A, Rev. 1, Wiring Block Diagram Emergency Feedwater Initiation and Control (EFIC).

5.6.26 ANO-1 Drawing No. E-258, sheet 1B, Rev. 1, Wiring Block Diagram Emergency Feedwater Initiation and Control (EFIC).

5.6.27 M-204, Sh. 4, Rev. 11, Piping & Instrument Diagram Emergency Feedwater.

5.6.28 M-206, Sh. 1, Rev. 117, Piping & Instrument Diagram Steam Generator Secondary System.

5.6.29 Vendor Drawing No. 58526-244, Rev. 0, EFIC Module Connection Diagram SGA Channel A & B.

5.6.30 Vendor Drawing No. 58526-245, Rev. 0, EFIC Module Connection Diagram SGB Channel A & B.

5.6.31 ANO-1 Drawing No. FSK-M-1054, Rev. 2, Emergency Feedwater Initiation and Control System Tube Routing for LT-2671 and LT-2673.

5.6.32 ANO-1 Drawing No. FSK-M-1059, Rev. 3, Emergency Feedwater Initiation and Control System Tube Routing for LT-2667 and LT-2669.

5.6.33 ANO-1 Drawing No. FSK-M-1063, Rev. 3, Emergency Feedwater Initiation and Control System Tube Routing for LT-2618 and LT-2620.

5.6.34 ANO-1 Drawing No. FSK-M-1065, Rev. 2, Emergency Feedwater Initiation and Control System Tube Routing for LT-2622 and LT-2624.

5.6.35 ANO Vendor File V43, Item #107, Rosemount Type Test Report D8600063, Low Level Radiation Dose Rate Test Small Break LOCA Test.

5.6.36 B&W Document Identifier 51-1163812-00.

5.6.37 ANO-1 Calculation No. 95-R-1025-01, Rev. 1, ANO-1 Safety Analysis Groundrules-Cycle 14.

5.6.38 Not Used.

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5.6.39 Procedure No. 1304.145, Rev. 028-00-0, Unit 1 EFIC Channel A Monthly Test.

5.6.40 Procedure No. 1304.146, Rev. 028-00-0, Unit 1 EFIC Channel B Monthly Test.

5.6.41 Procedure No. 1304.205, Rev. 012-00-0, Unit 1 EFIC Channel A Monthly Test, SG Pressure Greater Than 750 PSIG.

5.6.42 Vendor Technical Manual, TM B015.0600, Rev. 1; Section 3.1, drawing S9N76-1, and drawing KGU431K.

7 5.6.43 ISA-RP67.04.02-2000, Methodologies for the Determination of Setpoints for Nuclear Safety-Related Instrumentation.

5.6.44 ER-ANO-2005-0871-000, ERCN1
DRN 05-3577

5.6.45 ANO Calculation A1-NE-2005-005, Rev. 0, "ANO-1 Revised EFIC Low Level Setpoint Summary Report.

ATTACHMENT 5-1
EFIC LOW RANGE LEVEL TRANSMITTER CALIBRATION DRN 05-3577

PURPOSE

The purpose of this attachment is to give the basis for the calibration of the EFIC low range steam generator level transmitters. DRN 05-3577

SCOPE

This attachment is applicable to the following level transmitters:

LT-2618	SGA Low Range Level Transmitter (Channel A)
LT-2622	SGA Low Range Level Transmitter (Channel B)
LT-2667	SGB Low Range Level Transmitter (Channel A)
LT-2671	SGB Low Range Level Transmitter (Channel B)

ASSUMPTIONS AND GIVEN CONDITIONS

1) The high pressure side of the transmitter is connected to the lower tap at 6" above the lower tube sheet (LTS). [5.6.6]

2) The low pressure side of the transmitter is connected to the upper tap at 156" above the LTS. [5.6.6]

3) The upper tap is 100% level and the lower tap is 0% level.

4) The water in the reference leg is assumed to be at 120°F.

5) The water in the steam generator is assumed to be at 212°F.

6) The steam in the steam generator is assumed to be at 212°F.

7) The transmitter is direct acting, 4-20 mADC for 0%-100% level.

8) The transmitter static span shift is +0.75% of differential pressure input per 1000 psi static pressure. [5.6.8]

9) 27.753 "H_2O/psi will be used in converting psi to "H_2O (based on 68°F). [5.6.3]

10) The transmitter static span shift is determined based on the normal operating pressure of 900 psig.

CALCULATIONS

1) Reference Leg Fluid Density (ρ_R)

Per Reference 5.6.3, the specific volume of water at 120°F is 0.016204 ft^3/lbm.
The density is the reciprocal of the specific volume, or 61.7132 lbm/ft^3.
Dividing by 1728 to convert to inches: 0.03571 lbm/in^3.

2) Steam Generator Water Density (ρ_W)

Per Reference 5.6.3, the specific volume of water at 212°F is 0.016719 ft^3/lbm.
The density is the reciprocal of the specific volume, or 59.8122 lbm/ft^3.
Dividing by 1728 to convert to inches: 0.03461 lbm/in^3.

3) Steam Generator Steam Density (ρ_S)

Per Reference 5.6.3, the specific volume of steam at 212°F is 26.799 ft^3/lbm.
The density is the reciprocal of the specific volume, or 0.0373 lbm/ft^3.
Dividing by 1728 to convert to inches: 2.16E-05 lbm/in^3.

4) Height of the Reference Leg (H_R)

H_R = 156 - 6 = 150 inches [5.6.6]

5) Height of Water (H_W) and Height of Steam (H_S) at 0% Level

$H_W(0\%)$ = 0 inches
$H_S(0\%)$ = 150 inches

6) Height of Water (H_W) and Height of Steam (H_S) at 100% Level

$H_W(100\%)$ = 150 inches
$H_S(100\%)$ = 0 inches

7) Differential Pressure at 0% Level (DP_0)

DP_0 = Pressure Hi Side (P_H) - Pressure Lo Side (P_L)
= $[H_W(0\%)*\rho_W + H_S(0\%)*\rho_S] - [H_R*\rho_R]$
= $[H_S(0\%)*\rho_S] - [H_R*\rho_R]$
= -5.353 psi
= -148.56 $"H_2O$

8) Differential Pressure at 100% Level (DP_{100})

DP_{100} = Pressure Hi Side (P_H) - Pressure Lo Side (P_L)
= $[H_W(100\%)*\rho_W + H_S(100\%)*\rho_S] - [H_R*\rho_R]$
= $[H_W(100\%)*\rho_W] - [H_R*\rho_R]$
= -0.165 psi
= -4.58 $"H_2O$

9) Span

Span = $DP_{100} - DP_0$
= 143.98 $"H_2O$

10) Derive Static Pressure Correction Factor Equation
Using the procedure outlined in Reference 5.6.8:

$$CF_{mADC} = \frac{(0.0075)(\text{static pressure} / 1000\ psi)x(DPinput)}{Span} \quad X \quad 16\ mADC$$

$$CF_{mADC} = \frac{(0.0075)(900 / 1000\ psi)x(DPinput)}{143.98} \quad X \quad 16\ mADC$$

$$CF_{mADC} = \frac{(0.00675)x(DPinput)}{143.98} \quad X \quad 16\ mADC$$

11) Derive Low Range Calibration Table With and Without Correction Factor

INPUT (%Span)	INPUT ("H_2O)	Uncorrected (mADC)	CF (mADC)	Desired Corrected (mADC)
0.39	148	4.062	-0.111	3.951
24.70	113	7.952	-0.085	7.867
49.01	78	11.841	-0.059	11.783
73.32	43	15.730	-0.032	15.698
97.62	8	19.620	-0.006	19.614

6.0 EFIC SYSTEM CHANNELS C & D LOW RANGE LEVEL

6.1.0 PURPOSE/SCOPE

6.1.1 PURPOSE

The purpose of this section of this calculation is to determine the accuracy of the level loops associated with the ANO-1 Emergency Feedwater Initiate and Control (EFIC) System, Channels C & D. The specific loop of interest is the SG Low Level Initiate.

See Figure 1 for the block diagram.

6.1.2 SCOPE

This Section is applicable to the following instrument loops:

Unit	Instrument Loop No.	Service
1	LT-2668	SGA Level
1	LT-2617	SGB Level
1	LT-2672	SGA Level
1	LT-2621	SGB Level

The errors will be calculated for the Reference, Abnormal and Accident Conditions.

The loop output error is calculated for the following output devices:

Instrument Device	Function
EFIC Channel C: C37-3-TDB-C45	SG A Low Level Initiate
EFIC Channel C: C37-3-TDB-C55	SG B Low Level Initiate
EFIC Channel D: C37-4-TDB-D45	SG A Low Level Initiate
EFIC Channel D: C37-4-TDB-D55	SG B Low Level Initiate

6.2.0 INTRODUCTION

The ANO-1 Emergency Feedwater Initiation and Control (EFIC) System is an instrumentation system that monitors selected plant conditions and automatically initiates the Emergency Feedwater (EFW) System upon detection of abnormal conditions. The EFW System is required for the accident analysis of Loss of Feedwater for EFW Sizing (Ref. 6.6.36), Main Steam Line Break, Small Break LOCAs and Loss of All Unit AC Power (Ref. 6.6.14).

The SG level signals are corrected for process density changes relative to the calibration density values. As depicted in the block diagram (Figure 1), the inputs into the compensation module consist of a level signal and a pressure signal. Per Reference 6.6.10, these signals are combined using the equation below to produce the output signal that represents the compensated level signal.

$$v_o = 1 + \frac{23.91*(\Delta P_L - 2.5) - 4.0*\rho_{st}}{\rho_w - \rho_{st}}$$

where v_o is the output voltage fed to the Bistables.

In the equation above,

ΔP_L is the level signal corresponding to the SG level transmitter signal prior to density compensation (volts)

ρ_w is the density of water corresponding to the SG pressure transmitter signal. The density values are stored in EPROM and are retrieved based on the pressure signal. (lb/ft^3)

ρ_{st} is the density of steam corresponding to the SG pressure transmitter signal. The density values are stored in EPROM and are retrieved based on the pressure signal. (lb/ft^3)

All errors are converted to units of volts for a consistent analysis throughout the EFIC System modules. The equation above is used to determine the expected output voltage and the output voltage with maximum errors included. The output voltage with maximum errors is compared to the expected output voltage to determine the loop uncertainty. The resulting uncertainty is then combined with the manufacturers specifications for the EFIC System.

SG LOW LEVEL INITIATE

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The Low SG Level Initiate setpoint for EFIC determines the level at which emergency feedwater (EFW) is initiated during Loss of Main Feedwater (LOFW) events. The in-plant setpoint evaluated per Reference 6.6.39 is 11.0 inches above the lower tube sheet (5.0 inches above the lower tap). This setpoint will be evaluated with respect to the instrument uncertainty in the Conclusions Section.

The statistical method of the Square Root of the Sum of Squares (SRSS) is used to determine the random error on a component level and for the loop. Non-random errors are combined via simple addition with the random error term to establish the total error.

This calculation is done with the guidelines set forth in the Instrument Loop Error Analysis and Setpoint Methodology Manual (Ref. 6.6.1).

All percentages are expressed in terms of span unless otherwise noted.

All terms are considered random error terms unless noted by a lower case "b" suffix to indicate a bias or non-random error term or "t" suffix to indicate a total of bias and random terms.

6.3.0 ASSUMPTIONS AND GIVEN CONDITIONS

6.3.1 The minimum and maximum temperatures expected for the transmitter reference leg fluid, during normal operation, are 104°F and 118°F, respectively. These values are conservative per Reference 6.6.38, Table 1 for elev. 336'. 7

6.3.2 The maximum temperature expected for the transmitter reference leg fluid, during accident conditions, is 285°F. This value is found in Reference 6.6.2, Appendix A. For the calculation of the process measurement error, it is assumed that the reference leg fluid does not flash. Therefore, the density is taken from Reference 6.6.3 for 285°F and 54 psia (P_{SAT}).

6.3.3 The operating pressure range is assumed to be limited by the pressure inputs from the pressure loops (Ref. 6.6.7). Therefore, the operating pressure range is 0 to 1200 psig.

6.3.4 Per Reference 6.6.8, the static pressure zero and static pressure span errors are correctable during calibration. Per Attachment 6-1 and References 6.6.22 and 6.6.23, the transmitter is calibrated based on a static pressure of 900 psig. The minimum and maximum operating static pressures are 0 psig and 1200 psig, respectively. Since the transmitters are corrected for a static pressure of 900 psig (Pcor), the static pressure uncertainties will be computed using the maximum deviation from 900 psig, or 900 psi (900 - 0 psig). In addition, to maximize the static pressure span error, the maximum reading of 100% will be used.

6.3.5 Per Reference 6.6.8, static pressure causes a systematic span shift of -0.75% of input per 1000 psi increase which is correctable by applying a correction factor during calibration. Per Attachment 1 and References 6.6.22 and 6.6.23, a correction factor is applied during calibration based on a static pressure of 900 psig. A bias error is introduced when the actual operating static pressure deviates from the calibration pressure of 900 psig. A negative bias occurs for a deviation above 900 psig and a positive bias occurs for a deviation below 900 psig. The deviations are based on the minimum and maximum operating pressures (0 psig and 1200 psig). In addition, the maximum DP input (100%) is used in that it yields the maximum, i.e. the most conservative, error.

6.3.6 Individual error terms less than 0.05%Span are considered negligible (Ref. 6.6.1). Where a note to this effect has been provided, the error is not provided in the calculations. However, where error terms less than 0.05%Span exist in error analyses, they are used in calculations though the impact is negligible.

6.3.7 The measurement and test equipment (M&TE) used at ANO is controlled by a program to ensure traceability is maintained. In accordance with Reference 6.6.9, M&TE specified for use in calibration of instrumentation should have an accuracy at least two times that of the instrument being calibrated unless authorized by responsible management. Unless otherwise noted, the Calibration Error Effect for all devices is based upon using M&TE which is twice as accurate as the devices being calibrated. The calibration uncertainty assumes there are calibration devices on the input and output of the device being calibrated.

6.3.8 For purposes of determining Temperature Effect (TE) for the differential pressure transmitter, a variation of 50°F is used. This assumes a calibration temperature of 60°F and an Abnormal Temperature of 110°F (Ref. 6.6.2). For accident conditions, a variation of 225°F is used. This assumes the maximum temperature in an accident of 285°F (Ref. 6.6.2).

6.3.9 Unless otherwise noted, the line voltage is assumed to be 120 VAC with a variance of ±10 VAC and the DC power supplies are assumed to have a variance of ±10% rated voltage. These variances are assumed to be conservative per Reference 6.6.1.

6.3.10 Per Reference 6.6.8, the Rosemount transmitter drift is 0.20%URL over a 30 month period. References 6.6.22 and 6.6.23 indicate that the transmitters are calibrated every 72 weeks or 18 months. Tech Specs (Ref. 6.6.11) allow a 25% extension, making the calibration interval 22.5 months. Since the calibration interval is within the vendor supplied drift specification, the 0.20%URL will be used as a bounding drift error.

6.3.11 Per Reference 6.6.12, the normal error specifications for the transmitter, given by the vendor, are accurate to three sigma. All other specifications are two sigma values, therefore, the normal transmitter specifications will be multiplied by 2/3 to convert them to two sigma values before combining them with other two sigma values.

6.3.12 Per Reference 6.6.20, each component within the EFIC Compensation Module has an accuracy of 0.25%SPAN and the EFIC Bistable Module has an accuracy of 0.20%SPAN. The SG Low Level Initiate Bistable loop uses four components in the Compensation Module along with the Bistable (Refs. 6.6.29 and 6.6.30). Therefore, the reference accuracy for SU1 is assumed to be the SRSS of the accuracies for four Compensation Module components and the Bistable Module, or 0.539%SPAN.

6.3.13 The maximum normal temperature extremes for the Auxiliary Building is listed as 60 to 105 °F (Ref. 6.6.2).

6.3.14 The radiation effect for the transmitters is given in Reference 6.6.26 as ±1.0%URL for doses less than 1 MRad/ hr and a TID less than 5 MRads. Reference 6.6.13 gives a dose of 2.1 MRads over a 3 year period for a Small Break LOCA. Although the dose given in Reference 6.6.13 may not bound all SBLOCA cases, it is assumed that doses will remain lower than 5MRads.

6.3.15 The MTE used to calibrate the EFIC Modules is much more accurate than one-half the accuracy of the devices being calibrated (Ref. 6.6.22 and 6.6.23). Therefore, in lieu of using RA/2 for the MTE accuracy (6.3.7), the actual accuracy of the MTE (±0.125%) will be used.

6.3.16 The vendor did not supply a temperature effect or power supply effect error specification for the EFIC modules. Based on the small deviations in both the Control Room temperature and the power supply voltage, and based on similar devices in the Control Room, it is assumed that these deviations will have a negligible effect on the loop error.

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6.3.17 The vendor for the EFIC system did not provide any drift data for the components. Given the reference accuracy of the combination of the EFIC compensation module and bistable is 0.539 %span per 6.3.12 above, a drift allowance of approximately half of RA or 0.250 % is considered reasonable. This drift allowance will be increased to 0.258 % span by increasing it by a factor of 31/30 to account for the former 30 day vs. 31 day test frequency presently required by Technical Specifications.

6.3.18 The vendor specifies that the 625-ohm input resistor is a precision resistor (Ref. 6.6.10). Per Reference 6.6.24, the resistor tolerance is ±0.01%. The maximum error will result from maximum input, or 20 mADC and is determined as follows:

[625 + (.01% * 625)] * .02 A = 12.501 volts

The maximum voltage (without error) would be 12.5 volts. Therefore, the error in percent span is (12.501-12.5)/span*100%= 0.0125 %Span. The error will be considered negligible per Assumption 6.3.6.

6.3.19 Per Reference 6.6.19, the Control Room temperature is 75°F with a temperature variance of ±9°F for the Abnormal and Accident Conditions.

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6.3.20 The SG Low Level Initiate Bistable has a 9.900 second time delay (Ref. 6.6.39). The bistables are tested and assumed to be acceptable with a ±0.5 second tolerance (Refs. 6.6.22 and 6.6.23). Therefore, the time response analysis will assume a 10.400 second delay. second delay.

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6.3.21 The calibration procedures state that the Low SG Level Initiate Bistable is calibrated to 0.650%SPAN. This is slightly greater than the reference accuracy (RA) of 0.539% Span listed in Section 6.4.4.2 and less than the former tolerance of 1.0% Span. Therefore, a setting tolerance (ST) will be added to the reference accuracy (RA) to obtain a device tolerance (Dtol) of 0.650% SPAN.

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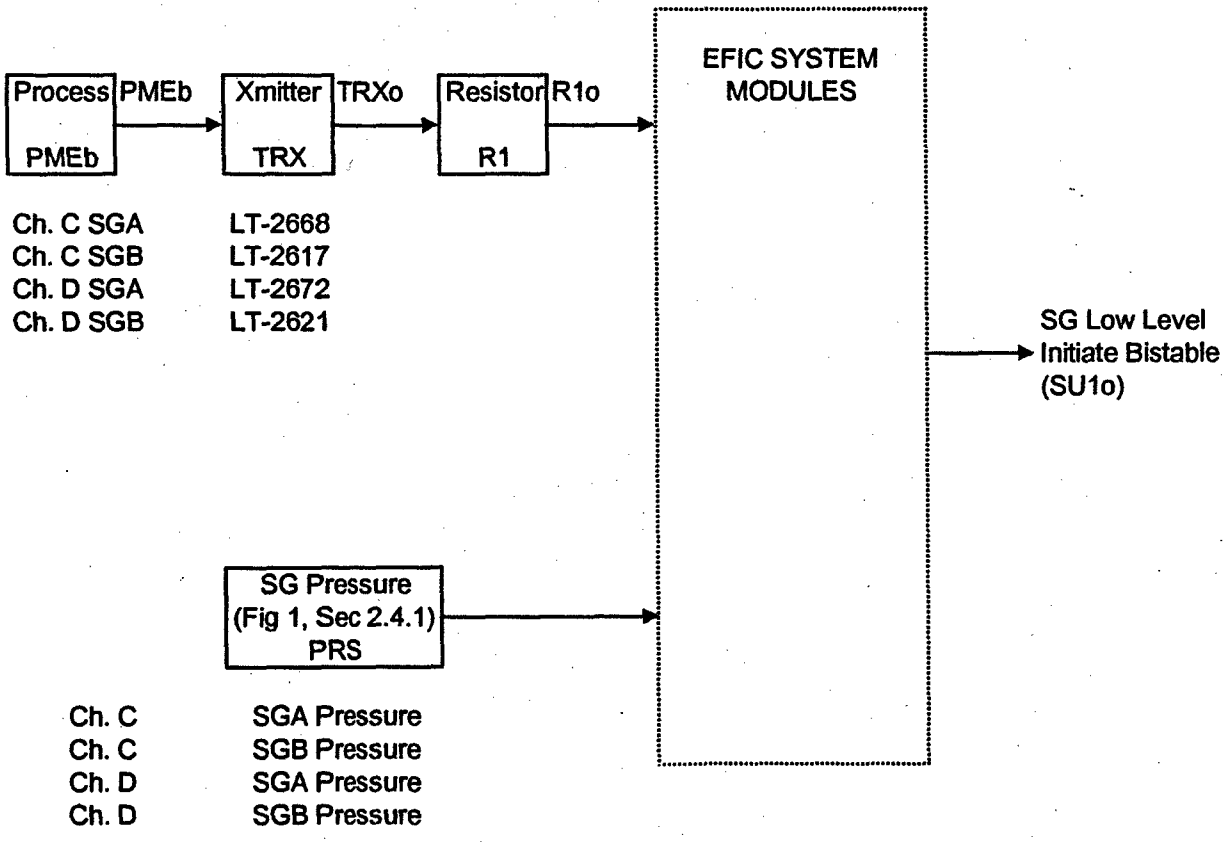
6.3.22 EFIC initiates on a low level of 11 inches above the lower tube sheet or 5 inches of calibrated span (3.3 % span, rounded), this is equivalent to an uncompensated voltage level of approximately 2.833 volts or 2.84 volts (rounded). This trip is credited for a Loss of Feedwater (LOFW) event which does not assume a main steam or main feedwater line break. For LOFW the actual SG pressure would be expected to remain the same or increase above normal operating pressure at the time of trip intitiation. Table 6.4.4.15 shows that for the range of bistable voltages from 2.5 to 6.0 vdc and for pressures equal to or greater than 900 psia the abnormal low level initiate bistable uncertainty (ABN SU1ot) is bounded by +2.02 / - 1.95 % Span.

6.6.4.0 ANALYSIS

6.6.4.1 FIGURE 1: BLOCK DIAGRAM--EFIC CHANNELS C & D [6.6.25, 6.6.27, 6.6.28, 6.6.29, 6.6.30]



6.4.2 SG PRESSURE (PRS)

The Steam Generator pressure signals for EFIC Channels C and D come from the following pressure transmitters:

PT-2617A
PT-2617B
PT-2668A
PT-2668B

The loop error analysis for the above pressure transmitter loops is calculated in Section 2.0. The following errors ("R1o" from Section 2.0) for the Reference, Abnormal and Accident conditions are the errors associated with the pressure signal that is input to the EFIC density compensation module:

REF PRSo	=	±	REF R1o (from Sect. 2.0)					
REF PRSo	=	±	0.427	%Span	=	±	5.1 psi	[Sect. 2.0]
ABN PRSo	=	±	ABN R1o (from Sect. 2.0)					
ABN PRSo	=	±	0.895	%Span	=	±	10.7 psi	[Sect. 2.0]
ACC PRSo	=	±	ACC R1o (from Sect. 2.0)					
ACC PRSo	=	±	0.895	%Span	=	±	10.7 psi	[Sect. 2.0]
ACC PRSob	=		ACC R1ob (from Sect. 2.0)					
ACC PRSob	=	+	0.000	%Span	=	+	0.0 psi	[Sect. 2.0]
ACC PRSob	=	-	0.070	%Span	=	-	0.8 psi	[Sect. 2.0]

Note: The errors are converted from %Span to units of psi since the density computation error (Section 6.4.4) is based on variations from actual SG pressure.

6.4.3 SG LEVEL (LVL)

The Steam Generator level signals for EFIC Channels C and D come from the following level transmitters:

LT-2668
LT-2617
LT-2672
LT-2621

The loop error analysis for the above level transmitter loops is calculated in Sections 6.4.3.1 through 6.4.3.4 of this calculation. The errors ("R1o" of Section 6.4.3.4) for the Reference, Abnormal and Accident conditions are summarized as follows:

	REF LVLo	=	±	REF R1o (from 6.4.3.4)					
7	REF LVLo	=	±	0.427	%Span	=	±	0.043 volts	[Sect. 6.4.3.4]
	ABN LVLo	=	±	ABN R1o (from 6.4.3.4)					
7	ABN LVLo	=	±	0.700	%Span	=	±	0.070 volts	[Sect. 6.4.3.4]
	ACC LVLo	=	±	ACC R1o (from 6.4.3.4)					
7	ACC LVLo	=	±	3.321	%Span	=	±	0.332 volts	[Sect. 6.4.3.4]
	ABN LVLob	=		ABN R1ob (from 6.4.3.4)					
7	ABN LVLob	=	+	0.675	%Span	=	+	0.068 volts	[Sect. 6.4.3.4]
	ABN LVLob	=	-	0.622	%Span	=	-	0.062 volts	[Sect. 6.4.3.4]
	ACC LVLob	=		ACC R1ob (from 6.4.3.4)					
7	ACC LVLob	=	+	7.982	%Span	=	+	0.798 volts	[Sect. 6.4.3.4]
	ACC LVLob	=	-	0.225	%Span	=	-	0.023 volts	[Sect. 6.4.3.4]

Note: The errors have been converted from %Span to units of volts since the loop errors within the EFIC System Modules will be calculated in volts. The input resistor, R1 from Section 6.4.3.4, is 625 Ω which makes the span 10 volts.

6.4.3.1 PROCESS MEASUREMENT ERROR (PME)

The process measurement error (PME) for this closed level loop is caused by density changes in the reference leg fluid due to ambient temperature variations. Since the loop is pressure compensated (Ref. 6.6.10), the density changes due to system pressure variations do not cause a process measurement error.

As the reference leg fluid temperature varies from the temperature assumed during calibration, the density of the reference leg fluid changes, causing the transmitter to sense a different differential pressure than expected, thus causing a bias process measurement error. The error will be positive when the reference leg temperature is greater than that assumed during calibration, and negative when the reference leg temperature is less than that assumed during calibration.

The assumed calibration conditions are given as follows: [Att. 6-1]

Span	=	143.99	"H_2O	(span of transmitter)
H_R	=	150	inches	(height of reference leg)

Reference Leg Fluid:

T_{CAL}	=	120 °F		(temperature assumed at calibration)
SV_{CAL}	=	0.016204	ft^3/lbm	(specific volume H_2O @ 120°F)
ρ_{CAL}	=	61.7132	lbm/ft^3	(density assumed at calibration)
ρ_{CAL}	=	0.0357	lbm/in^3	(density assumed at calibration)

The error introduced by variations in the reference leg fluid density is calculated for the abnormal and accident conditions as follows:

ABNORMAL CONDITIONS

Reference Leg Fluid: [6.3.1]

T_{MIN}	=	104 °F		(minimum temperature)	
SV_{MIN}	=	0.016142	ft^3/lbm	(specific volume H_2O @ 100°F)	[6.6.3]
ρ_{MAX}	=	61.9502	lbm/ft^3	(density at T_{MIN})	
ρ_{MAX}	=	0.0359	lbm/in^3	(density at T_{MIN})	
T_{MAX}	=	118 °F		(maximum temperature)	
SV_{MAX}	=	0.016192	ft^3/lbm	(specific volume H_2O @ 154°F)	[6.6.3]
ρ_{MIN}	=	61.7589	lbm/ft^3	(density at T_{MAX})	
ρ_{MIN}	=	0.0357	lbm/in^3	(density at T_{MAX})	

$eDP(-) = H_R * (\rho_{CAL} - \rho_{MAX})$ [6.6.1]

$= -0.02058$ psi

$= -0.571$ "H_2O = -0.397 %Span

$eDP(+) = H_R * (\rho_{CAL} - \rho_{MIN})$ [6.6.1]

$= -0.00397$ psi

$= -0.110$ "H_2O = -0.077 %Span

ACCIDENT CONDITIONS

Reference Leg Fluid: [6.3.2]

T_{MAX}	=	285 °F		(maximum temperature)
SV_{MAX}	=	0.01726	ft^3/lbm	(specific volume H_2O @ 285°F) [6.6.3]
ρ_{MIN}	=	57.9374	lbm/ft^3	(density at T_{MAX})
ρ_{MIN}	=	0.0335	lbm/in^3	(density at T_{MAX})

$eDP(+) = H_R * (\rho_{CAL} - \rho_{MIN})$ [6.6.1]

= 0.32775 psi

= 9.096 $"H_2O$ = 6.317 %Span

SUMMARY OF PROCESS MEASUREMENT ERROR (PMEb):

ABN PMEb	=	+	N/A	%Span
	=	-	0.397	%Span
ACC PMEb	=	+	6.317	%Span

6.4.3.2 LEVEL TRANSMITTER (TRX)

COMPONENT ID

Tag Number(s)	:	LT-2668, LT-2617 LT-2672, LT-2621			[6.6.28]
Manufacturer	:	Rosemount			[6.6.5]
Model Number	:	1154DP4RB			[6.6.5]
Upper Range Limit (URL)	:	150	"H_2O		[6.6.8]
Calibrated Range	:	-4.58 to -148.57	"H_2O		[Att. 6-1]
Calibrated Span	:	143.99	"H_2O		[Att. 6-1]
Turn Down Factor (TDF)	:	1.0417			

ENVIRONMENTAL CONDITIONS

Location	:	Reactor Building			[6.6.5]
Static Pressure Corr (Pcor)	:	900	psig		[Att. 6-1]
Operating Press Range	:	0 to 1200	psig		[6.3.3]
Pdiff(-)	:	-900	psi		[6.3.4, 6.3.5]
Pdiff(+)	:	300	psi		[6.3.5]
Calibration Temp (Tcal)	:	60	°F		[6.3.8]
Abnormal Temp (Tabn)	:	110	°F		[6.3.8]
DT (Tabn-Tcal)	:	50	°F		[6.3.8]
Accident Temp (Tacc)	:	285	°F		[6.3.8]
ADT (Tcal-Tacc)	:	225	°F		[6.3.8]
Power Supply Voltage	:	30	VDC		[6.6.10]
Power Supply Variance	: ±	10	%		[6.3.9]
Power Supply Variance (DV)	: ±	3	VDC		

ERROR SUMMARY

Reference Accuracy (RA)	= ±	0.250	%Span		[6.6.8]
Calibration (CAL)	= ±	$[(RA/2)^2+(RA/2)^2]^{1/2}$			[6.3.7]
Calibration (CAL)	= ±	0.177	%Span		
Drift (DR)	= ±	0.2%URL / 30 months			[6.3.10]
Drift (DR)	= ±	(0.2)*(TDF)			
Drift (DR)	= ±	0.208	%Span		
Power Supply Effect (PS)	= ±	0.005	% per Volt		[6.6.8]
Power Supply Effect (PS)	= ±	(0.005)*(DV)			
Power Supply Effect (PS)	= ±	0.015	%Span	(negligible)	[6.3.6]
Power Supply Effect (PS)	= ±	0.000	%Span		
Temperature Effect (TE)	= ±	0.75%URL + 0.5%Span per 100°F change			[6.6.8]
Temperature Effect (TE)	= ±	[(0.75)*(TDF)+(0.5)]*DT/100			
Temperature Effect (TE)	= ±	0.641	%Span		

Acc Temperature Effect (ATE)	=	±	2.5%URL + 0.5%Span	[6.6.8]
Acc Temperature Effect (ATE)	=	±	(2.5)*(TDF)+(0.5) %Span	
Acc Temperature Effect (ATE)	=	±	3.104 %Span	
Acc Radiation Effect (ARE)	=	±	1.0%URL	[6.3.14]
Acc Radiation Effect (ARE)	=	±	(1.0)*(TDF) %Span	
Acc Radiation Effect (ARE)	=	±	1.042 %Span	
Static Pressure Zero (SPZ)	=	±	0.2%URL per 1000 psi	[6.6.8, 6.3.4]
Static Pressure Zero (SPZ)	=	±	(0.2)*(TDF)*(Pdiff)/1000	
Static Pressure Zero (SPZ)	=	±	0.188 %Span	
Static Pressure Span (SPS)	=	±	0.5%RDG per 1000 psi	[6.6.8, 6.3.4]
Static Pressure Span (SPS)	=	±	(0.5)*(1)*(Pdiff)/1000	
Static Pressure Span (SPS)	=	±	0.450 %Span	
Stat Press Span Bias (SPSb)	=	-	0.75 % Input/1000 psi	[6.6.8, 6.3.5]
SPSb(+)	=		(-0.75)*[Pdiff(-)]/1000 %DP Input	
SPSb(+)	=	+	0.675 %DP Input	
SPSb(-)	=		(-0.75)*[Pdiff(+)]/1000 %DP Input	
SPSb(-)	=	-	0.225 %DP Input	
SPSb(+)	=	+	0.675 %Span	[6.3.5]
SPSb(-)	=	-	0.225 %Span	

The transmitter error (eTRX) for the Reference, Abnormal and Accident conditions is given as follows:

REF eTRX	=	±	RA + CAL	
REF eTRX	=	±	0.427 %Span	
ABN eTRX	=	±	$[(RA+CAL)^2+(2DR/3)^2+(2PS/3)^2+(2TE/3)^2+(2SPZ/3)^2+(2SPS/3)^2]^{1/2}$	[6.3.11]
ABN eTRX	=	±	0.700 %Span	
ACC eTRX	=	±	$[(RA+CAL)^2+(2DR/3)^2+(2PS/3)^2+ATE^2+ARE^2+(2SPZ/3)^2+(2SPS/3)^2]^{1/2}$	
ACC eTRX	=	±	3.321 %Span	[6.3.11]
ABN eTRXb	=		SPSb	
ABN eTRXb	=	+	0.675 %Span	
ABN eTRXb	=	-	0.225 %Span	
ACC eTRXb	=		SPSb	
ACC eTRXb	=	+	0.675 %Span	
ACC eTRXb	=	-	0.225 %Span	

The output error terms for the transmitter (TRXo) are given as follows:

REF TRXo	=	±	REF eTRX
REF TRXo	=	±	0.427 %Span
ABN TRXo	=	±	ABN eTRX
ABN TRXo	=	±	0.700 %Span
ACC TRXo	=	±	ACC eTRX
ACC TRXo	=	±	3.321 %Span
ABN TRXob	=		ABN PMEb + ABN eTRXb
ABN TRXob	=	+	0.675 %Span
ABN TRXob	=	-	0.622 %Span
ACC TRXob	=		ACC PMEb + ACC eTRXb
ACC TRXob	=	+	6.992 %Span
ACC TRXob	=	-	0.225 %Span

6.4.3.3 INSULATION RESISTANCE (IR)

The transmitters are located inside the containment building and as such, the effects of harsh environment on loop signal cabling must be considered. The accident environment effects are considered for cabling from the transmitter through the containment electrical penetrations. The IR effect was calculated in Reference 6.6.4 and is quoted below.

ACC IRb = + 0.990 %Span [6.6.4]

6.4.3.4 RESISTOR (R1)

COMPONENT ID

Type	:		625	ohms			[6.6.29, 30]
Input Range	:		4	to	20	ma	[6.6.10]
Output Range	:		2.5	to	12.5	VDC	[6.6.10]
Span	:		10	VDC			

ENVIRONMENTAL CONDITIONS

Location	:	Aux. Bldg.-Control Room			[6.6.5]
Calibration Temperature	:		75	°F	[6.3.19]
Temp Variance	:	±	9	°F	[6.3.19]

ERROR SUMMARY

Reference Accuracy (RA)	=	±	0.000	%Span	(negligible)	[6.3.18]

The errors for the resistor (eR1) are given as follows:

REF eR1	=	±	RA
REF eR1	=	±	0.000 %Span
ABN eR1	=	±	RA
ABN eR1	=	±	0.000 %Span
ACC eR1	=	±	RA
ACC eR1	=	±	0.000 %Span

The output error terms for the resistor (R1o) are given as follows:

REF R1o	=	±	$[(\text{REF TRXo})^2+(\text{REF eR1})^2]^{1/2}$
REF R1o	=	±	0.427 %Span
ABN R1o	=	±	$[(\text{ABN TRXo})^2+(\text{ABN eR1})^2]^{1/2}$
ABN R1o	=	±	0.700 %Span
ACC R1o	=	±	$[(\text{ACC TRXo})^2+(\text{ACC eR1})^2]^{1/2}$
ACC R1o	=	±	3.321 %Span
ABN R1ob	=		ABN TRXob
ABN R1ob	=	+	0.675 %Span
ABN R1ob	=	-	0.622 %Span
ACC R1ob	=		ACC TRXob + ACC IRb
ACC R1ob	=	+	7.982 %Span
ACC R1ob	=	-	0.225 %Span

6.4.4 LOW LEVEL INITIATE BISTABLES

6.4.4.1 EFIC ALGORITHM

Table 6.4.4.1 determines the errors in density expected based upon the error associated with the pressure signal (Section 6.4.2). Per Reference 6.6.10, the densities are stored in EPROM based on the ASME Steam Tables. Table 6.4.4.1 compares what the density is at the actual SG pressure with the density at the SG pressure with the uncertainty included. This methodology conservatively assumes that no interpolation is performed.

Table 6.4.4.2 determines the minimum and maximum input voltages for the uncompensated level signal based upon the error associated with the level signal (Section 6.4.3).

Table 6.4.4.3 computes the expected output voltages without errors. The equation used for the expected output voltages (Section 6.2.0) is as follows:

$$v_o = 1 + \frac{23.91*(\Delta P_L-2.5) - 4.0*\rho_{st}}{\rho_w - \rho_{st}}$$

where v_o is the output voltage fed to the Bistables.

Tables 6.4.4.4, 6.4.4.5 and 6.4.4.6 compute the output error due to the error in the uncompensated level signal for the reference, abnormal and accident conditions, respectively. The equation used is as follows:

$$V1o = 1 + \frac{23.91*[(\Delta P_L \pm LVLo)-2.5)] - 4.0*\rho_{st}}{\rho_w - \rho_{st}} - v_o$$

Table 6.4.4.7 computes the output error due to the error in the pressure signal for the reference, abnormal and accident conditions. This error is minimal compared to other errors in the loop. Therefore, for simplicity, only the accident error is considered for the pressure signal. The equation used is as follows:

$$V2o = 1 + \frac{23.91*(\Delta P_L-2.5) - 4.0*\rho_{st}}{\rho_w - \rho_{st}} - v_o$$

with the densities based upon the pressure signal with error PRSo

Tables 6.4.4.8 and 6.4.4.9 compute the bias output error based upon the bias error in the uncompensated level signal for the abnormal and accident conditions, respectively. The equation used is as follows:

$$Vob = 1 + \frac{23.91*[(\Delta P_L \pm LVLob)-2.5)] - 4.0*\rho_{st}}{\rho_w - \rho_{st}} - v_o$$

TABLE 6.4.4.1

SG PRESSURE (psia)		DENSITY-SATURATED CONDITIONS (lbm/ft ^{3})					
		Expected	w/ Error	Expected	w/ Error	Expected	w/ Error
Actual	w/ Error	ρ_w	ρ_w	ρ_{st}	ρ_{st}	ρ_w-ρ_{st}	ρ_w-ρ_{st}
14.7	14.7	59.8122	59.8122	0.0373	0.0373	59.7749	59.7749
	25.4		59.0772		0.0613		59.0159
50.0	39.3	57.8905	58.3499	0.1175	0.0930	57.7730	58.2568
	60.7		57.4944		0.1416		57.3528
100.0	89.3	56.3698	56.6540	0.2257	0.2021	56.1441	56.4519
	110.7		56.1167		0.2491		55.8676
150.0	139.3	55.2792	55.4939	0.3318	0.3085	54.9474	55.1854
	160.7		55.0964		0.3529		54.7435
300.0	289.3	52.9381	53.0504	0.6482	0.6270	52.2899	52.4234
	310.7		52.7983		0.6694		52.1289
450.0	439.3	51.1771	51.2821	0.9692	0.9476	50.2079	50.3345
	460.7		51.0465		1.0126		50.0339
600.0	589.3	49.6771	49.7760	1.2991	1.2768	48.3780	48.4992
	610.7		49.5786		1.3215		48.2571
750.0	739.3	48.3325	48.4262	1.6407	1.6175	46.6918	46.8086
	760.7		48.2625		1.6640		46.5986
900.0	889.3	47.1032	47.1921	1.9964	1.9722	45.1068	45.2199
	910.7		47.0146		2.0206		44.9940
1050.0	1039.3	45.9348	45.9982	2.3683	2.3430	43.5665	43.6552
	1060.7		45.8505		2.3938		43.4568
1214.7	1204.0	44.7227	44.8029	2.7857	2.7590	41.9370	42.0439
	1214.7		44.7227		2.7857		41.9370

DENSITY OF H_2O (WATER AND STEAM) ERRORS

TABLE 6.4.4.2

SG LEVEL (volts)										
	w/ REF LVLo		w/ ABN LVLo		w/ ABN LVLob		w/ ACC LVLo		w/ ACC LVLob	
Actual	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)
2.5	2.457	2.543	2.430	2.570	2.438	2.568	2.168	2.832	2.478	3.298
3.0	2.957	3.043	2.930	3.070	2.938	3.068	2.668	3.332	2.978	3.798
4.0	3.957	4.043	3.930	4.070	3.938	4.068	3.668	4.332	3.978	4.798
6.0	5.957	6.043	5.930	6.070	5.938	6.068	5.668	6.332	5.978	6.798
8.0	7.957	8.043	7.930	8.070	7.938	8.068	7.668	8.332	7.978	8.798
10.0	9.957	10.043	9.930	10.070	9.938	10.068	9.668	10.332	9.978	10.798
11.0	10.957	11.043	10.930	11.070	10.938	11.068	10.668	11.332	10.978	11.798
12.0	11.957	12.043	11.930	12.070	11.938	12.068	11.668	12.332	11.978	12.798
12.5	12.457	12.543	12.430	12.570	12.438	12.568	12.168	12.832	12.478	13.298

UNCOMPENSATED LEVEL ERRORS (volts)

TABLE 6.4.4.3

EXPECTED V_O									
PRESS.	SG LEVEL (volts)								
(psia)	2.5	3.0	4.0	6.0	8.0	10.0	11.0	12.0	12.5
14.7	0.998	1.198	1.598	2.398	3.198	3.998	4.398	4.798	4.998
50.0	0.992	1.199	1.613	2.440	3.268	4.096	4.510	4.924	5.130
100.0	0.984	1.197	1.623	2.474	3.326	4.178	4.604	5.030	5.243
150.0	0.976	1.193	1.629	2.499	3.369	4.239	4.675	5.110	5.327
300.0	0.950	1.179	1.636	2.551	3.465	4.380	4.837	5.294	5.523
450.0	0.923	1.161	1.637	2.590	3.542	4.494	4.971	5.447	5.685
600.0	0.893	1.140	1.634	2.622	3.611	4.599	5.094	5.588	5.835
750.0	0.859	1.115	1.628	2.652	3.676	4.700	5.212	5.724	5.980
900.0	0.823	1.088	1.618	2.678	3.738	4.799	5.329	5.859	6.124
1050.0	0.783	1.057	1.606	2.703	3.801	4.899	5.447	5.996	6.271
1214.7	0.734	1.019	1.590	2.730	3.870	5.010	5.580	6.151	6.436

EXPECTED OUTPUT VOLTAGE

TABLE 6.4.4.4

REF V1o																	
PRESS	LEVEL w/Error (volts)																
(psia)	2.457	2.543	2.957	3.043	3.957	4.043	5.957	6.043	7.957	8.043	9.957	10.043	10.957	11.043	11.957	12.043	12.457	12.543
14.7	-0.017	0.017	-0.017	0.017	-0.017	0.017	-0.017	0.017	-0.017	0.017	-0.017	0.017	-0.017	0.017	-0.017	0.017	-0.017	0.017
50.0	-0.018	0.018	-0.018	0.018	-0.018	0.018	-0.018	0.018	-0.018	0.018	-0.018	0.018	-0.018	0.018	-0.018	0.018	-0.018	0.018
100.0	-0.018	0.018	-0.018	0.018	-0.018	0.018	-0.018	0.018	-0.018	0.018	-0.018	0.018	-0.018	0.018	-0.018	0.018	-0.018	0.018
150.0	-0.019	0.019	-0.019	0.019	-0.019	0.019	-0.019	0.019	-0.019	0.019	-0.019	0.019	-0.019	0.019	-0.019	0.019	-0.019	0.019
300.0	-0.020	0.020	-0.020	0.020	-0.020	0.020	-0.020	0.020	-0.020	0.020	-0.020	0.020	-0.020	0.020	-0.020	0.020	-0.020	0.020
450.0	-0.020	0.020	-0.020	0.020	-0.020	0.020	-0.020	0.020	-0.020	0.020	-0.020	0.020	-0.020	0.020	-0.020	0.020	-0.020	0.020
600.0	-0.021	0.021	-0.021	0.021	-0.021	0.021	-0.021	0.021	-0.021	0.021	-0.021	0.021	-0.021	0.021	-0.021	0.021	-0.021	0.021
750.0	-0.022	0.022	-0.022	0.022	-0.022	0.022	-0.022	0.022	-0.022	0.022	-0.022	0.022	-0.022	0.022	-0.022	0.022	-0.022	0.022
900.0	-0.023	0.023	-0.023	0.023	-0.023	0.023	-0.023	0.023	-0.023	0.023	-0.023	0.023	-0.023	0.023	-0.023	0.023	-0.023	0.023
1050.0	-0.023	0.023	-0.023	0.023	-0.023	0.023	-0.023	0.023	-0.023	0.023	-0.023	0.023	-0.023	0.023	-0.023	0.023	-0.023	0.023
1214.7	-0.024	0.024	-0.024	0.024	-0.024	0.024	-0.024	0.024	-0.024	0.024	-0.024	0.024	-0.024	0.024	-0.024	0.024	-0.024	0.024

REF V1o (random output error due to uncompensated level signal error)

TABLE 6.4.4.5

ABN V1o																	
PRESS	LEVEL w/Error (volts)																
(psia)	2.430	2.570	2.930	3.070	3.930	4.070	5.930	6.070	7.930	8.070	9.930	10.070	10.930	11.070	11.930	12.070	12.430	12.570
14.7	-0.017	0.017	-0.017	0.017	-0.017	0.017	-0.017	0.017	-0.017	0.017	-0.017	0.017	-0.017	0.017	-0.017	0.017	-0.017	0.017
50.0	-0.018	0.018	-0.018	0.018	-0.018	0.018	-0.018	0.018	-0.018	0.018	-0.018	0.018	-0.018	0.018	-0.018	0.018	-0.018	0.018
100.0	-0.018	0.018	-0.018	0.018	-0.018	0.018	-0.018	0.018	-0.018	0.018	-0.018	0.018	-0.018	0.018	-0.018	0.018	-0.018	0.018
150.0	-0.019	0.019	-0.019	0.019	-0.019	0.019	-0.019	0.019	-0.019	0.019	-0.019	0.019	-0.019	0.019	-0.019	0.019	-0.019	0.019
300.0	-0.020	0.020	-0.020	0.020	-0.020	0.020	-0.020	0.020	-0.020	0.020	-0.020	0.020	-0.020	0.020	-0.020	0.020	-0.020	0.020
450.0	-0.020	0.020	-0.020	0.020	-0.020	0.020	-0.020	0.020	-0.020	0.020	-0.020	0.020	-0.020	0.020	-0.020	0.020	-0.020	0.020
600.0	-0.021	0.021	-0.021	0.021	-0.021	0.021	-0.021	0.021	-0.021	0.021	-0.021	0.021	-0.021	0.021	-0.021	0.021	-0.021	0.021
750.0	-0.022	0.022	-0.022	0.022	-0.022	0.022	-0.022	0.022	-0.022	0.022	-0.022	0.022	-0.022	0.022	-0.022	0.022	-0.022	0.022
900.0	-0.023	0.023	-0.023	0.023	-0.023	0.023	-0.023	0.023	-0.023	0.023	-0.023	0.023	-0.023	0.023	-0.023	0.023	-0.023	0.023
1050.0	-0.023	0.023	-0.023	0.023	-0.023	0.023	-0.023	0.023	-0.023	0.023	-0.023	0.023	-0.023	0.023	-0.023	0.023	-0.023	0.023
1214.7	-0.024	0.024	-0.024	0.024	-0.024	0.024	-0.024	0.024	-0.024	0.024	-0.024	0.024	-0.024	0.024	-0.024	0.024	-0.024	0.024

ABN V1o (random output error due to uncompensated level signal error)

TABLE 6.4.4.6

ACC V1o																	
PRESS	LEVEL w/Error (volts)																
(psia)	2.168	2.832	2.668	3.332	3.668	4.332	5.668	6.332	7.668	8.332	9.668	10.332	10.668	11.332	11.668	12.332	12.168	12.832
14.7	-0.133	0.133	-0.133	0.133	-0.133	0.133	-0.133	0.133	-0.133	0.133	-0.133	0.133	-0.133	0.133	-0.133	0.133	-0.133	0.133
50.0	-0.137	0.137	-0.137	0.137	-0.137	0.137	-0.137	0.137	-0.137	0.137	-0.137	0.137	-0.137	0.137	-0.137	0.137	-0.137	0.137
100.0	-0.141	0.141	-0.141	0.141	-0.141	0.141	-0.141	0.141	-0.141	0.141	-0.141	0.141	-0.141	0.141	-0.141	0.141	-0.141	0.141
150.0	-0.145	0.145	-0.145	0.145	-0.145	0.145	-0.145	0.145	-0.145	0.145	-0.145	0.145	-0.145	0.145	-0.145	0.145	-0.145	0.145
300.0	-0.152	0.152	-0.152	0.152	-0.152	0.152	-0.152	0.152	-0.152	0.152	-0.152	0.152	-0.152	0.152	-0.152	0.152	-0.152	0.152
450.0	-0.158	0.158	-0.158	0.158	-0.158	0.158	-0.158	0.158	-0.158	0.158	-0.158	0.158	-0.158	0.158	-0.158	0.158	-0.158	0.158
600.0	-0.164	0.164	-0.164	0.164	-0.164	0.164	-0.164	0.164	-0.164	0.164	-0.164	0.164	-0.164	0.164	-0.164	0.164	-0.164	0.164
750.0	-0.170	0.170	-0.170	0.170	-0.170	0.170	-0.170	0.170	-0.170	0.170	-0.170	0.170	-0.170	0.170	-0.170	0.170	-0.170	0.170
900.0	-0.176	0.176	-0.176	0.176	-0.176	0.176	-0.176	0.176	-0.176	0.176	-0.176	0.176	-0.176	0.176	-0.176	0.176	-0.176	0.176
1050.0	-0.182	0.182	-0.182	0.182	-0.182	0.182	-0.182	0.182	-0.182	0.182	-0.182	0.182	-0.182	0.182	-0.182	0.182	-0.182	0.182
1214.7	-0.189	0.189	-0.189	0.189	-0.189	0.189	-0.189	0.189	-0.189	0.189	-0.189	0.189	-0.189	0.189	-0.189	0.189	-0.189	0.189

ACC V1o (random output error due to uncompensated level signal error)

TABLE 6.4.4.7

REF, ABN, ACC V2o																		
LEVEL	PRESSURE w/Error (psia)																	
(volts)	14.7	25.4	39.3	60.7	89.3	110.7	139.3	160.7	289.3	310.7	439.3	460.7	589.3	610.7	739.3	760.7	889.3	910.7
2.5	0.000	-0.002	0.002	-0.002	0.002	-0.002	0.002	-0.002	0.002	-0.002	0.002	-0.004	0.002	-0.002	0.002	-0.002	0.003	-0.003
3.0	0.000	0.001	0.000	0.000	0.001	-0.001	0.001	-0.001	0.001	-0.001	0.001	-0.003	0.001	-0.002	0.002	-0.002	0.002	-0.002
4.0	0.000	0.006	-0.003	0.003	-0.002	0.001	-0.001	0.001	0.000	0.000	0.000	-0.001	0.000	0.000	0.000	-0.001	0.001	-0.001
6.0	0.000	0.016	-0.010	0.009	-0.006	0.006	-0.005	0.004	-0.002	0.003	-0.002	0.002	-0.002	0.002	-0.002	0.001	-0.002	0.002
8.0	0.000	0.027	-0.017	0.015	-0.011	0.010	-0.009	0.007	-0.005	0.006	-0.005	0.005	-0.005	0.005	-0.005	0.003	-0.005	0.005
10.0	0.000	0.037	-0.024	0.021	-0.016	0.014	-0.012	0.011	-0.007	0.009	-0.007	0.009	-0.007	0.007	-0.007	0.005	-0.007	0.007
11.0	0.000	0.042	-0.027	0.024	-0.018	0.016	-0.014	0.012	-0.008	0.010	-0.008	0.010	-0.008	0.008	-0.009	0.006	-0.009	0.009
12.0	0.000	0.047	-0.031	0.027	-0.020	0.018	-0.016	0.014	-0.009	0.012	-0.009	0.012	-0.010	0.010	-0.010	0.007	-0.010	0.010
12.5	0.000	0.050	-0.033	0.029	-0.021	0.019	-0.017	0.015	-0.010	0.012	-0.010	0.013	-0.010	0.010	-0.010	0.008	-0.011	0.011

REF, ABN, ACC V2o				
LEVEL	PRESSURE w/Error (psia)			
(volts)	1039.3	1060.7	1204.0	1214.7
2.5	0.003	-0.003	0.003	0.000
3.0	0.002	-0.002	0.002	0.000
4.0	0.001	-0.001	0.001	0.000
6.0	-0.001	0.002	-0.002	0.000
8.0	-0.003	0.005	-0.005	0.000
10.0	-0.006	0.007	-0.008	0.000
11.0	-0.007	0.009	-0.009	0.000
12.0	-0.008	0.010	-0.011	0.000
12.5	-0.008	0.011	-0.011	0.000

REF, ABN, ACC V2o (output error due to the pressure signal error)

TABLE 6.4.4.8

ABN Vob																		
PRESS	LEVEL w/Error (volts)																	
(psia)	2.438	2.568	2.938	3.068	3.938	4.068	5.938	6.068	7.938	8.068	9.938	10.068	10.938	11.068	11.938	12.068	12.438	12.568
14.7	-0.025	0.027	-0.025	0.027	-0.025	0.027	-0.025	0.027	-0.025	0.027	-0.025	0.027	-0.025	0.027	-0.025	0.027	-0.025	0.027
50.0	-0.026	0.028	-0.026	0.028	-0.026	0.028	-0.026	0.028	-0.026	0.028	-0.026	0.028	-0.026	0.028	-0.026	0.028	-0.026	0.028
100.0	-0.026	0.029	-0.026	0.029	-0.026	0.029	-0.026	0.029	-0.026	0.029	-0.026	0.029	-0.026	0.029	-0.026	0.029	-0.026	0.029
150.0	-0.027	0.029	-0.027	0.029	-0.027	0.029	-0.027	0.029	-0.027	0.029	-0.027	0.029	-0.027	0.029	-0.027	0.029	-0.027	0.029
300.0	-0.028	0.031	-0.028	0.031	-0.028	0.031	-0.028	0.031	-0.028	0.031	-0.028	0.031	-0.028	0.031	-0.028	0.031	-0.028	0.031
450.0	-0.030	0.032	-0.030	0.032	-0.030	0.032	-0.030	0.032	-0.030	0.032	-0.030	0.032	-0.030	0.032	-0.030	0.032	-0.030	0.032
600.0	-0.031	0.033	-0.031	0.033	-0.031	0.033	-0.031	0.033	-0.031	0.033	-0.031	0.033	-0.031	0.033	-0.031	0.033	-0.031	0.033
750.0	-0.032	0.035	-0.032	0.035	-0.032	0.035	-0.032	0.035	-0.032	0.035	-0.032	0.035	-0.032	0.035	-0.032	0.035	-0.032	0.035
900.0	-0.033	0.036	-0.033	0.036	-0.033	0.036	-0.033	0.036	-0.033	0.036	-0.033	0.036	-0.033	0.036	-0.033	0.036	-0.033	0.036
1050.0	-0.034	0.037	-0.034	0.037	-0.034	0.037	-0.034	0.037	-0.034	0.037	-0.034	0.037	-0.034	0.037	-0.034	0.037	-0.034	0.037
1214.7	-0.035	0.038	-0.035	0.038	-0.035	0.038	-0.035	0.038	-0.035	0.038	-0.035	0.038	-0.035	0.038	-0.035	0.038	-0.035	0.038

ABN Vob (bias output error due to uncompensated level signal error)

TABLE 6.4.4.9

ACC Vob																		
PRESS	LEVEL w/Error (volts)																	
(psia)	2.478	3.298	2.978	3.798	3.978	4.798	5.978	6.798	7.978	8.798	9.978	10.798	10.978	11.798	11.978	12.798	12.478	13.298
14.7	-0.009	0.319	-0.009	0.319	-0.009	0.319	-0.009	0.319	-0.009	0.319	-0.009	0.319	-0.009	0.319	-0.009	0.319	-0.009	0.319
50.0	-0.009	0.330	-0.009	0.330	-0.009	0.330	-0.009	0.330	-0.009	0.330	-0.009	0.330	-0.009	0.330	-0.009	0.330	-0.009	0.330
100.0	-0.010	0.340	-0.010	0.340	-0.010	0.340	-0.010	0.340	-0.010	0.340	-0.010	0.340	-0.010	0.340	-0.010	0.340	-0.010	0.340
150.0	-0.010	0.347	-0.010	0.347	-0.010	0.347	-0.010	0.347	-0.010	0.347	-0.010	0.347	-0.010	0.347	-0.010	0.347	-0.010	0.347
300.0	-0.010	0.365	-0.010	0.365	-0.010	0.365	-0.010	0.365	-0.010	0.365	-0.010	0.365	-0.010	0.365	-0.010	0.365	-0.010	0.365
450.0	-0.011	0.380	-0.011	0.380	-0.011	0.380	-0.011	0.380	-0.011	0.380	-0.011	0.380	-0.011	0.380	-0.011	0.380	-0.011	0.380
600.0	-0.011	0.395	-0.011	0.395	-0.011	0.395	-0.011	0.395	-0.011	0.395	-0.011	0.395	-0.011	0.395	-0.011	0.395	-0.011	0.395
750.0	-0.012	0.409	-0.012	0.409	-0.012	0.409	-0.012	0.409	-0.012	0.409	-0.012	0.409	-0.012	0.409	-0.012	0.409	-0.012	0.409
900.0	-0.012	0.423	-0.012	0.423	-0.012	0.423	-0.012	0.423	-0.012	0.423	-0.012	0.423	-0.012	0.423	-0.012	0.423	-0.012	0.423
1050.0	-0.012	0.438	-0.012	0.438	-0.012	0.438	-0.012	0.438	-0.012	0.438	-0.012	0.438	-0.012	0.438	-0.012	0.438	-0.012	0.438
1214.7	-0.013	0.455	-0.013	0.455	-0.013	0.455	-0.013	0.455	-0.013	0.455	-0.013	0.455	-0.013	0.455	-0.013	0.455	-0.013	0.455

ACC Vob (bias output error due to uncompensated level signal error)

6.4.4.2 EFIC--LOW LEVEL INITIATE (SU1)

			COMPONENT ID				
	Tag Number(s)	C37-3-TDB-C45, -C55 C37-4-TDB-D45, -D55					[6.6.5]
	Manufacturer	Vitro Engineering Corp.					[6.6.5]
	Model Number	3801-3034					[6.6.5]
		ENVIRONMENTAL CONDITIONS					
	Location	Aux. Bldg.-Control Room					[6.6.5]
	Calibration Temperature		75	°F			[6.3.19]
	Temp Variance	±	9	°F			[6.3.19]
		ERROR SUMMARY					
DRN 05-3577	Reference Accuracy (RA)	=	±	0.539	%Span		[6.3.12]
	Setting Tolerance (ST)	=	±	0.111	%Span		[6.3.21]
	Device Tolerance (Dtol)	=	±	0.650	%Span		[6.3.21]
	Calibration (CAL)	=	±	$[(0.125)^2+(0.125)^2]^{1/2}$			[6.3.15]
	Calibration (CAL)	=	±	0.177	%Span		
7	Drift (DR)	=	±	0.258	%Span		[6.3.17]
	Power Supply Effect (PS)	=	±	0.000	%Span		[6.3.16]
	Temperature Effect (TE)	=	±	0.000	%Span		[6.3.16]

The errors for the Low Range Level Signal (eSU1) are given as follows:

REF eSU1	=	± (Dtol + CAL)		
REF eSU1	=	± 0.827 %Span		DRN 05-3577
ABN eSU1	=	± $[(Dtol+CAL)^2+DR^2+PS^2+TE^2]^{1/2}$		
ABN eSU1	=	± 0.866 %Span		DRN 05-3577
ACC eSU1	=	± $[(Dtol+CAL)^2+DR^2+PS^2+TE^2]^{1/2}$		
ACC eSU1	=	± 0.866 %Span		DRN 05-3577

The output error for the Bistables (SU1o) are given based on the following equations:

REF SU1o = ± $[(\text{REF eSU1})^2+(\text{REF V1o})^2+(\text{REF V2o})^2]^{1/2}$
REF SU1o = ± $[(\text{REF eSU1})^2+(\text{Table 6.4.4.4})^2+(\text{Table 6.4.4.7})^2]^{1/2}$
REF SU1o = ± Table 6.4.4.10

ABN SU1o = ± $[(\text{ABN eSU1})^2+(\text{ABN V1o})^2+(\text{ABN V2o})^2]^{1/2}$
ABN SU1o = ± $[(\text{ABN eSU1})^2+(\text{Table 6.4.4.5})^2+(\text{Table 6.4.4.7})^2]^{1/2}$
ABN SU1o = ± Table 6.4.4.11

ACC SU1o = ± $[(\text{ACC eSU1})^2+(\text{ACC V1o})^2+(\text{ACC V2o})^2]^{1/2}$
ACC SU1o = ± $[(\text{ABN eSU1})^2+(\text{Table 6.4.4.6})^2+(\text{Table 6.4.4.7})^2]^{1/2}$
ACC SU1o = ± Table 6.4.4.13

ABN SU1ob = ABN Vob
ABN SU1ob = (Table 6.4.4.8)
ABN SU1ob = Table 6.4.4.12

ACC SU1ob = ACC Vob
ACC SU1ob = (Table 6.4.4.9)
ACC SU1ob = Table 6.4.4.14

Note: Errors in volts are converted to %Span prior to combining with the EFIC error (eSU1).

The total otput error for the reference condition is given in Table 6.4.4.10 since there is no bias error.

The total output error for the abnormal condition is the algebraic sum of the random and bias terms:
ABN SU1ot = ABN SU1o + ABN SU1ob
ABN SU1ot = (Table 6.4.4.11)+(Table 6.4.4.12)
ABN SU1ot = Table 6.4.4.15

The total output error for the accident condition is the algebraic sum of the random and bias terms:
ACC SU1ot = ACC SU1o + ACC SU1ob
ACC SU1ot = (Table 6.4.4.13)+(Table 6.4.4.14)
ACC SU1ot = Table 6.4.4.16

TABLE 6.4.4.10

REF SU1o (%Span)									
PRESS	LEVEL (volts)								
(psia)	2.5	3.0	4.0	6.0	8.0	10.0	11.0	12.0	12.5
14.7	0.93	0.93	0.94	1.02	1.14	1.31	1.40	1.50	1.55
50.0	0.94	0.94	0.94	0.97	1.03	1.11	1.16	1.21	1.24
100.0	0.94	0.94	0.94	0.96	0.98	1.02	1.05	1.07	1.09
150.0	0.95	0.95	0.95	0.96	0.97	1.00	1.01	1.03	1.04
300.0	0.96	0.96	0.96	0.96	0.97	0.98	0.98	0.99	0.99
450.0	0.97	0.97	0.97	0.97	0.98	0.99	1.00	1.02	1.02
600.0	0.98	0.98	0.98	0.98	0.99	1.00	1.00	1.01	1.01
750.0	0.99	0.99	0.99	0.99	1.00	1.01	1.01	1.02	1.02
900.0	1.00	1.00	1.00	1.00	1.01	1.02	1.03	1.03	1.04
1050.0	1.02	1.01	1.01	1.01	1.02	1.03	1.04	1.05	1.05
1214.7	1.03	1.03	1.03	1.03	1.03	1.04	1.05	1.06	1.06

REF SU1o--OUTPUT LOOP ERROR (%Span)

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TABLE 6.4.4.11

ABN SU1o (%Span)									
PRESS	LEVEL (volts)								
(psia)	2.5	3.0	4.0	6.0	8.0	10.0	11.0	12.0	12.5
14.7	0.97	0.97	0.98	1.05	1.17	1.34	1.43	1.52	1.58
50.0	0.97	0.97	0.98	1.01	1.06	1.14	1.19	1.24	1.27
100.0	0.98	0.98	0.98	0.99	1.02	1.05	1.08	1.10	1.12
150.0	0.98	0.98	0.98	0.99	1.01	1.03	1.04	1.06	1.07
300.0	1.00	0.99	0.99	1.00	1.00	1.01	1.01	1.02	1.02
450.0	1.01	1.01	1.00	1.01	1.01	1.03	1.04	1.05	1.05
600.0	1.02	1.01	1.01	1.02	1.02	1.03	1.04	1.04	1.05
750.0	1.03	1.02	1.02	1.03	1.03	1.04	1.05	1.05	1.06
900.0	1.04	1.04	1.03	1.04	1.04	1.05	1.06	1.06	1.07
1050.0	1.05	1.05	1.05	1.05	1.05	1.06	1.07	1.08	1.08
1214.7	1.06	1.06	1.06	1.06	1.07	1.08	1.08	1.09	1.10

ABN SU1o--OUTPUT LOOP ERROR (%Span)

TABLE 6.4.4.12

ABN SU1ob (%Span)																		
	LEVEL (volts)																	
PRESS	2.5		3.0		4.0		6.0		8.0		10.0		11.0		12.0		12.5	
(psia)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)
14.7	-0.62	0.68	-0.62	0.68	-0.62	0.68	-0.62	0.68	-0.62	0.68	-0.62	0.68	-0.62	0.68	-0.62	0.68	-0.62	0.68
50.0	-0.64	0.70	-0.64	0.70	-0.64	0.70	-0.64	0.70	-0.64	0.70	-0.64	0.70	-0.64	0.70	-0.64	0.70	-0.64	0.70
100.0	-0.66	0.72	-0.66	0.72	-0.66	0.72	-0.66	0.72	-0.66	0.72	-0.66	0.72	-0.66	0.72	-0.66	0.72	-0.66	0.72
150.0	-0.68	0.73	-0.68	0.73	-0.68	0.73	-0.68	0.73	-0.68	0.73	-0.68	0.73	-0.68	0.73	-0.68	0.73	-0.68	0.73
300.0	-0.71	0.77	-0.71	0.77	-0.71	0.77	-0.71	0.77	-0.71	0.77	-0.71	0.77	-0.71	0.77	-0.71	0.77	-0.71	0.77
450.0	-0.74	0.80	-0.74	0.80	-0.74	0.80	-0.74	0.80	-0.74	0.80	-0.74	0.80	-0.74	0.80	-0.74	0.80	-0.74	0.80
600.0	-0.77	0.83	-0.77	0.83	-0.77	0.83	-0.77	0.83	-0.77	0.83	-0.77	0.83	-0.77	0.83	-0.77	0.83	-0.77	0.83
750.0	-0.80	0.86	-0.80	0.86	-0.80	0.86	-0.80	0.86	-0.80	0.86	-0.80	0.86	-0.80	0.86	-0.80	0.86	-0.80	0.86
900.0	-0.82	0.89	-0.82	0.89	-0.82	0.89	-0.82	0.89	-0.82	0.89	-0.82	0.89	-0.82	0.89	-0.82	0.89	-0.82	0.89
1050.0	-0.85	0.93	-0.85	0.93	-0.85	0.93	-0.85	0.93	-0.85	0.93	-0.85	0.93	-0.85	0.93	-0.85	0.93	-0.85	0.93
1214.7	-0.89	0.96	-0.89	0.96	-0.89	0.96	-0.89	0.96	-0.89	0.96	-0.89	0.96	-0.89	0.96	-0.89	0.96	-0.89	0.96

ABN SU1ob--OUTPUT LOOP ERROR (%Span)

TABLE 6.4.4.13

ACC SU1o (%Span)									
PRESS	LEVEL (volts)								
(psia)	2.5	3.0	4.0	6.0	8.0	10.0	11.0	12.0	12.5
14.7	3.43	3.43	3.44	3.46	3.50	3.55	3.59	3.63	3.65
50.0	3.54	3.54	3.54	3.55	3.57	3.59	3.61	3.63	3.64
100.0	3.64	3.64	3.64	3.64	3.65	3.66	3.67	3.68	3.68
150.0	3.72	3.72	3.72	3.72	3.72	3.73	3.73	3.74	3.74
300.0	3.89	3.89	3.89	3.89	3.90	3.90	3.90	3.90	3.90
450.0	4.05	4.05	4.05	4.05	4.05	4.05	4.06	4.06	4.06
600.0	4.19	4.19	4.19	4.19	4.20	4.20	4.20	4.20	4.20
750.0	4.34	4.34	4.34	4.34	4.34	4.34	4.34	4.35	4.35
900.0	4.49	4.49	4.49	4.49	4.49	4.49	4.49	4.49	4.49
1050.0	4.64	4.64	4.64	4.64	4.64	4.64	4.64	4.65	4.65
1214.7	4.81	4.81	4.81	4.81	4.81	4.82	4.82	4.82	4.82

ACC SU1o--OUTPUT LOOP ERROR (%Span)

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TABLE 6.4.4.14

ACC SU1ob (%Span)																		
	LEVEL (volts)																	
PRESS	2.5		3.0		4.0		6.0		8.0		10.0		11.0		12.0		12.5	
(psia)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)
14.7	-0.23	7.98	-0.23	7.98	-0.23	7.98	-0.23	7.98	-0.23	7.98	-0.23	7.98	-0.23	7.98	-0.23	7.98	-0.23	7.98
50.0	-0.23	8.26	-0.23	8.26	-0.23	8.26	-0.23	8.26	-0.23	8.26	-0.23	8.26	-0.23	8.26	-0.23	8.26	-0.23	8.26
100.0	-0.24	8.50	-0.24	8.50	-0.24	8.50	-0.24	8.50	-0.24	8.50	-0.24	8.50	-0.24	8.50	-0.24	8.50	-0.24	8.50
150.0	-0.24	8.68	-0.24	8.68	-0.24	8.68	-0.24	8.68	-0.24	8.68	-0.24	8.68	-0.24	8.68	-0.24	8.68	-0.24	8.68
300.0	-0.26	9.12	-0.26	9.12	-0.26	9.12	-0.26	9.12	-0.26	9.12	-0.26	9.12	-0.26	9.12	-0.26	9.12	-0.26	9.12
450.0	-0.27	9.50	-0.27	9.50	-0.27	9.50	-0.27	9.50	-0.27	9.50	-0.27	9.50	-0.27	9.50	-0.27	9.50	-0.27	9.50
600.0	-0.28	9.86	-0.28	9.86	-0.28	9.86	-0.28	9.86	-0.28	9.86	-0.28	9.86	-0.28	9.86	-0.28	9.86	-0.28	9.86
750.0	-0.29	10.22	-0.29	10.22	-0.29	10.22	-0.29	10.22	-0.29	10.22	-0.29	10.22	-0.29	10.22	-0.29	10.22	-0.29	10.22
900.0	-0.30	10.58	-0.30	10.58	-0.30	10.58	-0.30	10.58	-0.30	10.58	-0.30	10.58	-0.30	10.58	-0.30	10.58	-0.30	10.58
1050.0	-0.31	10.95	-0.31	10.95	-0.31	10.95	-0.31	10.95	-0.31	10.95	-0.31	10.95	-0.31	10.95	-0.31	10.95	-0.31	10.95
1214.7	-0.32	11.38	-0.32	11.38	-0.32	11.38	-0.32	11.38	-0.32	11.38	-0.32	11.38	-0.32	11.38	-0.32	11.38	-0.32	11.38

ACC SU1ob--OUTPUT LOOP ERROR (%Span)

TABLE 6.4.4.15

ABN SU1ot (%Span)																		
	LEVEL (volts)																	
PRESS	2.5		3.0		4.0		6.0		8.0		10.0		11.0		12.0		12.5	
(psia)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)
14.7	1.59	1.64	1.59	1.64	1.60	1.65	1.67	1.72	1.79	1.85	1.96	2.01	2.05	2.10	2.15	2.20	2.20	2.25
50.0	1.62	1.67	1.62	1.67	1.62	1.67	1.65	1.70	1.71	1.76	1.79	1.84	1.83	1.89	1.89	1.94	1.91	1.97
100.0	1.64	1.70	1.64	1.70	1.64	1.70	1.65	1.71	1.68	1.73	1.72	1.77	1.74	1.80	1.76	1.82	1.78	1.83
150.0	1.66	1.72	1.66	1.72	1.66	1.72	1.67	1.72	1.68	1.74	1.71	1.76	1.72	1.78	1.74	1.80	1.75	1.80
300.0	1.71	1.77	1.71	1.77	1.70	1.77	1.71	1.77	1.71	1.77	1.72	1.78	1.73	1.79	1.73	1.79	1.74	1.80
450.0	1.75	1.81	1.75	1.81	1.74	1.81	1.75	1.81	1.75	1.82	1.77	1.83	1.78	1.84	1.79	1.85	1.79	1.86
600.0	1.78	1.85	1.78	1.85	1.78	1.85	1.78	1.85	1.79	1.85	1.80	1.86	1.80	1.87	1.81	1.88	1.81	1.88
750.0	1.82	1.89	1.82	1.89	1.82	1.89	1.82	1.89	1.83	1.89	1.84	1.90	1.84	1.91	1.85	1.92	1.85	1.92
900.0	1.86	1.93	1.86	1.93	1.86	1.93	1.86	1.93	1.86	1.94	1.87	1.95	1.88	1.95	1.89	1.96	1.89	1.96
1050.0	1.90	1.97	1.90	1.97	1.90	1.97	1.90	1.97	1.91	1.98	1.92	1.99	1.92	2.00	1.93	2.00	1.93	2.01
1214.7	1.95	2.02	1.95	2.02	1.94	2.02	1.95	2.02	1.95	2.03	1.96	2.04	1.97	2.04	1.98	2.05	1.98	2.06

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ABN SU1ot--TOTAL OUTPUT LOOP ERROR (%Span)

TABLE 6.4.4.16

ACC SU1ot (%Span)																		
	LEVEL (volts)																	
PRESS	2.5		3.0		4.0		6.0		8.0		10.0		11.0		12.0		12.5	
(psia)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)	(-)	(+)
14.7	3.66	11.41	3.66	11.41	3.66	11.42	3.68	11.44	3.72	11.48	3.78	11.54	3.81	11.57	3.85	11.61	3.88	11.63
50.0	3.78	11.80	3.78	11.80	3.78	11.80	3.79	11.81	3.80	11.83	3.83	11.85	3.84	11.87	3.86	11.89	3.87	11.90
100.0	3.88	12.14	3.88	12.14	3.88	12.14	3.88	12.14	3.89	12.15	3.90	12.16	3.91	12.17	3.92	12.17	3.92	12.18
150.0	3.96	12.40	3.96	12.40	3.96	12.40	3.96	12.40	3.97	12.40	3.97	12.41	3.98	12.42	3.98	12.42	3.98	12.42
300.0	4.15	13.02	4.15	13.02	4.15	13.02	4.15	13.02	4.15	13.02	4.16	13.02	4.16	13.02	4.16	13.03	4.16	13.03
450.0	4.32	13.55	4.32	13.55	4.32	13.55	4.32	13.55	4.32	13.55	4.32	13.56	4.32	13.56	4.33	13.56	4.33	13.56
600.0	4.47	14.06	4.47	14.06	4.47	14.06	4.47	14.06	4.47	14.06	4.48	14.06	4.48	14.06	4.48	14.06	4.48	14.06
750.0	4.63	14.56	4.63	14.56	4.63	14.56	4.63	14.56	4.63	14.56	4.63	14.56	4.63	14.56	4.63	14.56	4.63	14.57
900.0	4.78	15.06	4.78	15.06	4.78	15.06	4.78	15.06	4.79	15.07	4.79	15.07	4.79	15.07	4.79	15.07	4.79	15.07
1050.0	4.95	15.59	4.95	15.59	4.95	15.59	4.95	15.59	4.95	15.59	4.95	15.59	4.95	15.60	4.95	15.60	4.96	15.60
1214.7	5.13	16.19	5.13	16.19	5.13	16.19	5.13	16.19	5.13	16.19	5.14	16.19	5.14	16.20	5.14	16.20	5.14	16.20

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ACC SU1ot--TOTAL OUTPUT LOOP ERROR (%Span)

6.4.5 TIME RESPONSE

COMPONENT	TIME			
Transmitter	0.500	Sec.		[6.6.8]
EFIC Time Delay Bistable	10.400	Sec.	DRN 05-3577	[6.3.20]
Trip Interface Equipment (TIE)	0.025	Sec.		[6.6.37]
Total Time Response	10.925	Sec.	DRN 05-3577	

6.5.0 CONCLUSIONS

The instrument uncertainty for the ANO-1 EFIC Channels A & B SG Low Level Initiate Bistable (SU1o) is calculated below:

SG Low Level Initiate (SU1o)

The output error for each of these bistables is the output error determined at the output of the EFIC Bistable Modules.

REF SU1o[1]	=	±	1.55	%SPAN		=	±	2.33	inches
ABN SU1ot[2]	=	+	2.02	%SPAN	DRN	=	+	3.03	inches
ABN SU1ot[2]	=	-	1.95	%SPAN	05-3546	=	-	2.92	inches
ACC SU1ot[1]	=	+	16.20	%SPAN		=	+	24.30	inches
ACC SU1ot[1]	=	-	5.14	%SPAN		=	-	7.71	inches

Note: 1. These vaues are the worst cases (i.e. greatest possible errors) found in Tables 6.4.4.10, and 6.4.4.16.
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2. These values reflect Assumption & Given Condition 6.3.22.

Reference these tables if uncertainties are required at specific levels/pressures.

SETPOINT EVALUATION

7 **SG Low Level Initiate (SU1)**

Credit is only taken for the initiation of EFW using this setpoint under the conditions of normal reactor building environment. Therefore, the uncertainties for the Abnormal Condition will be used in setpoint evaluation. Per Reference 6.6.40, the process limit for SG Low Level Initiate is 6 inches above the lower tubesheet (LTS) . Since this trip provides protection for a decreasing level, the bistable positive abnormal error terms will be used.

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Calc. Setpoint	=	Analytical Limit + Total Loop Error + Margin to Lower Tap
	=	6 + ABN SU1ot(+) + 0.5
DRN	=	6 + 3.03 + 0.5
05-3577	=	9.53 inches (above LTS)

Note also that the Technical Specifications provide an Allowable Value of 9.34 inches (Ref. 6.6.11). A calculated Allowable Value can be determined using guidance provided in Reference 6.6.38 as shown below.

Test Error	=	$((RA^2 + CAL^2 + DR^2)^{1/2})$%SPAN	Note: Dtol will be used in place of RA
DRN	=	0.721 %SPAN	where applicable (Dtol = 0.650 %
05-3577	=	1.08 inches	SPAN or 0.975 inches)

Allowable Value = Calc. Setpoint - Test Error
= 8.45 inches

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The present setpoint of 5.0 inches above the lower tap (11.0 ± 0.975 inches above the LTS) is conservative with respect to the Allowable Value. Note that the Total Loop Error, Test Error and as-left bistable tolerance (see Dtol above) support the Technical Specification Allowable Value (Ref. 6.6.11) of 9.34 inches.

6.6.0 REFERENCES

6.6.1 Design Guide IDG-001-0, Instrument Loop Error Analysis and Setpoint Methodology Manual.

6.6.2 ANO Engineering Standard NES-13, Rev. 1, Environmental Qualification -Environmental Service Conditions.

6.6.3 ASME Steam Tables, Sixth Edition.

6.6.4 Calculation No. 92-EQ-0003-01, Rev. 5, Specific IR Effects Calculation.

6.6.5 SIMS, As of the calculation origination date.

6.6.6 ANO-1 System Training Manual, STM 1-66, Rev. 5, Emergency Feedwater Initiation and Control System.

6.6.7 Procedure No. 1304.208, Rev. 3, Unit 1 EFIC Channel D Monthly Test, SG Pressure Greater Than 750 PSIG.

6.6.8 TM R370.0010 Rev. 23, TD R370.0160, Rev. 5, Rosemount Pressure Transmitters for Nuclear Service Model 1154 Alphaline. DRN 05-3577

6.6.9 Conduct of Maintenance Procedure 1025.003, Rev. 43-01.

6.6.10 TM B015.0580, Rev. 5, Technical Manual For Unit 1 Emergency Feedwater and Initiation and Control System.

6.6.11 ANO-1 Technical Specifications Submittal 1CAN010601. DRN 05-3577

6.6.12 ANO Document No. MISC-96-022, Letter from Neil P. Lien (Rosemount) to Bob McCain (Entergy Operations) dated September 20, 1990 Regarding Rosemount transmitter specifications.

6.6.13 B&W Document Identifier 51-1163812-00.

6.6.14 ULD-1-SYS-12, Rev. 3, ANO-1 Emergency Feedwater System.

6.6.15 ANO-1 Drawing No. FSK-M-1052, Rev. 3, Emergency Feedwater Initiation and Control System Tube Routing for LT-2621 and LT-2623.

6.6.16 ANO-1 Drawing No. FSK-M-1056, Rev. 3, Emergency Feedwater Initiation and Control System Tube Routing for LT-2617 and LT-2619.

6.6.17 ANO-1 Drawing No. FSK-M-1062, Rev. 2, Emergency Feedwater Initiation and Control System Tube Routing for LT-2668 and LT-2670.

6.6.18 ANO-1 Drawing No. FSK-M-1063, Rev. 3, Emergency Feedwater Initiation and Control System Tube Routing for LT-2618 and LT-2620.

6.6.19 ANO Engineering Report, 95-R-0013-01, Rev. 0; Control Room Post Accident Requirements.

6.6.20 B & W Document Identifier 51-1142173-00, EFIC System Accuracies.

6.6.21 ANO-1 Calculation No. 92-R-1023-01, Rev. 0.

6.6.22 Procedure No. 1304.100, Rev. 015-00-0, Unit 1 EFIC Channel C Calibration. DRN 05-3577

6.6.23 Procedure No. 1304.101, Rev. 015-00-0, Unit 1 EFIC Channel D Calibration.

6.6.24 Vendor Drawing No. 58526-022-1, Rev. 1, B&W Emergency Feedwater Initiation and Control System Assembly.

6.6.25 ANO-1 Drawing No. E-258, sheet 1, Rev. 4, Wiring Block Diagram Emergency Feedwater Initiation and Control (EFIC).

6.6.26 ANO Vendor File V43, Item #107, Rosemount Type Test Report D8600063, Low Level Radiation Dose Rate Test Small Break LOCA Test.

6.6.27 M-204, Sh. 4, Rev. 11, Piping & Instrument Diagram Emergency Feedwater.

6.6.28 M-206, Sh. 1, Rev. 117, Piping & Instrument Diagram Steam Generator Secondary System.

6.6.29 Vendor Drawing No. 58526-247, Rev. 0, EFIC Module Connection Diagram SGA Channel C & D.

6.6.30 Vendor Drawing No. 58526-246, Rev. 0, EFIC Module Connection Diagram SGB Channel C & D.

6.6.31 ANO-1 Calculation No. 95-R-1025-01, Rev. 1, ANO-1 Safety Analysis Groundrules-Cycle 14.

6.6.32 Not Used.

6.6.33 Procedure No. 1304.147, Rev. 027-00-0, Unit 1 EFIC Channel C Monthly Test.

6.6.34 Procedure No. 1304.148, Rev. 029-00-0, Unit 1 EFIC Channel D Monthly Test.

6.6.35 Procedure No. 1304.207, Rev. 012-00-0, Unit 1 EFIC Channel C Monthly Test, SG Pressure Greater Than 750 PSIG. DRN 05-3577

6.6.36 Document No. 1CAN038104.

6.6.37 Vendor Technical Manual, TM B015.0600, Rev. 1; Section 3.1, drawing S9N76-1, and drawing KGU431K.

7 6.6.38 ISA-RP67.04.02-2000, Methodologies for the Determination of Setpoints for Nuclear Safety-Related Instrumentation.

6.6.39 ER-ANO-2005-0871-000, ERCN1 DRN 05-3577

6.6.40 ANO Calculation A1-NE-2005-005, Rev. 0, "ANO-1 Revised EFIC Low Level Setpoint Summary Report.

ATTACHMENT 6-1
EFIC LOW RANGE LEVEL TRANSMITTER CALIBRATION DRN 05-3577

PURPOSE

The purpose of this attachment is to give the basis for the calibration of the EFIC low range steam generator level transmitters. DRN 05-3577

SCOPE

This attachment is applicable to the following level transmitters:

LT-2668	SGA Low Range Level Transmitter (Channel C)
LT-2672	SGA Low Range Level Transmitter (Channel D)
LT-2617	SGB Low Range Level Transmitter (Channel C)
LT-2621	SGB Low Range Level Transmitter (Channel D)

ASSUMPTIONS AND GIVEN CONDITIONS

1) The high pressure side of the transmitter is connected to the lower tap at 6" above the lower tube sheet (LTS). [6.6.6]

2) The low pressure side of the transmitter is connected to the upper tap at 156" above the LTS. [6.6.6]

3) The upper tap is 100% level and the lower tap is 0% level.

4) The water in the reference leg is assumed to be at 120°F.

5) The water in the steam generator is assumed to be at 212°F.

6) The steam in the steam generator is assumed to be at 212°F.

7) The transmitter is direct acting, 4-20 mADC for 0%-100% level.

8) The transmitter static span shift is +0.75% of differential pressure input per 1000 psi static pressure. [6.6.8]

9) 27.753 "H_2O/psi will be used in converting psi to "H_2O (based on 68°F). [6.6.3]

10) The transmitter static span shift is determined based on the normal operating pressure of 900 psig.

CALCULATIONS

1) Reference Leg Fluid Density (ρ_R)

Per Reference 6.6.3, the specific volume of water at 120°F is 0.016204 ft^3/lbm.
The density is the reciprocal of the specific volume, or 61.7132 lbm/ft^3.
Dividing by 1728 to convert to inches: 0.03571 lbm/in^3.

2) Steam Generator Water Density (ρ_W)

Per Reference 6.6.3, the specific volume of water at 212°F is 0.016719 ft^3/lbm.
The density is the reciprocal of the specific volume, or 59.8122 lbm/ft^3.
Dividing by 1728 to convert to inches: 0.03461 lbm/in^3.

3) Steam Generator Steam Density (ρ_S)

Per Reference 6.6.3, the specific volume of steam at 212°F is 26.799 ft^3/lbm.
The density is the reciprocal of the specific volume, or 0.0373 lbm/ft^3.
Dividing by 1728 to convert to inches: 2.16E-05 lbm/in^3.

4) Height of the Reference Leg (H_R)

H_R = 156 - 6 150 inches [6.6.6]

5) Height of Water (H_W) and Height of Steam (H_S) at 0% Level

$H_W(0\%)$ = 0 inches
$H_S(0\%)$ = 150 inches

6) Height of Water (H_W) and Height of Steam (H_S) at 100% Level

$H_W(100\%)$ = 150 inches
$H_S(100\%)$ = 0 inches

7) Differential Pressure at 0% Level (DP_0)

DP_0 = Pressure Hi Side (P_H) - Pressure Lo Side (P_L)
= $[H_W(0\%)*\rho_W + H_S(0\%)*\rho_S] - [H_R*\rho_R]$
= $[H_S(0\%)*\rho_S] - [H_R*\rho_R]$
= -5.354 psi
= -148.57 "H_2O

8) Differential Pressure at 100% Level (DP_{100})

DP_{100} = Pressure Hi Side (P_H) - Pressure Lo Side (P_L)
= $[H_W(100\%)*\rho_W + H_S(100\%)*\rho_S] - [H_R*\rho_R]$
= $[H_W(100\%)*\rho_W] - [H_R*\rho_R]$
= -0.165 psi
= -4.58 "H_2O

9) Span

Span = $DP_{100} - DP_0$
= 143.99 "H_2O

10) Derive Static Pressure Correction Factor Equation
Using the procedure outlined in Reference 6.6.8:

$$CF_{mADC} = \frac{(0.0075)(\text{static pressure} / 1000\ \text{psi}) \times (DPinput)}{\text{Span}} \times 16\ \text{mADC}$$

$$CF_{mADC} = \frac{(0.0075)(900 / 1000\ \text{psi}) \times (DPinput)}{143.99} \times 16\ \text{mADC}$$

$$CF_{mADC} = \frac{(0.00675) \times (DPinput)}{143.99} \times 16\ \text{mADC}$$

11) Derive High Range Calibration Table With and Without Correction Factor

INPUT (%Span)	INPUT ("H_2O)	Uncorrected (mADC)	CF (mADC)	Desired Corrected (mADC)
0.39	148	4.063	-0.111	3.952
24.70	113	7.952	-0.085	7.868
49.01	78	11.842	-0.059	11.783
73.32	43	15.731	-0.032	15.698
97.62	8	19.620	-0.006	19.614

7.0 FURTHER DISCUSSION ON LOW LEVEL INITIATE SETPOINT

The following discussion and B&W calculation were prepared to analyze the possibility of spurious EFW actuation during startup.

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The B&W calculation was originally prepared assuming an EFIC Low Level Initiate setpoint of 8" above the lower tubesheet (LTS) and EFIC uncertainties of +3"/-5". The discussion on the following page clarifies that the actual EFIC Low Level Initiate setpoint was 7.5" above the LTS and that the calculated EFIC uncertainties were +3.5"/-5.5". The discussion further explains that the two assumptions (setpoint and uncertainty) counterbalance each other and that the calculated startup differential pressures should be applicable.

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The B&W calculation assumes that the most likely SG pressure for spurious EFW actuation is 900 psia. Per Table 5.4.4.15 in Section 5.0, the calculated EFIC Low Level Initiate uncertainties are bounded by 2.50% or +/- 3.75 inches for a SG pressure of 900 psia.

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The differences between the actual and assumed setpoints and between the actual (Table 5.4.4.15) and assumed uncertainties cause a minimal effect on the results of the B&W calculation. Furthermore, the revised setpoint of 5.0 inches (above the lower tap) gives additional margin. Therefore, the B&W calculation is considered applicable, and the possibility of spurious EFW actuation, during startup, is minimal.

DC-134 Rev. 0 Attachment 1 - Design Verification Record

Document Number: CALC-80-D-1083C-01 Rev: 7 (DRN 05-3577)

Title: EFIC System Loop Error and Setpoint Analysis

Method

☒ Design Review ☐ Alternate Calculations ☐ Qualification Testing

Documents Reviewed

Document Number	Rev.	Remarks
CALC-86-D-1101-01	2 (DRN 05-3578)	Establishes new time delay bistable setting of 9.9 +/- 0.5 secs. per ER-ANO-2005-0871-000 ERCN# 01
A1-NE-2005-005	0	Establishes new total EFW system time response requirement of 80 secs/ Low LE
CALC-80-D-1083C-01	7 (DRN 05-3577)	Establishes new EFIC low SG level setpoint and time delay. (In-plant setpoint = 11.0 ± 0.975 inches, analytical limit = 6.0 inches above lower tubesheet and time delay for bistable = 9.9 ± 0.5 secs.

DMC 1/2/06

Initiate requirement of 6" above LTS.

Review Summary

Reviewed documents above, checked methodology used, and checked numerical results.

Comment Resolution

#	Comment	Resolution	Accepted Initial/Date
1	Section 5.5.0 and 6.5.0 – Need to change the wording in the statement that justifies the acceptability of the 11.0 +/- 0.975 inch in-plant setpoint to compare to the Allowable Value not the calculated setpoint.	Changed wording to compare to the allowable value.	DMC 1/2/06
2	Section 5.5.0 and 6.5.0 – In the section where the test error is calculated, it would be good to explain that a Dtol of 0.650 % span or 0.975 inches was used so it will be obvious why we used an as-left tolerance of +/- 0.975 inches.	Added explanation.	DMC 1/2/06
3	Reference 5.6.11 and 6.6.11 – Typo on letter number. Should read 1CAN010601.	Changed to 1CAN010601	DMC 1/2/06
4	Section 6.2.0 – In the first paragraph under the SG LOW LEVEL INITIATE section, change the in-plant setpoint from 7.0 to 5.0 inches.	Changed in plant setpoint to 6.0 inches	DMC 1/2/06
5	Reference 5.6.38 and 6.6.32 – The 20% tube plugging LOFW analysis is no longer the analytical basis. Change to Not Used.	Changed references 5.6.38 & 6.6.32 to "not used".	DMC 1/2/06
6			

Design Verification Completed by: D. Thyne Coffey Date 1/2/06

Design Resolution Accepted by: D. Thyne Coffey Date 1/2/06

Engineering Supervisor: Phillip E. Walker Date 1/3/06