Florida Power CORPORATION

INTEROFFICE CORRESPONDENCE

Nuclear Engineering Department	NA1E	231-4593
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SUBJECT: Crystal River Unit 3
Quality Document Transmittal - Analysis/Calculation
File: CALC

TO: Records Management - NR2A

The following analysis/calculation package is submitted as the QA Record copy:

DOCNO (FPC DOCUMENT IDENTIFICATION NUMBER)	REV.	SYSTEM(S)	TOTAL PAGES TRANSMITTED
I - 92 - 0008	1	MS	157

TITLE
EFIC - Main Steam Instrumentation Loop String Accuracy and Setpoints

KWDS (IDENTIFY KEYWORDS FOR LATER RETRIEVAL)
Main Steam, EFIC, Error, Indication, Recorders, Recall, Pressure and EFW

DXREF (REFERENCES OR FILES - LIST PRIMARY FILE FIRST)	
SP-95-002	I - 84 - 0002
SP-193A and SP-146	I - 84 - 0005
I-84-0001	I - 88 - 0001 and I - 89 - 0004

VEND (VENDOR NAME)	VENDOR DOCUMENT NUMBER (DXREF)	SUPERSEDED DOCUMENTS (DXREF)
FPC	N/A	I - 92 - 0008 Revision 0
	TAG	
EF-100-EB2, EF-200-EB2	EF-100-JX6, EF-200-JX6	MS-106-PI2, MS-107-PI2
EF-300-EB1, EF-300-EB2	EF-300-JX6, EF-400-JX6	MS-110-PI2, MS-111-PI2
EF-300-EB4, EF-400-EB1	MS-106-PI1, MS-107-PI1	See Attached sheet for
EF-400-EB2, EF-400-EB4	MS-110-PI1, MS-111-PI1	additional listing of tags.
	PART NO.	

COMMENTS (USAGE RESTRICTIONS, PROPRIETARY, ETC.)
This calculation revision replaces revision 0 in its entirety.

NOTE:
Use Tag number only for valid tag numbers (i.e., RCV-8, SWV-34, DCH-99), otherwise; use Part number field (i.e., CSC14599, AC1459). If more space is required, write "See Attachment" and list on separate sheet.

DESIGN ENGINEER	DATE	VERIFICATION ENGINEER	DATE	SUPERVISOR, NUCLEAR ENG.	DATE
[signature]	03/31/95	George Hildebrandt	5/26/95	S. T. Babbitt	6/1/95

cc: MAR Office (If MAR Related) ☐ Yes ☒ No
MAR/Project File
Mgr. Nucl. Config. Mgt.
/attach
ttach
G. V. HILDEBRANDT w/ATTACH

Plant Document Review Required ☒ Yes ☐ No
Supervisor, Nuclear Document Control w/ Plant Doc. Rev.
Eval. and Analysis / Calc. Summary (If Plant Doc. Rev., is Yes)
A/E N/A ☐ Yes ☒ No
(If yes, Transmit w/attach)
R. E. WAGNER w/ATTACH.

9506130137 950531
PDR ADOCK 05000302
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Rev. 11/94

RET: Life of Plant RESP: Nuclear Engineering 900 626

TAG

Continuation sheet 1 of Quality Document Transmittal - Analysis/Calculation.

DOCNO. **I - 92 - 0008 Rev. 1**

This is a continuation of tag number listing:

MS-106-PIR
MS-107-PIR
MS-110-PIR
MS-111-PIR
MS-106-PS1 thru MS-113-PS1
MS-106-PS2 thru MS-113-PS2
MS-106-PS3 thru MS-113-PS3
MS-106-PT thru MS-113-PT
MS-106-PY1 thru MS-113-PY1
MS-106-PY3
MS-107-PY3
MS-110-PY3
MS-111-PY3
MSV-025-PC
MSV-026-PC
ZZ-001-JY
ZZ-002-JY

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PLANT DOCUMENT REVIEW EVALUATION

DOCUMENT TYPE / NUMBER TO BE EVALUATED

Calculation I - 92 - 0008, Revision 1

PART I

INSTRUCTIONS: Calculations, Document Change Notices, and Plant Equipment Equivalency Replacements have the potential to affect plant documents. The Originator of any of these documents is required to determine which, if any, plant organizations should review the subject document for impact. The Originator should use the best judgment to make this determination based on the nature of the changes. If in doubt as to whether or not a plant organization should review a particular document, it is suggested that the subject organization be contacted.

The Originator is to check the appropriate boxes below and attach to the subject package as follows:

Calculations - Insert behind Analysis/Calculation Transmittal
DCNs - Insert behind DCN page 1
PEEREs - Insert behind PEERE page 3
CIDPs - Insert behind CIDP page 1

The above referenced document must be distributed as follows:

- ☐ Senior Radiation Protection Engineer
- ☐ Manager, Site Nuclear Services
- ☒ Manager, Nuclear Maintenance
- ☒ Supervisor, Operations Engineering & Support
- ☒ Manager, Nuclear Plant Technical Support
- ☒ Other(s):
  - D. E. McPherson for Calibration Data Sheets Revisons
  - Supervisor, Nuclear Training Controls
  - Manager, Nuclear Operations Training

ORIGINATOR / DATE	SUPERVISOR / DATE
Richard Iwachow [signature] 03/21/95	S. K. Balliet [signature] 6/1/95

Upon completion of **Part I**, if applicable, attach to the subject document, check "Plant Document Review Required" block, "Yes," and give to Nuclear Engineering Department Support Specialist for distribution.
CIDPs - Distribute with Attachments
Calcs - Distribute with Transmittal Memo, Summary - **PEERE** - Distribute with Attachments - **DCNs** - Distribute with Attachments and Drawings

PART II

INSTRUCTIONS: Upon receipt of the subject document, the assigned Reviewer enters the "Reviewing Department" name below, reviews the subject document for impact on plant procedures, and completes the evaluation below.
CAUTION: IF THE SUBJECT DOCUMENT STATES SPECIFIC PLANT PROCEDURES/DOCUMENTS MUST BE DEVELOPED OR REVISED AND IT IS DETERMINED BY THE REVIEWER NOT TO REVISE OR DEVELOP THOSE PROCEDURES/DOCUMENTS, THE ORIGINATOR MUST BE CONTACTED BY THE REVIEWER.

REVIEWING DEPARTMENT

PLANT REVIEW IMPACT EVALUATION: The above referenced document has been reviewed and evaluated as follows:

- ☐ No Action Required
- ☐ Action Required: The below listed document(s) is affected and requires revision and/or other actions as indicated (i.e., generate a new procedure, void a procedure, etc.)

DOCUMENTS / ACTIONS

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UPON COMPLETION, FORWARD EVALUATION FORM ONLY TO NUCLEAR DOCUMENT CONTROL (NR2A)

REVIEWER / DATE	SUPERVISOR / DATE

* If the Supervisor or designee acts as the Originator or Reviewer, the applicable "Originator/Reviewer" block should be NA'd.

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ANALYSIS/CALCULATION SUMMARY

DOCUMENT IDENTIFICATION NUMBER	DISCIPLINE	CONTROL NO.	REVISION LEVEL
	I	92 - 0008	1

TITLE

EFIC - Main Steam Pressure Instrumentation Loop String Accuracy and Setpoints

CLASSIFICATION (CHECK ONE)

- [X] Safety Related
- [ ] Non Safety Related

MAR/SP/CGWR/PEERE NUMBER/FILE: SP-95-0002

VENDOR DOCUMENT NUMBER: N/A

	REVISION APPROVALS		ITEMS REVISED
Design Engineer	R. Iwachow		All pages have been affected. This revision replaces Revision 0
Date	03/21/95		of the calculation in it's entirety.
Verification Engineer	[signature]		
Date/Method*	5/26/95	R	
Supervisor	S.K. Balliet		
Date	6/1/95		

***VERIFICATION METHODS:** R - Design Review; A - Alternate Calculation; T - Qualification Testing

DESCRIBE BELOW IF METHOD OF VERIFICATION WAS OTHER THAN DESIGN REVIEW

PURPOSE SUMMARY

This calculation has been re-written to define the "As-Left" tolerances, the "As-Found" tolerances and "Calibrated Loop Errors" to the original base calculation so as to support the calibration uncertainties used in surveillance procedures SP-146A and SP-193A. This calculation also consolidates a number of other EFIC main steam related calculations into this one source document.

RESULTS SUMMARY

Section VI - Results/Conclusions summarizes in tabular form the " As-Left ", " As-Found " and " Calibrated Errors " associated with the individual string components that make-up the EFIC main steam pressure instrument loop. This calculation also re-defines the setpoint values which have changed and are summarized in the same manner in support of the Improved Technical Specification surveillance program.

I PURPOSE

Determination of instrument loop accuracies of the EFIC - Main Steam Pressure transmitters MS-106 through MS-113-PT for EFIC initiate and bypass permissive, "feed only good generator", and atmospheric dump valve control, for post-accident monitoring and for normal surveillance requirements.

Refer to Attachments 1 and 2 for the depiction of the main steam pressure loop string. Attachment 1 represents EFIC Channels A and B. Attachment 2 represents EFIC Channels C and D.

II DESIGN INPUTS (DI)

1. Drawings that define the loop configuration and components; 205-039, sheets MS-01, MS-02, MS-03, MS-04 MS-05 and MS-06 (Reference 24 thru 29).

2. Pressure transmitters MS-106-PT through MS-113-PT are located in the Intermediate Building.

   (1) Per drawing 308-129 (Reference 30), MS-110-PT and MS-112-PT are located on the south face of a structural column on column line 310 and between rows I1/J2; and 53 inches above floor elevation 119'-0" in the Intermediate Building.

   (2) Per drawing 308-129 (Reference 30), MS-111-PT and MS-113-PT are located on the southern structural wall at column line 310 and row K1; and 53 inches above floor elevation 119'-0" in the Intermediate Building.

   (3) Per drawing 308-130 (Reference 31), MS-106-PT and MS-108-PT are located on the northwest edge of the structural platform adjacent to the stairs between column lines 309/310 and rows G/H1; and 53 inches above floor elevation 119'-0" in the Intermediate Building.

   (4) Per drawing 308-130 (Reference 31), MS-107-PT and MS-109-PT are located on the southwest edge of the structural platform between column lines 309/310 and rows H1/I1; and 53 inches above floor elevation 119'-0" in the Intermediate Building.

   Per CMIS, MS-106-PT thru MS-113-PT are located in EQ Zone 16. Per the Environmental and Seismic Qualification Program Manual (E/SQPM - Reference 8) EQ Zone 16 is "HARSH" and has the following specifications:

Radiation - Normal:	~ 1.0 x 10^3 rads TID for 40 year dose.
Radiation - Accident:	1.5 x 10^4 rads TID (40 year TID + 6 months).
Temperature - Normal:	80° to 135°F.
Temperature - LOCA:	The same as " Normal "
Temperature - HELB:	149° to 417°F.

   Per drawing 308-129 (Reference 30) and 308-130 (Reference 31), the sensing lines are routed near the proximity of the main steam lines and do not go outside the structural boundary of the Intermediate Building area.

3. Enhanced Design Basis Document for Post Accident Instrumentation, Tab 5/11, (Reference 4), states that the main steam pressure is a R.G. 1.97 Type A, D, Cat.1 variable, as indicated and recorded in the control room and on demand in the TSC and EOF (provided by RECALL). The CMIS shows these are required post-

accident for six months. The post-accident LOCA (RB) and post-accident HELB (IB) environment are different and both will be used to determine the error for post-accident monitoring (PAM) Instrumentation.

4. Enhanced Design Basis Document for Emergency Feed Water and Emergency Feedwater Initiation and Control (EFIC), Tab 6/13, (Reference 5) states that the main steam pressure is used to initiate EFIC on low pressure in either steam generator (SG), and "feed only good generator" (FOGG) as determined by SG differential pressure. Main steam pressure is also used to compensate for SG fluid density and in determination of level control in the steam generators.

5. Enhanced Design Basis Document for the Main Steam System, Tab 6/10, (Reference 6) Section 3 notes the CR-3 Safety Analysis assumes the Atmospheric Dump Valves (ADV's) operate for Steam Generator Tube Rupture (STGR), loss of electric power and Steam Line Break (SLB). The SLB is the only scenario which will cause a harsh environment for the transmitters in the IB. The Analysis Basis Document for Steam Line Break (Reference 62) notes four cases (scenarios), where cases I, II and IV assume the ADV's are available in the analysis to function. The FSAR Section 14.2.2.1.4, (Reference 3) notes cases I, II and IV are breaks within the RB, and therefore would not cause a harsh environment for the transmitters in the IB. Therefore a non-accident environment will be used for ADV actuation loop error.

6. Enhanced Design Basis Document for Remote Shutdown System, Tab 5/9, (Reference 58) gives the main steam pressure range of 0 to 1200 psig. No accuracy requirements are given. Improved Technical Specification Section 3.3.18 (Reference 2) gives the requirements for remote shutdown.

7. Instrument Data Sheets MS-106-PT thru MS-113-PT (References 23g, 23o, 23t, 23x, 23ee, 23ll, 23qq and 23uu) show that the pressure transmitters are Rosemount Model 1154SH9RA pressure transmitters with a span of 0 to 1200 psig. The specifications for these transmitters are described in Instruction Manual #1896 (Reference 40). The transmitters have the following specifications (See Attachment 3):

Upper Range Limit (URL):		3,000 psig.
Reference Accuracy:	±	0.25% of calibrated span.
Temperature Effect:	±	(0.15% URL + 0.35% span)/50°F, between 40°F and 130 °F.
	±	(0.75% URL + 0.5% span)/100°F, between 40°F and 200 °F. (See Attachment 17)
Drift (Stability):	±	0.2% of upper range limit for 18 months. Attachment 16 documents that the published drift specification is applicable for 30 months.
Overpressure Effect:	±	0.5% of upper range limit after exposure to 4,500 psig.
Power Supply Effect:	<	0.005% of output span per volt.
Steam Pressure/Temp:	±	(2.0% URL + 0.5% span) during and after sequential exposure to steam at the following temperature and pressure, concurrent with chemical spray for the first 24 hours: 420°F, 85 psig for 3 minutes 350°F, 85 psig for 7 minutes 320°F, 75 psig for 8 hours 265°F, 24 psig for 56 hours.
Seismic Effect:	±	0.5% URL after a disturbance defined by a required response spectrum with a horizontal ZPA of 8.5 g's and a vertical ZPA of 5.2 g's.
Radiation Effect:	±	(0.2% URL + 0.2% span) during the first 30 minutes;
	±	(0.5% URL + 1.0% span) after 55 x 10^6 rads TID;
	±	(0.75% URL + 1.0% span) after 110 x 10^6 rads TID gamma radiation exposure.
Mounting Position Effect:		No span effect. Effect is superseded by accuracy specifications.

(1) Per VQP INST-R369-04 (Reference 21), Tab F1, pages 9 & 10, the Rosemount product specification for radiation effects for the first 30 minutes was established based on radiation testing where the test units were exposed to an accident dose rate of $2.07X10^6$ R/Hr for the first 2 hours. The dose at end of the first 30 minute exposure would be $1.035x10^6$ R (a quarter of the 2 hour dose), and considerably more than our expected radiation dose for Zone 16 ($1.5X10^4$ R for 40 years plus 6 months post-accident). Therefore the Rosemount product specification radiation accuracy term for the first 30 minutes is applicable for the error analysis under considerations

(2) Per the Enhanced Design Basis Document for the Main Steam System, Section 6/10 (Reference 6), the main steam code safety valves prevent the rise in the main steam pressures and the last bank of code safeties open at a set pressure of 1100 psig. Therefore, the overpressure effect for the pressure transmitters will be considered as ± 0.0% since the pressure transmitters will not experience 4,500 psig.

(3) Per Letter LFM90-0006 (Reference 42); "It is not required to apply LOCA + MHE simultaneously to system functions." Thus, a Seismic event (MHE) and a LOCA do not need to be considered to occur simultaneously. Therefore, this calculation will only consider the LOCA/HELB effects (Radiation Effect and Steam/Temperature Effect) since the Seismic Effect is less than the LOCA/HELB effects. Therefore, the Seismic effect will be considered as ± 0.0% for Normal and Accident conditions.

(4) Per Letter SNES94-0276 (Reference 43); "...Rosemount has stated that any of these radiation induced errors may be compensated by calibration up to the tested dose from environmental qualification testing or about 110 MRads. Thus, it is shown that compensation of the radiation induced errors by calibration is a viable method up to the qualification level of 110 MRads.

Per the Attachment to Letter SNES94-0276; "The lower the dose rate, the lesser the effect on instrument accuracy. For the lower dose rates (10^4 Rads/hour) it was shown that a TID of less than 1×10^5 Rads resulted in a maximum output shift within the stated accuracy of the transmitter. These results are meant to be an aid in determining effects of radiation on accuracy of Rosemount transmitters."

The highest dose rate expected for MS-106-PT thru MS-113-PT is 1.5×10^4 rads for 40 years plus 6 months per Design Input (DI) #2, therefore, the radiation effect for NORMAL operating conditions will be considered as ± 0.00% since the transmitters receive less than 1×10^5 rads.

(5) The normal performance specification limits for temperature effects will be replaced by the steam pressure/ temperature effects whenever the ambient conditions exceed the specified Rosemount temperature limits of 40°F to 200°F.

(6) Since the conditions required for the steam pressure/temperature effect during normal operating condition is not applicable, therefore the normal steam pressure/temperature effect will be considered as ± 0.0 %.

(7) The pressure transmitters installed are Rosemount Model 1154SH Range code 9 and according to the manufacture's product literature (Attachment 3) these units have a sealed reference leg. This sealed reference chamber was not evacuated nor was it sealed with a calibrated standard of atmospheric pressure. The chamber was plugged with a pocket of air at whatever the atmospheric condition was at the time of assembly. Because the chamber was not sealed with a known reference, there could be an effect on the transmitters ability to correctly measure the process pressure. This effect will be evaluated under process measurement errors in the Detailed Calculations section to establish the amount of uncertainty this effect can contribute to the pressure reading.

8. Pressure Indicators MS-106-PI2 and MS-107-PI2 are located on Remote Shutdown Panel "A" and indicators MS-110-PI2 and MS-111-PI2 are located on Remote Shutdown Panel "B" on the 108' elevation of the Control Complex.

   Per the E/SQPM (Reference 8), the 108' elevation of the Control Complex is designated as EQ Zone 43, which is "MILD" and has the following specifications:

   Radiation - Normal: 1.75×10^2 rads TID for 40 year dose.
   Radiation - Accident: 1.75×10^2 rads TID (40 year TID + 6 months).
   Temperature - Normal: 70° to 80°F.

9. Instrument Data Sheets MS-106-PI2 and MS-110-PI2 (Reference 23b and 23z), which includes MS-107-PI2 and MS-111-PI2; shows that the pressure indicators are International Instruments Model 1251WV-B010DCV-B010DCV with a 0 to 10 VDC input for a span of 0 to 1,200 psig. The specifications for this pressure indicator is described in International Instruments Series 1151/1251 bulletin, which is located in Instruction Manual 586 (Reference 35). The pressure indicator has the following specifications (See Attachment 5).

   Specified Accuracy: ± 1.5% span for DC ranges.
   Repeatability: ± 2% span.
   Minor Scale Division: 20 psig.

   Per Assumption (A) #6, the SRSS (Square Root of the Sum of the Squares) methodology for the Specified Accuracy and Repeatability will be used to determine the Reference Accuracy.

10. Compensation modules (MS-106-PY1 thru MS-113-PY1), pressure initiate bistables (MS-106-PS1 thru MS-113-PS1), pressure deltaP bistable (MS-106-PS2 thru MS-113-PS2), pressure permissive bistable (MS-106-PS3 thru MS-113-PS3), pressure control modules (MSV-025-PC and MSV-026-PC), analog isolation input modules (EF-100-EB2, EF-200-EB2, EF-300-EB1 and EF-400-EB1) and analog isolation output modules (EF-300-EB2, EF-300-EB4, EF-400-EB2 AND EF-400-EB4) are electronic printed circuit cards that are contained within the EFIC Cabinets A, B, C and D. The Cabinets themselves are located on elevation 124'-0" of the Control Complex. Also found in each of the cabinets is a zero (0) to 32 volt DC power supply that is the source of power for the main steam transmitters.

    Per the E/SQPM (Reference 8), the 124'-0" elevation of the Control Complex is designated as EQ Zone 58, which is " Mild " and has the following specifications:

    Radiation - Normal: 1.75×10^2 Rads TID for 40 year dose.
    Radiation - Accident: 1.75×10^2 Rads TID (40 years TID + 6 months).
    Temperature - Normal 70°F to 80°F

11. The functional elements of processing the main steam pressure signal are shown on the EFIC module connection diagram drawing series (Reference 68a thru 68c and 68f). The module connection diagram drawings are simplified versions of the manufacturer's functional logic diagram drawings. The element errors are as described in B&W document 51-1142173-00, attached to Quality Document Transmittal for MAR 80-10-66-09, dated 9/20/85 - SEEK Reel 3232 Frame 853 (See Attachment 6). The individual element errors involved in the processing of the various output signals are noted below:

    <u>The Compensation Module</u>:

    Input Buffer/Scalar - specified accuracy: ± 0.25% span

Output Buffer/Scalar - specified accuracy: ± 0.25% span
Summer - specified accuracy: ± 0.25% span

[Note that the scalar used in processing the SG pressure differentials has a subtractor (summer) whose output (C) is the sum of the inputs, with one having change in sign, each with a constant (K), or, $C = K_1A + K_2B$. From Reference 1, Section 4.3, the equation for the propagation of error thru the Summer is $e = [(K_1a)^2 + (K_2b)^2 + e^2]^{1/2}$. Since the proportion of input is the same from each SG, K is 1, and the errors are just SRSS in the loop equation].

<u>The Bistable</u>:

Specified accuracy: ± 0.20% span

<u>The Control Module</u>:

Subtractor - specified accuracy: ± 0.25 % span
Proportional Plus Integral - specified accuracy: ± 0.25% span
Setpoint - specified accuracy: ± 0.10% span

<u>Analog Isolation Modules</u>:

Attachment 7 describes the Class 1E to Non-1E isolated analog circuit accuracy which also includes the inaccuracy of the digital isolators. The signal process error for the combined analog isolator input module, digital isolator and analog isolator output module is:

Specified accuracy: ± 0.5% span

12. Instrument Data Sheets EF-100-JX6 (Reference 23eee), EF-200-JX6 (Reference 23ggg), EF-300-JX6 (Reference 23kkk), and EF-400-JX6 (Reference 23ooo) show that the EFIC sensor power supplies are Lambda Electronics LCS-A-03 Series regulated power supply with a 0 to 32 VDC output. The specifications for these power supplies are described in Lambda LCS-A Series Instruction Manual which is located in FPC Instruction Manual 1172, Volume 1 (Reference 36). The power supplies have the following specifications (See Attachment 15):

Output:	0 - 32 VDC
Output Setting:	32 VDC
Regulation - Line:	0.01% plus 1.0 millivolt for input variations from 105 - 132 or 132 - 105 volts AC.
Regulation - Load:	0.01% plus 1.0 millivolt for load variations from no load to full load or full load to no load.
Temperature Coefficient:	(0.015% + 0.3 millivolt)/°C

(1) Power supply EF-100-JX6 provides power to MS-106-PT and MS-110-PT. Per drawing 210-769 (Reference 64) show that the EFIC " A " cabinet power supply source is fed from 120 VAC Vital Bus 3A, VBDP-8, Fuse #8. The electrical one line diagram drawing 206-041 (Reference 63), shows that VBDP-8 can be fed from either the dual input inverter 3A (VBTR-1A) or the 480 V ES MCC 3A2 thru the 30 KVA voltage regulating transformer VBTR-4A. According to the enhanced design basis document (EDBD) for the Class 1E - Alternating Current (AC) system (Reference 59) lists the design regulation parameters associated with VBIT-1A and VBTR-4A to VBDP-8 as being ± 1% to ensure that the line voltage is maintained within the design requirements of the EFIC Cabinet.

(2) Power supply EF-200-JX6 provides power to MS-107-PT and MS-111-PT. Per drawing 210-771 (Reference 65) show that the EFIC " B " cabinet power supply source is fed from 120 VAC Vital Bus 3B, VBDP-10, Fuse #6. The electrical one line diagram drawing 206-041 (Reference 63), shows that VBDP-10 can be fed from either the dual input inverter 3B (VBTR-1B) or the 480 V ES MCC 3B1 thru the 30 KVA voltage regulating transformer VBTR-4B. According to the enhanced design basis document (EDBD) for the Class 1E - Alternating Current (AC) system (Reference 59) lists the design regulation parameters associated with VBIT-1B and VBTR-4B to VBDP-10 as being ± 1% to ensure that the line voltage is maintained within the design requirements of the EFIC Cabinet.

(3) Power supply EF-300-JX6 provides power to MS-108-PT and MS-112-PT. Per drawing 210-772 (Reference 66) show that the EFIC " C " cabinet power supply source is fed from 120 VAC Vital Bus 3C, VBDP-9, Fuse #6. The electrical one line diagram drawing 206-041 (Reference 63), shows that VBDP-9 can be fed from either the dual input inverter 3C (VBTR-1C) or the 480 V ES MCC 3A2 thru the 30 KVA voltage regulating transformer VBTR-4C. According to the enhanced design basis document (EDBD) for the Class 1E - Alternating Current (AC) system (Reference 59) lists the design regulation parameters associated with VBIT-1C and VBTR-4C to VBDP-9 as being ± 1% to ensure that the line voltage is maintained within the design requirements of the EFIC Cabinet.

(4) Power supply EF-400-JX6 provides power to MS-109-PT and MS-113-PT. Per drawing 210-773 (Reference 67) show that the EFIC " D " cabinet power supply source is fed from 120 VAC Vital Bus 3D, VBDP-11, Fuse #6. The electrical one line diagram drawing 206-041 (Reference 63), shows that VBDP-11 can be fed from either the dual input inverter 3C (VBTR-1D) or the 480 V ES MCC 3B1 thru the 30 KVA voltage regulating transformer VBTR-4D. According to the enhanced design basis document (EDBD) for the Class 1E - Alternating Current (AC) system (Reference 59) lists the design regulation parameters associated with VBIT-1D and VBTR-4D to VBDP-11 as being ± 1% to ensure that the line voltage is maintained within the design requirements of the EFIC Cabinet.

For conservatism, the total effect associated with the power supplies will be considered as follows for the transmitters with the highest allowable voltage setting on the Lambda power supply being 32 VDC:

Line Regulation = ± (0.01% of setting voltage + 1.0 mV)
= ± [(0.01%) x (32 VDC)] / 100% + 1.0 mV
= ± (.0032 VDC) + (0.001 VDC)
= ± 0.0042 VDC
= ± [(0.0042 VDC/32 VDC)] x 100%
= ± 0.0131%

Load Regulation = ± (0.01% of setpoint + 1.0 mV)
= ± [(0.01%) x (32 VDC)] / 100% + 1.0 mV
= ± (.0032 VDC) + (0.001 VDC)
= ± 0.0042 VDC
= ± [(0.0042 VDC/32 VDC)] x 100%
= ± 0.0131%

Total Regulation = Line Regulation + Load Regulation
= ± [0.0131% + 0.0131%]
= ± 0.0262%

Temperature Effects = ± (0.015% + 0.3 millivolt)/°C

Per design input (DI) #10, the temperature range for the power supply is 80°F - 70°F = 10°F. Therefore the temperature change is equal to [10°F x (5°C/9°F)] = 5.56 °C.

$$= \pm [(0.015\% \times 32\ VDC)]/100\% + \{0.3\ mV(5.56^\circ C)\}/^\circ C$$
$$= \pm [(0.0048\ VDC) + (0.00167\ VDC)]$$
$$= \pm (0.00647\ VDC/32\ VDC) \times 100\%$$
$$= \pm 0.0202\%$$

Therefore, the Total Power Supply Effect will be determined from the SRSS of the total regulation and the temperature effect:

$$\text{Total Power Eff.} = \pm \{[\text{Total Regulation}]^2 + [\text{Temperature Effect}]^2\}^{1/2}$$
$$= \pm \{[0.0262\%]^2 + [0.0202\%]^2\}^{1/2}$$
$$= \pm \{(0.00069) + (0.00041)\}^{1/2}$$
$$= \pm [0.0011]^{1/2}$$
$$= \pm 0.0332\%$$
$$= \pm (0.0332\% \times 32\ VDC) = \pm 0.0106\ VDC$$

13. Pressure indicators MS-106-PI1, MS-107-PI1, MS-110-PI1 and MS-111-PI1 and pressure indicating recorders MS-106-PIR MS-107-PIR, MS-110-PIR and MS-111-PIR are located in the Main Control Room on the 145' elevation of the Control Complex.

    Per the E/SQPM (Reference 8), the 145' elevation of the Control Complex is designated as EQ Zone 13, which is "MILD" and has the following specifications:

Radiation - Normal:	1.75 x 10^2 rads TID for 40 year dose.
Radiation - Accident:	1.75 x 10^2 rads TID (40 year TID + 6 months).
Temperature - Normal:	70° to 80°F.

14. Instrument Data Sheets MS-106-PI1 including MS-110-PI1 and MS-107-PI1 including MS-111-PI1 (Reference 23a and 23i) show that these pressure indicators are International Instruments Model 1251WV-B010DCV-B010DCV with a 0 to 10 VDC input for a span of 0 to 1,200 psig. The specifications for this pressure indicator is described in International Instruments Series 1151/1251 bulletin, which is located in Instruction Manual #1300 (Reference 38). The pressure indicator has the following specifications (See Attachment 5).

Specified Accuracy:	±	1.5% span for DC ranges.
Repeatability:	±	2% span.
Minor Scale Division:		20 psig.

    Per Assumption (A) #6, the SRSS (Square Root of the Sum of the Squares) methodology for the Specified Accuracy and Linearity will be used to determine the Reference Accuracy.

15. Instrument Data Sheets MS-106-PIR including MS-110-PIR and MS-107-PIR including MS-111-PIR (Reference 23c and 23k), shows that the pressure indicating recorders are a Foxboro Model N227P-2R6-CS-N/SRC with an 0 to 10 VDC input for a span of 0 to 1,200 psig. The specifications for this pressure indicating recorder are described in Foxboro Product Specifications PSS 9-7C1-A which is located in Instruction Manual #1524 (Reference 57). The pressure indicating recorders have the following specifications (See Attachment 10):

Indicating Accuracy:	±	0.5% of span.
Recording Accuracy:	±	0.75% of span.

Temperature Effect:	±	0.5% of span/50°F change.
Humidity Influence:		
Indicating:	±	0.3% of span for a change of 50 to 95% relative humidity.
Recording:	+	0.75% to - 1.5% of span for a change of 50 to 95% relative humidity.
Power Supply Effect:	<	0.1% of span for ±5% change from nominal.
Minor Scale Division:		50 psig (Indicating)
		20 psig (Chart)

16. Instrument data sheets ZZ-001-JY (Reference 23ppp) and ZZ-002-JY (Reference 23qqq) list that Foxboro Model N2AX-PS9A nest power supplies are used to supply power for the above mentioned Foxboro pressure indicating recorder. The Specifications for these power supplies are described in Foxboro TI 2AX-151, which is located in Instruction Manual #1524 (Reference 57). The power supplies have the following specifications (See Attachment 11):

Output:	+15 VDC at 1.5 amps and -15 VDC at 1.5 amps.
Regulation - Line:	0.2% output voltage change for ±10% change from nominal line voltage.
Regulation - Load:	1.5% output voltage change for load change from 50 to 100%.

(1) Power supply ZZ-001-JY provides power to MS-106-PIR. Per drawing 210-814 (Reference 71) show that the ZZ-001-JY power supply source is fed from 120 VAC Vital Bus 3A, VBDP-3, Breaker #2. The electrical one line diagram drawing 206-041 (Reference 63), shows that VBDP-8 can be fed from either the dual input inverter 3A (VBTR-1A) or the 480 V ES MCC 3A2 thru the 30 KVA voltage regulating transformer VBTR-4A. According to the enhanced design basis document (EDBD) for the Class 1E - Alternating Current (AC) system (Reference 59) lists the design regulation parameters associated with VBIT-1A and VBTR-4A to VBDP-3 as being ±1% to ensure that the line voltage is maintained within the design requirements of the EFIC Cabinet.

(2) Power supply ZZ-002-JY provides power to MS-107-PIR. Per drawing 210-814 (Reference 71) show that ZZ-002-JY power supply source is fed from 120 VAC Vital Bus 3A, VBDP-4, Break #11. The electrical one line diagram drawing 206-041 (Reference 63), shows that VBDP-8 can be fed from either the dual input inverter 3B (VBTR-1B) or the 480 V ES MCC 3B12 thru the 30 KVA voltage regulating transformer VBTR-4B. According to the enhanced design basis document (EDBD) for the Class 1E - Alternating Current (AC) system (Reference 59) lists the design regulation parameters associated with VBIT-1A and VBTR-4B to VBDP-4 as being ±1% to ensure that the line voltage is maintained within the design requirements of the EFIC Cabinet

For conservatism, the total regulation associated with the power supplies will be considered as ±1.7% (0.2% + 1.5%) for the transmitters and recorder.

17. Foxboro distribution module (terminal block) MS-106-PY3 including MS-110-PY3 and MS-107-PY3 including MS-111-PY3 (References 23h and 23p), will not be considered in this calculation, because the above mentioned modules are only used for distribution or for testing. The modules do not contribute to the loop error.

18. The I&C Design Criteria (Reference 1) and Calculation I-89-0004 (Reference 14) provide the bases for the development of calculations which require the incorporation of Insulation Resistance (IR) effects.

19. Per Calculation I-88-0015 (Reference 16), the following is a list of the circuit data for the loop components which are located in a "HARSH" environment:

(1) Sensor: MS-106-PT

(a) Rosemount Model 1154 Series H transmitter

(b) Rosemount conduit seal.

(c) Circuit number MSS43 (EK-36A, Reel 002).

(d) Circuit Length - 282 feet.

(e) 1 splice in circuit

(2) Sensor: MS-107-PT

(a) Rosemount Model 1154 Series H transmitter.

(b) Rosemount conduit seal.

(c) Circuit number MSS45 (EK-37A, Reel 002).

(d) Circuit Length - 317 feet.

(e) 1 splice in circuit

(3) Sensor: MS-108-PT

(a) Rosemount Model 1154 Series H transmitter

(b) Rosemount conduit seal.

(c) Circuit number MSS47 (EK-35A, Reel 336).

(d) Circuit Length - 351 feet.

(e) 1 splice in circuit

(4) Sensor: MS-109-PT

(a) Rosemount Model 1154 Series H transmitter.

(b) Rosemount conduit seal.

(c) Circuit number MSS49 (EK-35A, Reel 327).

(d) Circuit Length - 324 feet.

(e) 1 splice in circuit

(5) Sensor: MS-110-PT

(a) Rosemount Model 1154 Series H transmitter

(b) Rosemount conduit seal.

(c) Circuit number MSS42 (EK-36A, Reel 004).

(d) Circuit Length - 435 feet.

(e) 1 splice in circuit

(6) Sensor: MS-111-PT

(a) Rosemount Model 1154 Series H transmitter.

(b) Rosemount conduit seal.

(c) Circuit number MSS44 (EK-37A, Reel 002).

(d) Circuit Length - 393 feet.

(e) 1 splice in circuit

(7) Sensor: MS-112-PT

(a) Rosemount Model 1154 Series H transmitter

(b) Rosemount conduit seal.

(c) Circuit number MSS46 (EK-35A, Reel 336).

(d) Circuit Length - 386 feet.

(e) 1 splice in circuit

(8) Sensor: MS-113-PT

(a) Rosemount Model 1154 Series H transmitter.

(b) Rosemount conduit seal.

(c) Circuit number MSS48 (EK-35A, Reel 327).

(d) Circuit Length - 394 feet.

(e) 1 splice in circuit

20. Calculation I-88-0009 (Reference 15) depicts a generic 4 - 20 mADC instrument sensor circuit and covers the design input aspects given to the derivation of the insulation resistance error equation. The circuit presented in the calculation is a representation of ungrounded voltage power supply loop. Also, the calculation itself is only concerned with the current leakage path resulting from a degradation of dielectric material to cause a conductor to conductor IR affect. For a conductor to conductor current leakage path configuration this results in an insulation resistance loop error of magnitude in the positive direction.

Closer examination of the internal cabinet wiring drawings (Reference 33, 34, 68g and 68h) for the circuit mentioned in the calculation, has identified that the common (or negative) side of the circuit is not

ungrounded. Tracing the common (or negative) side wire leads has shown that these are all grounded to an isolated instrument ground bus within the cabinet which is tied to the plant's instrument ground grid. This loop configuration differs from the generic application covered in calculation I-88-0009 (Reference 15), where two additional current leakage paths are now introduced for a grounded voltage source.

Consideration is now given to looking at a grounded transmitter loop configuration in a harsh environment where a conductor to ground current leakage path is created on the positive side of the loop. A leakage path on the positive side of the circuit causes an increase in the current output from the voltage source . The consideration of this resistive ground path can be ignored since the voltage source will maintain the increase in current load and not affect the current path through the transmitter and the instrument load resistance. The second consideration that needs to be taken into account is a conductor to ground current leakage path on the common (or negative) side of the circuit which results in the leakage path bypassing a portion of the transmitter current around the load impedance (R_e) to the common side of the voltage source through the ground path. The leakage current in this case is a negative bias opposed to the positive bias noted in the first consideration. The magnitude of this current is a function of the leakage path to ground resistance and voltage drop across the loop resistance. Therefore, this ground leakage is greatest on the full signal output for the loop when the transmitter current is 20 mADC, as opposed to the conductor to conductor leakage being the greatest at minimum signal (i.e. 4 mADC).

Utilizing the approach given in calculation I-88-0009 (Reference 15) for determination of the IR error, except considering the transmitter current at 4 mADC, the following equation will be used in calculating the positive bias IR error for a conductor to ground transmitter circuit loop:

$$A_{IR} = + [(V_s - R_e I_T) / (I_s \times \{R_e + R_P\})] \times 100$$

where:
- V_s = power supply voltage = 32 volts
- R_e = equivalent resistance of the loop in a mild environment = 625 ohms
- I_S = loop current span = 16 mA
- I_T = loop current across the transmitter = 4 mA.
- R_p = equivalent parallel resistance of the cables, splices and connectors in a harsh environment.

Substituting the constants into the equation, we have;

$$A_{IR} = + [(32 - (625 \times 0.004)) / (0.016 \times \{625 + R_P\})] \times 100$$
$$= + [(32 - 2.5) / (10 + 0.016R_P)] \times 100$$
$$= + [29.5 / (10 + 0.016R_p)] \times 100$$

Again utilizing the approach given in calculation I-88-0009 (Reference 15), the following equation will be used in calculating the negative bias IR error due to a conductor to ground current leakage path on the common (or negative) side of the transmitter loop circuit:

$$A_{IR} = - [(R_e I_T) / (I_s \times \{R_e + R_P\})] \times 100$$

where:
- R_e = equivalent resistance of the loop in a mild environment = 625 ohms
- I_S = loop current span = 16 mA
- I_T = loop current across the transmitter = 20 mA.
- R_p = equivalent parallel resistance of the cables, splices and connectors in a harsh environment.

Substituting the constants into the equation, we have;

$$A_{IR} = -[(625 \times 0.020)) / (0.016 \times \{625 + R_P\})] \times 100$$
$$= -[(12.5) / (10 + 0.016R_P)] \times 100$$

Per Section 6.2.B of the Instrument String Error/Setpoint Determination Methodology (Reference 1): "IR error due to accident environments are considered systematic." The error term is therefore, additive.

21. The cables used in the instrument loops are CR-3 Bill Of Material (B.O.M.) type EK-35A, EK-36A and EK-37A which are all 2 conductor #16 AWG cable. Vendor Qualification Report CABL-B365-01 (Reference 18) is used to determine the IR value associated with these cable types. Per Tab I1 of the VQP, all of the cable has similar construction as the BIW (Boston Insulated Wire) Bostrad 7E, whose test results are documented under the VQP.

The peak temperature in the Intermediate Building (IB) is 417°F per Design Input (DI) #2. This temperature peak in the IB lasts approximately 31seconds before returning to 300°F within 3 minutes.

BIW Bostrad 7E cable was tested under Sandia National Laboratories Report SAND89-1755C, which is included as Attachment B2 to Calculation I-89-0004 (Reference 14). Per Conclusion 4.e of the Sandia report; "Total thermal lag time was typically 3 minutes for multi-conductor cables and 30 seconds for single conductors." Under Tab I8, page 2 of the VQP report a thermal finite element analysis found that the BIW when installed in conduit is exposed to a maximum temperature excursion of 338°F before falling off to below 300°F. Therefore the minimum cable IR of 2.9×10^6 ohms for the 20 foot specimen length, which is listed in Figure 7 of VQP CABL-B365-01 (Reference 18) will be used in this calculation. Therefore, the following information is applicable:

Specimen Length (L_{SPL}):	20 feet.
Minimum IR value (R_C):	2.9×10^6 ohms at 300°F.

The cable IR (R_{CE}) is derived from the cable qualification test specimen IR (R_C), the specimen length (L_{SPL}) and the total length of cable in the HARSH environment (L_{CKT}), in feet. Therefore, the following formula is used:

$$R_{CE} = (R_C \times L_{SPL})/L_{CKT}$$

22. Based on the Walkdown Packages for transmitters MS-106-PT thru MS-113-PT (Reference 22), the splices in the circuits associated with MS-106-PT thru MS-113-PT consists of butt splices with Raychem heat shrink tubing. No non-standard splice configurations were identified. The splices at the transmitters were identified as having Raychem WCSF-N tubing sleeves; therefore, VQP TERM-R098-04 (Reference 20) which documents the test data associated with Raychem WCSF-N splice sleeves will be used for this calculation.

Per Tab F5 of the VQP (Wyle Test Report 58442-1), each test circuit consists of three (3) test splices each consisting of a single layer of WCSF-N sleeving. Per Table 1 of the test report, the minimum IR during the simulated LOCA/MSLB test was:

Cable Splice (R_S):	1.8×10^7 ohms at 314°F (excluding the test specimens that had cable insulation failures).

Figure 1 of Tab D1. in the above mentioned VQP, describes the thermal lag associated with the Raychem sleeving. The RB temperature profile and the thermal lag associated with the Raychem sleeving cross at approximately 310°F. Therefore, the use of the 1.8×10^7 ohms at 314°F is acceptable.

23. VQP INST-R369-04 (Reference 21) covers the nuclear qualification testing of the Rosemount Model 1154 Series H transmitters. Tab F3, page 4 and 38; specify that a Swagelok fitting and a length of copper tubing be used to seal the electrical conduit entries in preparation for testing the units in a steam/temperature environment within a steam chamber. No conduit seal assembly was used for the test duration. Tab B - Summary of Qualification; Paragraph 3.1 within the VQP instructs the use of a Rosemount 353C conduit seal to avoid moisture intrusion into electronics housing portion of the transmitter assembly. The walkdown packages covering the transmitter installations identified that a conduit seal connector was fitted onto each transmitter's electronic housing.

VQP PEN-R369-01 (Reference 19) documents the testing of the Rosemount Model 353C conduit seal. Calculation I-88-0003 (Reference 13) calculated an IR based upon the acceptance criteria given in the test report, in which the voltage measured across the 500 ohm resistor in the test loop could not shift by more than 40 mV. According to the calculation, the test set-up used in the qualification test measured total leakage (lead-to-lead and leads-to-case). It further added that since it is not possible to determine how the leakage is divided, all measured leakage current was assumed to be lead-to-lead leakage. The calculation then used the 40 volts between the seal leads to arrive at an IR value of 5×10^5 ohms. This value is conservative since it represents the maximum allowed deviation for the conduit seal and is used in the instrument string error calculation for the post accident monitoring conditions.

Conduit Seal (R_{SEAL}): 5×10^5 ohms for temperatures up to 420°F, based on the above mentioned VQP.

In determination of an IR value for the low pressure initiate condition, a more realistic approach needs to be taken in order demonstrate that the conduit seal IR affect when combined with the other component IR's has a negligible affect on the string error. To arrive at this conclusion the actual test data from the VQP is used to determine the appropriate IR value. Rosemount tested two different design seal configurations and according to Tab I4, page 2, the conduit seals furnished to CR-3 are of the Design 2 configuration. Per Tab F, Appendix A, page 18, the initial LOCA test was interrupted due to steam escaping from the chamber and an inspection was performed of the test units which revealed that the heat shrink tubing on the lead wires of the units had been perforated during the test setup. A modification of the configuration was made, and the units were re-tested. The results of the test showed that a maximum shift of 21 mV was observed on unit A003 during the first test and 4 mV during the re-test. The other unit (A001) had suffered degradation; therefore, test data will be based on unit A003.

According to Tab 2, Sections 17.3.1 and 17.3.2 of the VQP PEN-R369-01 (Reference 19), the acceptance criteria during the LOCA test for voltage shifts across the 500 ohm resistor and the IR measurement was 40 mV and 6×10^5 ohms. This IR measurement was to be taken from lead-to-case, as prescribed in Sections 17.2.4 and 10.1.2.4.2. Although the test procedure gave instructions for taking IR measurements while at elevated temperatures during the test, this apparently was not done until after the chamber had cooled. (Tab F1, Table 7). Therefore, the only way to establish an IR value for the LOCA temperature is to evaluate the voltage shift measured during the LOCA test.

One approach is to reason that the 40 mV and 6×10^5 ohms acceptance criteria correlated a 4 mV shift (representing 1/10 th of the acceptance criteria) which should translate into a lead-to- case IR value approximately ten times that of the IR acceptance criteria, or 6×10^6 ohms.

Using the mathematical approach given in Calculation I-88-0003 (Reference 13) and the 4 mV shift value from the test, a leakage current of 0.004 V/500 ohms = 8×10^{-6} amperes. Tab F, Appendix A, page 2 indicates the voltage potential between leads was 40 volts. Insulation resistance is then 40 V/8×10^{-6} amperes = 5×10^6 ohms, which agrees closely with that determined above.

Since the data does not indicate when the maximum 4 mV shift occurred, it is reasonable to assume that it occurred at the maximum seal temperature (due to the nature of IR). According to page 19 of Appendix A (Tab F) of the VQP (Reference 19), the specimen test chamber temperature was held at 320 °F for 8 hours whereby the conduit seal device would have experienced the same ambient condition. Therefore, a reasonable estimate for an IR value at 320°F for the seal is 5 x 10^6 ohms. This value along with the other component IR values will determine the magnitude of the total circuit IR error such that it can be neglected from consideration in the loop error calculation for the low pressure initiate condition.

24. The Remote Shutdown equipment is not postulated to be required concurrent with a Design Basis Accident (DBA), per FSAR Section 7.4.6.5 (Reference 3).

25. The "As-Left" tolerances are to be determined from the SRSS of the Reference Accuracy for all of the components in the string. Since "As-Left" tolerances are only used to determine drift between calibrations, only Normal operating condition parameters affect the determination of the tolerances.

26. The "Calibrated" Loop Error will be determined from the summation of the Calculated Loop Error and the "As-Found" tolerances for the components in the loop plus any Margin, if applicable. The "Calibrated" Loop Error is the maximum error that operations could expect after the calibration of the loop.

27. The "As-Found" tolerances are to be determined from the summation of the "As-Left" tolerances plus the SRSS of the Drift of any components and the M&TE error associated with the string.

28. "Partial Loop" tolerances are to be determined from the difference of the total loop tolerance ("As-Left" and "As-Found") and the actuation device tolerances ("As-Left" and "As-Found"). "Partial Loop" tolerances are determined to aid in the calibration of loops which include actuation devices (i.e.: pressure switches).

29. Future surveillance procedure revisions will use the test equipment listed below for the main steam pressure loop strings. Therefore, M&TE error uncertainty as stated in calculation I-95-0005 (Reference 41) will be as follows:

    a) The Druck DPI-510 Pressure Controller/Calibrator, has the capability for measurement 0 - 3000 psig. Since our process measurement span is 0 - 1200 psig, the M&TE error uncertainty from Reference 41 has to be adjusted for the 1200psig span as follows:

    For the pressure calibrator portion in Zone 5 (Intermediate Bldg. Elev 119'-0") as:

    <u>0 - 3000 PSI Range</u>

    $DPI\text{-}510_{5P2}$ = ± 0.129% full scale

    = ± 0.129% (3000 psig/1200 psig)
    = ± 0.323 % span

    For the current measurement portion in Zone 5 (Intermediate Bldg. Elev 119'-0") as:

    <u>20mA Range</u>

    $DPI\text{-}510_{5A2}$ = ± 0.372% span

b) In accordance with Reference 41, the referenced document has determined that the Keithley 197A test equipment has a M&TE error uncertainty of:

For current measurement in Zone 2 (Control Complex):

<u>20mA Range</u>

$197A_{2MA}$ = ± 0.190% span

c) In accordance with Reference 41, the referenced document has determined that the Fluke 8522A test equipment has a M&TE error uncertainty of:

For current measurement in Zone 2 (Control Complex):

<u>1 - 5 VDC Range</u>

$8522A_{2V5}$ = ± 0.041% span

<u>0 - 10 VDC Range</u>

$8522A_{2V10}$ = ± 0.023% span

30. Surveillance Procedures SP-146A (Reference 44) and SP-193A (Reference 45) have the following "As-Left" and "As-Found" tolerances:

Loop End Device	AS-LEFT	AS-FOUND
MS-106-PY1	± 0.013 VDC	± 0.042 VDC
MS-106-PI1	± 15 PSIG	± 20 PSIG
MS-106-PI2	± 15 PSIG	± 20 PSIG
MS-106-PIR (Chart)	± 15 PSIG	± 20 PSIG
MS-106-PIR (Indicating)	± 25 PSIG	± 25 PSIG
MS-106-PS1	± 0.008 VDC	± 0.008 VDC
MS-106-PS2	± 0.008 VDC	± 0.008 VDC
MS-106-PS3	± 0.008 VDC	± 0.008 VDC
MS-106-PT (Recall Pt. RCL252)	± 24 PSIG	± 36 PSIG
MS-107-PY1	± 0.013 VDC	± 0.042 VDC
MS-107-PI1	± 15 PSIG	± 20 PSIG
MS-107-PI2	± 15 PSIG	± 20 PSIG
MS-107-PIR (Chart)	± 15 PSIG	± 20 PSIG
MS-107-PIR (Indicating)	± 25 PSIG	± 25 PSIG
MS-107-PS1	± 0.008 VDC	± 0.008 VDC

Loop End Device	AS-LEFT	AS-FOUND
MS-107-PS2	± 0.008 VDC	± 0.008 VDC
MS-107-PS3	± 0.008 VDC	± 0.008 VDC
MS-108-PY1	± 0.013 VDC	± 0.042 VDC
MS-108-PS1	± 0.008 VDC	± 0.008 VDC
MS-108-PS2	± 0.008 VDC	± 0.008 VDC
MS-108-PS3	± 0.008 VDC	± 0.008 VDC
MS-109-PY1	± 0.013 VDC	± 0.042 VDC
MS-109-PS1	± 0.008 VDC	± 0.008 VDC
MS-109-PS2	± 0.008 VDC	± 0.008 VDC
MS-109-PS3	± 0.008 VDC	± 0.008 VDC
MS-110-PY1	± 0.013 VDC	± 0.042 VDC
MS-110-PI1	± 15 PSIG	± 20 PSIG
MS-110-PI2	± 15 PSIG	± 20 PSIG
MS-110-PIR (Chart)	± 15 PSIG	± 20 PSIG
MS-110-PIR (Indicating)	± 15 PSIG	± 20 PSIG
MS-110-PS1	± 0.008 VDC	± 0.008 VDC
MS-110-PS2	± 0.008 VDC	± 0.008 VDC
MS-110-PS3	± 0.008 VDC	± 0.008 VDC
MS-110-PT (Recall Pt. RCL255)	± 24 PSIG	± 36 PSIG
MS-111-PY1	± 0.013 VDC	± 0.042 VDC
MS-111-PI1	± 15 PSIG	± 20 PSIG
MS-111-PI2	± 15 PSIG	± 20 PSIG
MS-111-PIR (Chart)	± 15 PSIG	± 20 PSIG
MS-111-PIR (Indicating)	± 15 PSIG	± 20 PSIG
MS-111-PS1	± 0.008 VDC	± 0.008 VDC
MS-111-PS2	± 0.008 VDC	± 0.008 VDC
MS-111-PS3	± 0.008 VDC	± 0.008 VDC
MS-112-PY1	± 0.013 VDC	± 0.042 VDC
MS-112-PS1	± 0.008 VDC	± 0.008 VDC
MS-112-PS2	± 0.008 VDC	± 0.008 VDC
MS-112-PS3	± 0.008 VDC	± 0.008 VDC

Loop End Device	AS-LEFT	AS-FOUND
MS-113-PY1	± 0.013 VDC	± 0.042 VDC
MS-113-PS1	± 0.008 VDC	± 0.008 VDC
MS-113-PS2	± 0.008 VDC	± 0.008 VDC
MS-113-PS3	± 0.008 VDC	± 0.008 VDC

31. Surveillance Procedure SP-146A (Reference 44) has the following "As-Left" and "As-Found" setpoint data.

Loop End Device	AS-LEFT		AS-FOUND	
	Voltage Setting	Engr'g Unit Setting	Voltage Setting	Engr'g Unit Setting
MS-106-PS1 thru MS-113-PS1	3.059 VDC	617.76 PSI	3.059 VDC	617.76 PSI
MS-106-PS2 thru MS-113-PS2	1.356 VDC	106.80 PSID	1.356 VDC	106.80 PSID
MS-106-PS3 thru MS-113-PS3	3.441 VDC	732.37 PSI	3.441 VDC	732.37 PSI

32. The position taken by ISA-RP67.04, Part II, Paragraph 6.2.6.1 (Reference 56) which typically considers input and output test equipment used during the calibration of a device as independent, and could thus be combined by the SRSS method.

33. Per Calculation I-94-0012 (Reference 17), the error associated with RECALL/SPDS is ± 0.366% of Full Scale Range (20 VDC or 4096 counts).

34. The NRC has accepted instrument error calculations based upon a 2 sigma confidence level via R.G. 1.105 (Reference 47). Per the I&C Design Criteria (Reference 1), published instrument errors are usually expressed at a confidence level of 3 sigma, unless otherwise indicated. That philosophy should be valid for error terms which pertain to equipment operated in a controlled environment. However, for equipment which must survive the environmental effects of an accident (LOCA, HELB), that philosophy cannot be adhered to. The reason for such is that special environmental testing to quantify the temperature, pressure, and radiation effects due to accident conditions are usually done on too small a sample to represent a 3 sigma value. Therefore, environmental error terms shall be considered as 2 sigma values unless otherwise indicated. This calculation does not convert any 3 sigma non-environmental error terms (i.e. reference accuracy, drift, etc.) into 2 sigma terms when it combines the non-environmental with the environmental terms. This approach adds conservatism to the end result.

35. The following method will be used to determine the overall error for component(s) and/or loop(s) that have Positive (+) and/or Negative (-) Biases:

    (1) Positive Biases will be added to the SRSS of the Positive random errors, while ignoring Negative Biases.

    (2) Negative Biases will be added to the SRSS of the Negative random errors, while ignoring Positive Biases.

36. In the determination of the low steam generator pressure initiate and isolation setpoint, the calculated setpoint must be high enough to initiate main steam/main feedwater isolation on a depressurized condition in either steam generator. Also, at the same time actuate the emergency feedwater system. This same value must be low enough to avoid isolation of a steam generator during plant operation that is not indicative of a depressurized condition. FSAR Chapter 14.2.2.1 (Reference 3) describes the depressurizing condition occurring at 600 psig.

    [Note: In the original setpoint calculation as documented in FPC Calculation I-84-0005 (B&W Document ID 51-1153083-02) [Reference 9] this low pressure initiate point was identified to occur at 585 psig. This pressure trip point was based on a Safety Analysis for Midland I and II].

37. The permissive for bypassing the EFIC trip setpoint must be accomplished when the main steam pressure decreases below 750 psig in either generator and before reaching the low pressure initiate setpoint of 600 psig. The low pressure bypass permissive can be bypass whenever one of the two main steam pressure transmitter's input has reached the pre-determined bistable setpoint. One permissive bypass will trip the other regardless of the other pressure signal level. The lowest of the two input pressure signals will also be the first to actuate the low pressure initiate bistable. The setpoint condition must ensure operator initiation of emergency feedwater in order to produce results that are bounded by the accident basis analysis [or safety analysis]. During controlled plant start-up the steam generator bypass permissive bistable automatically arms itself. Reference 53 is the source document which explains the determination for the acceptability of the 750 psig bypass setpoint. In addition, the setpoint must not interfere with plant start-up and cooldown without causing spurious actuation of the EFW system.

38. Determination of the ADV pressure control setpoint dictates the controlled relief pressure for managing the main steam line header pressure. The selected setpoint must not challenge the main steam code safeties and at the same, avoid unnecessary release of mass energy (steam) up the vent stacks to atmosphere during normal operation. According to Improved Technical Specification paragraphs B3.7.1 and SR 3.7.1.1 (Reference 2), both mention that one safety relief valve on each steam generator has a lift setpoint of 1050 psig (± 3%). An administrative limit of 1050 psig is in place on valves MSV-33, MSV-34, MSV-35 AND MSV-36 to maintain this as the minimum zero tolerance "As-Left" lift setpoint (Reference 49).

39. Curve 8 from Operating Procedure OP-103A (Reference 48) depicts the main steam operating pressure for various plant power levels where at full power the maximum operating steam pressure is shown as 916.5 psig.

40. The FOGG Logic Assessment Study (Reference 52 and Attachment 12) assumed a differential pressure value of the 150 psid including a 25 psi margin for instrument error. Calculation I-84-0005 (Reference 9) assumes 150 psid with 12.38 psi error. The setpoint ensures that automatic isolation of emergency feedwater occurs to a depressurized steam generator for varying sizes of steam line breaks.

41. Environmental conditions have an influence on transmitter accuracy where the influence is dependent on the type of plant transient event causing substantial differences in ambient conditions. This calculation considers the following environmental scenarios under which the transmitters will operate to satisfy the design requirements:

    a. Normal Environmental Conditions
    b. Environmental Effects Prior to EFIC - Low Pressure/Differential Pressure Actuation Following MSLB
    c. Environmental Effects Post-Accident (MSLB)

The above environmental conditions will now be discussed as to their impact on various transmitter accuracy components (i.e. temperature, insulation resistance on the circuit, steam pressure/temperature, and radiation).

a. Normal Environmental Conditions
The only effects considered are the transmitter temperature effects created by the differential temperature between the transmitter's calibration temperature and the normal operating temperature in the Intermediate Building. IR is not a concern since there is no steam environment and no high temperatures present to reduce insulation resistance. As explained in DI7.4, radiation effects are not a factor for the normal operating environment.

EQ Zone 16 lists that for a 5 hour duration period the zone is expected to experience an ambient temperature change between 129°F and 135°F. This 5 hour variation in ambient condition could be attributed to a plant upset event that results in the lifting of the main steam code safeties. The mass energy release through the 16 code safety vent stacks can create an immense amount of heat energy that is radiated to the surrounding area to cause an increase in the ambient temperatures. This 5 hour duration will be considered as an infrequent occurrence and have minimal impact on the transmitters since they are located below the discharge point of the code safeties to the vent stacks. Therefore, the transmitter will not be exposed to a surrounding ambient temperature (normal) of greater than 130 °F.

b. Environmental Effects Prior to EFIC - Low Pressure/Differential Pressure Actuation Following HELB.

The FOGG Logic Assessment (Reference 52) had examined a wide spectrum of main steam line break cases in order to assess that sufficient differential pressure existed between two steam generators for FOGG to function. The assessment concluded that given a main steam isolation valve signal (low pressure initiate) adequate differential pressure between the two generators was distinguishable to cause a FOGG to occur. A review of the steam line break curves in the assessment document (Reference 52) and the FSAR Figure 14-26 (Reference 3) showed that an affected steam generator can depressurize to 600 psig anywhere between one second to 30 seconds (30 seconds being worse case) depending on the steam line break size.

Since there is a thermal lag associated with the transmitter, the transmitter internals will not reach the HELB Intermediate Building temperature of 417°F (as per EQ Zone 16) before the main steam low pressure actuation is reached. Rosemount conducted a thermal response test of the internals of its 1153D transmitter (using the same stainless steel housing as used on the subject transmitters) and found the thermal time constant to be approximately 4.8 minutes (Attachment 18). In addition, a letter from Rosemount allows the use of this data on 1154 Series H transmitters (Attachment 18). Using a lumped system analysis approach to heat transfer, a transmitter internal temperature at the time of main steam actuation can be derived. This method provides good results whenever the internal conductive resistance is small compared to the external convective resistance. Whenever this is true, the temperature of the object will be spatially uniform at any given time. Rosemount used this approach in Attachment 4 to determine transmitter internal temperature as a function of time. Using the approach given in Attachment 4, the transmitter internal temperature can be derived 30 seconds after the HELB occurs. As long as the time constant of the transmitter is much larger than the time to EFIC - low pressure, the IB temperature rise can be treated as a step change. This does add conservatism since a higher internal temperature will result. Therefore, using the lumped system heat transfer analysis method, the internal electronic temperature can be determined at the low pressure initiate (along with deltaP) using the equation from Attachment 4 will be:

$$(T1 - T0) = (T2 - T0)[1 - \exp(-t/TC)]$$

$$\therefore T1 = T0 + (T2 - T0)[1 - \exp(-t/TC)]$$

where:

T1 = Temperature of internal electronics board at time t
T0 = Temperature of internal electronics board at time 0
T2 = Temperature of the ambient at time t
TC = Time constant of transmitter housing (4.8 minutes or 288 seconds)
t = time

$$\begin{aligned} T_{30s} &= 130°F + (417°F - 130°F)[1 - \exp(-30s/288s)] \\ &= 130°F + (287°F)[1 - \exp(-0.104)] \\ &= 130°F + (287°F)[1 - 0.9012] \\ &= 130°F + 28.36°F \\ &= 158.36°F \\ &= 158°F \text{ (Temperature rounded down)} \end{aligned}$$

As determined, the transmitter's electronic internal temperature has not heated-up to the surrounding HELB temperature and actually lags it. This, then shows that the transmitter's temperature effect is still within Rosemount's normal operating design limit of + 40°F and 200°F (DI #7). Therefore, the normal temperature effects will be used in the determination of the transmitter inaccuracy for the low pressure and differential pressure loop errors.

During the actuation period the instrumentation cable, conduit seals and splices are exposed to the same elevated environment as the transmitter and a certain magnitude of IR may have an influence on the loop error. As with the transmitter, there is a thermal lag associated with these devices. Rather than performing a rather rigorous finite element thermal analysis on each device to determine its approximate temperature at the time of actuation, the above lumped parameter approach will be used for each device in order to show that the combined IR's have a negligible affect and therefore need not be considered in the calculation of the loop error.

Design Input (DI) #21 states that thermal lag of multiconductor cable is typically about 3 minutes for those mentioned in SAND89-1755C. According to the report , this 3 minute period was the time it took for the cable to reach a stable value of IR. The report does not cover how many time constant this steady state constant represents. Assuming this 3 minute represents 3 time constants, one time constant would equal to 60 seconds. This time constant should be conservative since the cables were not tested in conduit. The main steam pressure transmitter instrumentation cable are routed in conduit. The conduit provides an additional thermal resistance to cable temperature increases and would thus increase the actual thermal time constant of the cable (i.e. reduces the cable temperature).

Using the 60 seconds as a conservative thermal time constant, the following cable, temperature at the time of the low pressure actuation can be determined using the same lump systems analysis approach:

$$\begin{aligned} T_{30S} &= 130°F + (417°F - 130°F)[1 - \exp(-30s/60s)] \\ &= 130°F + (287°F)[1 - \exp(-0.5)] \\ &= 130°F + (287°F)[1 - 0.6065] \\ &= 130°F + 112.93°F \\ &= 242.93°F \end{aligned}$$

From VQP CABL-B365-01, Figure 7 (Reference 18), the closest cable temperature which matches the above calculated value is listed as 250°F. The IR value listed for this temperature is 1.7×10^7 ohms.

According to Tab I4 of VQP TERM-R098-04 (Reference 20), Raychem has not published data regarding thermal lag through its WCSF-N splice sleeving; however, contained within Tab I4 are results of laboratory testing done on a sample of WCSF-200 material. From those test results , a thermal time constant for the main steam actuation period (0 - 30 seconds) based upon the inside sleeve temperature will be determined using the same lumped systems analysis approach established earlier:

$$90^\circ C = 50^\circ + (225^\circ C - 50^\circ C)(1 - e^{-(60s)/TC})$$
$$40^\circ C = 175^\circ C - 175^\circ C\,[e^{-(60s)/TC}]$$
$$-135^\circ C = -175^\circ C\,[e^{-(60s)/TC}]$$
$$0.77143 = e^{-(60s)/TC}$$
$$-0.2595 = -60\ s/TC$$
$$TC = 231.20\ \text{seconds}$$

the inner sleeve temperature at low pressure actuation is therefore:

$$T_{30S} = 130^\circ F + (417^\circ F - 130^\circ F)[1 - \exp(-30s/231.20s)]$$
$$= 130^\circ F + (287^\circ F)[1 - \exp(-0.1298)]$$
$$= 130^\circ F + (287^\circ F)[1 - 0.8783]$$
$$= 130^\circ F + (287^\circ F)[0.1217]$$
$$= 130^\circ F + 34.93^\circ F$$
$$= 164.93^\circ F$$

From VQP TERM-R098-04 Table 1 (Reference 20), the closest splice temperature that matches the above calculated value is listed as 210°F. The IR value listed for this temperature is 4.6×10^8 ohms.

No thermal time constant information is available for the Rosemount conduit seals used at the transmitters: therefore, it will be conservatively assumed that the seal has the same thermal time constant as the cable. This should be conservative since the seal is an extension of the cable and more dense than the cable. From this assumption, the transmitter seal temperature at low pressure initiation is assumed to be the same as the cable temperature of 243.93°F. Refering to Design Input (DI) #23, the IR value was defined for our condition as 5×10^6 ohms.

With all of the pertient IR data assemblied, it can now be used to establish the magintude of these combined affect has in contribution to the overall loop error. Using the equation from Design Input (DI) #20, the magnitude of the IR affect is:

$$A_{IR} = +[29.5 / (10 + 0.016R_P)] \times 100$$
$$-[12.5 / (10 + 0.016R_P)] \times 100$$

Using the worst circuit length as being for MS-110-PT; L_{CKT} for MSS42 is 435 feet.

$$R_{CE} = (1.7 \times 10^7 \text{ ohms} \times 20 \text{ feet})/435 \text{ feet}$$
$$= 0.782 \times 10^6 \text{ ohms}$$
$$R_S = 4.6 \times 10^8 \text{ ohms}$$
$$R_{SEAL} = 5 \times 10^6 \text{ ohms}$$

$$1/R_P = [(1/0.782 \times 10^6) + (1/4.6 \times 10^8) + (1/5 \times 10^6)]$$
$$= [1.279 \times 10^{-6} + 2.174 \times 10^{-9} + 2.00 \times 10^{-7}]$$
$$= 1.48 \times 10^{-6}$$

$R_p = (1/1.48 \times 10^{-6})$
$= 0.676 \times 10^6$ ohms

$A_{IR} = + [29.5/(10 + (0.016 \times 0.676 \times 10^6))] \times 100$
$= + [29.5/(10826)] \times 100$
$= + 0.272\%$ span $= (0.272\% \times 1200) = 3.26$ psig
$= - [12.5/ (10 + (0.016 \times 0.676 \times 10^6)] \times 100$
$= - [12.5/10826] \times 100$
$= - 0.115\%$ span $= -(0.115\% \times 1200) = - 1.38$ psig

The calculated IR affect for the low pressure errors is relatively small in magnitude in comprasion to the transmitter error of ± 1.87% span. Therefore, IR affects will not be considered, since it is not significant and would not appreciately change the magnitude of the overall loop error accuracy which is predominately dictated by the the transmitter error.

c. Environmental Effects Post-Accident (MSLB)
The steam pressure/temperature effects published in the transmitter literature apply to the transmitter since it will be exposed to the environment for the duration specified in the product specification.

There is no significant release of radiation on an MSLB; therefore, radiation effects are not considered for this event.

III ASSUMPTIONS (A)

1. Assume that modules, indicators and recorders located in EQ Zones 13 (Control Room), 43 (Remote Shutdown) and 58 (EFIC Rooms) are calibrated at 70°F, which is the lowest ambient temperature condition to be expected for these Zones. This will ensure that any temperature effects are conservatively calculated.

2. Assume that the pressure transmitters located in EQ Zone 16 are calibrated at 80°F, which is the lowest ambient temperature condition expected for this zone. This will ensure that any temperature effects are conservatively calculated.

3. It is assumed that the test equipment referenced under Design Input (DI) 29 will be used in the future to calibrate MS-106-PT thru MS-113-PT loops.

(1) The transmitters are calibrated using the Druck DPI-510 for pressure and current, therefore, the M&TE error for the pressure transmitter is:

$MTE_{PT} = \pm (MTE_{DP}^2 + MTE_{DI}^2)^{1/2}$ DI29a

$= \pm (0.323^2 + 0.372^2)^{1/2}$
$= \pm (0.2427)^{1/2}$
$= \pm 0.493\%$ span

(2) The EFIC pressure bistables (pressure switches) are calibrated using one (1) Fluke 8522A for voltage on a 1 - 5 VDC signal. Therefore, the M&TE error for this item is:

$MTE_{FM} = \pm (8522A_{2V5})$ DI29c
$= \pm 0.041\%$ span

(3) The EFIC - Low Pressure and Bypass Permissive Bistable (Pressure Switch) Loops are to be calibrated by calibrating the pressure transmitter, then inputting the transmitter current values with a Keithley 197A into the EFIC compensation module while monitoring the voltage input to the bistables (pressure switches) with a Fluke 8522A for voltage on 1 - 5 VDC signal. Therefore, the MTE required is:

$$MTE_{PSL} = \pm (DPI\text{-}510_{5P2}{}^2 + DPI\text{-}510_{5A2}{}^2 + 197A_{2MA}{}^2 + 2 \times (8522A_{2V5})^2)^{1/2} \quad \text{DI29}$$

$$= \pm (0.323^2 + 0.372^2 + 0.190^2 + 2 \times (0.041)^2)^{1/2}$$
$$= \pm (0.2822)^{1/2}$$
$$= \pm 0.531\% \text{ span}$$

(4) The other loops are to be calibrated by calibrating the pressure transmitter, then inputting the transmitter current values with a Keithley 197A into the EFIC compensation module while also monitoring the indicators, recorders, and etc .

$$MTE_{OL} = \pm (DPI\text{-}510_{5P2}{}^2 + DPI\text{-}510_{5A2}{}^2 + 197A_{2MA}{}^2)^{1/2} \quad \text{DI29}$$

$$= \pm (0.323^2 + 0.372^2 + 0.190^2)^{1/2}$$
$$= \pm (0.2788)^{1/2}$$
$$= \pm 0.528\% \text{ span}$$

(5) The EFIC - Differential Pressure Bistable (Pressure Switch) Loops are to be calibrated by calibrating the two pressure transmitter, then inputting both transmitter current values at the same time with a Keithley 197A into the two (2) EFIC compensation module within the same cabinet and monitoring the voltage input to the bistables (pressure switches) using two Keithley 197A. Therefore, the MTE required is:

$$MTE_{DPSL} = \pm [(2) \times (DPI\text{-}510_{5P2})^2 + (2) \times (DPI\text{-}510_{5A2})^2 + (2) \times (197A_{2MA})^2 + (2) \times (8522A_{2V5})^2)^{1/2} \quad \text{DI29}$$

$$MTE_{DPSL} = \pm [(2) \times (0.323)^2 + (2) \times (0.372)^2 + (2) \times (0.190)^2 + (2) \times (0.041)^2]^{1/2}$$
$$= \pm [(2 \times 0.1043) + (2 \times 0.1384) + (2 \times 0.0361) + (2 \times 0.001681)]^{1/2}$$
$$= \pm [(0.2086) + (0.2768) + (0.0722) + (0.0034)]^{1/2}$$
$$= \pm [0.5610]^{1/2}$$
$$= \pm 0.749\% \text{ span}$$

(6) The EFIC - Control module are to be calibrated by calibrating the pressure transmitter, then inputting the transmitter current values with a Keithley 197A into the EFIC compensation module while monitoring the voltage input to the control module (pressure control) using a Fluke 8522A voltage on a 0 - 10 VDC signal. Therefore, the MTE required is:

$$MTE_{CML} = \pm (DPI\text{-}510_{5P2}{}^2 + DPI\text{-}510_{5A2}{}^2 + 197A_{2MA}{}^2 + 8522A_{2V10}{}^2)^{1/2} \quad \text{DI29}$$

$$= \pm (0.323^2 + 0.372^2 + 0.190^2 + 0.023^2)^{1/2}$$
$$= \pm (0.2793)^{1/2}$$
$$= \pm 0.528\% \text{ span}$$

4. For components were a drift term is not specified, it is assumed that any drift is present is bounded by the reference accuracy of the device.

5. The Control Complex is considered a Controlled Environment; therefore, no significant changes in humidity will be considered.

6. Per Section 6.3.A of I&C Design Criteria (Reference 1);

   "Accuracy as identified in a vendor specification is usually assumed to be Reference Accuracy. .....Reference Accuracy includes the combined effects of conformity (linearity), hysteresis and repeatability."

   Where conformity (linearity), hysteresis and repeatability values are less than the specified accuracy, the above statement is to be considered true. For conservatism, where conformity (linearity), hysteresis and/or repeatability values are equal to or greater than the specified accuracy, then the value(s) will be combined via the SRSS method with the specified accuracy term to determine the Reference Accuracy value.

IV REFERENCES (R)

1. I&C Design Criteria "Instrument String Error/Setpoint Determination Methodology", Revision 1, dated 03/23/92.

2. Improved Technical Specification Sections 3.3.11, 3.3.12, 3.3.13, 3.3.14, 3.3.18 and 3.7.1, Amendment 150.

3. FSAR Sections 7.2.4, 7.4.6.5, 10.3.4, 14.2.2.1 and FSAR Figure 14-26, Revision 21.

4. Design Basis Document (DBD) for Post-Accident Monitoring Instrumentation (Section 5/Tab 11), Revision 2.

5. Enhanced Design Basis Document (EDBD) for the Emergency Feedwater and Emergency Feedwater Initiation and Control System (Section 6/Tab 13), Revision 3.

6. Enhanced Design Basis Document (EDBD) for the Main Steam System, (Section 6/Tab 10), Revision 3.

7. Request for Engineering Assistance's (REA) 94-1255, 94-1256 and 94-1257.

8. Environmental and Seismic Qualification Program Manual (E/SQPM), Revision 7.

9. FPC Calculation I-84-0005, Revision 5, dated 02/19/90, titled "Post EFW Upgrade: Limits and Precautions, EFIC Setpoints.

10. FPC Calculation I-85-0001, Revision 0, dated 06/18/85, titled " FPC EFIC String Error Calculation ".

11. FPC Calculation I-85-0002, Revision 0, dated 06/13/85, titled " EFW/EFIC String Error Calculation Methodology ".

12. FPC Calculation I-88-0001, Revision 1, dated 10/03/89, titled " EFIC Indicator Errors ".

13. FPC Calculation I-88-0003, Revision 3, dated, "Insulation Resistance of Rosemount Conduit Seal ".

14. FPC Calculation I89-0004, Revision 5, dated, "Instrument Loop and Insulation Resistance (IR) Accuracy Calculations" provides the bases for determination of the IR effects (error).

15. FPC Calculation I88-0009, Revision 3, dated 10/26/92, " IR Accuracy 4-20 mA Loop (Vitro Nest)".

16. FPC Calculation I-88-0015, Revision 6, dated 10/02/92, "Selection of Circuit Data for IR Accuracy Calculations ".

17. FPC Calculation I-94-0012, Revision 1, dated 2/17/95, titled, "Computer Instrument Accuracy".

18. Vendor Qualification Package (VQP) CABL-B365-01, "Boston Insulated Wire Bostrad 7E Instrumentation & Control Cable", Revision 2.

19. Vendor Qualification Package (VQP) PEN-R369-01, "Rosemount Model 353C Conduit Seals", Revision 2.

20. Vendor Qualification Package (VQP) TERM-R098-04, "Raychem NPKC, NPKP, and NPKS Transition Splice Assemblies", Revision 2.

21. Vendor Qualification Package (VQP) INST-R369-04, "Rosemount Inc., 1154 Series H Transmitter", Revision 1.

22. Walkdown Package Numbers 27 through 34 for end devices MS-106-PT through MS-113-PT.

23. Instrument Data Sheets:

a.	MS-106-PI1, Rev. 4	aa.	Deleted	aaa.	EFV-055-LC1, Rev. 3
b.	MS-106-PI2, Rev. 3	bb.	MS-110-PS1, Rev. 3	bbb.	Deleted
c.	MS-106-PIR, Rev. 3	cc.	MS-110-PS2, Rev. 2	ccc.	Deleted
d.	MS-106-PS1, Rev. 3	dd.	MS-110-PS3, Rev. 2	ddd.	EF-100-EB2, Rev. 1
e.	MS-106-PS2, Rev. 2	ee.	MS-110-PT, Rev. 3	eee.	EF-100-JX6, Rev. 1
f.	MS-106-PS3, Rev. 2	ff.	SP-021-LY1, Rev. 1	fff.	EF-200-EB2, Rev. 1
g.	MS-106-PT, Rev. 3	gg.	SP-018-LY1, Rev. 1	ggg.	EF-200-JX6, Rev. 1
h.	MS-106-PY3, Rev. 1	hh.	SP-019-LY1, Rev. 1	hhh.	EF-300-EB1, Rev. 1
i.	MS-107-PI1, Rev.1	ii.	MS-111-PS1, Rev. 3	iii.	EF-300-EB2, Rev. 2
j.	SP-017-PY1, Rev. 1	jj.	MS-111-PS2, Rev. 2	jjj	EF-300-EB4, Rev. 1
k.	MS-107-PIR, Rev. 3	kk.	MS-111-PS3, Rev. 2	kkk.	EF-300-JX6, Rev. 1
l.	MS-107-PS1, Rev. 3	ll.	MS-111-PT, Rev. 3	lll.	EF-400-EB1, Rev. 1
m.	MS-107-PS2, Rev. 2	mm.	SP-022-LY1, Rev. 1	mmm.	EF-400-EB2, Rev. 2
n.	MS-107-PS3, Rev. 2	nn.	MS-112-PS1, Rev. 3	nnn.	EF-400-EB4, Rev. 1
o.	MS-107-PT, Rev. 3	oo.	MS-112-PS2, Rev. 2	ooo.	EF-400-JX6, Rev. 1
p.	MS-107-PY3, Rev. 1	pp.	MS-112-PS3, Rev. 2	ppp.	ZZ-001-JY, Rev. 1
q.	MS-108-PS1, Rev. 3	qq.	MS-112-PT, Rev. 3	qqq.	ZZ-002-JY, Rev. 1
r.	MS-108-PS2, Rev. 2	rr.	MS-113-PS1, Rev. 3	rrr.	SP-023-LY1, Rev. 1
s.	MS-108-PS3, Rev. 2	ss.	MS-113-PS2, Rev. 2	sss.	SP-024-LY1, Rev. 1
t.	MS-108-PT, Rev. 3	tt.	MS-113-PS3, Rev. 2		
u.	MS-109-PS1, Rev. 3	uu.	MS-113-PT, Rev. 3		
v.	MS-109-PS2, Rev. 2	vv.	Deleted		
w.	MS-109-PS3, Rev. 2	ww.	EFV-058-LC1, Rev. 3		
x.	MS-109-PT, Rev. 3	xx.	Deleted		
y.	SP-020-LY1, Rev.1	yy.	Deleted		
z.	MS-110-PI2, Rev. 3	zz.	Deleted		

24. Drawing 205-039, sheet MS-01, Revision 7.

25. Drawing 205-039, sheet MS-02, Revision 7.

26. Drawing 205-039, sheet MS-03, Revision 4.

27. Drawing 205-039, sheet MS-04, Revision 4.

28. Drawing 205-039, sheet MS-05, Revision 6.

29. Drawing 205-039, sheet MS-06, Revision 5.

30. Drawing 308-129, Revision 10.

31. Drawing 308-130, Revision 11.

32. Drawing 308-603 sheet 2, Revision 1.

33. Vendor Drawing 3801-3008, sheet 3, Revision 5.

34. Vendor Drawing 3801-3008, sheet 4, Revision 6.

35. FPC Instruction Manual No. 586, Revision 6, titled, " Remote Shutdown Relay and Auxiliary Cabinets ".

36. FPC Instruction Manual No. 1172, Volume 1, Revision 3, titled, " Emergency Feedwater Initiation and Control System ".

37. FPC Instruction Manual No. 1283, Revision 3, titled, " EFIC Auxiliary Cabinets ".

38. FPC instruction Manual No. 1300, Revision 0, titled, " EFIC Panel Assembly ".

39. ISA-S67.04, Part 1, titled " Setpoint For Nuclear Safety Related Instrumentation", Approved September, 1994.

40. FPC Instruction Manual No. 1896, Revision 1, titled, " Rosemount Instruction Manual Model 1154 Series H Alphaline Pressure Transmitters for Nuclear Services ".

41. FPC Calculation I95-0005, Revision 0, titled "Measurement and Test Equipment Accuracy Calculation".

42. Letter LFM90-0006, dated 1/29/90 - "Licensing Interpretation Seismic and LOCA".

43. Letter SNES94-0276, dated 9/12/94 - "Response to NEA94-0694 on RPS Instruments".

44. Surveillance Procedure SP-146A, Revision 8, dated 12/14/94, titled, " EFIC Monthly Functional Test (Modes 1, 2 and 3) ".

45. Surveillance Procedure SP-193A, Revision 2, dated 04/14/94, titled "EFIC Transmitter Calibration during Modes 4 through 6 ".

46. Surveillance Procedure SP-416, Revision 27, dated 05/16/94, titled, "Emergency Feedwater Automatic Actuation ".

47. Reg. Guide 1.105, Revision 2 , titled, " Instrument Setpoints for Safety-Related Systems ".

48. Operating Procedure OP-103A, Revision 1, dated 05/20/88, titled, " Operating Curves ".

49. Surveillance Procedure SP-650, Revision 26, dated 04/14/95, titled, "ASME Code Safety Valve Test ".

50. FPC design modification MAR 77-04-14, dated 10/05/77, titled, " Ac . circuit to provide operation of ADV's whenever steam pressure exceeds 1025 psig ".

51. Deleted

52. Babcock and Wilcox Engineering Information Record (EIR) Document Identifier 51-1223786-01, titled, "FOGG Verification Study".

53. Babcock and Wilcox Engineering Information Record (EIR) Document Identifier 51-1138803-00, dated 11/23/82, titled, " EFIC Shutdown Bypass - Operator Action".

54. FAX Transmission to J. B. FitzGerald of Vitro Corp. from R. Iwachow of FPC dated 03/02/95 regarding error accuracy of the analog isolation input and output modules.

55. FAX Transmission to R. Iwachow of FPC from J. B. FitzGerald of Vitro Corp. dated 03/07/95 regarding the isolated analog circuity accuracy.

56. ISA-RP67.04, Part II, Methodologies for the determination of setpoints for the Nuclear Safety-Related Instrumentation", Approved September,1994.

57. FPC Instruction Manual No. 1524, Revision 4, titled, " Foxboro Electronic Indicating Recorder ".

58. Design Basis Document (DBD) for Remote Shutdown System (Section 5/Tab 9), Revision 1.

59. Enhanced Design Basis Document (EDBD) for the Class 1E AC Systems (Section 4/Tab 1) , Revision 2.

60. Design Basis Document for Meteorological Measurement System (Section 5/Tab 6), Revision 1.

61. Rosemount FAX Transmission to R. Iwachow of FPC from Jane Sandstrom of Rosemount Nuclear Instruments, Inc. regarding latest product data sheet PDS 4631, Revision Date 8/93 for Model 1154 Series H transmitter.

62. Steam Line Failure Accident Analysis Rasis Document for Florida Power Corporation Crystal River Unit 3, Revision 1, dated 12/20/89.

63. Drawing 206-041, Revision 15.

64. Drawing 210-769, Revision 9.

65. Drawing 210-771, Revision 6.

66. Drawing 210-772, Revision 6.

67. Drawing 210-773, Revision 8.

68. a) Drawing 1184731D, sheet 1, Revision A.
    b) Drawing 1184731D, sheet 3A, Revision B.
    c) Drawing 1184731D, sheet 3B, Revision B.
    d) Drawing 1184731D, sheet 3C, Revision B.
    e) Drawing 1184731D, sheet 3D, Revision B.
    f) Drawing 1184731D, sheet 9, Revision A.
    g) Drawing 1184731D, sheet 14A, Revision A.
    h) Drawing 1184731D, sheet 14B, Revision A.

69. Rosemount Report 78212, Revision A, titled "Internal Thermal Response of Transmitter Housing to Steam Impingement of Rosemount Models 1153 Series B and D".

70. ASME Steam Tables, Fourth Edition, Copyright 1979.

71. Drawing 210-814, Revision 8.

72. Rosemount Report 108220A, Revision A, titled "Analysis of the Model 1153 Series D Transmitter to 420°F for Three Minutes".

V. DETAILED CALCULATIONS

This calculation will evaluate the instrument loop accuracies associated with the main steam pressure transmitters (MS-106-PT through MS-113-PT) during Normal and Accident (HELB) conditions.

COMPONENT ERRORS:

Process Error:

Per Design Input (DI) #2, the majority of the sensing lines associated with MS-106-PT and MS-113-PT are routed within EQ Zone 16, which has the following temperature ranges:

Temperature - Normal:	80° to 135°F.
Temperature - LOCA:	The same as normal.
Temperature - HELB:	149° to 417°F.

Sealed Reference Leg.

Per Design Input (DI #7.7), there is a need to examine the effects due to a sealed reference chamber not at existing atmospheric conditions.

The main steam pressure transmitters are calibrate on site utilizing a gauge pressure test instrument. The measurable atmospheric conditions at Crystal River Unit 3 are between 28 to 32 inches of mercury (13.75 psi to 15.77 psi) according to Reference 60. Since the transmitters are calibrated on-site and the atmospheric conditions vary between 28 to 32 inches of mercury (13.75 psi to 15.77 psi), then the maximum error due atmospheric pressure fluctuation at CR-3 resulting in transmitter inaccuracy reading is:

$$(32 - 28)(0.4912 \text{ psi/in Hg})/1200 = 1.64 \times 10^{-3} = 0.164\% \text{ error}$$

This variation in atmospheric condition causes a 0.00164 error in m... ...ent which has an insignificant affect when compared to the magnitude of the err... ...d by tranmitter reference error inaccuracy of ± 0.25%. Therefore, process measuremen... due to the sealed reference leg will be considered as negligible and have no effect on the loop string error.

Transmitter Scaling.

The eight main steam transmitter sensing line configurations have their process connection routed off the top of the main steam line header and connected to the transmitter below the steam line tap connection. This configuration allows the sensing line to be filled and prevents contact of live steam with the transmitter. This configuration can be viewed as a manometer where the reference datum is the center line of the transmitter and the column of water above the datum will represent the applied static pressure.

The water in the sensing line of the pressure transmitter is at the same temperature as the intermediate building. Per the EQ Zone Sheet 16, the area can vary from 80°F to 135°F, but a good portion of the time (32.2%) the area experiences temperature conditions of 120°F to 124°F, therefore 124°F will be used as the normal sensing line temperature. The normal operating pressure of the main steam line is 900 psig.

The change in elevation between the tap connection on the main steam line and the reference datum is 20 inches (or 1.67 feet) which is typical for all of the transmitter locations.

With the interpolation of the data from Table 3 of the ASME Steam Tables (Reference 70), the specific volume of water at 124°F and 914.7 psia (900 pisg) is:

$$130°F = 0.01620\ ft^3/lb_m$$
$$124°F = x$$
$$120°F = 0.01616\ ft^3/lb_m$$

$$4°F/10°F = x/0.00004\ ft^3/lb_m$$
$$x = 1.6 \times 10^{-5}\ ft^3/lb_m$$

At 124°F the specific volume is 0.01616 + 0.000016 = 0.01618 ft^3/lb_m.
Thus, the weight density is 61.805 lb_m/ft^3 (1/ 0.01618 ft^3/lb_m) and then the following correction is necessary for calibration of the transmitters:

$$(61.805\ lb_m/ft^3)\ (1ft^2/144\ in^2) = 0.429\ lb_m/in^2\text{-}ft$$

$$(0.429\ lb_m/in^2\text{-}ft)(1.67\ ft) = 0.716\ psig$$

This scaling correction adjustment to the transmitter is outside the calibration limitations of the Druck which has an ability to accurately calibrate within the tolerance of ± 3.87 psig (Reference 41). Therefore, process measurement due to transmitter scaling will be considered as negligible and have no effect on the loop string error.

So then, **TRANSMITTER SCALING = 0 psig (0.00 %) to 1200 psig (100%).**

Sensing Line.

The HELB temperature in the intermediate building peaks at 417°F where this temperature value will be used to determine the maximum error due to density changes in the sense line. The hotter, less dense post-accident

condition in the transmitter sensing lines will lower the indicated pressure. Per Table 3 of the ASME Steam Tables (Reference 70), the specific volume of water at 417°F and 914.7 psia (900 psig) must be interpolated between 0.01886 ft^3/lb_m (at 420°F and 900 psia) and 0.01871 ft^3/lb_m (410°F and 900 psia). Therefore, the weight density is between 53.02 lb_m/ft^3 and 53.45 lb_m/ft^3. For conservatism, a weight density of 53.02 lb_m/ft^3 will be selected for this calculation.

The change in pressure for the sensing lines of the pressure transmitter is related to the change in sense line density as follows:

$$A_{SENSE\text{-}LINE} = \{[(d_{T2} - d_{T1}) / (144\ in^2 / 1\ ft^2)] \times (L/Span)\} \times 100\%$$
$$= \{[(53.02 - 61.805)/144] \times (1.67/1200)\} \times 100\%$$
$$= \{[-8.785/144] \times [1.392 \times 10^{-3}]\} \times 100\ \%$$
$$= \{[-0.061][1.392 \times 10^{-3}]\} \times 100\%$$
$$= -0.00849\%\ span$$

As determined, the contribution due to sensing line errors is quite small in comparison to the transmitter reference accuracy error of 0.25% span. Therefore, process measurement errors due to sensing line density changes will be assumed as negligible and have no affect on the loop string accuracy.

So then, $A_{SENSE\text{-}LINE} = 0.00\%$.

<u>Device PT</u>: Rosemount 1154SH9RA pressure transmitter. DI7

Span = 1200 psig

URL = 3000 psig (Upper Range Limit)

<u>Normal Conditions</u> (E_{PTN}) DI41a

E_{REF} = Reference Accuracy = ± 0.25%

E_T = Temperature Effect = ± (0.15% URL + 0.35% span)/50°F A2
= ± [(.15 x 3000 + .35 x 1200)/1200] x (130° - 80°)/50°
= ± [(450 + 420)/1200] x 1.00
= ± (0.725) x (1.00)
= ± 0.725% span

E_{OP} = Overpressure Effects = ± 0.0% DI7.2

E_{PSE} = Power Supply Effect = ± 0.005% span/volt DI12
= ± [0.005% span/volt x (0.0106 volts)]
= ± 0.000053% span
This effect will be ignored because it is negligible compared to the other effects.

$E_{P/T}$ = Steam Pressure/Temperature Effect = ± 0.0% DI7.6

E_S = Seismic Effect = ± 0.0% DI7.3

E_{RAD} = Radiation Effect = ± 0.0% DI7.4

E_{PTN} = $\pm [(E_{REF})^2 + (E_T)^2]^{1/2}$
= $\pm [(0.25)^2 + (0.725)^2]^{1/2}$
= $\pm [(0.0625) + (0.5256)]^{1/2}$
= $\pm [0.5881]^{1/2}$
= ± 0.767% span

Normal Condition ($E_{PTN-ACT}$) - Low Pressure Initiate/Differential Pressure — DI41b.

E_{REF} = Reference Accuracy = ± 0.25%

E_T = Temperature Effect = ± (0.75% URL + 0.5% span)/100°F — A2
= ± [(.75 x 3000 + .5 x 1200)/1200] x (158° - 80°)/100°
= ± [(2250 + 600)/1200] x 0.78
= ± (2.375) x (0.78)
= ± 1.853% span

E_{OP} = Overpressure Effect = ± 0.0% — DI7.2

E_{PSE} = Power Supply Effect = ± 0.005% span/volt — DI12
= ± [0.005% span/volt x (0.0106 volts)]
= ± 0.000053% span
This effect will be ignored because it is negligible compared to the other effects.

$E_{P/T}$ = Steam Pressure/Temperature Effect = ± 0.0% — DI7.6

E_S = Seismic Effect = ± 0.0% — DI7.3

E_{RAD} = Radiation Effect = ± 0.00% — DI7.4

$E_{PTN-ACT}$ = $\pm [(E_{REF})^2 + (E_T)^2]^{1/2}$
= $\pm [(0.25)^2 + (1.853)^2]^{1/2}$
= $\pm [(0.0625) + (3.4336)]^{1/2}$
= $\pm [3.4961]^{1/2}$
= ± 1.870 % span

Accident Condition ($E_{P/A-HELB}$) — DI41c.

E_{REF} = Reference Accuracy = ± 0.25%

E_T = Temperature Effects = ± 0.0% — DI7.5

E_{OP} = Overpressure Effect = ± 0.0% — DI7.2

E_{PSE} = Power Supply Effect = ± 0.005% span/volt — DI12
= ± [0.005 span/volt x (0.0106 volts)]
= ± 0.000053% span
This effect will be ignored because it is negligible compared to the other effects.

$E_{P/T}$ = Steam Pressure/Temperature Effect = ± (2.0% URL + 0.5% span)
= ± [(2.0 x 3000 psig) + (0.5 X 1200)]/ 1200 psig
= ± [(6000 + 600)]/1200
= ± [6600]/1200
= ± 5.5% span

E_S = Seismic Effect = ± 0.0% DI7.3

E_{RAD} = Radiation Effect = ± [0.2% URL + 0.2% Span] DI7.1
= ± [(0.2 x 3000) + (0.2 x 1200)] / 1200
= ± [(600 + 240)/1200]
= ± 0.700% span

$E_{PTA\text{-}HELB}$ = $\pm [(E_{REF})^2 + (E_{P/T})^2 + (E_{RAD})^2]^{1/2}$
= $\pm [(0.25)^2 + (5.5)^2 + (0.70)^2]^{1/2}$
= $\pm [(0.0625) + (30.25) + (0.490)]^{1/2}$
= $\pm [30.8025]^{1/2}$
= ± 5.550% span

Device COMP1: VITRO COMPENSATION MODULE - Main Control Room Indication [PI1], Remote Shutdown Indication [PI2], Control Module, Pressure Initiate Bistable and Pressure Permissive Bistable and Recording - (E_{COMP1}) DI11

$E_{IB/S}$ = Input Buffer/Scalar Inaccuracy = ± 0.25% span

$E_{OB/S}$ = Output Buffer/Scalar Inaccuracy = ± 0.25% span

E_{COMP1} = $\pm [(E_{IB/S})^2 + (E_{OB/S})^2]^{1/2}$
= $\pm [(0.25)^2 + (0.25)^2]^{1/2}$
= $\pm [(0.0625) + (0.0625)]^{1/2}$
= $\pm [0.125]^{1/2}$
= ± 0.354% span

Device COMP2: VITRO COMPENSATION MODULE - Pressure Difference Bistable - (E_{COMP2}) DI11

$E_{IB/S}$ = Input Buffer/Scalar Inaccuracy = ± 0.25% span

E_{SUM} = Summer Inaccuracy = ± 0.25% span

$E_{OB/S}$ = Output Buffer/Scalar Inaccuracy = ± 0.25% span

E_{COMP2} = $\pm[(\text{Error from Comp Mod.})^2 + (\text{Error input from PT})^2 + (\text{Error Output to dP Bistable})^2]^{1/2}$
= $\pm \{ (E_{COMP1})^2 + [(E_{IB/S})^2 + (E_{OB/S})^2] + (E_{SUM})^2 \}^{1/2}$
= $\pm [(0.354)^2 + (0.25)^2 + (0.25)^2 + (0.25)^2]^{1/2}$
= $\pm [(0.1253) + (0.0625) + (0.0625) + (0.0625)]^{1/2}$
= $\pm [0.3128]^{1/2}$
= ± 0.559 % span

Device BPS: VITRO BISTABLE MODULE - Pressure Initiate, Pressure Permissive and Pressure Difference - (E_{BPS}) DI11

E_{BPS} = Reference Accuracy = ± 0.20% span

Device AII/AIO: VITRO ANALOG ISOLATION INPUT /ANALOG ISOLATION OUTPUT MODULE-($E_{AII/AIO}$) DI11

$E_{AII/AIO}$ = Reference Accuracy = ± 0.50% span

Device PI1: INTERNATIONAL INSTRUMENTS 1251 INDICATOR (E_{PI1}) DI14

E_{PI1} = $\pm [(\text{Specified Accuracy})^2 + (\text{Repeatability})^2]^{1/2}$ A6
= $\pm [(1.5)^2 + (2.0)^2]^{1/2}$
= $\pm [(2.25) + (4.0)]^{1/2}$
= $\pm [6.25]^{1/2}$
= ± 2.5% span.

E_{SC} = Scale Error = ± ½ minor scale division
= ± [(0.5 x 20 psig)/1200 psig] x 100%
= ± 0.833% span

E_{PI1} = $\pm [(E_{REF})^2 + (E_{SC})^2]^{1/2}$
= $\pm [(2.5)^2 + (0.833)^2]^{1/2}$
= $\pm [(6.25) + (0.6939)]^{1/2}$
= $\pm [6.9439]^{1/2}$
= ± 2.635% span

Device PI2: INTERNATIONAL INSTRUMENTS 1251 INDICATOR - (E_{PI2}) DI9

E_{PI2} = $\pm [(\text{Specified Accuracy})^2 + (\text{Repeatability})^2]^{1/2}$ A6
= $\pm [(1.5)^2 + (2.0)^2]^{1/2}$
= $\pm [(2.25) + (4.0)]^{1/2}$
= $\pm [6.25]^{1/2}$
= ± 2.5% span.

E_{SC} = Scale Error = ± ½ minor scale division
= ± [(0.5 x 20 psig)/1200 psig] x 100%
= ± [10/1200] x 100%
= ± 0.833% span

E_{PI2} = $\pm [(E_{REF})^2 + (E_{SC})^2]^{1/2}$
= $\pm [(2.5)^2 + (0.833)^2]^{1/2}$
= $\pm [(6.25) + (0.6939)]^{1/2}$
= $\pm [6.9439]^{1/2}$
= ± 2.635% span

Device PC: VITRO CONTROL MODULE Part No. - Pressure control portion of module - (E_{PC}) DI11

E_{SUB} = Subtractor Inaccuracy = ± 0.25% span

E_{PROINT} = Proportional Plus Integral = ± 0.25% span

$E_{SETPOINT}$ = Setpoint Inaccuracy = ± 0.10% span

$$E_{PC} = \pm [(E_{SUB})^2 + (E_{PROINT})^2 + (E_{SETPOINT})^2]^{1/2}$$
$$= \pm [(0.25)^2 + (0.25)^2 + (0.10)^2]^{1/2}$$
$$= \pm [(0.0625) + (0.0625) + (0.01)]^{1/2}$$
$$= \pm [0.135]^{1/2}$$
$$= \pm 0.367\% \text{ span}$$

Device PIR: FOXBORO N227P-2R6-CS-N/SRC recorder - (E_{PIRR} & E_{PIRI})

Recording (E_{PIRR}) DI15

E_{REFR} = Recording Reference Accuracy = ± 0.75% span

E_T = Temperature Effect = ± 0.5% span/50°F A1
= ± (0.5/50°F) x 10°F
= ± 0.10% span

E_H = Humidity Influence = ± 0.0% span A5

E_{SCR} = Recording Scale Error = ± ½ minor scale division
= ± [(0.5 x 20 psig)/1200 psig] x 100%
= ± 0.833% span

E_{PSE} = Power Supply Effect = ± 0.1% span DI16
= ± [0.1% Span/5% x (1.7% Span)]
= ± [0.02% x 1.7%]
= ± 0.034% span

$$E_{PIRR} = \pm [(E_{REFR})^2 + (E_T)^2 + (E_{SC})^2 + (E_{PSE})^2]^{1/2}$$
$$= \pm [(0.75)^2 + (0.10)^2 + (0.833)^2 + (0.034)^2]^{1/2}$$
$$= \pm [(0.5625) + (0.01) + (0.6939) + (0.0012)]^{1/2}$$
$$= \pm [1.2676]^{1/2}$$
$$= \pm 1.13\% \text{ span}$$

Indicating (E_{PIRI}) DI15

E_{REFI} = Indicating Reference Accuracy = ± 0.5% span

E_T = Temperature Effect = ± 0.5% span/50°F A1
= ± (0.5/50°F) x 10°F
= ± 0.10% span

E_H = Humidity Influence = ± 0.0% span — A5

E_{SCR} = Recording Scale Error = ± ½ minor scale division
= ± [(0.5 x 50 psig)/1200 psig] x 100%
= ± 2.083% span

E_{PSE} = Power Supply Effect = ± 0.1% span — DI16
= ± [0.1% Span /5% x (1:7% Span)]
= ± [0.02% x 1.7%]
= ± 0.034% span

E_{PIRI} = $\pm [(E_{REFI})^2 + (E_T)^2 + (E_{SC})^2 + (E_{PSE})^2]^{1/2}$
= $\pm [(0.5)^2 + (0.10)^2 + (2.083)^2 + (0.034)^2]^{1/2}$
= $\pm [(0.25) + (0.01) + (4.3389) + (0.0012)]^{1/2}$
= $\pm [4.6001]^{1/2}$
= **± 2.14% span**

Device RECALL/SPDS:

$E_{RC\text{-}PRESS}$ = Recall Reference Accuracy = ± 0.366% FSR — DI33
= ± (0.366%) x (20 VDC/10VDC)
= **± 0.732% of span**

Insulation Resistance (IR) Errors:

A_{IR} = Insulation Resistance (IR) Effect
A_{IR} = IR Positive Bias = + [29.5/ (10 + 0.016R_P)] x 100 — DI20
= IR Negative Bias = - [12.5/ (10 + 0.016R_P)] x 100
R_P = Is the total parallel leakage path (in ohms)
$1/R_P$ = $1/R_{CONN} + 1/R_S + 1/R_{CE}$
R_{CONN} = Is the insulation resistance for the Rosemount connector at the transmitter
R_S = Is the insulation resistance of the splice at the connector seal
R_{CE} = Is the cable IR as determined by the equation:
= $(R_C \times L_{SPL}) / L_{CKT}$ — DI21

R_C = Is the cable test specimen IR (ohms)
L_{SPL} = Is the cable test specimen length (feet)

L_{CKT} = Is the total length of cable in the IB harsh environment (feet).

MS-106-PT IR Error:

L_{CKT} for MSS43 is 282 feet. — DI19.1

R_{CE} = $(2.9 \times 10^6$ ohms x 20 feet)/282 feet
= 2.06×10^5 ohms — DI21

R_S = 1.8×10^7 ohms — DI22

R_{SEAL} = 5×10^5 ohms DI23

$1/R_p$ = $[(1/2.06 \times 10^5) + (1/1.8 \times 10^7) + (1/5 \times 10^5)]$
= $[4.854 \times 10^{-6} + 5.555 \times 10^{-8} + 2.00 \times 10^{-6}]$
= 6.909×10^{-6}

R_p = $(1/ 6.909 \times 10^{-6})$
= 1.447×10^5 ohms

A_{IR} = $+ [29.5/(10 + (0.016 \times 1.447 \times 10^5))] \times 100$
= $+ [29.5/(2325.2)] \times 100$
= **+ 1.269% span**
= $- [12.5/ (10 + (0.016 \times 1.447 \times 10^5)] \times 100$
= $- [12.5/2325.2] \times 100$
= **- 0.538% span**

<u>MS-107-PT IR Error</u>:

L_{CKT} for MSS45 is 317 feet. DI19.2

R_{CE} = $(2.9 \times 10^6$ ohms x 20 feet)/317 feet DI21
= 1.829×10^5 ohms

R_S = 1.8×10^7 ohms DI22

R_{SEAL} = 5×10^5 ohms DI23

$1/R_p$ = $[(1/1.829 \times 10^5) + (1/1.8 \times 10^7) + (1/5 \times 10^5)]$
= $[5.467 \times 10^{-6} + 5.555 \times 10^{-8} + 2.00 \times 10^{-6}]$
= 7.523×10^{-6}

R_p = $(1/7.523 \times 10^{-6})$
= 1.329×10^5 ohms

A_{IR} = $+ [29.5/(10 + (0.016 \times 1.329 \times 10^5))] \times 100$
= $+ [29.5/(2136.4)] \times 100$
= **+ 1.381% span**
= $- [12.5/ (10 + (0.016 \times 1.329 \times 10^5)] \times 100$
= $- [12.5/2136.4] \times 100$
= **- 0.585% span**

<u>MS-108-PT IR Error</u>:

L_{CKT} for MSS47 is 351 feet. DI19.3

R_{CE} = $(2.9 \times 10^6$ ohms x 20 feet)/351 feet DI21
= 1.652×10^5 ohms

R_S = 1.8×10^7 ohms DI22

R_{SEAL} = 5×10^5 ohms DI23

$1/R_p$ = $[(1/1.652 \times 10^5) + (1/1.8 \times 10^7) + (1/5 \times 10^5)]$
= $[6.053 \times 10^{-6} + 5.555 \times 10^{-8} + 2.00 \times 10^{-6}]$
= 8.109×10^{-6}

R_p = $(1/8.109 \times 10^{-6})$
= 1.233×10^5 ohms

A_{IR} = $+ [29.5/(10 + (0.016 \times 1.233 \times 10^5))] \times 100$
= $+ [29.5/(1982.8)] \times 100$
= **+ 1.488% span**
= $- [12.5/ (10 + (0.016 \times 1.233 \times 10^5)] \times 100$
= $- [12.5/1982.8] \times 100$
= **- 0.630% span**

MS-109-PT IR Error:

L_{CKT} for MSS49 is 324 feet. DI19.4

R_{CE} = $(2.9 \times 10^6$ ohms $\times$ 20 feet)/324 feet
= 1.790×10^5 ohms DI21

R_S = 1.8×10^7 ohms DI22

R_{SEAL} = 5×10^5 ohms DI23

$1/R_p$ = $[(1/1.790 \times 10^5) + (1/1.8 \times 10^7) + (1/5 \times 10^5)]$
= $[5.586 \times 10^{-6} + 5.555 \times 10^{-8} + 2.00 \times 10^{-6}]$
= 7.641×10^{-6}

R_p = $(1/7.641 \times 10^{-6})$
= 1.309×10^5 ohms

A_{IR} = $+ [29.5/(10 + (0.016 \times 1.309 \times 10^5))] \times 100$
= $+ [29.5/(2104.4)] \times 100$
= **+ 1.402% span**
= $- [12.5/ (10 + (0.016 \times 1.309 \times 10^5)] \times 100$
= $- [12.5/2104.4] \times 100$
= **- 0.594% span**

MS-110-PT IR Error:

L_{CKT} for MSS42 is 435 feet. DI19.5

R_{CE} = $(2.9 \times 10^6$ ohms $\times$ 20 feet)/435 feet
= 1.333×10^5 ohms DI21

R_S = 1.8×10^7 ohms DI22

R_{SEAL} = 5×10^5 ohms DI23

$1/R_P$ = $[(1/1.333 \times 10^5) + (1/1.8 \times 10^7) + (1/5 \times 10^5)]$
= $[7.502 \times 10^{-6} + 5.555 \times 10^{-8} + 2.00 \times 10^{-6}]$
= 9.558×10^{-6}

R_P = $(1/9.558 \times 10^{-6})$
= 1.046×10^5 ohms

A_{IR} = $+ [29.5/(10 + (0.016 \times 1.046 \times 10^5))] \times 100$
= $+ [29.5/(1683.6)] \times 100$
= **+ 1.752% span**
= $- [12.5/ (10 + (0.016 \times 1.046 \times 10^5)] \times 100$
= $- [12.5/1683.6] \times 100$
= **− 0.742% span**

MS-111-PT IR Error:

L_{CKT} for MSS44 is 393 feet. DI19.6

R_{CE} = $(2.9 \times 10^6$ ohms $\times$ 20 feet)/393 feet
= 1.476×10^5 ohms DI21

R_S = 1.8×10^7 ohms DI22

R_{SEAL} = 5×10^5 ohms DI23

$1/R_P$ = $[(1/1.476 \times 10^5) + (1/1.8 \times 10^7) + (1/5 \times 10^5)]$
= $[6.775 \times 10^{-6} \div 5.555 \times 10^{-8} + 2.00 \times 10^{-6}]$
= 8.831×10^{-6}

R_P = $(1/8.831 \times 10^{-6})$
= 1.132×10^5 ohms

A_{IR} = $+ [29.5/(10 + (0.016 \times 1.132 \times 10^5))] \times 100$
= $+ [29.5/(1812.2)] \times 100$
= **+ 1.619% span**
= $- [12.5/ (10 + (0.016 \times 1.132 \times 10^5)] \times 100$
= $- [12.5/1821.2] \times 100$
= **− 0.686% span**

MS-112-PT IR Error:

L_{CKT} for MSS46 is 386 feet. DI19.7

R_{CE} = $(2.9 \times 10^6$ ohms $\times$ 20 feet)/386 feet
= 1.503×10^5 ohms DI21

R_S = 1.8×10^7 ohms DI22

R_{SEAL} = 5×10^5 ohms DI23

$1/R_P$ = $[(1/1.503 \times 10^5) + (1/1.8 \times 10^7) + (1/5 \times 10^5)]$
= $[6.653 \times 10^{-6} + 5.555 \times 10^{-8} + 2.00 \times 10^{-6}]$
= 8.708×10^{-6}

R_P = $(1/8.708 \times 10^{-6})$
= 1.148×10^5 ohms

A_{IR} = $+ [29.5/(10 + (0.016 \times 1.148 \times 10^5))] \times 100$
= $+ [29.5/(1846.8)] \times 100$
= **+ 1.597% span**
= $- [12.5/ (10 + (0.016 \times 1.148 \times 10^5)] \times 100$
= $- [12.5/1846.8] \times 100$
= **− 0.677% span**

MS-113-PT IR Error:

L_{CKT} for MSS48 is 394 feet. DI19.8

R_{CE} = $(2.9 \times 10^6$ ohms $\times$ 20 feet)/394 feet
= 1.472×10^5 ohms DI21

R_S = 1.8×10^7 ohms DI22

R_{SEAL} = 5×10^5 ohms DI23

$1/R_P$ = $[(1/1.472 \times 10^5) + (1/1.8 \times 10^7) + (1/5 \times 10^5)]$
= $[6.793 \times 10^{-6} + 5.555 \times 10^{-8} + 2.00 \times 10^{-6}]$
= 8.849×10^{-6}

R_P = $(1/8.849 \times 10^{-6})$
= 1.13×10^5 ohms

A_{IR} = $+ [29.5/(10 + (0.016 \times 1.13 \times 10^5))] \times 100$
= $+ [29.5/(1818.2)] \times 100$
= **+ 1.622% span**
= $- [12.5/ (10 + (0.016 \times 1.13 \times 10^5)] \times 100$
= $- [12.5/1818.2] \times 100$
= **− 0.687% span**

LOOP ERRORS:

Remote Shutdown Indication (E_{RSI}) DI24

E_{RSI} = $\pm [(E_{PTN})^2 + (E_{COMP1})^2 + (E_{PI2})^2]^{1/2}$
= $\pm [(0.767)^2 + (0.354)^2 + (2.635)^2]^{1/2}$
= $\pm [(0.5883) + (0.1253) + (6.9432)]^{1/2}$
= $\pm [7.6568]^{1/2}$
= $\pm$ 2.77% span = $\pm$ (2.77% $\times$ 1200 psig)
= **$\pm$ 33.24 psig**

Control Room Indication (Normal - E_{PIN}; Accident - E_{PIA}).

E_{PIN} = $\pm [(E_{PTN})^2 + (E_{COMP1})^2 + (E_{PI1})^2]^{1/2}$
= $\pm [(0.767)^2 + (0.354)^2 + (2.635)^2]^{1/2}$
= $\pm [(0.5883) + (0.1253) + (6.9432)]^{1/2}$
= $\pm [7.6568]^{1/2}$
= $\pm$ 2.77% span = $\pm$ (2.77% x 1200 psig)
= **$\pm$ 33.24 psig**

MS-106-PT/PI1

$E_{PIA-HELB}$ = + $[(E_{PTA-HELB})^2 + (E_{COMP1})^2 + (E_{PI1})^2]^{1/2} + A_{IR}$ DI35
= + $[(5.550)^2 + (0.354)^2 + (2.635)^2]^{1/2}$ + 1.269
= + $[(30.8025) + (0.1253) + (6.9432)]^{1/2}$ + 1.269
= + $[37.871]^{1/2}$ + 1.269
= + 6.154 + 1.269
= + 7.423% span = + (7.423% x 1200 psig)
= **+ 89.08 psig**

= - $[(E_{PTA-HELB})^2 + (E_{COMP1})^2 + (E_{PI1})^2]^{1/2} - A_{IR} - A_{SENSE-LINE}$ DI35
= - $[(5.550)^2 + (0.354)^2 + (2.635)^2]^{1/2}$ - 0.538 - 0.00
= - $[(30.8025) + (0.1253) + (6.9432)]^{1/2}$ - 0.538
= - $[37.871]^{1/2}$ - 0.538
= - 6.154 - 0.538
= - 6.692% span = - (6.692% x 1200 psig)
= **- 80.30 psig**

MS-107-PT/PI1

$E_{PIA-HELB}$ = + $[(E_{PTA-HELB})^2 + (E_{COMP1})^2 + (E_{PI1})^2]^{1/2} + A_{IR}$ DI35
= + $[(5.550)^2 + (0.354)^2 + (2.635)^2]^{1/2}$ + 1.381
= + $[(30.8025) + (0.1253) + (6.9432)]^{1/2}$ + 1.381
= + $[37.871]^{1/2}$ + 1.381
= + 6.154 + 1.381
= + 7.535% span = + (7.542% x 1200 psig)
= **+ 90.42 psig**

= - $[(E_{PTA-HELB})^2 + (E_{COMP1})^2 + (E_{PI1})^2]^{1/2} - A_{IR} - A_{SENSE-LINE}$ DI35
= - $[(5.550)^2 + (0.354)^2 + (2.635)^2]^{1/2}$ - 0.585 - 0.00
= - $[(30.8025) + (0.1253) + (6.9432)]^{1/2}$ - 0.585
= - $[37.871]^{1/2}$ - 0.585
= - 6.154 - 0.585
= - 6.739% span = - (6.739% x 1200 psig)
= **- 80.87 psig**

MS-110-PT/PI1

$E_{PIA\text{-}HELB} = + [(E_{PTA\text{-}HELB})^2 + (E_{COMP1})^2 + (E_{PI1})^2]^{1/2} + A_{IR}$ DI35

$= + [(5.550)^2 + (0.354)^2 + (2.635)^2]^{1/2} + 1.752$

$= + [(30.8025) + (0.1253) + (6.9432)]^{1/2} + 1.752$

$= + [37.871]^{1/2} + 1.752$

$= + 6.154 + 1.752$

$= + 7.906\%\text{ span} = + (7.906\% \times 1200\text{ psig})$

$= + 94.87\text{ psig}$

$= - [(E_{PTA\text{-}HELB})^2 + (E_{COMP1})^2 + (E_{PI1})^2]^{1/2} - A_{IR} - A_{SENSE\text{-}LINE}$ DI35

$= - [(5.550)^2 + (0.354)^2 + (2.635)^2]^{1/2} - 0.742 - 0.00$

$= - [(30.8025) + (0.1253) + (6.9432)]^{1/2} - 0.742$

$= - [37.871]^{1/2} - 0.742$

$= - 6.154 - 0.742$

$= - 6.896\%\text{ span} = - (6.896\% \times 1200\text{ psig})$

$= - 82.75\text{ psig}$

MS-111-PT/PI1

$E_{PIA\text{-}HELB} = + [(E_{PTA\text{-}HELB})^2 + (E_{COMP1})^2 + (E_{PI1})^2]^{1/2} + A_{IR}$ DI35

$= + [(5.550)^2 + (0.354)^2 + (2.635)^2]^{1/2} + 1.619$

$= + [(30.8025) + (0.1253) + (6.9432)]^{1/2} + 1.619$

$= + [37.871]^{1/2} + 1.619$

$= + 6.154 + 1.619$

$= + 7.773\%\text{ span} = + (7.773\% \times 1200\text{ psig})$

$= + 93.28\text{ psig}$

$= - [(E_{PTA\text{-}HELB})^2 + (E_{COMP2})^2 + (E_{PI2})^2]^{1/2} - A_{IR} - A_{SENSE\text{-}LINE}$ DI35

$= - [(5.550)^2 + (0.354)^2 + (2.635)^2]^{1/2} - 0.686 - 0.00$

$= - [(30.8025) + (0.1253) + (6.9432)]^{1/2} - 0.686$

$= - [37.871]^{1/2} - 0.686$

$= - 6.154 - 0.686$

$= - 6.84\%\text{ span} = - (6.84\% \times 1200\text{ psig})$

$= - 82.08\text{ psig}$

Control Room Recording (Normal - E_{PRRN}; Accident - E_{PRRA})

$E_{PRRN} = \pm [(E_{PTN})^2 + (E_{COMP1})^2 + (E_{PIRR})^2]^{1/2}$

$= \pm [(0.767)^2 + (0.354)^2 + (1.13)^2]^{1/2}$

$= \pm [(0.5883) + (0.1253) + (1.2769)]^{1/2}$

$= \pm [1.9905]^{1/2}$

$= \pm 1.41\%\text{ span} = \pm (1.41\% \times 1200\text{ psig})$

$= \pm 16.92\text{ psig}$

MS-106-PIR

$E_{PRRA\text{-}HELB} = + [(E_{PTA\text{-}HELB})^2 + (E_{COMP1})^2 + (E_{PIRR})^2]^{1/2} + A_{IR}$ DI35

$= + [(5.550)^2 + (0.354)^2 + (1.13)^2]^{1/2} + 1.269$

$= + [(30.8025) + (0.1253) + (1.2769)]^{1/2} + 1.269$

$= + [32.2047]^{1/2} + 1.269$
$= + 5.675 + 1.269$
$= + 6.944\%$ span $= + (6.944\% \times 1200$ psig$)$
$= + 83.33$ psig

$= - [(E_{PTA-HELB})^2 + (E_{COMP1})^2 + (E_{PIRR})^2]^{1/2} - A_{IR} - A_{SENSE-LINE}$ DI35
$= - [(5.550)^2 + (0.354)^2 + (1.13)^2]^{1/2} - 0.538 - 0.00$
$= - [(30.8025) + (0.1253) + (1.2769)]^{1/2} - 0.538$
$= - [32.2047]^{1/2} - 0.538$
$= - 5.675 - 0.538$
$= - 6.213\%$ span $= - (6.213\% \times 1200$ psig$)$
$= - 74.56$ psig

MS-107-PIR

$E_{PRRA-HELB} = + [(E_{PTA-HELB})^2 + (E_{COMP1})^2 + (E_{PIRR})^2]^{1/2} + A_{IR}$ DI35
$= + [(5.550)^2 + (0.354)^2 + (1.13)^2]^{1/2} + 1.381$
$= + [(30.8025) + (0.1253) + (1.2769)]^{1/2} + 1.381$
$= + [32.2047]^{1/2} + 1.381$
$= + 5.675 + 1.381$
$= + 7.056\%$ span $= + (7.056\% \times 1200$ psig$)$
$= + 84.67$ psig

$= - [(E_{PTA})^2 + (E_{COMP1})^2 + (E_{PIRR})^2]^{1/2} - A_{IR} - A_{SENSE-LINE}$ DI35
$= - [(5.550)^2 + (0.354)^2 + (1.13)^2]^{1/2} - 0.585 - 0.00$
$= - [(30.8025) + (0.1253) + (1.2769)]^{1/2} - 0.585$
$= - [32.2047]^{1/2} - 0.585$
$= - 5.675 - 0.585$
$= - 6.26\%$ span $= - (6.26\% \times 1200$ psig$)$
$= - 75.12$ psig

MS-110-PIR

$E_{PRRA-HELB} = + [(E_{PTA})^2 + (E_{COMP1})^2 + (E_{PIRR})^2]^{1/2} + A_{IR}$ DI35
$= + [(5.550)^2 + (0.354)^2 + (1.13)^2]^{1/2} + 1.752$
$= + [(30.8025) + (0.1253) + (1.2769)]^{1/2} + 1.752$
$= + [32.2047]^{1/2} + 1.752$
$= + 5.675 + 1.752$
$= + 7.427\%$ span $= + (7.427\% \times 1200$ psig$)$
$= + 89.12$ psig

$= - [(E_{PTA})^2 + (E_{COMP1})^2 + (E_{PIRR})^2]^{1/2} - A_{IR} - A_{SENSE-LINE}$ DI35
$= - [(5.550)^2 + (0.354)^2 + (1.13)^2]^{1/2} - 0.742 - 0.00$
$= - [(30.8025) + (0.1253) + (1.2769)]^{1/2} - 0.742$
$= - [32.2047]^{1/2} - 0.742$
$= - 5.675 - 0.742$
$= - 6.417\%$ span $= - (6.417\% \times 1200$ psig$)$
$= - 77.00$ psig

MS-111-PIR

$E_{PIRRA-HELB}$ = $+ [(E_{PTA-HELB})^2 + (E_{COMP1})^2 + (E_{PIRR})^2]^{1/2} + A_{IR}$ DI35
= $+ [(5.550)^2 + (0.354)^2 + (1.13)^2]^{1/2} + 1.619$
= $+ [(30.8025) + (0.1253) + (1.2769)]^{1/2} + 1.619$
= $+ [32.2047]^{1/2} + 1.619$
= $+ 5.675 + 1.619$
= $+ 7.294\%$ span = $+ (7.294\% \times 1200$ psig)
= **+ 87.53 psig**

= $- [(E_{PTA-HELB})^2 + (E_{COMP1})^2 + (E_{PIRR})^2]^{1/2} - A_{IR} - A_{SENSE-LINE}$ DI35
= $- [(5.550)^2 + (0.354)^2 + (1.13)^2]^{1/2} - 0.686 - 0.00$
= $- [(30.316) + (0.1253) + (1.2769)]^{1/2} - 0.686$
= $- [32.2047]^{1/2} - 0.686$
= $- 5.675 - 0.686$
= $- 6.361\%$ span = $- (6.361\% \times 1200$ psig)
= **- 76.33 psig**

Control Room Recorder Indication (Normal - E_{PIRN} ; Accident - E_{PIRA})

E_{PIRN} = $\pm [(E_{PTN})^2 + (E_{COMP1})^2 + (E_{PIRI})^2]^{1/2}$
= $\pm [(0.767)^2 + (0.354)^2 + (2.14)^2]^{1/2}$
= $\pm [(0.5883) + (0.1253) + (4.5796)]^{1/2}$
= $\pm [5.2932]^{1/2}$
= $\pm 2.30\%$ span = $\pm (2.30\% \times 1200$ psig)
= **± 27.60 psig**

MS-106-PT/PIRI

$E_{PIRA-HELB}$ = $+ [(E_{PTA-HELB})^2 + (E_{COMP1})^2 + (E_{PIRI})^2]^{1/2} + A_{IR}$ DI35
= $+ [(5.550)^2 + (0.354)^2 + (2.15)^2]^{1/2} + 1.269$
= $+ [(30.8025) + (0.1253) + (4.6225)]^{1/2} + 1.269$
= $+ [35.5503]^{1/2} + 1.269$
= $+ 5.962 + 1.269$
= $+ 7.231\%$ span = $+ (7.231\% \times 1200$ psig)
= **+ 86.77 psig**

= $- [(E_{PTA-HELB})^2 + (E_{COMP1})^2 + (E_{PIRI})^2]^{1/2} - A_{IR} - A_{SENSE-LINE}$ DI35
= $- [(5.550)^2 + (0.354)^2 + (2.15)^2]^{1/2} - 0.538 - 0.00$
= $- [(30.8025) + (0.1253) + (4.6225)]^{1/2} - 0.538$
= $- [35.5503]^{1/2}$
= $- 5.962 - 0.538$
= $- 6.500\%$ span = $- (6.50\% \times 1200$ psig)
= **- 78.00 psig**

MS-107-PT/PIRI

$E_{PIRA-HELB}$ = $+ [(E_{PTA-HELB})^2 + (E_{COMP1})^2 + (E_{PIRI})^2]^{1/2} + A_{IR}$ DI35
= $+ [(5.550)^2 + (0.354)^2 + (2.15)^2]^{1/2} + 1.381$
= $+ [(30.8025) + (0.1253) + (4.6225)]^{1/2} + 1.381$

$= + [35.5503]^{1/2} + 1.381$
$= + 5.962 + 1.381$
$= + 7.343\%$ span $= + (7.343\% \times 1200$ psig$)$
$=$ **+ 88.12 psig**

$= - [(E_{PTA-HELB})^2 + (E_{COMP1})^2 + (E_{PIRI})^2]^{1/2} - A_{IR} - A_{SENSE-LINE}$ DI35
$= - [(5.550)^2 + (0.354)^2 + (2.15)^2]^{1/2} - 0.585 - 0.00$
$= - [(30.8025) + (0.1253) + (4.6225)]^{1/2} - 0.585$
$= - [35.8025]^{1/2} - 0.585$
$= - 5.962 - 0.585$
$= - 6.547\%$ span $= - (6.547\% \times 1200$ psig$)$
$=$ **- 78.56 psig**

<u>MS-110-PT/PIRI</u>

$E_{PIRA-HELB} = + [(E_{PTA-HELB})^2 + (E_{COMP1})^2 + (E_{PIRI})^2]^{1/2} + A_{IR}$ DI35
$= + [(5.550)^2 + (0.354)^2 + (2.15)^2]^{1/2} + 1.752$
$= + [(30.8025) + (0.1253) + (4.6225)]^{1/2} + 1.752$
$= + [35.5503]^{1/2} + 1.752$
$= + 5.962 + 1.752$
$= + 7.714\%$ span $= + (7.714\% \times 1200$ psig$)$
$=$ **+ 92.57 psig**

$= - [(E_{PTA-HELB})^2 + (E_{COMP1})^2 + (E_{PIRI})^2]^{1/2} - A_{IR} - A_{SENSE-LINE}$ DI35
$= - [(5.550)^2 + (0.354)^2 + (3.57)^2]^{1/2} - 0.742 - 0.00$
$= - [(30.8025) + (0.1253) + (4.6225)]^{1/2} - 0.742$
$= - [35.5503]^{1/2} - 0.742$
$= - 5.962 - 0.742$
$= - 6.704\%$ span $= - (6.704\% \times 1200$ psig$)$
$=$ **- 80.45 psig**

<u>MS-111-PT/PIRI</u>

$E_{PIRA-HELB} = + [(E_{PTA-HELB})^2 + (E_{COMP1})^2 + (E_{PIRI})^2]^{1/2} + A_{IR}$ DI35
$= + [(5.550)^2 + (0.354)^2 + (2.15)^2]^{1/2} + 1.619$
$= + [(30.8025) + (0.1253) + (4.6225)]^{1/2} + 1.619$
$= + [35.5503]^{1/2} + 1.619$
$= + 5.962 + 1.619$
$= + 7.581\%$ span $= + (7.581\% \times 1200$ psig$)$
$=$ **+ 90.97 psig**

$= - [(E_{PTA-HELB})^2 + (E_{COMP1})^2 + (E_{PIRI})^2]^{1/2} - A_{IR} - A_{SENSE-LINE}$ DI35
$= - [(5.550)^2 + (0.354)^2 + (2.15)^2]^{1/2} - 0.686 - 0.00$
$= - [(30.8025 + (0.1253) + (4.6225)]^{1/2} - 0.686$
$= - [35.5503]^{1/2} - 0.686$
$= - 5.962 - 0.686$
$= - 6.648\%$ span $= - (6.648\% \times 1200$ psig$)$
$=$ **- 79.78 psig**

Pressure Signal for ADV Control ($E_{PRESS-ADV}$)

MSV-025 (MS-106-PT)

$$
\begin{aligned}
E_{PRESS-ADV} &= \pm [(E_{PTN})^2 + (E_{COMP1})^2]^{1/2} \\
&= \pm [(0.767)^2 + (0.354)^2]^{1/2} \\
&= \pm [(0.5883) + (0.1253)]^{1/2} \\
&= \pm [0.7136]^{1/2} \\
&= \pm 0.845\% \text{ span} = \pm (0.845\% \times 1200 \text{ psig}) = \pm 10.14 \text{ psig}
\end{aligned}
$$

MSV-026 (MS-111-PT)

$$
\begin{aligned}
E_{PRESS-ADV} &= \pm [(E_{PTN})^2 + (E_{COMP1})^2]^{1/2} \\
&= \pm [(0.767)^2 + (0.354)^2]^{1/2} \\
&= \pm [(0.5883) + (0.1253)]^{1/2} \\
&= \pm [0.7136]^{1/2} \\
&= \pm 0.845\% \text{ span} = \pm (0.845\% \times 1200 \text{ psig}) = \pm 10.14 \text{ psig}
\end{aligned}
$$

Atmospheric Dump Valve Control Loop (E_{ADV})

MSV-025 (MS-106-PT)

$$
\begin{aligned}
E_{ADV} &= \pm [(E_{PTN})^2 + (E_{COMP1})^2 + (E_{PC})^2]^{1/2} \\
&= \pm [(0.767)^2 + (0.354)^2 + (0.367)^2]^{1/2} \\
&= \pm [(0.5883) + (0.1253) + (0.13469)]^{1/2} \\
&= \pm [0.84829]^{1/2} \\
&= \pm 0.921\% \text{ span} = \pm (0.921\% \times 1200 \text{ psig}) \\
&= \pm 11.05 \text{ psig}
\end{aligned}
$$

MSV-026 (MS-111-PT)

$$
\begin{aligned}
E_{ADV} &= \pm [(E_{PTN})^2 + (E_{COMP1})^2 + (E_{PC})^2]^{1/2} \\
&= \pm [(0.767)^2 + (0.354)^2 + (0.367)^2]^{1/2} \\
&= \pm [(0.5883) + (0.1253) + (0.13469)]^{1/2} \\
&= \pm [0.84829]^{1/2} \\
&= \pm 0.921\% \text{ span} = \pm (0.921\% \times 1200 \text{ psig}) \\
&= \pm 11.05 \text{ psig}
\end{aligned}
$$

EFIC - Permissive Bypass Bistables (E_{BS})

$$
\begin{aligned}
E_{BS} &= \pm [(E_{PTN})^2 + (E_{COMP1})^2 + (E_{BPS})^2]^{1/2} \\
&= \pm [(0.767)^2 + (0.354)^2 + (0.20)^2]^{1/2} \\
&= \pm [(0.5883) + (0.1253) + (0.04)]^{1/2} \\
&= \pm [0.7536]^{1/2} \\
&= \pm 0.868\% \text{ span} = \pm (0.868\% \times 1200 \text{ psig}) = \pm 10.42 \text{ psig}
\end{aligned}
$$

EFIC - Low Pressure Bistables (E_{LPBS})

DI41b

$$
\begin{aligned}
E_{LPBS} &= \pm [(E_{PTN-ACT})^2 + (E_{COMP1})^2 + (E_{BPS})^2]^{1/2} \\
&= \pm [(1.87)^2 + (0.354)^2 + (0.20)^2]^{1/2} \\
&= \pm [(3.4969) + (0.1253) + (0.04)]^{1/2} \\
&= \pm [3.6622]^{1/2} \\
&= \pm 1.914\% \text{ span} = \pm (1.914\% \times 1200 \text{ psig}) = \pm 22.97 \text{ psig}
\end{aligned}
$$

EFIC - Differential Pressure Bistable (E_{DPBS})

$E_{DPBS} = \pm [\{2 \times (E_{PTN\text{-}ACT})^2\} + (E_{COMP2})^2 + (E_{BPS})^2]^{1/2}$
$= \pm [\{2 \times (1.87)^2\} + (0.559)^2 + (0.20)^2]^{1/2}$
$= \pm [(6.9938) + (0.3125) + (0.04)]^{1/2}$
$= \pm [7.3463]^{1/2}$
$= \pm$ 2.71% span = $\pm$ (2.71% x 1200 psig) = **± 32.52 psi**

Pressure Signals to RECALL ($E_{RC\text{-}NORMAL}$, $E_{RC\text{-}HELB}$)

$E_{RC\text{-}NORMAL} = \pm [(E_{PTN})^2 + (E_{COMP1})^2 + (E_{BPS})^2 + (E_{AII/AIO})^2 + (E_{RC\text{-}PRESS})^2]^{1/2}$ DI41b
$= \pm [(0.767)^2 + (0.354)^2 + (0.20)^2 + (0.50)^2 + (0.732)^2]^{1/2}$
$= \pm [(0.5883) + (0.1253) + (0.04) + (0.25) + (0.5358)]^{1/2}$
$= \pm [1.5394]^{1/2}$
$= \pm$ 1.241% span = $\pm$ (1.241% x 1200 psig) = **± 14.89 psig**

MS-106-PT

$E_{RC\text{-}HELB} = + [(E_{PTA\text{-}HELB})^2 + (E_{COMP1})^2 + (E_{BPS})^2 + (E_{AII/AIO})^2 + (E_{RC\text{-}PRESS})^2]^{1/2} + A_{IR}$ DI35
$= + [(5.550)^2 + (0.354)^2 + (0.02)^2 + (0.50)^2 + (0.732)^2]^{1/2} + 1.269$
$= + [(30.8025) + (0.1253) + (0.04) + (0.25) + (0.5358)]^{1/2} + 1.269$
$= + [31.7536]^{1/2} + 1.269$
$= + 5.635 + 1.269$
$= +$ 6.904% span = + (6.904% x 1200 psig) = **+ 82.85 psig**

$= - [(E_{PTA\text{-}HELB})^2 + (E_{COMP1})^2 + (E_{BPS})^2 + (E_{AII/AIO})^2 + (E_{RC\text{-}PRESS})^2]^{1/2} - A_{IR} - A_{SENSE\text{-}LINE}$ DI35
$= - [(5.550)^2 + (0.354)^2 + (0.02)^2 + (0.50)^2 + (0.732)^2]^{1/2} - 0.538 - 0.00$
$= - [(30.8025) + (0.1253) + (0.04) + (0.25) + (0.5358)]^{1/2} - 0.538$
$= - [31.7536]^{1/2} - 0.538$
$= - 5.635 - 0.538$
$= -$ 6.173% span = - (6.173% x 1200 psig) = **- 74.08 psig**

MS-107-PT

$E_{RC\text{-}HELB} = + [(E_{PTA\text{-}HELB})^2 + (E_{COMP1})^2 + (E_{BPS})^2 + (E_{AII/AIO})^2 + (E_{RC\text{-}PRESS})^2]^{1/2} + A_{IR}$ DI35
$= + [(5.550)^2 + (0.354)^2 + (0.02)^2 + (0.50)^2 + (0.732)^2]^{1/2} + 1.381$
$= + [(30.8025) + (0.1253) + (0.04) + (0.25) + (0.5358)]^{1/2} + 1.381$
$= + [31.7536]^{1/2} + 1.381$
$= + 5.635 + 1.381$
$= +$ 7.016% span = +(7.016% x 1200 psig) = **+ 84.19 psig**

$= - [(E_{PTA\text{-}HELB})^2 + (E_{COMP1})^2 + (E_{BPS})^2 + (E_{AII/AIO})^2 + (E_{RC\text{-}PRESS})^2]^{1/2} - A_{IR} - A_{SENSE\text{-}LINE}$ DI35
$= - [(5.550)^2 + (0.354)^2 + (0.02)^2 + (0.50)^2 + (0.732)^2]^{1/2} - 0.585 - 0.00$
$= - [(30.8025) + (0.1253) + (0.04) + (0.25) + (0.5358)]^{1/2} - 0.585$
$= - [31.7536]^{1/2} - 0.585$
$= - 5.635 - 0.585$
$= -$ 6.22% span = - (6.22% x 1200 psig) = **- 74.64 psig**

MS-110-PT

$E_{RC\text{-}HELB}$ = $+ [(E_{PTA\text{-}HELB})^2 + (E_{COMP1})^2 + (E_{BPS})^2 + (E_{AII/AIO})^2 + (E_{RC\text{-}PRESS})^2]^{1/2} + A_{IR}$ DI35

= $+ [(5.550)^2 + (0.354)^2 + (0.02)^2 + (0.50)^2 + (0.732)^2]^{1/2} + 1.752$

= $+ [(30.8025) + (0.1253) + (0.04) + (0.25) + (0.5358)]^{1/2} + 1.752$

= $+ [31.7536]^{1/2} + 1.752$

= + 5.635 + 1.752

= + 7.387% span = + (7.387% x 1200 psig) = **+ 88.64 psig**

= $- [(E_{PTA\text{-}HELB})^2 + (E_{COMP1})^2 + (E_{BPS})^2 + (E_{AII/AIO})^2 + (E_{RC\text{-}PRESS})^2]^{1/2} - A_{IR} - A_{SENSE\text{-}LINE}$ DI35

= $- [(5.550)^2 + (0.354)^2 + (0.02)^2 + (0.50)^2 + (0.732)^2]^{1/2} - 0.742 - 0.00$

= $- [(30.8025) + (0.1253) + (0.04) + (0.25) + (0.5358)]^{1/2} - 0.742$

= $- [31.7536]^{1/2} - 0.742$

= - 5.635 - 0.742

= - 6.377% span = - (6.377% x 1200 psig) = **- 76.52 psig**

"AS-LEFT" TOLERANCES: DI25

Pressure Transmitters (AL_{PT})

AL_{PT} = ± (PT-E_{REF}) DI7

= ± 0.25% span = ±(0.25% x 1200 psig) = ± 3.0 psig

= ± (0.25% x 16 mA) = ± 0.04 mA

Per surveillance procedure SP-193A (Reference 45) the pressure transmitters MS-106-PT thru MS-113-PT, "As-Left" tolerance for calibrating all eight transmitters was ± 0.013 VDC on an 5 VDC scale or ±0.26%. As can be seen the calculated tolerance is approximately equal to the current assigned "As-Left" tolerance for the devices. Therefore;

AL_{PT} = **± 0.25% span = ± 3.0 psig = ± 0.04 mA**

Pressure Bistable (Initiate, Permissive Bypass and Differential Pressure) (AL_{PS}) DI11

AL_{PS} = ± (BISTABLE- E_{REF})

= ± 0.20% span = ± (0.20% x 1200 psig) = ± 2.4 psig

= ± (0.20% x 4 VDC) = ± 0.008 VDC

Per Design Input (DI) #30, the "As-Left" tolerance currently used in SP-146A for the Pressure Initiate Bistable (MS-106-PS1 Thru MS-113-PS1), Pressure Permissive Bypass Bistable (MS-106-PS3 thru MS-113-PS3) and Differential Pressure Bistable (MS-106-PS2 thru MS-113-PS2) is ± 0.008 volts. Since the calculated is the same as the tolerance currently used, the "As - Left" tolerance will remain as ± 0.008 volts. Therefore:

AL_{PS} = **0.20% span = ± 2.4 psig = ± 0.008 volts**

Remote Shutdown Indication (AL_{RSI})

$$AL_{RSI} = \pm [(PT\text{-}E_{REF})^2 + (COMP1 - E_{REF})^2 + (PI2\text{-}E_{REF})^2]^{1/2}$$
$$= \pm [(0.25)^2 + (0.354)^2 + (2.5)^2]^{1/2}$$
$$= \pm [(0.0625) + (0.1253) + (6.25)]^{1/2}$$
$$= \pm [6.4378]^{1/2}$$
$$= \pm 2.54\% \text{ span} = \pm (2.54\% \times 1200 \text{ psig}) = \pm 30.48 \text{ psig}$$

Since PI2 can only be read to 10 psig (½ minor division), and because the calculated tolerance is close to a ½ minor division point, the "As-Left" tolerance for the Remote Shutdown Indication will be rounded down to 30 psig or 2.50%.

Per Design Input (DI) #30, the "As-Left" tolerance currently used in SP-193A for the Remote Shutdown Indication (MS-106-PI2, MS-107-PI2, MS-110-PI2 and MS-111-PI2) is ± 15 psig. Based on past experience of being able to calibrate the indicator loop to the tighter tolerance and because the indicator can only be read to 10 psig increments, then the existing "As - Left" will need to be changed to ± 20 psig. Therefore:

$$AL_{RSI} = 1.67\% \text{ span} = \pm 20 \text{ psig}$$

Control Room Indication (AL_{PI})

$$AL_{PI} = \pm [(PT\text{-}E_{REF})^2 + (COMP1\text{-}E_{REF})^2 + (PI1\text{-}E_{REF})^2]^{1/2}$$
$$= \pm [(0.25)^2 + (0.354)^2 + (2.5)^2]^{1/2}$$
$$= \pm [(0.0625) + (0.1253) + (6.25)]^{1/2}$$
$$= \pm [6.4378]^{1/2}$$
$$= \pm 2.54\% \text{ span} = \pm (2.54\% \times 1200 \text{ psig}) = \pm 30.48 \text{ psig}$$

Since PI1 can only be read to 10 psig (½ minor division), the "As-Left" tolerance for the Control Room Indicator will be rounded down to 30 psig or 2.50%.

Per Design Input (DI) #30, the "As-Left" tolerance currently used in SP-193A for the Control Room Indication (MS-106-PI1, MS-107-PI1, MS-110-PI1 and MS-111-PI1) is ± 15 psig. Based on past experience of being able to calibrate the indicator loop to the tighter tolerance and because the indicator can only be read to 10 psig increments, then the existing "As - Left" will need to be changed to ± 20 psig. Therefore:

$$AL_{PI} = 1.67\% \text{ span} = \pm 20 \text{ psig}$$

Control Room Recording (AL_{CRR})

$$AL_{CRR} = \pm [(PT\text{-}E_{REF})^2 + (COMP1\text{-}E_{REF})^2 + (PIR\text{-}E_{REF})^2]^{1/2}$$
$$= \pm [(0.25)^2 + (0.354)^2 + (0.75)^2]^{1/2}$$
$$= \pm [(0.0625) + (0.1253) + (0.5625)]^{1/2}$$
$$= \pm [0.7503]^{1/2}$$
$$= \pm 0.866\% \text{ span} = \pm (0.866\% \times 1200 \text{ psig}) = \pm 10.39 \text{ psig}$$

Since PIR Recordings can only be read to 10 psig (½ minor division), the "As-Left" tolerance for the Control Room Indicator will be rounded down to 10 psig or 0.83%.

Per Design Input (DI) #30, the "As-Left" tolerance currently used in SP-193A for the Control Room Recording (MS-106-PIR, MS-107-PIR, MS-110-PIR and MS-111-PIR) is ± 15 psig. As can be seen the calculated tolerance is less than the current assigned "As-Left" tolerance for the devices. Therefore; we will use the calculated tolerance since it's the more restrictive between the two.

AL_{CRR} = **± 0.83% span = ± 10.0 psig**

Control Room Recorder Indicating (AL_{CIR})

$$
\begin{aligned}
AL_{CIR} &= \pm [(PT\text{-}E_{REF})^2 + (COMP1\text{-}E_{REF})^2 + (PIR\text{-}E_{REF})^2]^{1/2} \\
&= \pm [(0.25)^2 + (0.354)^2 + (0.5)^2]^{1/2} \\
&= \pm [(0.0625) + (0.1253) + (0.25)]^{1/2} \\
&= \pm [0.4378]^{1/2} \\
&= \pm 0.662\% \text{ span} = \pm (0.662\% \times 1200 \text{ psig}) = \pm 7.94 \text{ psig}
\end{aligned}
$$

Since PIR Indicator can only be read to 25 psig (½ minor division), the calculated "As-Left" tolerance as determined above is less than the scalar readability of 1/2 minor division and cannot be truncated downward for a " zero error "; therefore, the Control Room Indicator will be rounded up to 25 psig or 2.08% .

Per Design Input (DI) #30, the "As-Left" tolerance currently used in SP-193A for the Control Room Recorder Indication (MS-110-PIR and MS-111-PIR) is ± 15 psig. Also, the procedure provided instruction to use a 1/2 division of the smallest scale division if the stated tolerance cannot be read on the recorder scale (MS-106-PIR and MS-107-PIR). Since the calculated tolerance of 1/2 minor division is readable, we will use the calculated tolerance of ± 25 psig. Therefore:

AL_{CIR} = **2.08% span = ± 25 psig**

Pressure Signal for ADV Control ($AL_{PRESS\text{-}ADV}$)

$$
\begin{aligned}
AL_{PRESS\text{-}ADV} &= \pm [(PT\text{-}E_{REF})^2 + (COMP1\text{-}E_{REF})^2]^{1/2} \\
&= \pm [(0.25)^2 + (0.354)^2]^{1/2} \\
&= \pm [(0.0625) + (0.1253)]^{1/2} \\
&= \pm [0.1878]^{1/2} \\
&= \pm 0.43\% \text{ span} = \pm (0.43\% \times 1200 \text{ psig}) = \pm 5.16 \text{ psig} \\
&= \pm (0.43\% \times 10 \text{ volts}) = \pm 0.043 \text{ volts}
\end{aligned}
$$

EFIC - Pressure Initiate and Permissive Bypass Bistables (AL_{BS})

$$
\begin{aligned}
AL_{BS} &= \pm [(PT\text{-}E_{REF})^2 + (COMP1\text{-}E_{REF})^2]^{1/2} \pm (BISTABLE\text{-}E_{REF}) \\
&= \pm [(0.25)^2 + (0.354)^2]^{1/2} \pm (0.20) \\
&= \pm [(0.0625) + (0.1253)]^{1/2} \pm (0.20) \\
&= \pm [0.1878]^{1/2} \pm (0.20) \\
&= \pm 0.433 \pm 0.20 \\
&= \pm 0.633\% \text{ span} = \pm (0.633\% \times 1200 \text{ psig}) = \pm 7.60 \text{ psig}
\end{aligned}
$$

EFIC - Differential Pressure Bistable (AL_{DBS})

$$AL_{DBS} = \pm [\{2 \times (PT\text{-}E_{REF})^2\} + (COMP2\text{-}E_{REF})^2]^{1/2} \pm (BISTABLE\text{-}E_{REF})$$
$$= \pm [\{2 \times (0.25)^2\} + (0.559)^2]^{1/2} \pm (0.20)$$
$$= \pm [(0.125) + (0.3125)]^{1/2} \pm (0.20)$$
$$= \pm [0.4375]^{1/2} \pm (0.20)$$
$$= \pm 0.661 \pm (0.20)$$
$$\pm 0.861\% \text{ span} = \pm (0.861\% \times 1200 \text{ psig}) = + 10.33 \text{ psi}$$

Pressure Signals to Recall

$$AL_{RC\text{-}PRESS} = \pm [(PT\text{-}E_{REF})^2 + (COMP1\text{-}E_{REF})^2 + (BISTABLE\text{-} E_{BPS})^2 + (ANALOG\ ISO\text{-}E_{REF})^2 + (RECALL\text{-}E_{REF})^2]^{1/2}$$
$$= \pm [(0.25)^2 + (0.354)^2 + (0.20)^2 + (0.50)^2 + (0.732)^2]^{1/2}$$
$$= \pm [(0.0625) + (0.1253) + (0.04) + (0.25) + (0.5358)]^{1/2}$$
$$= \pm [1.0136]^{1/2}$$
$$= \pm 1.007\% \text{ span} = \pm (1.007\% \times 1200 \text{ psig}) = \pm 12.08 \text{ psig}$$
$$= \pm (1.007\% \times 10 \text{ volts}) = \pm 0.101 \text{ volts}$$

The "As-Left" tolerance for the Recall Point Indication will be rounded down to 12.00 psig or 1.00%.

Per Design Input (DI) #30, the "As-Left" tolerance currently used in SP-193A for the Control Room Recall Points (RCL252, RCL253 and RCL255) is ± 24 psig. As can be seen the calculated tolerance is less than the current assigned "As-Left" tolerance for the devices. Therefore; we will use the calculated tolerance since it's the more restrictive between the two.

$$AL_{RC\text{-}PRESS} = \pm 1.00\% \text{ span} = \pm 12 \text{ psig}$$

"AS-FOUND" TOLERANCES: DI27

The only component which has a specified Drift is the Rosemount transmitter; therefore, the only drift term in the following calculations will be the drift associated with the transmitters ($PT\text{-}E_{SB}$).

$$PT\text{-}E_{SB} = \text{Stability (Drift)} = \pm 0.2\% \text{ URL per 30 months}$$
$$= \pm 0.2\% (3000 \text{ psig}/1200 \text{ psig})$$
$$= \pm 0.5\% \text{ span}$$

Therefore $PT\text{-}E_{SB} = \pm 0.5\%$ span.

Pressure Transmitters (AF_{PT})

$$AF_{PT} = \pm \{AL_{PT} + [(PT\text{-}E_{SB})^2 + (MTE_{PT})^2]^{1/2}\}$$ DI7 & A3.1
$$= \pm \{(0.25) + [(0.5)^2 + (0.493)^2]^{1/2}\}$$
$$= \pm \{(0.25) + [(0.25) + (0.2430)]^{1/2}\}$$
$$= \pm \{(0.25) + [0.493]^{1/2}\}$$
$$= \pm \{(0.25) + (0.702)\}$$
$$= \pm 0.95\% \text{ span} = \pm (0.95\% \times 1200 \text{ psig}) = \pm 11.4 \text{ psig}$$
$$= \pm (0.95\% \times 16 \text{ mA}) = \pm 0.152 \text{ mA}$$

Per surveillance procedure SP-193A (Reference 45) for MS-106-PT thru MS-113-PT the "As-Found" tolerance for calibrating all eight transmitters was ± 0.042 VDC on a 5 VDC scale or ± 0.84%. Based on past calibration, the pressure transmitter has been able to meet the tighter tolerance and to remove additional conservatism, the "As - Left" tolerance of ± 0.84% will be used. Therefore;

AF_{PT} = **± 0.84% span = ± 10.08 psig = ± 0.134 mA**

Pressure Bistable (Initiate, Permissive Bypass and Differential Pressure) (AF_{PS}) DI11 & A3.2

$$
\begin{aligned}
AF_{PS} &= \pm \{(AL_{PS}) + [(MTE_{FM})^2]^{1/2}\} \\
&= \pm \{(0.20) + [(0.041)^2]^{1/2}\} \\
&= \pm \{(0.20) + (0.041)\} \\
&= \pm 0.241\% \text{ span} = \pm (0.241\% \times 1200 \text{ psig}) = \pm 2.89 \text{ psig} \\
&= \pm (0.241\% \times 4 \text{ VDC}) = \pm 0.010 \text{ VDC}
\end{aligned}
$$

Per Design Input (DI) #30, the "As-Found" tolerance currently used in SP-146A for the Bistables is ± 0.008 volts. Since the calculated is greater than as the tolerance currently used, the "As-Found" tolerance will remain ± 0.008 volts. Therefore;

AF_{PS} = **0.20% span = ± 0.008 volts**

Remote Shutdown Indication (AF_{RSI})

$$
\begin{aligned}
AF_{RSI} &= \pm \{(AL_{RSI}) + [(PT\text{-}E_{SB})^2 + (MTE_{OL})^2]^{1/2}\} \\
&= \pm \{(1.67) + [(0.5)^2 + (0.528)^2]^{1/2}\} \\
&= \pm \{(1.67) + [(0.25) + (0.2788)]^{1/2}\} \\
&= \pm \{(1.67) + [0.5288]^{1/2}\} \\
&= \pm \{(1.67) + (0.727)\} \\
&= \pm 2.40\% \text{ span} = \pm (2.40\% \times 1200 \text{ psig}) = \pm 28.8 \text{ psig}
\end{aligned}
$$

DI7 & A3.4

Since PI2 can only be read to 10 psig (½ minor division), and because the calculated tolerance is close to a ½ minor division point, the "As-Found" tolerance for the Remote Shutdown Indication will be rounded up to 30 psig or 2.50%.

Per Design Input (DI) #30, the "As-Found" tolerance currently used in SP-193A for the Remote Shutdown Indication (MS-106-PI2, MS-107-PI2, MS-110-PI2 and MS-111-PI2) is ± 20 psig. Based on past calibration, the recorder indicator loop has been able to meet the tighter tolerance and to remove additional conservatism, which affect the ability of the operator using the indicator, an "As - Left" tolerance of ± 20 psig will be used. Therefore;

AF_{RSI} = **1.67% span = ± 20 psig**

Control Room Indication (AF_{PI})

$$
\begin{aligned}
AF_{PI} &= \pm \{(AL_{PI}) + [(PT\text{-}E_{SB})^2 + (MTE_{OL})^2]^{1/2}\} \\
&= \pm \{(1.67) + [(0.5)^2 + (0.528)^2]^{1/2}\} \\
&= \pm \{(1.67) + [(0.25) + (0.2788)]^{1/2}\} \\
&= \pm \{(1.67) + [0.5288]^{1/2}\} \\
&= \pm \{(1.67) + (0.727)\} \\
&= \pm 2.40\% \text{ span} = \pm (2.40\% \times 1200 \text{ psig}) = \pm 28.8 \text{ psig}
\end{aligned}
$$

DI7 & A3.4

Since PI1 can only be read to 10 psig (½ minor division), and because the calculated tolerance is close to a ½ minor division point, the "As-Found" tolerance for the Control Room Indication will be rounded up to 30 psig or 2.50%.

Per Design Input (DI) #30, the "As-Found" tolerance currently used in SP-193A for the Control Room Indication (MS-106-PI1, MS-107-PI1, MS-110-PI1 and MS-111-PI1) is ± 20 psig. Based on past calibration, the recorder indicator loop has been able to meet the tighter tolerance and to remove additional conservatism, which could affect the ability of the operator using the indicator, an "As - Left" tolerance of ± 20 psig will be used. Therefore;

AF_{PI} = **1.67% span = ± 20 psig**

Control Room Recording (AF_{CRR})

$$\begin{aligned} AF_{CRR} &= \pm\{(AL_{CRR}) + [(PT\text{-}E_{SB})^2 + (MTE_{OL})^2]^{1/2}\} \quad \text{DI7 \& A3.4} \\ &= \pm\{(0.830) + [(0.5)^2 + (0.528)^2]^{1/2}\} \\ &= \pm\{(0.830) + [(0.25) + (0.2788)]^{1/2}\} \\ &= \pm\{(0.830) + [0.5288]^{1/2}\} \\ &= \pm\{(0.830) + (0.727)\} \\ &= \pm 1.56\% \text{ span} = \pm(1.56\% \times 1200 \text{ psig}) = \pm 18.72 \text{ psig} \end{aligned}$$

Since PIR can only be read to 10 psig (½ minor division), and because the calculated tolerance is close to a ½ minor division point, the "As-Found" tolerance for the Control Room Recorder will be rounded up to 20 psig or 1.67%.

Per Design Input (DI) #30, the "As-Found" tolerance currently used in SP-193A for the Control Room Recording (MS-106-PIR, MS-107-PIR, MS-110-PIR and MS-111-PIR) is ± 20 psig. Since the calculated is the same as the tolerance currently used, the "As-Found" tolerance will remain ± 20 psig. Therefore;

AF_{CRR} = **± 1.67% span = ± 20.0 psig**

Control Room Recorder Indicating (AF_{CIR})

$$\begin{aligned} AF_{CIR} &= \pm\{(AL_{CIR}) + [(PT\text{-}E_{SB})^2 + (MTE_{OL})^2]^{1/2}\} \quad \text{DI7 \& A3.4} \\ &= \pm\{(2.08) + [(0.5)^2 + (0.528)^2]^{1/2}\} \\ &= \pm\{(2.08) + [(0.25) + (0.2788)]^{1/2}\} \\ &= \pm\{(2.08) + [0.5288]^{1/2}\} \\ &= \pm\{(2.08) + (0.727)\} \\ &= \pm 2.81\% \text{ span} = \pm(2.81\% \times 1200 \text{ psig}) = \pm 33.72 \text{ psig} \end{aligned}$$

Since PIR Indicator can only be read to 25 psig (½ minor division), and because the calculated tolerance is close to a ½ minor division point, the "As-Found" tolerance for the Control Room Indication will be rounded down to 25 psig or 2.08%.

Per Design Input (DI) #30, the "As-Found" tolerance currently used in SP-193A for the Control Room Recorder Indication (MS-106-PIR, MS-107-PIR, MS-110-PIR and MS-111-PIR) is ± 20 psig. Based on past calibration, the recorder indicator loop has been able to meet the tighter tolerance and because the indicator can only be read to 25 psig, then the existing "As - Left" tolerance will need to be changed to ± 25 psig. Therefore;

AF_{CIR} = **± 2.08% span = ± 25.0 psig**

Pressure Signal for ADV Control ($AF_{PRESS\text{-}ADV}$) DI7 & A3.6

$$AF_{PRESS\text{-}ADV} = \pm\{(AL_{ADV}) + [(PT\text{-}E_{SB})^2 + (MTE_{CML})^2]^{1/2}\}$$
$$= \pm\{(0.43) + [(0.50)^2 + (0.528)^2]^{1/2}\}$$
$$= \pm\{(0.43) + [(0.25) + (0.2788)]^{1/2}\}$$
$$= \pm\{(0.43) + [0.5288]^{1/2}\}$$
$$= \pm\{(0.43) + (0.727)\}$$
$$= \pm 1.157\% \text{ span} = \pm(1.157\% \times 1200 \text{ psig}) = \pm 13.88 \text{ psig}$$
$$= \pm(1.157\% \times 10 \text{ volts}) = \pm 0.116 \text{ volts}$$

EFIC - Pressure Initiate and Permissive Bypass Bistable (AF_{BS})

DI7 & A3.3

$$AF_{BS} = \pm\{(AL_{BS}) + [(PT\text{-}E_{SB})^2 + (MTE_{PSL})^2]^{1/2}\}$$
$$= \pm\{(0.633) + [(0.50)^2 + (0.531)^2]^{1/2}\}$$
$$= \pm\{(0.633) + [(0.25) + (0.2820)]^{1/2}\}$$
$$= \pm\{(0.633) + [0.532]^{1/2}\}$$
$$= \pm\{(0.633) + (0.729)\}$$
$$= \pm 1.362\% \text{ span} = \pm(1.362\% \times 1200 \text{ psig}) = \pm 16.34 \text{ psig}$$

EFIC - Differential Pressure Bistable (AF_{DPS})

DI7 & A3.5

$$AF_{DBS} = \pm\{(AL_{DBS}) + [\{2 \times (PT\text{-}E_{SB})^2\} + (MTE_{DPSL})^2]^{1/2}\}$$
$$= \pm\{(0.861) + [\{2 \times (0.50)^2\} + (0.749)^2]^{1/2}\}$$
$$= \pm\{(0.861) + [(0.50) + (0.5610)]^{1/2}\}$$
$$= \pm\{(0.861) + [1.0610]^{1/2}\}$$
$$= \pm\{(0.861) + (1.03)\}$$
$$= \pm 1.891\% \text{ span} = \pm(1.891\% \times 1200 \text{ psig}) = \pm 22.69 \text{ psi}$$

Pressure Signals to RECALL ($AF_{RC\text{-}PRESS}$)

DI7 & A3.4

$$AF_{RC\text{-}PRESS} = \pm\{(AL_{BS}) + [(PT\text{-}E_{SB})^2 + (MTE_{OL})^2]^{1/2}\}$$
$$= \pm\{(1.00) + [(0.50)^2 + (0.528)^2]^{1/2}\}$$
$$= \pm\{(1.00) + [(0.25) + (0.2788)]^{1/2}\}$$
$$= \pm\{(1.00) + [0.5288]^{1/2}\}$$
$$= \pm\{(1.00) + (0.727)\}$$
$$= \pm 1.727\% \text{ span} = \pm(1.727\% \times 1200 \text{ psig}) = \pm 20.72 \text{ psig}$$
$$= \pm(1.727\% \times 10 \text{ volts}) = \pm 0.173 \text{ volts}$$

The "As-Found" tolerance for the Recall Point Indication will be rounded down to 20 psig or 1.67%.

Per Design Input (DI) #30, the "As-Found" tolerance currently used in SP-193A for the Control Room Recall Points (RCL252, RCL253 and RCL255) is ± 36 psig. As can be seen the calculated tolerance is less than the current assigned "As-Found" tolerance for the devices. Therefore; we will use the calculated tolerance since it's the more restrictive between the two.

$$AF_{RC\text{-}PRESS} = \pm 1.67\% = \pm 20.00 \text{ psig}$$

CALIBRATED LOOP ERRORS: DI26

Remote Shutdown Indication (CE_{RSI})

CE_{RSI} = $\pm$ [(E_{RSI}) + (AF_{RSI})]
= $\pm$ [(2.77) + (1.67)]
= $\pm$ 4.44% span = $\pm$(4.44% x 1200 psig) = **$\pm$ 53.28 psig**

Control Room Indication (Normal - CE_{PIN}, Accident - CE_{PIA})

CE_{PIN} = $\pm$ [(E_{PIN}) + (AF_{PI})]
= $\pm$ [(2.77) + (1.67)]
= $\pm$ 4.44% span = $\pm$ (4.44% x 1200 psig) = **$\pm$ 53.28 psig**

MS-106-PT/PI1:

$CE_{PIA-HELB}$ = $\pm$ [($E_{PIA-HELB}$) + (AF_{PI})]
= + [(7.423) + (1.67)]
= + 9.09% span = + (9.09% x 1200 psig) = **+109.08 psig**

= - [(6.692) + (1.67)]
= - 8.36% span = - (8.36% x 1200 psig) = **- 100.32 psig**

MS-107-PT/PI1:

$CE_{PIA-HELB}$ = $\pm$ [($E_{PIA-HELB}$) + (AF_{PI})]
= + [(7.535) + (1.67)]
= + 9.21% span = + (9.27% x 1200 psig) = **+110.52 psig**

= - [(6.739) + (1.67)]
= - 8.41% span = - (8.41% x 1200 psig) = **- 100.92 psig**

MS-110-PT/PI1:

$CE_{PIA-HELB}$ = $\pm$ [($E_{PIA-HELB}$) + (AF_{PI})]
= + [(7.906) + (1.67)]
= + 9.58% span = + (9.58% x 1200 psig) = **+114.96 psig**

= - [(6.896) + (1.67)]
= - 8.57% span = - (8.57% x 1200 psig) = **- 102.84 psig**

MS-111-PT/PI1:

$CE_{PIA-HELB}$ = $\pm$ [($E_{PIA-HELB}$) + (AF_{PI})]
= + [(7.773) + (1.67)]
= + 9.44% span = + (9.44% x 1200 psig) = **+113.28 psig**

= - [(6.84) + (1.67)]
= - 8.51% span = - (8.51% x 1200 psig) = **- 102.12 psig**

Control Room Recording (Normal - CE_{RN}, Accident - CE_{RA})

CE_{RN} = ± [(E_{PRRN}) + (AF_{CRR})]
= ± [(1.41) + (1.67)]
= ± 3.08% span = ± (3.08% x 1200 psig) = **± 36.96 psig**

MS-106-PIR:

$CE_{RA\text{-}HELB}$ = ± [($E_{PRRA\text{-}HELB}$) + (AF_{CRR})]
= + [(6.944) + (1.67)]
= + 8.61% span = + (8.61% x 1200 psig) = **+103.32 psig**

= - [(6.213) + (1.67)]
= - 7.88% span = - (7.88% x 1200 psig) = **- 94.56 psig**

MS-107-PIR:

$CE_{RA\text{-}HELB}$ = ± [($E_{PRRA\text{-}HELB}$) + (AF_{CRR})]
= + [(7.056) + (1.67)]
= + 8.73% span = + (8.73% x 1200 psig) = **+104.76 psig**

= - [(6.26) + (1.67)]
= - 7.93% span = - (7.93% x 1200 psig) = **- 95.16 psig**

MS-110-PIR:

$CE_{RA\text{-}HELB}$ = ± [($E_{PRRA\text{-}HELB}$) + (AF_{CRR})]
= + [(7.427) + (1.67)]
= + 9.10% span = + (9.10% x 1200 psig) = **+109.2 psig**

= - [(6.417) + (1.67)]
= - 8.09% span = - (8.09% x 1200 psig) = **- 97.08 psig**

MS-111-PIR:

$CE_{RA\text{-}HELB}$ = ± [($E_{PRRA\text{-}HELB}$) + (AF_{CRR})]
= + [(7.294) + (1.67)]
= + 8.96% span = + (8.96% x 1200 psig) = **+107.52 psig**

= - [(6.361) + (1.67)]
= - 8.03% span = - (8.03% x 1200 psig) = **- 96.36 psig**

Control Room Recorder Indicating (Normal - CE_{RIN}, Accident - CE_{RIA})

CE_{RIN} = ± [(E_{PIRN}) + (AF_{CIR})]
= ± [(2.30) + (2.08)]
= ± 4.38% span = ± (4.38% x 1200 psig) = **± 52.56 psig**

MS-106-PT/PIRI:

$$CE_{RIA-HELB} = \pm [(E_{PIRA-HELB}) + (AF_{CIR})]$$
$$= + [(7.231) + (2.08)]$$
$$= + 9.31\%\ span = + (9.31\% \times 1200\ psig) = + 111.72\ psig$$

$$= - [(6.50) + (2.08)]$$
$$= - 8.58\%\ span = - (8.58\% \times 1200\ psig) = - 102.96\ psig$$

MS-107-PT/PIRI:

$$CE_{RIA-HELB} = \pm [(E_{PIRA-HELB}) + (AF_{CIR})]$$
$$= + [(7.343) + (2.08)]$$
$$= + 9.42\%\ span = + (9.42\% \times 1200\ psig) = + 113.04\ psig$$

$$= - [(6.547) + (2.08)]$$
$$= - 8.63\%\ span = - (8.63\% \times 1200\ psig) = - 103.56\ psig$$

MS-110-PT/PIRI:

$$CE_{RIA-HELB} = \pm [(E_{PIRA-HELB}) + (AF_{CIR})]$$
$$= + [(7.714) + (2.08)]$$
$$= + 9.79\%\ span = + (9.79\% \times 1200\ psig) = + 117.48\ psig$$

$$= - [(6.704) + (2.08)]$$
$$= - 8.78\%\ span = - (8.78\% \times 1200\ psig) = - 105.36\ psig$$

MS-111-PT/PIRI:

$$CE_{RIA-HELB} = \pm [(E_{PIRA-HELB}) + (AF_{CIR})]$$
$$= + [(7.581) + (2.08)]$$
$$= + 9.66\%\ span = + (9.66\% \times 1200\ psig) = + 115.92\ psig$$

$$= - [(6.648) + (2.08)]$$
$$= - 8.73\%\ span = - (8.73\% \times 1200\ psig) = - 104.76\ psig$$

Pressure Signal for ADV Control ($CE_{PRSS-ADV}$)

MSV-025

$$CE_{PRESS-ADV} = \pm [(E_{PRESS-ADV}) + (AF_{PRESS-ADV})]$$
$$= \pm [(0.845) + (1.157)]$$
$$= \pm 2.002\%\ span = \pm (2.002\% \times 1200\ psig) = \pm 24.02\ psig$$
$$= \pm (2.002\% \times 10\ volts) = \pm 0.200\ volts$$

MSV-026

$$CE_{PRESS-ADV} = \pm [(E_{PRESS-ADV}) + (AF_{PRESS-ADV})]$$
$$= \pm [(0.845) + (1.157)]$$
$$= \pm 2.002\%\ span = \pm (2.002\% \times 1200\ psig) = \pm 24.02\ psig$$
$$= \pm (2.002\% \times 10\ volts) = \pm 0.200\ volts$$

Atmospheric Dump Valve Control Loop (CE_{ADV})

MSV-025

$$CE_{ADV} = \pm [(E_{ADV}) + (AF_{PRESS\text{-}ADV})]$$
$$= \pm [(0.921) + (1.157)]$$
$$= \pm 2.078\%\ span = \pm (2.078\% \times 1200\ psig) = \pm 24.94\ psig$$

MSV-026

$$CE_{ADV} = \pm [(E_{ADV}) + (AF_{PRESS\text{-}ADV})]$$
$$= \pm [(0.921) + (1.157)]$$
$$= \pm 2.078\%\ span = \pm (2.078\% \times 1200\ psig) = \pm 24.94\ psig$$

Pressure Signals to RECALL

$$CE_{RC\text{-}NORMAL} = \pm [(E_{RC\text{-}NORMAL}) + (AF_{RC\text{-}PRESS})]$$
$$= \pm [(1.241) + (1.67)]$$
$$= \pm 2.91\%\ span = \pm (2.91\% \times 1200\ psig) = \pm 34.92\ psig$$

MS-106-PT:

$$CE_{RC\text{-}HELB} = \pm [(E_{RC\text{-}HELB}) + (AF_{RC\text{-}PRESS})]$$
$$= + [(6.904) + (1.67)]$$
$$= + 8.57\%\ span = + (8.57\% \times 1200\ psig) = +102.84\ psig$$

$$= - [(6.173) + (1.67)]$$
$$= - 7.84\%\ span = - (7.84\% \times 1200\ psig) = - 94.08\ psig$$

MS-107-PT:

$$CE_{RC\text{-}HELB} = \pm [(E_{RC\text{-}HELB}) + (AF_{RC\text{-}PRESS})]$$
$$= + [(7.016) + (1.67)]$$
$$= + 8.69\%\ span = + (8.69\% \times 1200\ psig) = +104.28\ psig$$

$$= - [(6.22) + (1.67)]$$
$$= - 7.89\%\ span = - (7.89\% \times 1200\ psig) = - 94.68\ psig$$

MS-110-PT:

$$CE_{RC\text{-}HELB} = \pm [(E_{RC\text{-}HELB}) + (AF_{RC\text{-}PRESS})]$$
$$= + [(7.387) + (1.67)]$$
$$= + 9.06\%\ span = + (9.06\% \times 1200\ psig) = + 108.72\ psig$$

$$= - [(6.377) + (1.67)]$$
$$= - 8.05\%\ span = - (8.05\% \times 1200\ psig) = - 96.60\ psig$$

Low Pressure Initiate Bistable Setpoint.

EFIC - Pressure Initiate Bistable (CE_{LPBS})

$$CE_{LPBS} = \pm [(E_{LPBS}) + (AF_{BS})]$$
$$= \pm [(22.97 \text{ psig}) + (16.34 \text{ psig})]$$
$$= \pm 39.31 \text{ psig}$$

Since the low steam generator SG pressure initiate setpoint actuates on a decreasing pressure at an analytical limit of 585 psig (per DI #36), the actual setpoint must be set high enough to be above 585 psig. Therefore, the setpoint for the low pressure actuation will be as follows:

Setpoint = Analytical Limit + CE_{LPBS}
= 585 + 39.31
= 624.31 psig
= 624.50 psig (Setpoint rounded up for ease of setting)

Per Design Input (DI) #31, the current setpoint used in SP-146A for the low pressure initiate bistable (MS-106-PS1 thru MS-113-PS1) is 617.76 psig. As can be seen the calculated low pressure initiate setpoint is greater than the current assigned setpoint setting in the bistable. Considering the existing setpoint of 617.76 psig and subtracting off the calculated "As-Found" tolerance of 16.34 psig results in a lower "As-Found" setpoint limit of 601.42 psig. In comparison with the Improved Technical Specification (ITS) limit of 600 psig, the lower "As-Found" limit of 601.42 psig is 1.42 psig above and still assures that the ITS limit is not violated during surveillance testing. The current setpoint complies with assuring that the ITS limits aren't violated but, using the current in-plant setpoint causes the calculated loop error to shift the analytical limit below it's present value of 585 psig by 6.55 psig (578.45 psig). This is unacceptable and therefore,

Low Pressure Initiate Setpoint = 624.5 psig

Now that the low pressure initiate setpoint has been established, then this value must now be adjusted into the EFIC bistables in each of the cabinets (MS-106-PS1 thru MS-113-PS1) in order for the EFIC Control system to cause main steam and main feedwater isolation along with starting the EFW. To adjust this setpoint value into the bistable we must change the setpoint jack per the instructions outlined in the Vitro Instruction Manual (Reference 36) on page 6-21. The manual instructions provide us with an equation on how to determine the desire pressure setting in terms of a voltage setpoint as follows:

Low Pressure Bistable Setpoint Voltage = [(P) x 3.333 mV] + 1.0 Volt
= [624.5 x 3.333 mV] + 1.0
= [2.081] + 1.0
= 3.081 volts

Also,

Test level voltage = Setpoint voltage - 0.1 volts
= 3.081 - 0.1
= 2.981 volts

Steam Generator Shutdown Bypass Permissive Setpoint.

EFIC - Permissive Bypass Bistable (CE_{LPBS})

CE_{BS} = ± [(E_{BS}) + (AF_{BS})]
= ± [(10.42 psig) + (16.34 psig)]
= ± 26.76 psig

The SG pressure bypass setpoint is determine in the following manner:
First, using the low pressure initiate setpoint as the lowest bound limit for the bypass permissive, we find that the;

Minimum Setpoint = Low pressure setpoint + CE_{BS}
= 624.50 psig + 26.76 psig
= 651.26 psig
= 651 psig (Setpoint rounded down for ease of setting)

Maximum Setpoint = FSAR Value + CE_{BS}
= 750 psig - 26.76 psig
= 723.24 psig
= 723 psig (Setpoint rounded down for ease of setting)

Choosing the minimum setpoint does not provide adequate margin above the low pressure setpoint to avoid spurious trips resulting from a main control board operator's inability for lack of time to bypass the trip feature. Selecting the maximum setpoint gives the operator increase margin (723.00 psig - 624.5 psig = 98.5 psig) for bypassing the low pressure condition. Also, the maximum setpoint maintains the differential pressure between the SG's in order to distinguish the depressurized one and isolate it. Therefore, the maximum setpoint is selected.

Per Design Input (DI) #31, the current plant setpoint used in SP-146A for the permissive bypass bistable (MS-106-PS3 thru MS-113-PS3) is 732.37 psi. As can be seen the calculated bypass setpoint is lower than the current assigned setpoint setting in the bistable. Considering the existing setpoint of 732.37 psi and adding the calculated "As-Found" tolerance of 16.34 psi results in a high "As-Found" setpoint limit of 748.71 psi. In comparison with the Improved Technical Specification limit of 750 psig, the high "As-Found" limit of 748.71 psi is 1.29 psig below and still provides assures that the ITS limit is not violated during surveillance testing. Therefore, the current permissive bypass setpoint as listed in SP-146A as 732.37 psig is acceptable and complies with assuring that the limits don't violate the ITS requirements.

Permissive Bypass Setpoint = 732.37 psig

Now that the bypass permissive setpoint has been established, then this value must now be adjusted into the EFIC bistables in each of the cabinets (MS-106-PS3 thru MS-113-PS3) in order for the EFIC Control system to avoid actuation of the low pressure trip on normal plant cooldowns. To adjust this setpoint value into the bistable we must change the counting dial per the instructions outlined in the Vitro Instruction Manual (Reference 36) on page 6-19. The manual instructions provide us with an equation on how to determine the desired setting in terms of a voltage setpoint as follows:

Bypass Permissive Bistable Setpoint Voltage = [(P) x 3.333 mV] + 1.0 Volt
= [732.37 x 3.333 mV] + 1.0
= [2.441] + 1.0
= 3.441 volts

Also,

Test level voltage	=	Setpoint voltage − 0.1 volts
	=	3.441 − 0.1
	=	**3.341 volts**

Steam Generator Differential Pressure Setpoint.

EFIC - Differential Pressure Bistable (CE_{DPBS})

$$CE_{DPBS} = \pm [(E_{DPBS}) + (AF_{DBS})]$$
$$= \pm [(32.52 \text{ psi}) + (22.69 \text{ psi})]$$
$$= \pm 55.21 \text{ psi}$$

Per Design Input #40 the differential pressure that isolates a depressurized steam generator is listed as 150 psi. The maximum setpoint is calculate as:

Maximum Setpoint	=	FSAR Value − CE_{DPBS}
	=	150 psid − 55.21 psi
	=	94.79 psid
	=	94.5 psid (Setpoint rounded down for ease of setting)

Now determine the minimum setpoint which prevents isolation of a non-leaking/depressurized steam generator which is based a zero (0) differential across both steam generators at operation.

Minimum Setpoint	=	Steam Generator dP + CE_{DBS}
	=	0 psid + 55.21 psi
	=	55.21 psid

To prevent inadverent steam generator isolation the maximum differential pressure setpoint is selected.

Per Design Input (DI) #31, the current plant setpoint used in SP-146A for the steam generator differential pressure bistable (MS-106-PS2 thru MS-113-PS2) is 106.80 psid. As can be seen the calculated differential pressure is less than the current assigned setpoint setting in the bistable. Considering the existing setpoint of 106.80 psid and adding the calculated "As-Found" tolerance of 22.69 psi results in a higher "As-Found" setpoint limit of 129.49 psid. In comparison with the Improved Technical Specification limit of 125 psid, the higher limit of 129.49 psid exceeds the ITS limit. Therefore, the existing steam generator differential pressure bistable will need to be changed to 94.5 psid.

SG Differential Pressure Setpoint = 94.5 psid

Now that the differential pressure setpoint has been established, then this value must now be adjusted into the EFIC bistables in each of the cabinets (MS-106-PS2 thru MS-113-PS2) in order for the EFIC Control system to achieve the FOGG logic function. To adjust this setpoint value into the bistable we must change the counting dial per the instructions outlined in the Vitro Instruction Manual (Reference 36) on page 6-19. The manual instructions provide us with an equation on how to determine the desired differential setting in terms of a voltage setpoint as follows:

Differential Pressure Bistable Setpoint Voltage = [(P) x 3.333 mV] + 1.0 Volt
= [94.5 x 3.333 mV] + 1.0
= [0.315] + 1.0
= 1.315 volts

Also,

Test level voltage = Setpoint voltage + 0.1 volts
= 1.315 + 0.1
= 1.415 volts

Atmosphere Dump Valve Pressure Control Module Setpoint.

The setpoint is determined as follows:

a) the minimum ADV setpoint is based on the maximum operating main steam pressure where the setpoint will avoid unnecessary release of steam up the vent stacks. Per Design Input #39, the maximum steam pressure at full power is 916.5 psig. Therefore,

Minimum Setpoint = Maximum Steam Pressure + CE_{ADV}
= 916.5 psig + 24.94 psig
= 941.44 psig

b) According to Design Input #38, the low plant administrative limit on the MS Code Safeties is 1050 psig. The maximum ADV setpoint is low enough to avoid challenges and lifting of safeties; and determined as:

Maximum Setpoint = MSSV Lower Lift Setpoint - CE_{ADV}
= 1050 psig - 24.94 psig
= 1025.06 psig
= 1025 psig (Setpoint rounded down for ease of setting)

The current plant setpoint for the atmospheric dump valves is set at 1025 psig, as stated on page 19 of the Main Steam EDBD (Reference 6). It is acceptable to use current plant setpoint.

Atmosphere Dump Valve Pressure Control Setpoint = 1025 psig

Now that we know the setpoint value for the atmospheric dump valves, then this numeric value must now be adjusted into the EFIC pressure control portion of the control modules (MSV-025-PC and MS-113-PC) in order to maintain the desired control function. To adjust this setpoint value into the two control modules, we must set the switch arrangements on dip switch " S1 " which is physically mounted on the Digital/Analog Board per the instructions outlined in the Vitro Instruction Manual (Reference 36) on page 6-9. The manual statement requires us to determine the equivalent binary expression which is done as follows:

The dip switch has a range setting from zero (0) to 4095 where zero (0) represents zero (0) pressure and 4095 represents 1200 pounds of pressure.
So then,

0 = 0
x = 1025
4095 = 1200

Differential Pressure Bistable Setpoint Voltage = [(P) x 3.333 mV] + 1.0 Volt
= [94.5 x 3.333 mV] + 1.0
= [0.315] + 1.0
= **1.315 volts**

Also,

Test level voltage = Setpoint voltage + 0.1 volts
= 1.315 + 0.1
= **1.415 volts**

Atmosphere Dump Valve Pressure Control Module Setpoint.

The setpoint is determined as follows:

a) the minimum ADV setpoint is based on the maximum operating main steam pressure where the setpoint will avoid unnecessary release of steam up the vent stacks. Per Design Input #39, the maximum steam pressure at full power is 916.5 psig. Therefore,

Minimum Setpoint = Maximum Steam Pressure + CE_{ADV}
= 916.5 psig + 24.94 psig
= 941.44 psig

b) According to Design Input #38, the low plant administrative limit on the MS Code Safeties is 1050 psig. The maximum ADV setpoint is low enough to avoid challenges and lifting of safeties; and determined as:

Maximum Setpoint = MSSV Lower Lift Setpoint - CE_{ADV}
= 1050 psig - 24.94 psig
= 1025.06 psig
= 1025 psig (Setpoint rounded down for ease of setting)

The current plant setpoint for the atmospheric dump valves is set at 1025 psig, as stated on page 19 of the Main Steam EDBD (Reference 6). It is acceptable to use current plant setpoint.

Atmosphere Dump Valve Pressure Control Setpoint = 1025 psig

Now that we know the setpoint value for the atmospheric dump valves, then this numeric value must now be adjusted into the EFIC pressure control portion of the control modules (MSV-025-PC and MS-113-PC) in order to maintain the desired control function. To adjust this setpoint value into the two control modules, we must set the switch arrangements on dip switch " S1 " which is physically mounted on the Digital/Analog Board per the instructions outlined in the Vitro Instruction Manual (Reference 36) on page 6-9. The manual statement requires us to determine the equivalent binary expression which is done as follows:

The dip switch has a range setting from zero (0) to 4095 where zero (0) represents zero (0) pressure and 4095 represents 1200 pounds of pressure.

So then,

0 = 0
x = 1025
4095 = 1200

$$(x / -4095) = (-175 / -1200)$$
$$x = [(-175 \times -4095) / -1200]$$
$$x = -597.188$$

4095 - 597 = 3498

The answer obtained is the value that must be converted to a binary expression in order to set the dip switch logic. By calculator conversion, the binary value of 3498 is equated to an " S1 " coding of:

MSB . . . . .LSB
1 1 0 1 1 0 1 0 1 0 1 0
S12 . . . . .S1

On page 6-9 of the manual is a Table 6-1 that provides the relative scale value for each switch when set in the open (0) or Closed (1) position. So then mathematically we can see dip switch " S1 " is at:

Switch Segment	Binary	Scale Value
1 (LSB)	0	0
2	1	0.586
3	0	0
4	1	2.344
5	0	0
6	1	9.375
7	0	0
8	1	37.500
9	1	75.000
10	0	0
11	1	300.000
12 MSB	1	600.000
		1025.805

PARTIAL LOOP TOLERANCE: (Loop Error - Bistable)

Partial Loop Error is the difference between the Total Loop Error and the Bistable (Pressure Switch) Error.

Pressure Initiate and Permissive Bypass Bistable

Partial Loop "As -Left" Tolerance (PL_{AL-PS})

$$PL_{AL-PS} = \pm (AL_{BS} - AL_{PS})$$
$$= \pm (7.60 \text{ psig} - 2.4 \text{ psig})$$
$$= \pm 5.2 \text{ psig} = \pm [(5.2 \text{ psig}/1200 \text{ psig}) \times 100\%] = \pm 0.433\% \text{ span}$$
$$= \pm [(0.433\%/100\%) \times 4 \text{ volts}] = \pm 0.01732 \text{ volts}$$

For ease of setting, the tolerance will be rounded down to 0.017 volts. Therefore:

$$PL_{AL-PS} = \pm 0.017 \text{ volts} = \pm 0.425\% \text{ span} = \pm 5.10 \text{ psig}$$

Partial Loop "As - Found" Tolerance (PL_{AF-PS})

PL_{AF-PS} = ± (AF_{BS} - AF_{PS})
= ± (16.34 psig - 2.4 psig)
= ± 13.94 psig = ± [(13.94/1200 psig) x 100%] = ± 1.16% span
= ± (1.16%/100% x 4 volts) = ± 0.0464 volts

For ease of setting (and to ensure that the sum of the Partial Loop errors do not exceed the Total Loop error), the tolerance will be rounded down to 0.046 volts.Therefore:

PL_{AF-PS} = ± 0.046 volts = ± 1.15% span = ± 13.80 psig

Differential Pressure Bistable

Partial Loop "As -Left" Tolerance (PL_{AL-DPS})

PL_{AL-DPS} = ± (AL_{DPS} - AL_{PS})
= ± (10.33 psig - 2.4 psig)
= ± 7.93 psig = ± [(7.93 psig/1200 psig) x 100%] = ± 0.661% span
= ± [(0.661%/100%) x 4 volts] = ± 0.02644 volts

For ease of setting, the tolerance will be rounded down to 0.026 volts. Therefore:

PL_{AL-DPS} = ± 0.026 volts = ± 0.650% span = ± 7.80 psig

Partial Loop "As - Found" Tolerance (PL_{AF-DPS})

PL_{AF-DPS} = ± (AF_{DPS} - AF_{PS})
= ± (22.69 psig - 2.4 psig)
= ± 20.29 psig = ± [(20.29 psig/1200 psig) x 100%) = ± 1.69% span
= ± [(1.69%/100%) x 4 volts] = ± 0.0676 volts

For ease of setting (and to ensure that the sum of the Partial Loop errors do not exceed the Total Loop error), the tolerance will be rounded down to 0.068 volts. Therefore:

PL_{AF-DPS} = ± 0.068 volts = ± 1.70% span = ± 20.40 psig

VI. RESULTS/CONCLUSIONS:

The following Tables list the applicable results of this calculation.

TABLE I
FSAR/Technical Specification Setpoints

END DEVICE	DESIGN SETPOINT	FSAR/TECHNICAL SPECIFICATION SECTION
MS-106-PS1 thru MS-113-PS1	600 PSIG	FSAR SECTION 7.2.4.2
MS-106-PS2 thru MS-113-PS2	125 PSID	FSAR SECTION 7.2.4.2
MS-106-PS3 thru MS-113-PS3	750 PSIG	FSAR SECTION 7.2.4.3.2

TABLE II
Transmitter Scaling/Calibration

TRANSMITTER	SCALING CORRECTION	CALIBRATION SPAN 0%	100%
MS-106-PT thru MS-113-PT	N/A	0 PSIG	1200 PSIG

TABLE III
Transmitter Setting Tolerances

TRANSMITTER	AS-LEFT (± % SPAN, mA, PSIG)	AS-FOUND (± % SPAN, mA, PSIG)
MS-106-PT	± 0.25% SPAN; 0.04 mA; 3.0 PSIG	± 0.84% SPAN; 0.134 mA; 10.08 PSIG
MS-107-PT	± 0.25% SPAN; 0.04 mA; 3.0 PSIG	± 0.84% SPAN; 0.134 mA; 10.08 PSIG
MS-108-PT	± 0.25% SPAN; 0.04 mA; 3.0 PSIG	± 0.84% SPAN; 0.134 mA; 10.08 PSIG
MS-109-PT	± 0.25% SPAN; 0.04 mA; 3.0 PSIG	± 0.84% SPAN; 0.134 mA; 11.08 PSIG
MS-110-PT	± 0.25% SPAN; 0.04 mA; 3.0 PSIG	± 0.84% SPAN; 0.134 mA; 11.08 PSIG
MS-111-PT	± 0.25% SPAN; 0.04 mA; 3.0 PSIG	± 0.84% SPAN; 0.134 mA; 11.08 PSIG
MS-112-PT	±0.25% SPAN, 0.04 mA, 3.0 PSIG	± 0.84% SPAN; 0.134 mA; 11.08 PSIG
MS-113-PT	±0.25% SPAN, 0.04 mA, 3.0 PSIG	± 0.84% SPAN; 0.134 mA; 11.08 PSIG

TABLE IV
Pressure Bistable Setting Tolerances

PRESSURE SWITCH	NORMAL CALIBRATED SETPOINT (PSIG)	SETPOINT VOLTAGE SETTING	TEST VOLTAGE SETTING	AS-LEFT	AS-FOUND
MS-106-PS1 thru MS-113-PS1	624.5 PSIG	3.081 VDC	2.981 VDC	± 0.008 VDC	± 0.008 VDC
MS-106-PS2 thru MS-113-PS2	94.5 PSID	1.315 VDC	1.415 VDC	± 0.008 VDC	± 0.008 VDC
MS-106-PS3 thru MS-113-PS3	732.37 PSIG	3.441 VDC	3.341 VDC	± 0.008 VDC	± 0.008 VDC

TABLE V
Total Loop Tolerance

LOOP END DEVICE	NORMAL CALIBRATION LOOP ERROR (± PSIG)	LOOP AS-LEFT (± PSIG)	LOOP AS-FOUND (± PSIG)
MS-106-PS1 thru MS-113-PS1	± 39.31 PSIG	± 7.60 PSIG	± 16.34 PSIG
MS-106-PS2 thru MS-113-PS2	± 55.21 PSIG	± 10.33 PSIG	± 22.69 PSIG
MS-106-PS3 thru MS-113-PS3	± 26.76 PSIG	± 7.60 PSIG	± 16.34 PSIG

TABLE VI
Partial Loop Tolerance
(Transmitter To Input of Bistable)

LOOP END DEVICE	LOOP - PRESSURE SWITCH AS - LEFT (± VDC, PSIG)	LOOP - PRESSURE SWITCH AS - FOUND (± VDC, PSIG)
MS-106-PS1 thru MS-113-PS1	± 0.017 VDC, 5.10 PSIG	± 0.046 VDC, 13.80 PSIG
MS-106-PS2 thru MS-113-PS2	± 0.026 VDC, 7.80 PSIG	± 0.068 VDC, 20.40 PSIG
MS-106-PS3 thru MS-113-PS3	± 0.017 VDC, 5.10 PSIG	± 0.046 VDC, 13.80 PSIG

TABLE VII
ADV Pressure Control Setting

LOOP END DEVICE	NORMAL CALIBRATION SETPOINT	DIP SWITCH " S1 " SETTING	INTEGRAL RATE	PROPORTIONAL BAND
MSV-025-PC	1025 PSIG	MSB. . . . . LSB 1 1 0 1 1 0 1 0 1 0 1 0 S12 . . . . S1	00333 (2 Rep/min.)	05000 (K=5)
MSV-026-PC	1025 PSIG	MSB. . . . . LSB 1 1 0 1 1 0 1 0 1 0 1 0 S12 . . . . S1	00333 (2 Rep/min.)	05000 (K=5)

TABLE VIII
Pressure Control Loop Tolerance
(Transmitter to Input of Control Module)

LOOP END DEVICE	NORMAL CALIBRATION LOOP ERROR (± % SPAN, VDC, PSIG)	LOOP AS-LEFT (± VDC; PSIG)	LOOP AS-FOUND (±VDC; PSIG)
MSV-025-PC	± 2.002% SPAN; 0.200 VDC; 24.02 PSIG	± 0.043 VDC; 5.16 PSIG	±0.116 VDC; 13.88 PSIG
MSV-026-PC	± 2.002% SPAN; 0.200 VDC; 24.02 PSIG	± 0.043 VDC; 5.16 PSIG	± 0.116 VDC; 13.88 PSIG

TABLE IX
Total Loop Errors

END DEVICE	NORMAL CALIBRATED LOOP ERROR (± % SPAN, PSIG)	HELB POST-ACCIDENT CALIBRATED LOOP ERROR (+,- % SPAN) (+,- PSIG)	LOOP AS-LEFT (± PSIG)	LOOP AS-FOUND (± PSIG)
MS-106-PI2 (Remote Shutdown)	± 4.44%, 53.28 PSIG	N/A	± 20	± 20
MS-107-PI2 (Remote Shutdown)	± 4.44%, 53.28 PSIG	N/A	± 20	± 20
MS-110-PI2 (Remote Shutdown)	± 4.44%, 53.28 PSIG	N/A	± 20	± 20
MS-111-PI2 (Remote Shutdown)	± 4.44%, 53.28 PSIG	N/A	± 20	± 20
MS-106-PI1 (Control Room)	± 4.44%, 53.28 PSIG	+9.09%, -8.36% +109.08, -100.32 PSIG	±20	±20

END DEVICE	NORMAL CALIBRATED LOOP ERROR (± % SPAN, PSIG)	HELB POST-ACCIDENT CALIBRATED LOOP ERROR (+,- % SPAN) (+,- PSIG)	LOOP AS-LEFT (± PSIG)	LOOP AS-FOUND (± PSIG)
MS-107-PI1 (Control Room)	± 4.44%, 53.28 PSIG	+ 9.21%, -8.41% +110.52, -100.92 PSIG	±20	±20
MS-110-PI1 (Control Room)	± 4.44%, 53.28 PSIG	+ 9.58%, - 8.57% +114.96, -102.84 PSIG	±20	±20
MS-111-PI1 (Control Room)	± 4.44%, 53.28 PSIG	+ 9.44%, -8.51% + 113.28, -102.12 PSIG	±20	±20
MS-106-PIR (Recording-106)	± 3.08%, 36.96 PSIG	+8.61%, -7.88% +103.32, -94.56 PSIG	±10	±20
MS-106-PIR (Indicating-106)	± 4.38%, 52.56 PSIG	+9.31%, - 8.58% + 111.72, - 102.96 PSIG	±25	±25
MS-107-PIR (Recording-107)	± 3.08%, 36.96 PSIG	+ 8.73%, -7.93% + 104.76,-95.16 PSIG	±10	±20
MS-107-PIR (Indicating-107)	± 4.38%, 52.56 PSIG	+ 9.42%, - 8.63% + 113.04, -103.56 PSIG	±25	±25
MS-110-PIR (Recording-110)	± 3.08%, 36.96 PSIG	+ 9.10%, -8.09% +109.2, -97.08 PSIG	±10	±20
MS-110-PIR (Indicating-110)	± 4.38%, 52.56 PSIG	+ 9.79%, -8.78% + 117.48, -105.36 PSIG	±25	±25
MS-111-PIR (Recording-111)	± 3.08%, 36.96 PSIG	+ 8.96%, - 8.03% + 107.52, -96.36 PSIG	±10	±20
MS-111-PIR (Indicating-111)	± 4.38%, 52.56 PSIG	+ 9.66%, - 8.73% + 115.92, -104.76 PSIG	±25	±25
RECALL Pt. RCL252 (MS-106-PT)	±2.91%, 34.92 PSIG	+ 8.57%, - 7.84% +102.84, - 94.08 PSIG	±12	±20
RECALL Pt. RCL253 (MS-107-PT)	±2.91%, 34.92 PSIG	+ 8.69%,-7.89% +104.28, -94.68 PSIG	±12	±20
RECALL Pt. RCL255 (MS-110-PT)	±2.91%, 34.92 PSIG	+ 9.06%, - 8.05% +108.72, - 96.60 PSIG	±12	±20

DOCUMENT IDENTIFICATION NO.	REVISION	REI/MAR/SP NUMBER/FILE
I92-0008	1	SP95 - 0002

FIGURE 1
EFIC Trip/Setpoints

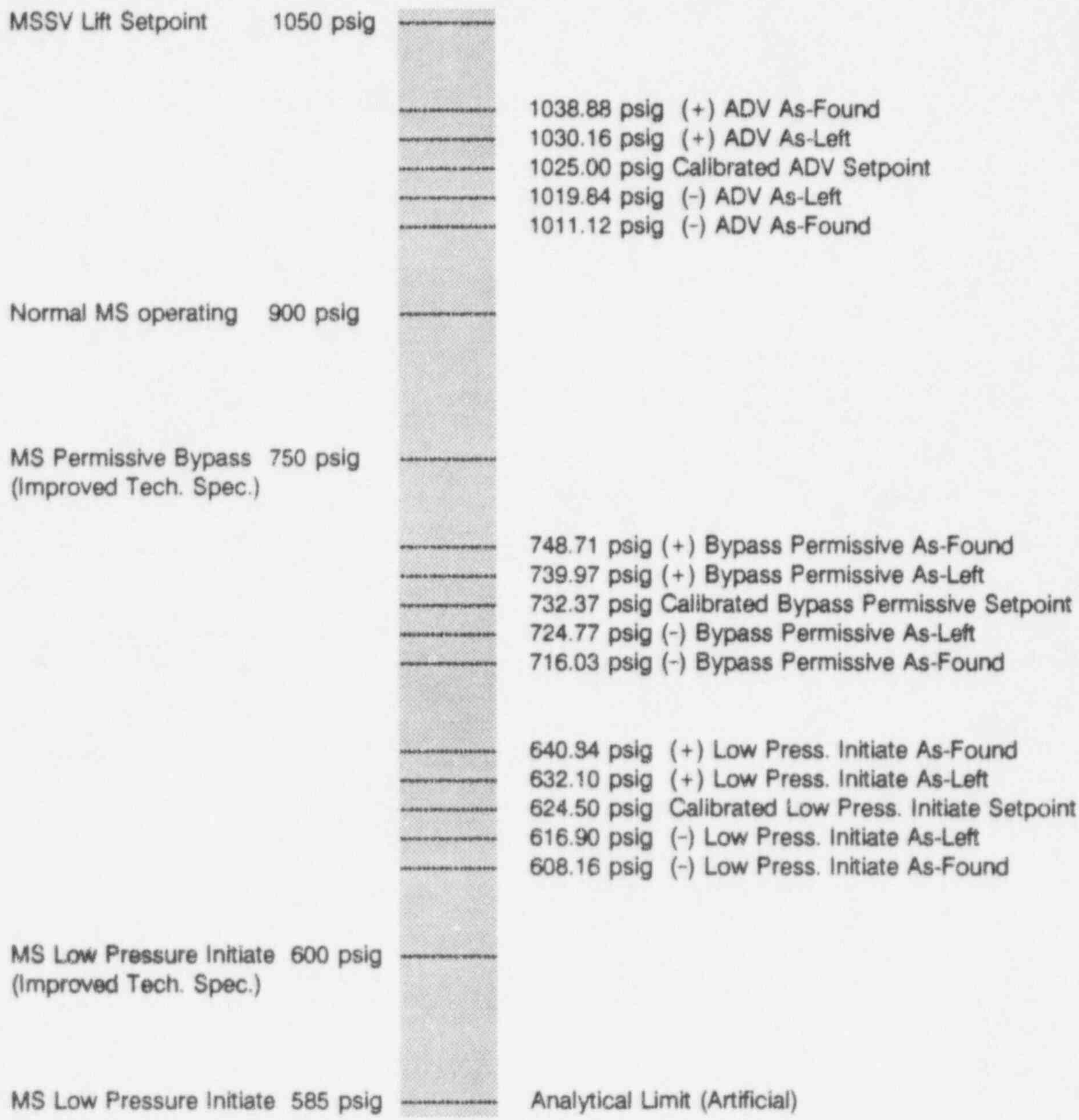
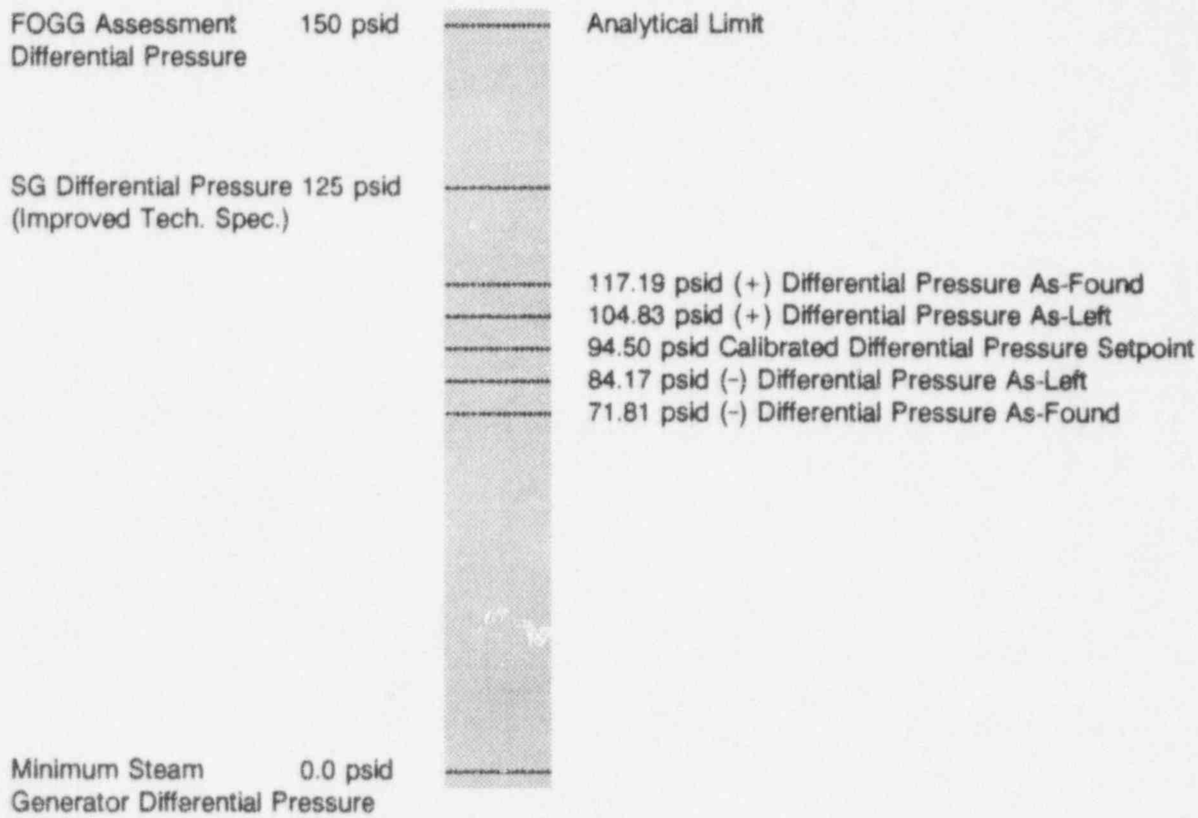
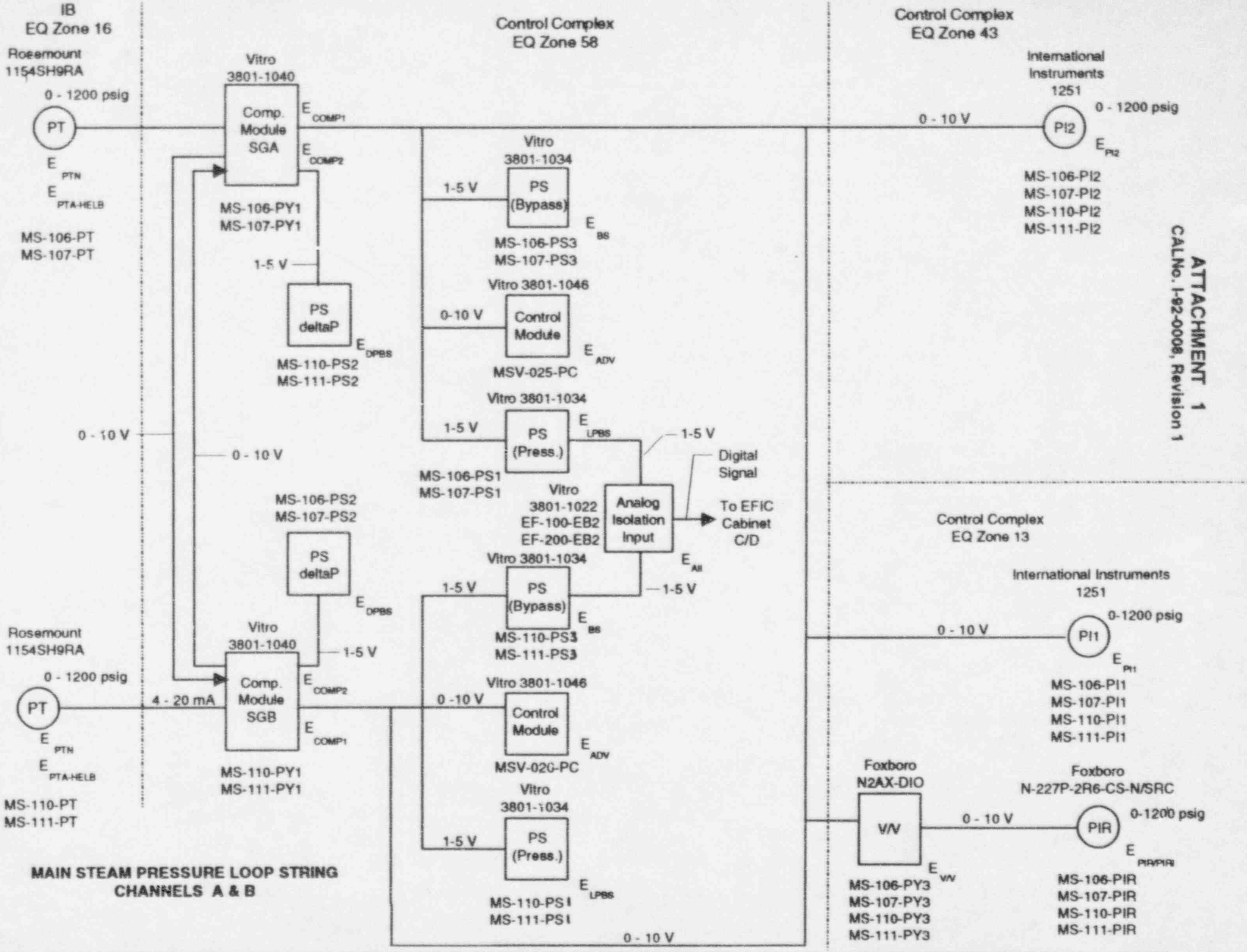


FIGURE 2
EFIC - Differential Pressure Setpoints



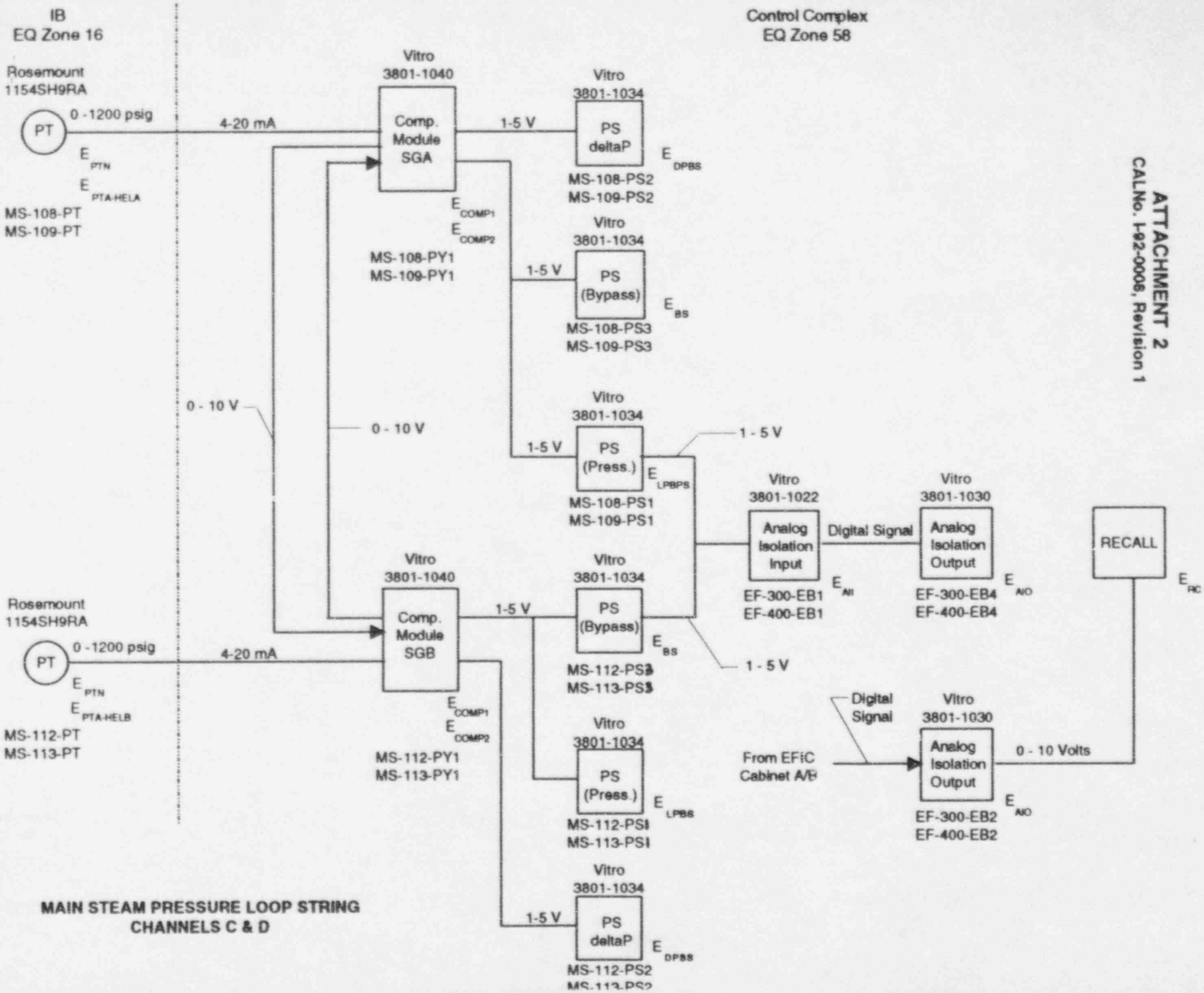
VII ATTACHMENTS

1. Main Steam Pressure Loop String Channels A and B.
2. Main Steam Pressure Loop String Channels C and D.
3. Rosemount Specification for the 1154 Series H transmitters from IM 1896, Rev. 0 (4 pages)
4. Rosemount Report 108220A, Revision A, titled " Analysis of the Model 1153 Series D Transmitter to 420°F for Three Minutes ". (7 pages)
5. International Instruments specification for the 1251 indicator from IM #586, Rev. 6 and IM #1300, Rev. 0 (2 pages).
6. B&W Document Identifier 51-1142173-00, EFIC System Accuracies (4 pages)
7. FAX Transmission dated 03/07/95 regarding isolated analog circuitry accuracy. (3 pages)
8. FAX Transmission to J. B. FitzGerald of Vitro Corp. from R. Iwachow of FPC dated 03/02/95 regarding error accuracy of the analog isolation input and output modules. (7 pages)
9. Babcock and Wilcox Engineering Information Record (EIR) Document Identifier 51-1138803-00, dated 11/23/82, titled, " EFIC Shutdown Bypass - Operator Action". (22 pages)
10. Foxboro Product Specification PSS 9-7C1 A for N227P recorder dated 1987. (4 pages)
11. Foxboro Technical Information TI 2AX-151 dated 1980. (2 pages)
12. Excerpt of Page 2 of Babcock and Wilcox Document Identifier 51-1123786-01, titled, " FOGG Verfication Study ". (1 page)
13. Deleted.
14. Deleted.
15. Lambda Electronics Instruction Manual for LCS-A Series Regulated Power Supplies (6 pages)
16. FAX Transmission dated March 16, 1995 from Rosemount Nuclear Instruments regarding drift specification for 1154 Series H transmitters. (2 pages)
17. FAX Transmission dated April 03, 1995 from Rosemount Nuclear Instruments regarding latest product data sheet PDS 4631, Revision Date 8/93 for Model 1154 Series H transmitters. (3 pages)
18. Rosemount Letter dated October 23, 1991 regarding the applicability of Rosemount Report 78212 to Model 1154 and 1154 Series H Transmitters (14 pages)
19. Atmospheric Dump Valve Control Tuning Parameters.



MAIN STEAM PRESSURE LOOP STRING CHANNELS A & B

ATTACHMENT 1
CALNo. I-92-0008, Revision 1



MAIN STEAM PRESSURE LOOP STRING
CHANNELS C & D

ANALYSIS/CALCULATION
DOC ID # I-92-0008 ATT # 3
REV 1 SHEET 1 OF 4

Section IV
SPECIFICATIONS AND REFERENCE DATA

NUCLEAR SPECIFICATIONS

(Qualified to IEEE Std. 323-1974 and IEEE Std. 344-1975 per Rosemount Report D8700096)

Radiation

Accuracy within ±(0.2% of Upper Range Limit + 0.2% of span) during first 30 minutes; ±(0.5% Upper Range Limit + 1% span) after 55 megarads TID; ±(0.75% Upper Range Limit + 1% span) after 110 megarads TID gamma radiation exposure.

Seismic

Accuracy within ±0.5% of Upper Range Limit after a disturbance defined by a required response spectrum with a horizontal ZPA of 8.5 g's, and a vertical ZPA of 5.2 g's.

Steam Pressure/Temperatures

Accuracy within ±(1.0% of Upper Range Limit + 1.0% of span) for Range Code 4-8; ±(2.0% Upper Range Limit + 0.5% span) for range code 9 during and after sequential exposure to steam at the following temperatures and pressures, concurrent with chemical spray for the first 24 hours:

420 °F, 85 psig for 3 minutes
350 °F, 85 psig for 7 minutes
320 °F, 75 psig for 8 hours
265 °F, 24 psig for 56 hours

Chemical Spray

Composition is 0.28 molar Boric Acid, 0.064 molar Sodium Thiosulfate, and Sodium Hydroxide as required to make an initial pH of 11.0 and a subsequent pH ranging from 8.5 to 11.0. Chemical spray is sprayed at a rate of 0.25 gal/min/ft^2.

Post DBE Operation

Accuracy at reference conditions shall be within ±2.5% of Upper Range Limit after exposure to DBE as described above for one year following DBE.

Quality Assurance Program

In accordance with 10CFR50, Appendix B.

Nuclear Cleaning

To 1 ppm maximum chloride content.

Hydrostatic Testing

To 150% of maximum working pressure or 2000 psi, (13.8 MPa), whichever is greater.

Traceability

In accordance with 10CFR50, Appendix B; chemical and physical material certification of process wetted parts.

Qualified Life

Dependent on average ambient temperature at the installation site (Figure 4-1). Replacement of amplifier and calibration circuit boards at the end of their qualified life permits extension of the transmitter's qualified life to the module's qualified life. Details of the test are in the Qualification Test Report D8700096.

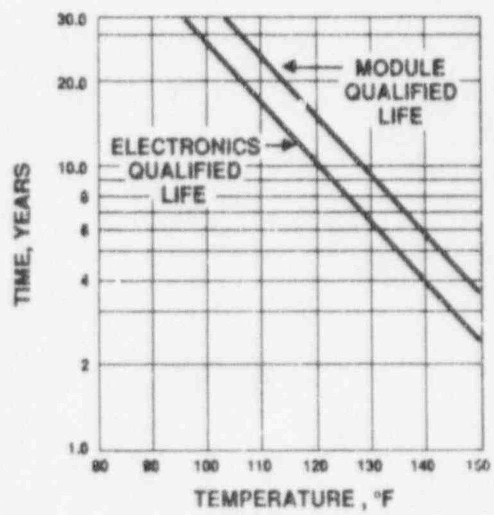


Figure 4-1. QUALIFIED LIFE VS. AMBIENT TEMPERATURE

FUNCTIONAL SPECIFICATIONS

Service

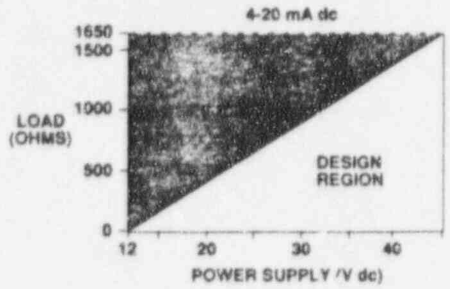
Liquid, gas or vapor.

Output

4-20 mA dc

Power Supply

Design limits as shown below:



Span and Zero

Continuously adjustable externally.

Zero Elevation and Suppression

Maximum zero elevation: 600% of calibrated span. Maximum zero suppression: 500% of calibrated span. Zero elevation and suppression must be such that neither the span nor the upper or lower range value exceed 100% of the Upper Range Limit.

Temperature Limits

Normal Operating Design Limits: +40° to 200 °F (+4.4° to 93.3 °C). Qualified Storage Limits: –40° to 120 °F (–40.0° to 48.9 °C).

Humidity Limits

0-100% RH. (NEMA 4X).

Volumetric Displacement

Less than 0.01 cubic inches. (0.16cm^3).

Turn-On Time

2 seconds maximum. No warmup required.

MODEL 1154DH AND 1154HH

Ranges

(4) 0-25 to 0-150 inH$_2$O (0-6.22 to 0-37.50 kPa)
(5) 0-125 to 0-750 inH$_2$O (0-31.08 to 0-186.50 kPa)
(6) 0-17 to 0-100 psi (0-0.12 to 0-0.69 MPa)
(7) 0-50 to 0-300 psi (0-0.34 to 0-2.07 MPa)
(8) 0-170 to 0-1000 psi (0-1.17 to 0-6.89 MPa) (DH Units Only)

Maximum Working Pressure

Static Pressure Limit

Static Pressure and Overpressure Limits

Model 1154DH: 0.5 psia to 2000 psig (3.4 kPa to 13.8 MPa) maximum rated static pressure for operation within specifications. 2000 psig (13.8 MPa) overpressure on either side without damage to the transmitter.

Model 1154HH: 0.5 psia to 3000 psig (3.4 kPa to 20.7 MPa) maximum rated static pressure for operation within specifications. 3000 psig (20.7 MPa) overpressure on either side without damage to the transmitter.

MODEL 1154SH

Ranges

(9) 0-500 to 0-3000 psig (0-3.45 to 0-20.68 MPa)

Maximum Working Pressure

Upper Range Limit.

Overpressure Limits

Operates within specifications from 0.5 psia (3.4 kPa) to Upper Range Limit. Overpressure limit is (4500 psig (31.0 MPa) without damage to the transmitter.

PHYSICAL SPECIFICATIONS ALL MODELS

Materials of Construction

Isolating Diaphragms and Drain/Vent Valves
316 SST

Process Flanges
316 SST

Process O-Rings
316 SST

Electronics Housing O-Rings
Ethylene Propylene

Fill Fluid
Silicone Oil

Flange Bolts
Plated Alloy Steel, per ASTM A-540

Electronics Housing
316 SST

Module Shroud
304L SST

Module Shroud Potting
Silicone RTV

Process Connections

3/8 in. *Swagelok*† compression fitting, 316 SST. (1/4 in.-18 NPT optional).

Electrical Connections

1/2-14 NPT conduit with screw terminals

Weight

26.6 pounds, (12.1 kg) including mounting bracket.

†Swagelok is a trademark of Swagelok Co.

PERFORMANCE SPECIFICATIONS

(At Reference Conditions)

Accuracy

±0.25% of calibrated span. Includes combined effects of linearity, hysteresis and repeatability.

Deadband

None.

Drift

±0.2% of Upper Range Limit for eighteen months.

Temperature Effect

±(0.15% of Upper Range Limit + 0.35% span) per 50 °F ambient temperature change between 40° F and 130° F.

Overpressure Effect

Model 1154DH: Maximum zero shift after 2000 psi (13.8 MPa) overpressure: ±0.25% of Upper Range Limit (Range Code 4); ±1.0% of Upper Range Limit (Range Code 5); ±3.0% of Upper Range Limit (Range Codes 6, 7); 6% of Upper Range Limit (Range Code 8).

Model 1154SH Maximum zero shift after 4500 psi (31.0 MPa) overpressure: ±0.5% of Upper Range Limit.

Model 1154HH: Maximum zero shift after 3000 psi (20.68 MPa) overpressure: ±1.0% of Upper Range Limit (Range Code 4); ±2.0% of Upper Range Limit (Range Code 5); ±5.0% of Upper Range Limit (Range Codes 6, 7).

Static Pressure Zero Effect

Model 1154DH Zero Effect: ±0.2% of Upper Range Limit per 1000 psi (6.9 MPa) (Range Codes 4, 5); ±0.5% of Upper Range Limit per 1000 psi (6.9 MPa) (Range Codes 6, 7, 8).

Model 1154HH Zero Effect: ±0.66% of Upper Range Limit per 1000 psi (6.9 MPa) (all Range Codes).

Static Pressure Span Effect

Is systematic and can be calibrated out for a particular pressure before installation. Correction uncertainty: ±0.5% of reading/1000 psi.

Power Supply Effect

Less than 0.005% of output span/volt.

Load Effect

No load effect other than the change in voltage supplied to the transmitter.

Mounting Position Effect

No span effect. Zero shift of up to 1.5 inH_2O (372 MPa) (Range Codes 4, 5) which can be calibrated out. For higher ranges, effect is superseded by Accuracy Specifications.

Response Time

Fixed time constant (63%) at 100 °F (37.8 °C) as follows: 0.5 sec. for Range Code 4, 0.2 sec. for all other Range Codes.

Adjustable damping option available.

Table 4-1. TRANSMITTER DESIGN SPECIFICATIONS

MODEL	
1154	ALPHALINE PRESSURE TRANSMITTERS FOR NUCLEAR APPLICATIONS

CODE	PRESSURE MEASUREMENT
D	Differential Pressure, 2000 psig (13.8 MPa) Static Pressure Rating
H	Differential Pressure, 3000 psig (20.62 MPa) Static Pressure Rating
S	Sealed Reference Pressure

CODE	SERIES
H	Transmitter Enclosed in a Stainless Steel Module Shroud

	PRESSURE RANGES		
CODE	MODEL 1154DH (DIFFERENTIAL)	MODEL 1154HH (DIFFERENTIAL)	MODEL 1154SH (SEALED REF.)
4	0-25 to 0-150 inH_2O (0-6.22 to 0-37.5 kPa)	0-25 to 0-150 inH_2O (0-6.22 to 0-37.5 kPa)	N/A
5	0-125 to 0-750 inH_2O (0-31.08 to 0-186.5 kPa)	0-125 to 0-750 inH_2O (0-31.08 to 0-186.5 kPa)	N/A
6	0-17 to 0-100 psid (0-0.12 to 0-0.69 MPa)	0-17 to 0-100 psid (0-0.12 to 0-0.69 MPa)	N/A
7	0-50 to 0-300 psid (0-0.35 to 0-2.07 MPa)	0-50 to 0-300 psid (0-0.35 to 0-2.07 MPa)	N/A
8	0-170 to 0-1000 psid (0-1.15 to 0-6.89 MPa)	N/A	N/A
9	N/A	N/A	0-500 to 0-3000psig (0-3.45 to 0-20.62MPa)

CODE	OUTPUT
R†	Standard 4-20 mA

CODE	FLANGE OPTION
A	Welded 3/8 in. *Swagelok*™ Compression Fitting Process Connection and Vent/Drain Valve Welded to Flanges
B*	1/4 in. NPT Process Connection (Vent Drain Welded to Flange)
C*	1/4 in. NPT Process Connection and Drain Hole (Vent/Drain Valve Not Supplied)

1154	D	H	4	R	A	← TYPICAL MODEL NUMBER

† The Model 1154 Series H with the R OUTPUT CODE ELECTRONICS is also available with adjustable damping. This option is specified by appending "N0037" to the end of the complete model number. For Example: 1154DH4RAN0037

* NOTE: Customer assumes responsibility for qualifying process interfaces on these options. Contact Rosemount Inc. for details.

ANALYSIS/CALCULATION

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Rosemount

ROSEMOUNT INC., POST OFFICE BOX 35129 / MINNEAPOLIS, MINNESOTA 55435 / TEL. (612) 941-5560

TWX 910-576-3103, TELEX 29-0183

NUCLEAR OPERATIONS GROUP

ANALYSIS OF THE MODEL 1153 SERIES D TRANSMITTERS

TO 420°F FOR THREE MINUTES

RMT REPORT 108220A

REVISION A

Approved by Eng. *Sharon Wildgen* Date 10/21/82

SHARON WILDGEN - Nuclear Project Engineer

Approved by Eng. *Charles A Odegaard* Date 10/5/82

CHUCK ODEGAARD - Nuclear Operations Manager

Approved by Q.A. *Gerald G Anderson* Date 11/5/82

JERRY ANDERSON - Quality Assurance Supervisor

Approved by Q.A. *Michael N Pollack* Date 10-25-82

MIKE POLLACK - Quality Project Engineer

REVISION STATUS

Rev	Page	Paragraph	Change Description	Eng. App.	Eng. Supv. App.	Mfg. Eng. App.	Q.A. App.	Env. Test Supv. App.	Cust. Data Coord. App.	Effectivity S/N or Date
A			Original Release	[signature]	[signature]		[signature]			11/5/82

ANALYSIS OF THE MODEL 1153 SERIES D TRANSMITTER TO 420 F FOR THREE MINUTES

RMT REPORT 108220A

REVISION A

1.0 SCOPE

The 1153 Series D transmitter was tested during qualification to the following steam temperature/pressure profile: 350 F, 85 psig for 10 minutes; 320 F, 60 psig for 3 hours; 240 F, 27 psig for 21 hours; 175.4 F, 3 psig for 30 days. There are numerous applications where a LOCA condition will cause high temperature transients in excess of 350 F. For these applications it is necessary to have a transmitter that is qualified to operate above 350 F for short time periods. The intent of this report is to justify raising the temperature limit during a LOCA condition to 420 F for 3 minutes, followed by 350 F for 7 minutes in place of the 1153 Series D steam profile of 350 F for 10 minutes.

2.0 REFERENCES

2.1 420 F Temperature Test Results, Model 1153 Series B, RMT Report 482230, Rev. None.

2.2 1153 Series D Qualification Test Report (pending).

2.3 Internal Thermal Response of Transmitter Housings to Steam Impingement, Rosemount models 1153 Series B and D, RMT Report 78212, Rev. A.

3.0 ANALYSIS

The 1153 Series D transmitter is virtually identical to the 1153 Series B transmitter. The only differences are: 1) the use of an elev. /supp. switch vs. jumper wires, and 2) different electronics housings. The 1153 Series B is intended for BWR applications (and out-of-containment PWR applications) and has an aluminum housing. The 1153 Series D is intended for PWR applications and has a stainless steel housing. Functionally, they are identical, therefore, the 420 F temperature test performed on the 1153 Series B will provide the basis for justifying a 420 F temperature spike for the 1153 Series D.

A test was setup to expose seven 1153 Series B transmitters to superheated steam at 420 F for 3 minutes. The transmitters had previously been exposed to 24.4 megarads gamma radiation and two steam temperature/pressure tests typical of a BWR. Radiation shielding for stainless steel is about twice the value for aluminum, therefore 24.4 megarads on an aluminum housing is approximately equivalent to 50 megarads on a stainless steel housing.

During the test, thermocouple readings inside the steam chamber indicated the transmitters were exposed to temperatures in excess of 435 F for more than four minutes. The temperature transient from room temperature to 420 F took approximately 1 minute to achieve. During the test, chamber pressure was in excess of 115 psig for more than two minutes. Throughout the test all seven units continued functioning and the maximum errors were within the present LOCA specification of ± 8.0% of upper range limit.

Since the electronics housings are different, the temperature effect on the electronics must be determined separately. During the 1153 Series B test, the maximum average electronics board temperature was 326 F. (Ref. 2.1). Since the electronics in the two models are identical, test results will be identical if the 1153 Series D electronics board does not exceed 326 F.

The time constant for the stainless steel housing used on the 1153 Series D is approximately 4.8 minutes. (Ref. 2.3). Using this value, the electronics board temperature can be determined as follows:

$$(T1 - T0) = (T2 - T0)\,(1 - \exp(-t/TC))$$

Where:

T0 = Temperature of the electronics board at time = 0 (= 70 F)
T1 = Temperature of the electronics board at time = t
T2 = Temperature of the chamber at time = t (= 420 F)
t = time (= 3 minutes)
TC = time constant (= 4.8 minutes)

$T1 - 70\ F = (420F - 70\ F)\ (1 - \exp(-3/4.8))$

$T1 = 233\ F$

The temperature of the electronics board will be approximately 233 F after the transmitter has been exposed to superheated steam at 420 F for 3 minutes. After the chamber temperature is lowered to 350 F, the electronics board temperature will continue to heat as follows:

$T1 - T0 = (T2 - T0)\ (1 - \exp(-t/TC))$

Where:

T0 = Temperature of the electronics board at time = 0 (= 233 F)

T1 = Temperature of the electronics board at time = t

T2 = Temperature of the chamber at time = t (= 350 F)

t = time (= 7 minutes)

TC = time constant (= 4.8 minutes)

$T1 - 233\ F = (350\ F - 233\ F)\ (1 - \exp(-7/4.8))$

$T1 = 323\ F$

The temperature of the electronics board will be about 323 F after the temperature profile of 420 F for 3 minutes, followed by 350 F for 7 minutes. This is approximately the temperature achieved during the 1153 Series B test.

4.0 CONCLUSION

There are situations where an 1153 Series D transmitter could see a 420 F temperature for 3 minutes during a LOCA condition. Although the 1153 Series D has never been tested to 420 F, the 1153 Series B transmitter was exposed to

temperatures in excess of 420 F for at least 3 minutes. During the 1153 Series B test, the maximum errors were within the existing ± 8.0% of upper range limit LOCA specification and the maximum temperature of the electronics was 326 F. The calculated maximum temperature is 323 F for the 1153 Series D electronics exposed to 420 F for 3 minutes, followed by 350 F for 7 minutes. The electronics and function of the two models are identical, therefore by similarity, the 1153 Series D would continue to function within specification if exposure to 420 F for 3 minutes was included in the accident profile.

ANALYSIS/CALCULATION

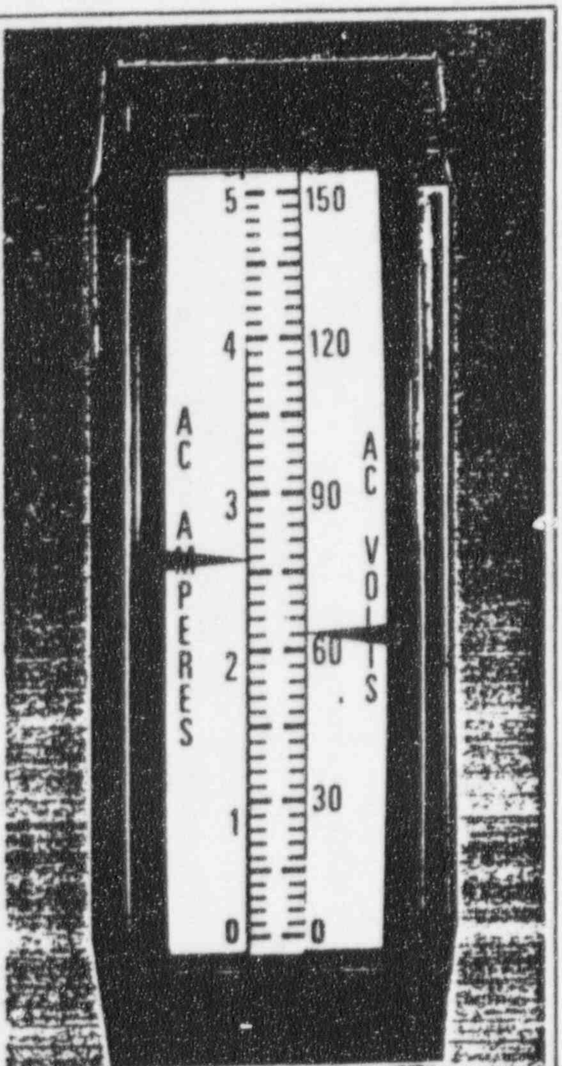
DOC ID # I-92-0008 ATT # 5

REV 1 SHEET 1 OF 2

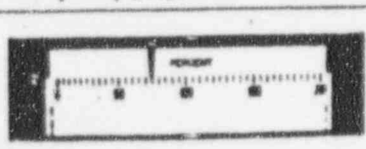
International Instruments
DIVISION OF SIGMA

SERIES
1151/1251

Single-Dual 6" Edgewise Switchboard Instruments



Series 1251 — Dual Vertically Mounted Instrument with two independent inputs



Series 1151 Single Horizontally Mounted Instrument

Description

The Series 1151 is a single, edgewise, switchboard class instrument utilizing a patented flat meter movement. The exclusive cantilevered coil construction of the jeweled D'Arsonval movement produces torque to weight ratios (meter efficiency) four times greater than conventional edgewise movements of equivalent size.

The availability of this thin, high performance movement permits the inclusion of two fully independent meters in a single popular case. 1251 is the Series Number for the dual unit.

The case of the Series 1151 or 1251 is made of a self-extinguishing, non-dripping plastic, and the window is Lexan.* An external zero adjustor screw for each movement is located in the front.

Anti-parallax, bi-level scales reduce reading errors on both Series 1151 and Series 1251.

Illuminated Instruments are also available.

Exclusive Features

Designed for Nuclear Power Industry
The Series 1151/1251 edgewise, switchboard instruments were initially developed to meet the demanding specifications of the Atomic Energy Commission with respect to seismic qualifications, long-life and high accuracy. The resulting product line is the most rugged and reliable instrument available.

Independent Dual Instruments
Two independent meters can be included in one popular size six inch instrument case. Thus, related functions from a single source can be displayed in a single unit, e.g., specific gravity and temperature, tank level and density, speed and R.P.M. etc.

Additionally, you save three ways with the Series 1251 through:

- Lower Initial Cost per Meter
- Reduced Panel Space
- Less panel fabrication and assembly labor time

ANALYSIS/CALCULATION
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Standard Engineering Legends

ELECTRICAL

AC	DC	Misc.
AC Amperes	DC Amperes	Hertz
AC Kiloamperes	DC Kiloamperes	Horsepower
AC Kilovars	DC Kilovolts	Generator Amps
AC Kilovolts	DC Microamperes	Percent Current
AC Kilowatts	DC Milliamperes	Percent Load
AC Megawatts	DC Millivolts	Phase Angle
AC Milliamperes	DC Volts	Power Factor
AC Millivolts		
AC Vars		
AC Volts		
AC Watts		

TIME

Hours	Minutes	Seconds	Misc.
BBL/HR	BBL/MIN	—	Gallons Per Minute
CFH	CFM	CFS	LBS Per Minute
CPH	CPM	—	Tons Per Hour
FPH	FPM	FPS	LBS/HR x 10[4]
GPH	GPM	GPS	LBS/HR
IPH	IPM	IPS	
KPH	KPM	KPS	
LPH	LPM	LPS	
MPH	MPM	—	
PPH	PPM	PPS	
RPH	RPM	RPS	
YPH	YPM	YPS	

TEMPERATURE	PRESSURE (VACUUM)	VOLUME/WEIGHT	LEVEL (LENGTH)	MISCELLANEOUS
Degrees	PSI	Gallons	Feet	Percent
Deg. C	PSIA	LBS	Feet W.C.	Percent Open
Deg. F	PSID	LBS Per Gallon	Feet Water Level	Steps/Min.
Deg. K	PSIG	Tons	Inches	
	VAC. IN. HG.		Inches W.C.	
	VAC. MM. HG.		Level Feet	
			Level Gallons	
			Level Inches	
			Level Percent	

Specifications

Accuracy:	±1-½% F.S. Value for DC Ranges ±2-½% F.S. Value for AC Ranges
Repeatability:	±2% F.S.
Overload:	Sustained—120% for 8 hours Momentary—10 times rated current
Response Time:	2.5 Secs. Max.
Damping Factor:	5 minimum (Per ASA C39.1)
Hi-Pot:	2600 Volts RMS terminal to case for 1 minute
Temperature (Operating):	−20 to 50°C
Shock:	50 G's
Pointer:	Triangular type, color—cerise red
Scale:	Length—4.5 inches Marking—black lettering on white background. Other combinations available.
Standard Movement:	Zero left on horizontal or zero bottom on vertical (Zero center, right or top optional)
Mounting:	Front of panel with captivated mounting assembly.
Terminals:	¼"-28, ¾" long (Plug-in connector optional)
Materials of Construction:	Case—Noryl® Crystal—Lexan®
Finish:	Standard—black case Optional—gray case
Weight:	Single Movement—25 oz. Dual Movement—30 oz.
Siesmic Qualification:	See International Instruments Test Report # SBI-2

Standard Ranges

RANGES	APPROX. RESISTANCE (OHMS)
D.C. Microammeters	
0-100	2300
0-200	1540
0-500	275
D.C. Milliammeters	
0-1	71.0
0-2	14.5
0-3	9.7
0-5	2.7
0-10	1.8
0-50	0.8
0-100	0.5
0-200	0.25
0-500	0.1
0-800	0.062
Suppressed	
1-5	2.20
4-20	1.25
10-50	.8
D.C. Ammeters	
0-1	0.05
0-3	0.0166
0-5	50 MV
0-10	50 MV
0-15	50 MV
Over 15	Require external 50 MV Shunt

RANGES	APPROX. RESISTANCE (OHMS)
D.C. Millivoltmeters	
0-50	12.5
0-100	25.0
D.C. Voltmeters	
0-5	1000 ohms/volt
0-10	sensitivity
0-15	all ranges
0-25	
0-30	
0-50	
0-100	
0-150	
0-200	
0-300	
0-500	
A.C. Milliammeter	
0-1	1000
0-10	125
0-100	10
0-500	2
A.C. Voltmeters	
0-10	1000 ohms/volt
0-50	sensitivity
0-150	all ranges
0-300	
0-500	
A.C. Ammeters	
0-5	

BWNP-20440-1 (11-82)

BABCOCK & WILCOX - NPGD

ENGINEERING INFORMATION RECORD

Safety Related: Yes ☒ No ☐

DOCUMENT IDENTIFIER 51 - 1142173-00

TITLE EFIC System Accuracies

PREPARED BY M.E. Thistle DATE 4/11/83

REVIEWED BY N. Rodgers DATE 4/11/83

REMARKS:

This document is to put in to Records the Vendor's analysis of the EFIC accuracies and provide the basis for closed loop control accuracy.

The EFIC specification 08-1123898 in Section 9.7 required the vendor to provide for information, the overall accuracies for the EFIC strings. The analytical method was also required. Vitro letter VL-CS-T-75(83) has been provided to fulfill these requirements. A copy of the memo is attached for record.

As stated in the memo the compensation module accuracy is ±1.00% for high/low range and ±1.25% for full range. Trip functions use only the high/low range. The trip accuracy will be the sum of the compensation module and the bistable accuracy (Ref. 08-1123898 section 6.2.7) of 0.2%. For trip functions the EFIC accuracy is ±1.2%.

The accuracy for the control module is given as open loop worst case. For application of the EFIC as a system, however, the control module is in a closed loop configuration. The system's level transmitters provide feedback through the compensation module.

The purpose of the feedback is to reduce the response error. This is accomplished by the feedback signal returning all errors from the output to the error detection stage. Any errors introduced by the various stages are detected and corrected by the subtractor (error detection) stage. Only errors introduced by the subtractor stage and the setpoint itself will not be corrected.

Therefore for closed loop control the error of the control module can be considered to be ± 0.35% (± 0.25% subtractor and 0.1% setpoint).

For the EFIC portion of a total string in a closed loop configuration the accuracy will be the compensation module plus the control module closed loop accuracy of 0.35%.

Low range accuracy = ± (1.0% + 0.35%) = ± 1.35%
High range accuracy = ± (1.25% + 0.35%) = ± 1.60%

ANALYSIS/CALCULATION

DOC ID # I-92-0008 ATT # 6

REV 1 SHEET 2 OF 4

AUTOMATION INDUSTRIES, INC.
VITRO LABORATORIES DIVISION
14000 GEORGIA AVE
SILVER SPRING MARYLAND 20910
(301) 871-7200

VL-CS-T-75(83)
(Job 03801)

March 31, 1983

Mr. C. M. Seay, C.P.M.
Group Leader
The Babcock and Wilcox Company
Utility Power Generation Division
Post Office Box 1260
Lynchburg, Virginia 24505-1260

NPGD PURCHASING
APR 04 1983
RECEIVED

P.O. Nos. 039238LF, 039239LF, and 039240LF
EMERGENCY FEEDWATER INITIATION AND CONTROL SYSTEM

Dear Mr. Seay:

As requested by Babcock and Wilcox TWX CMS-#82-1782 dated December 13, 1982, Vitro Laboratories Division hereby clarifies the derivation of the design accuracy requirements for the EFIC System being supplied to Arkansas Nuclear 1, Crystal River 3, and Rancho Seco Nuclear Power Plants. The subject TWX references specification paragraph 6.4.5 which addresses accuracy requirements of an "Analog Computing Unit". The EFIC System contains no "Analog Computing Unit" as described in paragraph 6.4. The EFIC System as designed, also contains no "Low Selector", paragraph 6.10, "Rate Limited Follower", paragraph 6.11, "Proportional Plus Integral", paragraph 6.12, or "Setpoint and Bias Units", paragraph 6.15. The EFIC System does contain two high-density, custom-designed modules which accomplish the functions of paragraphs 6.4, 6.10, 6.11, 6.12, and 6.15. The Compensation Module performs all analog input conditioning functions, including steam generator level compensation. The Control Module performs all steam generator control associated functions.

Both analog and digital circuitry are utilized in the Compensation Module design. The Control Module is exclusively digital in design between the input analog-to-digital conversion and the output digital-to-analog conversion. State-of-the-art digital techniques and high-density circuit packaging techniques were required in these modules to achieve the overall space requirement, accuracy, and spare capability of the B&W specification. This necessitated combining several functions detailed in the specification into these two single modules.

The inaccuracy of each module (±1.00% of span for Compensation Module low and high range outputs, ±1.25% of span for Compensation Module full range output, and 1.20% of span plus 0.2% of output for Control Module outputs) was determined by algebraically adding the individual inaccuracies of each functional stage. Algebraically adding individual inaccuracies to obtain worst case design inaccuracies is standard engineering practice.[1]

[1] See Curtis D. Johnson, Process Control Instrumentation Technology, John Wiley & Sons, New York, NY, 1982, p.26.

EIR 51-1142173-00

SH 2 of 4

ANALYSIS/CALCULATION
DOC ID # I-92-0008 ATT # 6
REV 1 SHEET 3 OF 4

AUTOMATION INDUSTRIES, INC.
VITRO LABORATORIES DIVISION

VL-CS-T-75(83)
(Job 03801)
March 31, 1983

B&W/C. M. Seay

For the Compensation Module, these stages and inaccuracies are detailed in Vitro proposal VL-C-63162, dated April 20, 1981, Section 3.4.1.1. Each Computing Function within the Compensation Module is apportioned an inaccuracy of ±0.25% of span as specified in paragraph 6.4.5 of Specification 08-1123898-03. Therefore, the total Compensation Module inaccuracy is as summarized below:

Computing Function	Full Range Inaccuracy	Low/High Range Inaccuracy
Input Buffer/Scaler	±0.25%	±0.25%
Density Computation	±0.25%	±0.25%
Compensation	±0.25%	±0.25%
Full Range Summing	±0.25%	———
Output Buffer/Scaler	±0.25%	±0.25%
	±1.25%	±1.00%

For the Control Module, the total worst case is in the full range mode and was determined as shown below. For those Computing Functions not otherwise specifically identified, paragraph 6.4.5 was applied.

Computing Function	B&W Logic 12 Dwg	Inaccuracy	B&W Specification Paragraph
12" Bias	C5	(±0.10%)	6.15
Summer	C4	±0.25%	6.4.5
RLF	C7	±0.20%	6.11.3
Function Generator	C9	(±0.25%)	6.4.5
Multiplier	C10	(±0.25%)	6.4.5
Low Selector	C8	±0.15%	6.10.2
20'/31.5' Setpoint	C12/C13	±0.10%	6.15
Subtractor	C6	±0.25%	6.4.5
Proportional Plus Integral	C3	±0.25%	6.4.5
		±1.20%	

The output buffer stage of the Control Module is accurate to within ±0.2% of its input (reference paragraph 6.7). The total inaccuracy of the Control Module is ±1.40%.

For determining total accuracy, the values in parenthesis were disregarded since they only affect the rate of change of the rate limited follower, and therefore are not truly an additive error.

ANALYSIS/CALCULATION

DOC ID # I-92-0008 ATT # 6

REV 1 SHEET 4 OF 4

AUTOMATION INDUSTRIES, INC.
VITRO LABORATORIES DIVISION

VL-CS-T-75(83)
(Job 03801)
March 31, 1983

B&W/C. M. Seay

The above derivations provide the total open loop, worst case inaccuracies for both the Compensation Module and the Control Module. These inaccuracies are verified in the individual module test procedures by taking the algebraic differences between the measured value of the output and the calculated ideal value. Because the modules are designed as integral units, the accuracy of the individual Computing Functions cannot be verified. Since the inaccuracy of the total module is verified to be within the inaccuracy of the above calculations, this procedure is justification of compliance with the accuracy requirements of paragraph 6.4.5.

If there are any questions of a technical nature pertaining to the above, please contact J. B. FitzGerald at (301) 251-3511.

Very truly yours,

C. E. Suer
Department Head
CS Department

JBF:fm
Distribution
B&W/CMSeay

ANALYSIS/CALCULATION
DOC ID # 1-92-0008 ATT # 7
REV 1 SHEET 1 OF 3

Vitro
a Tracor company

Vitro Corporation
45 West Gude Drive
Rockville, MD 20850-1160
301 738-4000

COF FAX COVER SHEET

DATE: 3/7/95

LOG # COF-F-6(95)

TO: Richard Iwachow
Florida Power Corporation
St. Petersburg, FL 33711

TELEPHONE NUMBER: 813-866-4593 FAX # 4984

FROM: Joseph B. FitzGerald JBF

TELEPHONE NUMBER: 301-231-1117

SENT BY: Peg Olen

TELEPHONE NUMBER: 301-231-2809

Per your fax request dated March 2, 1995, I have reviewed the EFIC design data files for information on the accuracies for the Non-1E analog isolated outputs. The ±0.5% isolated analog circuit accuracy specified by B&W Specification 08-1123898-03 is the accuracy of this circuit. This was a change from Specification 08-1123898-01 as requested by Vitro letter VL-CS-T-22(82) dated May 25, 1982, which is attached. This accuracy is from 1E analog isolation input to Non-1E analog isolation output (includes digital isolator accuracy).

If you have any questions regarding this information, please call me at 301-231-1117.

ANALYSIS/CALCULATION

DOC ID # I-92-0008 ATT # 7

REV 1 SHEET 2 OF 3

AUTOMATION INDUSTRIES, INC.
VITRO LABORATORIES DIVISION
14000 GEORGIA AVE
SILVER SPRING, MARYLAND 20910
(301) 871-7200

VL-CS-T-22(82)
(Job 03801.01)

May 25, 1982

Mr. C. M. Seay, C.P.M. Senior Buyer, NPGD Purchasing
The Babcock and Wilcox Company
Nuclear Power Generation Division
3315 Old Forest Road
Lynchburg, Virginia 24505

P.O. Nos. 039238LF, 039239LF, and 039240LF
EMERGENCY FEEDWATER INITIATION AND CONTROL SYSTEMS (EFIC)
ARKANSAS POWER AND LIGHT
FLORIDA POWER CORPORATION
SACRAMENTO MUNICIPAL UTILITY DISTRICT

Dear Mr. Seay:

The following clarifications and modifications are required to the EFIC Equipment Specification 08-1123898-01.

1. Specification paragraph 6.5.2.A requires ±0.25% isolated analog circuit accuracy. The multiplexed analog isolation scheme previously developed for B&W equipment and proposed for the EFIC equipment is capable of an accuracy of ±0.5%. This was reported to Mr. Al Lloyd of B&W on March 11, 1982 who stated that the ±0.5% accuracy was adequate and agreed to take appropriate action.

2. Light-Emitting-Diodes located in the EFIC to annunciate test confirmation signals, will illuminate continuously if the full complement of test confirmation signals is present; will flash if one or more but less than the full complement of test results is present; will not illuminate if no test confirmation signals are present. This is in accordance with specification paragraphs 5.4.5.I and 5.4.5.J. However, specification paragraph 7.5 states "Lamp failures shall be self-indicating unless justified by the Vendor." As presented above, the specified functional operation of test confirmation indicators is not compatible with the self-annunciating fault requirements of paragraph 7.5, therefore, the test confirmation indicators are hereby requested to be exempt from the requirement of paragraph 7.5.

3. Specification drawing 1122948, Logic 12, depicts a time delay utilized in transfers T2, T3 and T7. No time delay adjustability range or accuracy is specified. Therefore, Vitro will provide adjustment from 1/64 of a second to 64 seconds and an accuracy compatible with the accuracy requirements of the Control Module.

ANALYSIS/CALCULATION		
DOC ID # 1-92-0008	ATT # 7	
REV 1	SHEET 3	OF 3

AUTOMATION INDUSTRIES, INC.
VITRO LABORATORIES DIVISION

VL-CS-T-22(82)
(Job 03801.01)
May 25, 1982

The Babcock and Wilcox Company

If there are any questions of a technical nature pertaining to the above item, please contact J. B. FitzGerald at (301)871-4710. For questions of a contractural nature, please contact C. L. Meredith at (301)871-2382.

Very truly yours,

CESuer

C. E. Suer
Department Head
CS Department

JBF:tao
Distribution
B&W/CMSeay

Internal Distribution
WLFreienmuth/JCDougherty
CESuer/PRHepner
GLMeredith
WCChandler
LRLepkowski/JBFitzGerald

ANALYSIS/CALCULATION		
DOC ID # I-92-0008	ATT # 8	
REV 1	SHEET 1	OF 7

Florida Power CORPORATION

Fax Transmission

FROM: Richard Iwachow **Phone No. 813-866-4593**

Nuclear Operations Engineering
3201 - 34th St. S. C2I
St. Petersburg, Fl 33711
(813) 866-4703
(Fax) 866-4984

TO: Joe FitzGerald of Vitro Corporation **Phone No. 301-231-1117**

FAX #: 301-231-2988

DATE: March 02, 1995 **Pages (including cover): 7**

If any of the pages in this fax are not received, or not readable, please contact our office at the above number immediately.

ADDITIONAL COMMENTS:
See next sheet for explanation our request.

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ANALYSIS/CALCULATION		
DOC ID # I-92-0008	ATT # 8	
REV 1	SHEET 2	OF 7

Florida Power
CORPORATION

March 2, 1995

Mr. Joseph B. FitzGerald
Vitro Corporation
14000 Georgia Avenue
Silver Spring, Maryland 20906-2972

Subject: Crystal River Unit 3
EFIC Module Accuracies

Dear Mr. FitzGerald:

In March of 1983, C. E. Suer furnished a letter (VL-CS-T-75(83) dated 03/31/83; copy attached) to Babcock & Wilcox which described the error inaccuracies for the compensation and control modules. The information on the letter was used in the development of instrument loop string error calculations.

Presently, our instrument loop accuracy calculations are being expanded to include other functions of the cabinets which were not addressed in our initial design. Especially those concerning the Non-1E analog isolated outputs.

B&W design specification 08-1123898-03, paragraph 6.5.2, page 33 requested that these signal isolators have "an accuracy available at the Non-1E side with respect to input shall be ± 0.5% worst case ". Was this specified accuracy meet or exceeded? Since the above mentioned Vitro letter did not cover the "analog isolation input (part no. 3801-1024) and the analog isolation output (part no. 3801-1030) modules, is it possible for Vitro to supply the same type of information as previously given either on a module level or on an individual sub-component level. If given for the modular sub-component level, only those IC's that take the analog signal and convert it to a digital output; and then convert it on the other side of the AIO. Also, is there any error inaccuracy associated with the 1E to Non-1E digital isolator's which are part of the loop string between the analog input and analog output isolators.

Your assistance in this area will be greatly appreciated and help my efforts in completing the necessary instrument string calculations. If there are any questions or problems in providing the requested data, please call me at 813-866-4593.

R. Iwachow
Sr. Nuclear I&C Engineer

Attachments: 1. C.M. Suer letter VL-CS-T-75(83), 3 shts.
2. Excerpt from B&W Spec 08-112898-03, pages 32 & 33

cc: R. E. Wagner

ANALYSIS/CALCULATION

DOC ID # I-92-0008 ATT # 8

REV 1 SHEET 3 OF 7

AUTOMATION INDUSTRIES, INC.
VITRO LABORATORIES DIVISION
14000 GEORGIA AVE
SILVER SPRING MARYLAND 20910
(301) 871-7200

VL-CS-T-75(83)
(Job 03801)

To FAX FOR

March 31, 1983

ATTACHMENT J. B. FITZGERALD

SHEET 3 OF 7

Mr. C. M. Seay, C.P.M.
Group Leader
The Babcock and Wilcox Company
Utility Power Generation Division
Post Office Box 1260
Lynchburg, Virginia 24505-1260

NPGD PURCHASING
APR 04 1983
RECEIVED

P.O. Nos. 039238LF, 039239LF, and 039240LF
EMERGENCY FEEDWATER INITIATION AND CONTROL SYSTEM

Dear Mr. Seay:

As requested by Babcock and Wilcox TWX CMS-#82-1782 dated December 13, 1982, Vitro Laboratories Division hereby clarifies the derivation of the design accuracy requirements for the EFIC System being supplied to Arkansas Nuclear 1, Crystal River 3, and Rancho Seco Nuclear Power Plants. The subject TWX references specification paragraph 6.4.5 which addresses accuracy requirements of an "Analog Computing Unit". The EFIC System contains no "Analog Computing Unit" as described in paragraph 6.4. The EFIC System as designed, also contains no "Low Selector", paragraph 6.10, "Rate Limited Follower", paragraph 6.11, "Proportional Plus Integral", paragraph 6.12, or "Setpoint and Bias Units", paragraph 6.15. The EFIC System does contain two high-density, custom-designed modules which accomplish the functions of paragraphs 6.4, 6.10, 6.11, 6.12, and 6.15. The Compensation Module performs all analog input conditioning functions, including steam generator level compensation. The Control Module performs all steam generator control associated functions.

Both analog and digital circuitry are utilized in the Compensation Module design. The Control Module is exclusively digital in design between the input analog-to-digital conversion and the output digital-to-analog conversion. State-of-the-art digital techniques and high-density circuit packaging techniques were required in these modules to achieve the overall space requirement, accuracy, and spare capability of the B&W specification. This necessitated combining several functions detailed in the specification into these two single modules.

The inaccuracy of each module (±1.00% of span for Compensation Module low and high range outputs, ±1.25% of span for Compensation Module full range output, and 1.20% of span plus 0.2% of output for Control Module outputs) was determined by algebraically adding the individual inaccuracies of each functional stage. Algebraically adding individual inaccuracies to obtain worst case design inaccuracies is standard engineering practice.[1]

[1] See Curtis D. Johnson, Process Control Instrumentation Technology, John Wiley & Sons, New York, NY, 1982, p.26.

EIR 51-1142173-00

SH 2 of 4

AUTOMATION INDUSTRIES, INC.
VITRO LABORATORIES DIVISION

VL-CS-T-75(83)
(Job 03801)
March 31, 1983

ATTACHMENT TO FAX FOR I. G. FITZGERALD

B&W/C. M. Seay

For the Compensation Module, these stages and inaccuracies are detailed in Vitro proposal VL-C-63162, dated April 20, 1981, Section 3.4.1.1. Each Computing Function within the Compensation Module is apportioned an inaccuracy of ±0.25% of span as specified in paragraph 6.4.5 of Specification 08-1123898-03. Therefore, the total Compensation Module inaccuracy is as summarized below:

Computing Function	Full Range Inaccuracy	Low/High Range Inaccuracy
Input Buffer/Scaler	±0.25%	±0.25%
Density Computation	±0.25%	±0.25%
Compensation	±0.25%	±0.25%
Full Range Summing	±0.25%	———
Output Buffer/Scaler	±0.25%	±0.25%
	±1.25%	±1.00%

For the Control Module, the total worst case is in the full range mode and was determined as shown below. For those Computing Functions not otherwise specifically identified, paragraph 6.4.5 was applied.

Computing Function	B&W Logic 12 Dwg	Inaccuracy	B&W Specification Paragraph
12" Bias	C5	(±0.10%)	6.15
Summer	C4	±0.25%	6.4.5
RLF	C7	±0.20%	6.11.3
Function Generator	C9	(±0.25%)	6.4.5
Multiplier	C10	(±0.25%)	6.4.5
Low Selector	C8	±0.15%	6.10.2
20'/31.5' Setpoint	C12/C13	±0.10%	6.15
Subtractor	C6	±0.25%	6.4.5
Proportional Plus Integral	C3	±0.25%	6.4.5
		±1.20%	

The output buffer stage of the Control Module is accurate to within ±0.2% of its input (reference paragraph 6.7). The total inaccuracy of the Control Module is ±1.40%.

For determining total accuracy, the values in parenthesis were disregarded since they only affect the rate of change of the rate limited follower, and therefore are not truly an additive error.

AUTOMATION INDUSTRIES, INC.
VITRO LABORATORIES DIVISION

VL-CS-T-75(83)
(Job 03801)
March 31, 1983

ATTACHMENT TO FAX FOR J. B. FITZGERALD

B&W/C. M. Seay

SHEET 5 OF 7

The above derivations provide the total open loop, worst case inaccuracies for both the Compensation Module and the Control Module. These inaccuracies are verified in the individual module test procedures by taking the algebraic differences between the measured value of the output and the calculated ideal value. Because the modules are designed as integral units, the accuracy of the individual Computing Functions cannot be verified. Since the inaccuracy of the total module is verified to be within the inaccuracy of the above calculations, this procedure is justification of compliance with the accuracy requirements of paragraph 6.4.5.

If there are any questions of a technical nature pertaining to the above, please contact J. B. FitzGerald at (301) 251-3511.

Very truly yours,

C. E. Suer
Department Head
CS Department

JBF:fm
Distribution
B&W/CMSeay

6.4.1 General Requirements

The analog computing units shall meet the requirements of Sections 6.1, 6.1.1, 6.1.2, 6.1.3, 6.1.4, 6.1.5, 6.1.6, 6.1.6.A, 6.1.6.B, 6.1.6.D, 6.1.7, 6.1.8, 6.1.8.A, 6.1.8.B or C, 6.1.9, 6.1.12, 6.1.13, and 6.1.14.

6.4.2 Adjustment Ranges

As required to meet functional requirements.

6.4.3 Inputs

One or more electric analog signals in accordance with functional requirements.

6.4.4 Output

Electric analog signal in accordance with functional requirements.

6.4.5 Accuracy

±0.25% of span.

6.5 Electrical Isolation Class 1E to Non-1E

All signal paths by means of which signals are conveyed from the Class 1E EFIC to equipment (such as the plant computer) in the Non-Class 1E environment shall be provided with electrical isolation (see Section 4.3). The electrical isolators shall be included in and qualified as a part of the EFIC. Since one side of the electrical isolator is supplied a signal from the Class 1E EFIC circuitry and the other side supplies a signal to the Non-Class 1E equipment, the electrical isolator contains both a Class 1E and Non-1E side. These terms are used in the following discussions of minimum isolator requirements. In the context of this section the term electrical isolator refers to all wiring and terminals providing for electrical connections to both sides of the isolator, all hardware for mounting, all hardware for barriers, and any other aspect of the arrangement and design which can compromise the function and integrity of the isolator as well as the isolator proper.

6.5.1 General Requirements

A. The function of the isolator is to assure that electrical faults (Section 6.5.1.B) at the Non-1E side has no detrimental effect on the Class 1E portion of the EFIC supplying the input signal to the Class 1E side of the isolator.

B. The isolator shall be qualified to perform its function (A above) with 750 V peak ac 60 Hz or 480 VDC applied across the Non-1E side or between either or both terminals of the Non-1E side and ground. The only acceptable electrical effects of the fault shall be loss of ability of the Non-1E side to function. In meeting this qualification requirement it shall be considered that the fault can occur simultaneously at any one, some, or all electrical isolators. It shall be assumed that the electrical fault sources have essentially unlimited current capacity.

C. The EFIC cabinets shall be arranged so that the wiring attendent to the Class 1E side and the wiring attendent to the Non-1E side do not mix or approach each other in accordance with the requirements of Reference 2.7, Appendix A.

D. To the extent possible, the electrical isolation arrangement shall employ non-flamable materials.

6.5.2 Analog Isolators

Analog isolators receive analog inputs at the Class 1E side and make them available to Non-Class 1E systems at the Non-1E side. Analog isolators, in addition to meeting the requirements of Section 6.5.1, shall meet the requirements of this section.

A. Accuracy

The accuracy of the signal available at the Non-1E side with respect to the input shall be ±0.5% worst case through design range environmental conditions. (03)

B. Loading

The analog isolator shall be capable of meeting the accuracy requirements of A above when loaded with a resistance of 5000 ohms or greater.

C. Output Signal Polarity

The polarity of the output signal is unimportant. The output signal shall, however, be unipolar.

D. Output Electrical Range

The output electrical range shall be determined by the Vendor and stated in the equipment documentation.

ANALYSIS/CALCULATION

DOC ID # I-92-000B ATT # 9

REV. 1 SHEET 1 OF 22

BWNP-20440 (4-80)

BABCOCK & WILCOX - NPGD

ENGINEERING INFORMATION RECORD

DOCUMENT IDENTIFIER 51-1138803-00

TITLE EFIC SHUTDOWN BYPASS - OPERATOR ACTION

PREPARED BY WN Millaman DATE 11-19-82

REVIEWED BY J. E. Lemon DATE 11.23.82

REMARKS:

SEE ATTACHED

This document is for SMUD only.

ANALYSIS/CALCULATION
DOC ID # I-92-0008 ATT # 9
REV 1 SHEET 2 OF 22

EFIC SHUTDOWN BYPASS

OPERATOR ACTION

B&W DOCUMENT NO. 51-1138803-00

TABLE OF CONTENTS

ANALYSIS/CALCULATION

DOC ID # I-92-0008 ATT # 9

REV 1 SHEET 4 OF 22

1.0 INTRODUCTION

For operational convenience, SMUD would like to bypass all automatic Emergency Feedwater Initiation and Control (EFIC) functions utilizing one permissive setpoint during plant cooldown. SMUD letter, Raasch to Holt, "AFW Upgrade Implementation; MSC Task 218; EFIC Shutdown Bypasses, Rancho Seco Nuclear Generating Station Unit No. 1," dated September 2, 1982, requested some additional information to be used by the District in evaluating the shutdown bypass schemes. Specifically, "at what pressure could EFIC be bypassed during a [redacted] such [redacted]ator action fo[redacted]? For this transient, the core must remain subcooled and the pressurizer must not go solid."

The purpose of this report is to respond to the operator action question. The reactor coolant system repressurization transient as a result of loss of MFW during cooldown was examined utilizing two different methods. The conditions, assumptions and results are presented to assist SMUD in their shutdown bypass evaluation.

2.0 TIME AVAILABLE FOR OPERATOR ACTION - METHODS

2.1 Calculations

Calculations (B&W Document No. 32-1137970-00) were performed to determine the times available for operator action before reaching the pressurizer code safety valves' setpoint and before filling the pressurizer solid with water. The ma[redacted] The single setpoint used is 750 psig secondary OTSG pressure because the low OTSG pressure initiate function must be bypassed at this value to avoid unwanted automatic emergency feedwater initiation during shutdown.

2.1.1 Assumptions

- [redacted]
- Primary RC temperature is approximately equal to the secondary temperature for the cooldown.
- Heat losses from the RC system are considered negligible.
- RC system mass includes water only.
- No pressurizer spray flow is assumed.
- Power operated relief valve (PORV) block valve is assumed closed.
- Heat input to the RC system includes decay heat per ANS 5.1x1.0 and pump heat for four RC pumps.

2.1.2 System Conditions

- Reactor Coolant (RC) system is in a 100°F/hr. cooldown mode.
- Initial RC system temperature is 580°F.
- RC system pressure is 2155 psig.
- RC system volume (hot) is 11,314 $ft.^3$.
- Steam volume in pressurizer corresponds to a 200 inch level or approximately 636 $ft.^3$.
- Pressurizer code safety valve setpoint is 2500 psig.
- Secondary side OTSG level is the low load main feedwater control level or 24 inches on the startup range.

2.1.3 Results

Under these conditions and assumptions, RC system thermal expansion calculations estimate the time to lift the pressurizer code safety valves at 5.1 minutes and the time to fill the pressurizer solid at 12.0 minutes.

2.2 Simulator

Since the calculated times are close to the 10 minute operator action criterion, and, since the calculational method is simplistic in nature, a corroborative method was desired. The B&W simulator was determined to be an expeditious way to provide such a check. Some conditions for the simulator run were slightly different than for the calculations.

The following differences and their effect are noted.

Calculation	Simulator	Effect
100^{o}F/hr. cooldown	Reactor trip @ t=0 then begin 100^{o}F/hr. cooldown when conditions stabilize.	Simulator will reach 750 psig approx. 10 minutes earlier and, consequently, have a slightly higher initial decay heat level.
Initial OTSG level = 24 inches on startup range.	Initial OTSG level = 30 inches on startup range.	Additional 6 inches of inventory on simulator will take longer to boil off.
Pressurizer level maintained at 200 inches.	Pressurizer level maintained at 220 inches.	Repressurization will be quicker at the higher level. Both cases conservative as operator would ordinarily decrease level setpoint with decreasing temperature to a minimum of 100 inches.

2.2.1 Assumptions

- Main feedwater pumps were tripped at approximately 750 psig secondary pressure at approximately t = 31 minutes after reactor trip.
- Heat balance is modeled by the simulator.
- No pressurizer spray.
- No PORV.
- Heat input to the RC system includes decay heat per ANS 5.1x1.0, 4 RC pump heat, and pressurizer heaters.

2.2.2 System Conditions

- Reactor trip at t=0.
- Initial RC system temperature 580^{o}F.

RC system pressure is 2150 psig.

- Stabilize and start 100^{0}F/hr. cooldown at approximately 9 minutes after reactor trip.
- Steam volume in pressurizer corresponds to a 220 inch level or approximately 574 ft.^{3}.
- Pressurizer code safety valve setpoint is 2500 psig.
- Secondary side OTSG level initially at 30 inches on the startup range.

2.2.3 Results

The simulator run resulted in lifting the pressurizer code safety valve in approximately 6.5 minutes after LOMFW and the pressurizer going solid in approximately 11.9 minutes. The response of selected system parameters was taped and is graphically represented in Figures 1 through 12.

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3.0 DISCUSSION

Both the calculations and simulator run show that the loss of main feedwater transient during cooldown causes a rapid RC system repressurization. Previcus shutdown bypass evaluations conducted by B&W have applied the 10 minutes operator action criterion to the time before reaching the pressurizer code safety valve setpoint. The primary reason being that it is considered good engineering judgement not to unnecessarily challenge the code safety valves. The SMUD request for information and subsequent discussions at the September, 1982 project review meeting indicate that SMUD feels the 10 minute criterion should be applied to the time before the pressurizer becomes solid with water. Since no real licensing limits are violated in either case, the degree of undesirable consequences is the basic difference. For example, Figure 1 shows the safety valves lifting more than twenty times before the pressurizer goes solid.

4.0 CONCLUSIONS

For the transient investigated utilizing a 750 psig OTSG secondary pressure bypass permissive setpoint, the calculation and simulator results show that the core remains subcooled and that greater than 10 minutes is available for manual operator action before the pressurizer becomes solid.

Other considerations which should be factored into the final technical decision on the most appropriate shutdown bypass scheme have been documented previously in B&W Doc. No. 51-1134493-01, "SMUD EFIC System Shutdown Bypass Scheme Evaluation".

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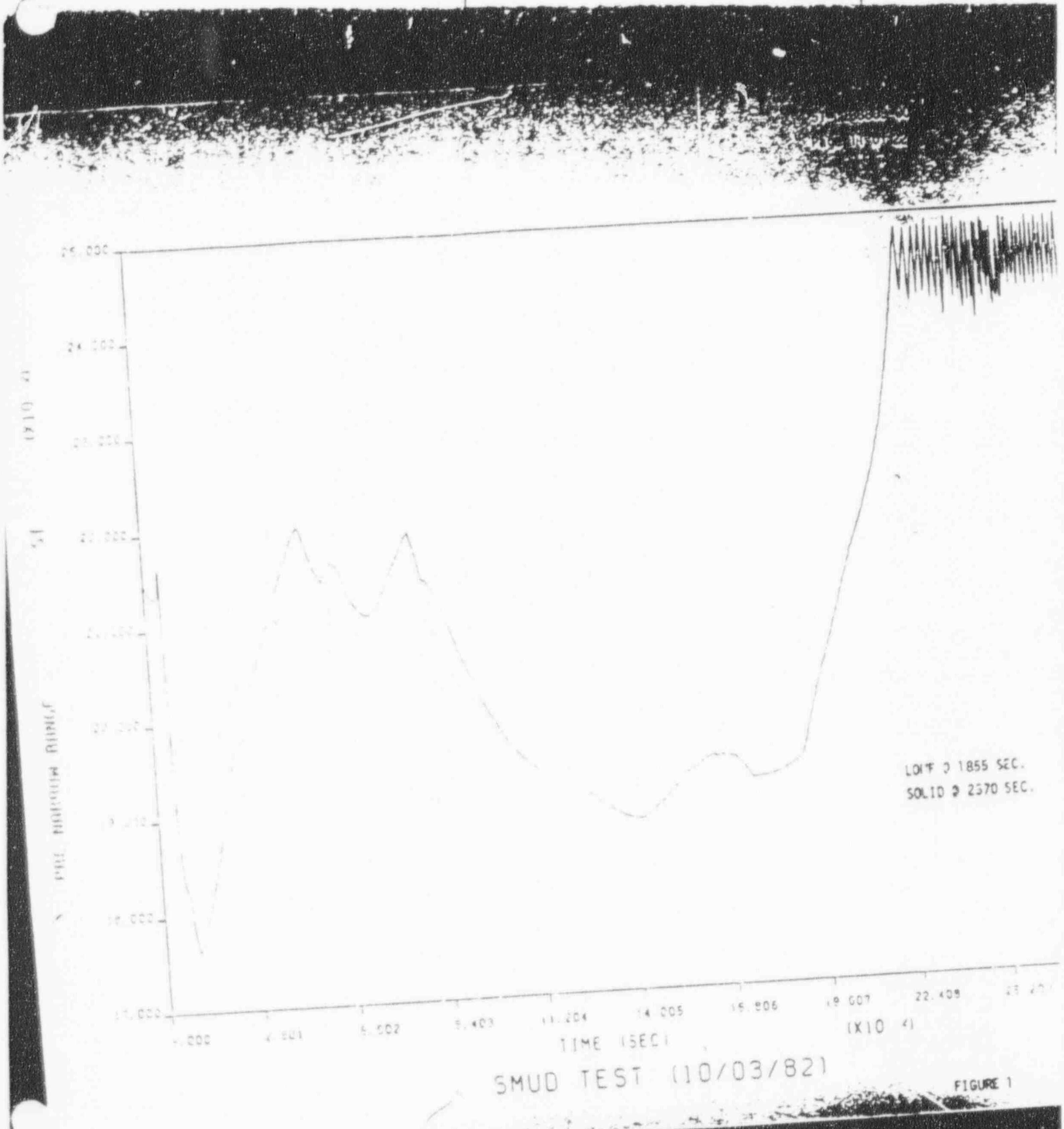

FIGURE 1

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FIGURE 2

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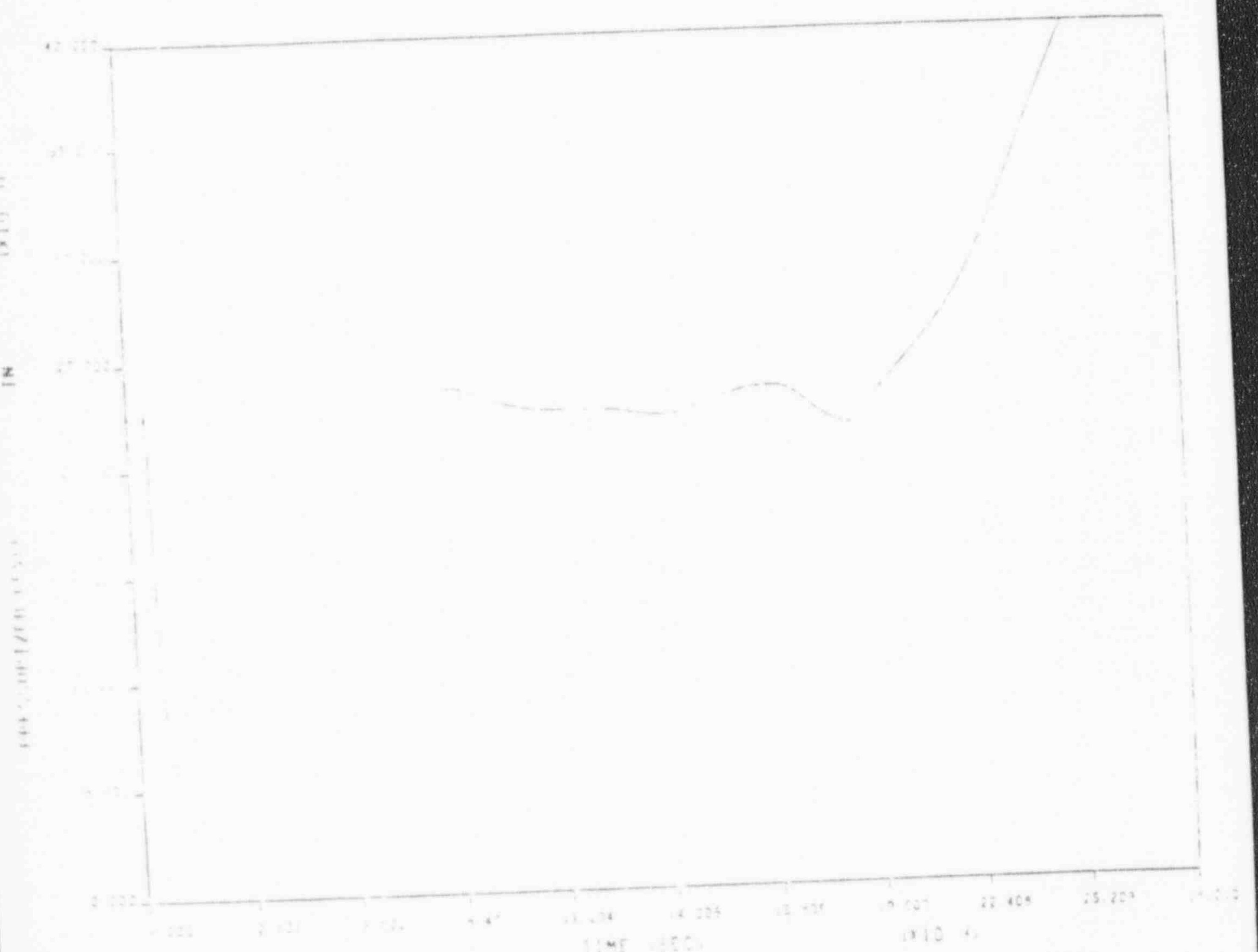

SMUD TEST (10/03/82)

FIGURE 3

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SMUD TEST (10/03/82)

FIGURE 4

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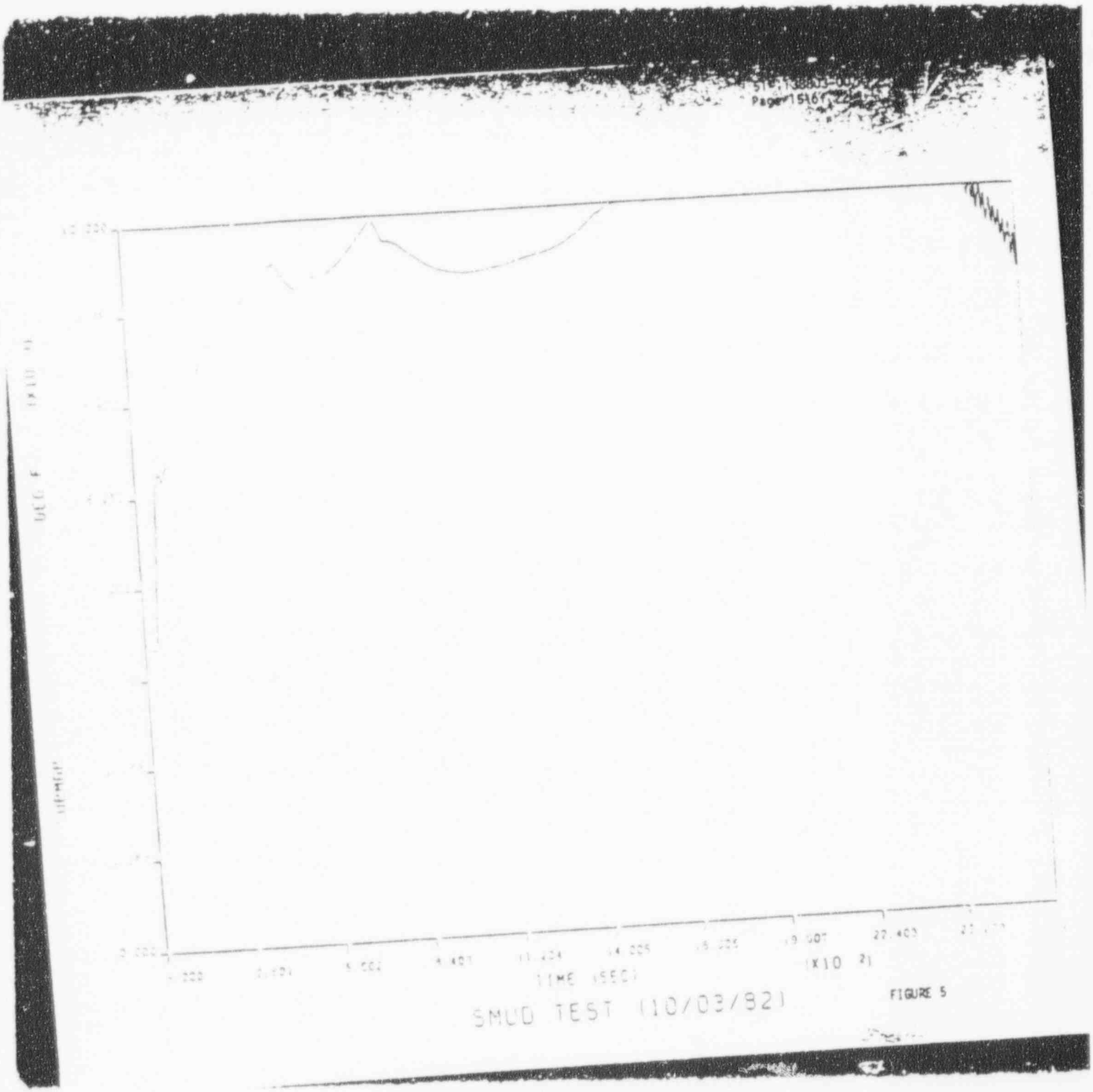

FIGURE 5

CALCULATION

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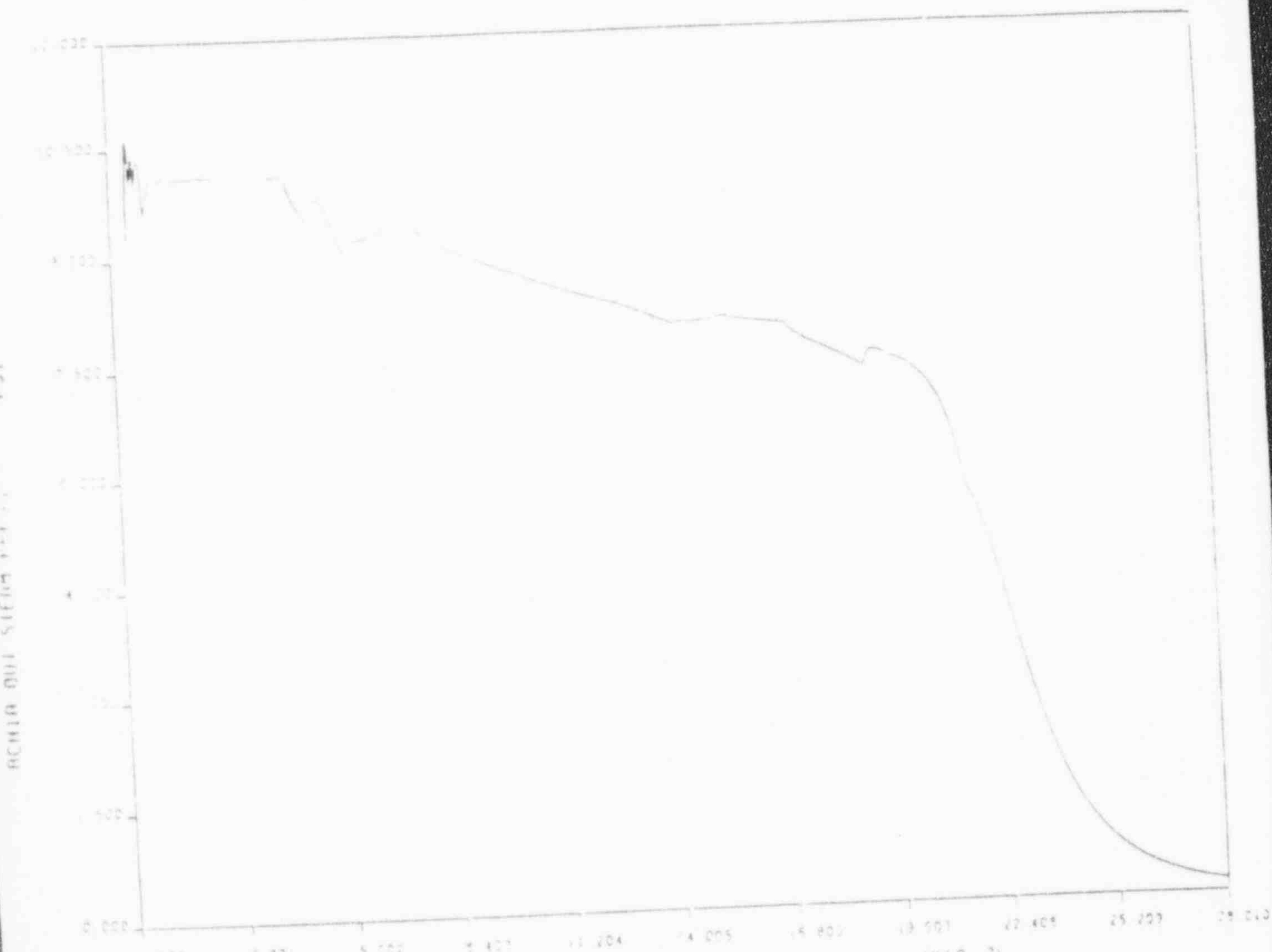

SMUD TEST (10/03/82)

FIGURE 6

ANALYSIS/CALCULATION

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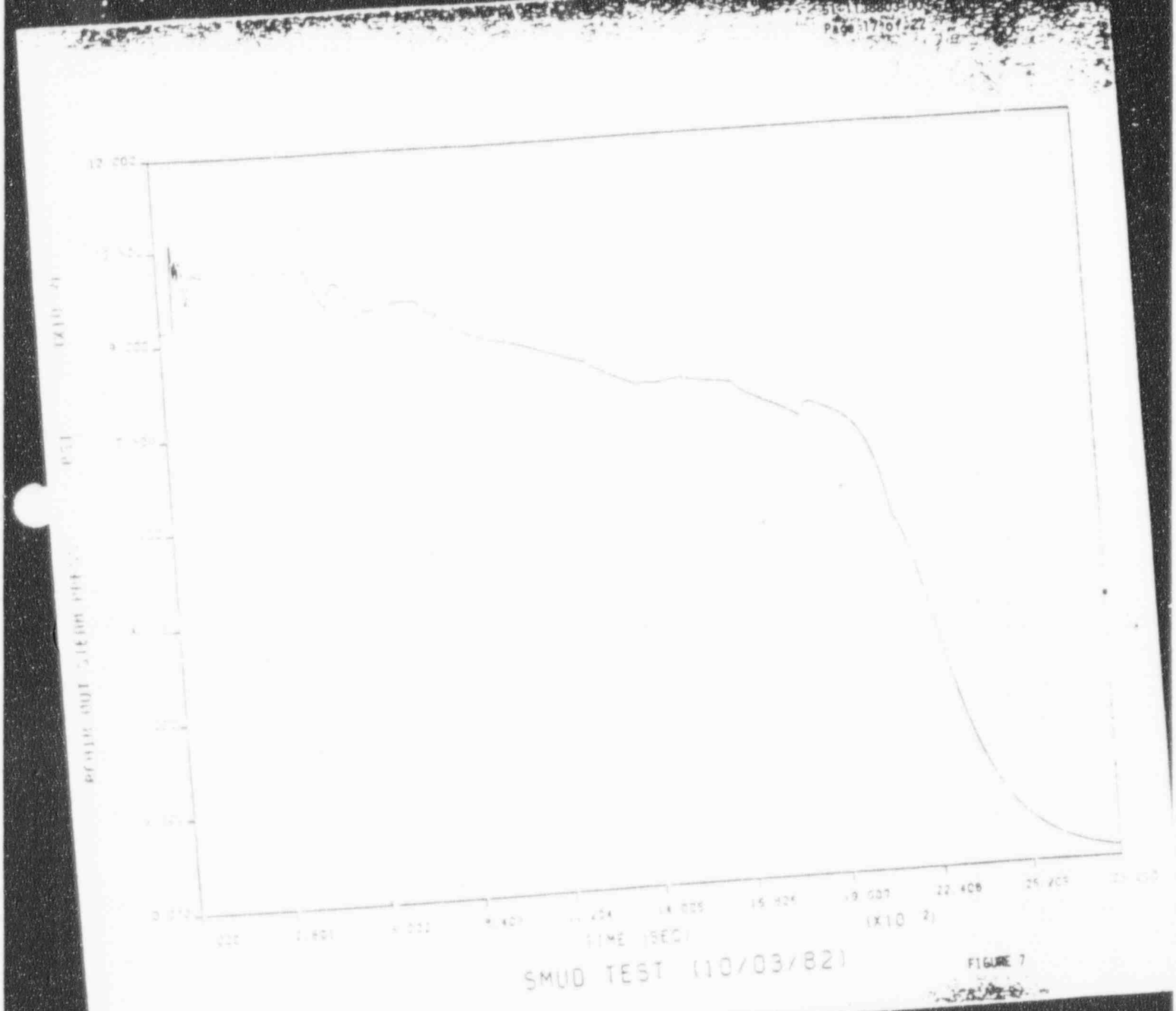

SMUD TEST (10/03/82)

FIGURE 7

ANALYSIS/CALCULATION

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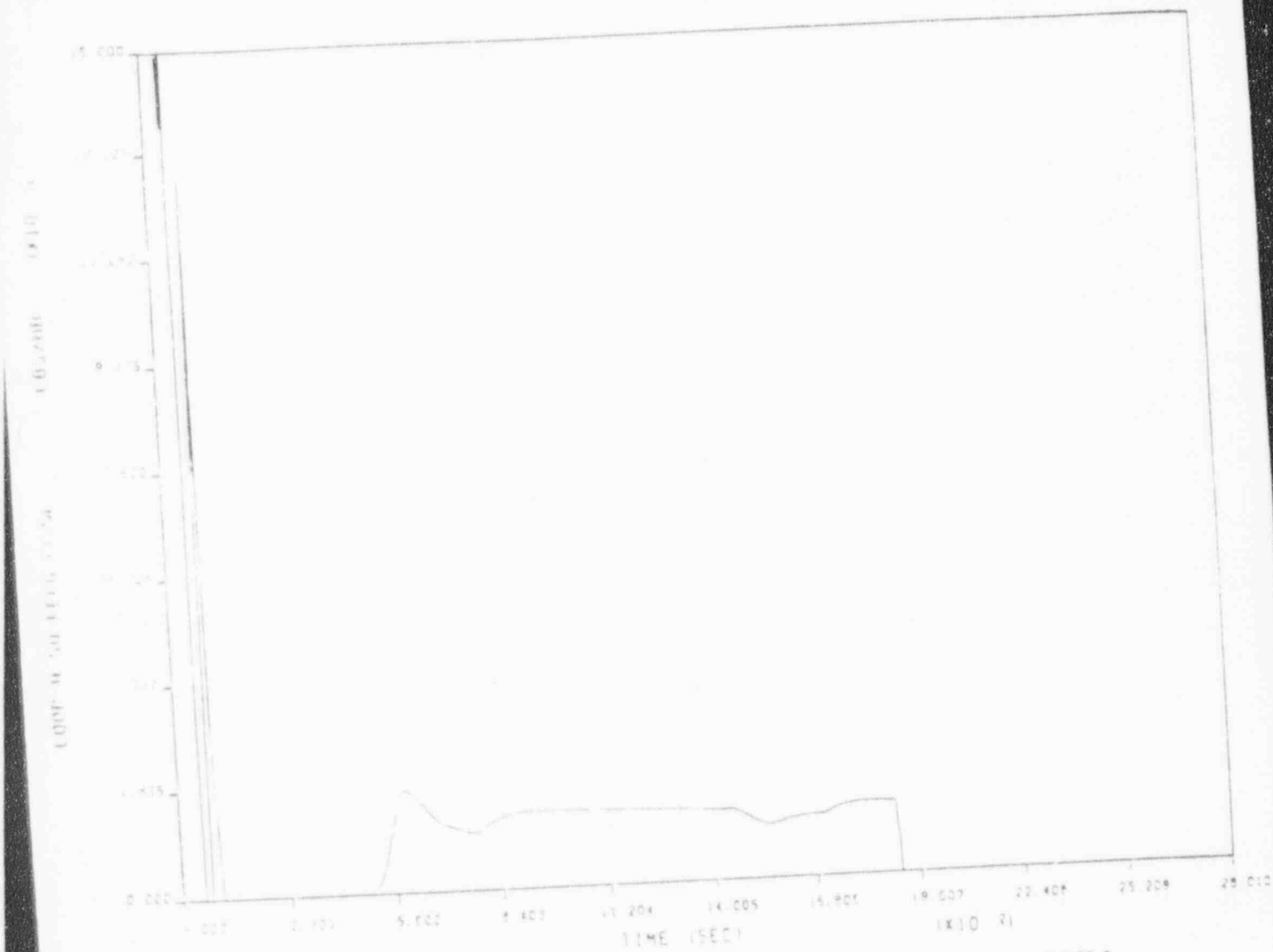

SMUD TEST (10/03/82)

FIGURE 8

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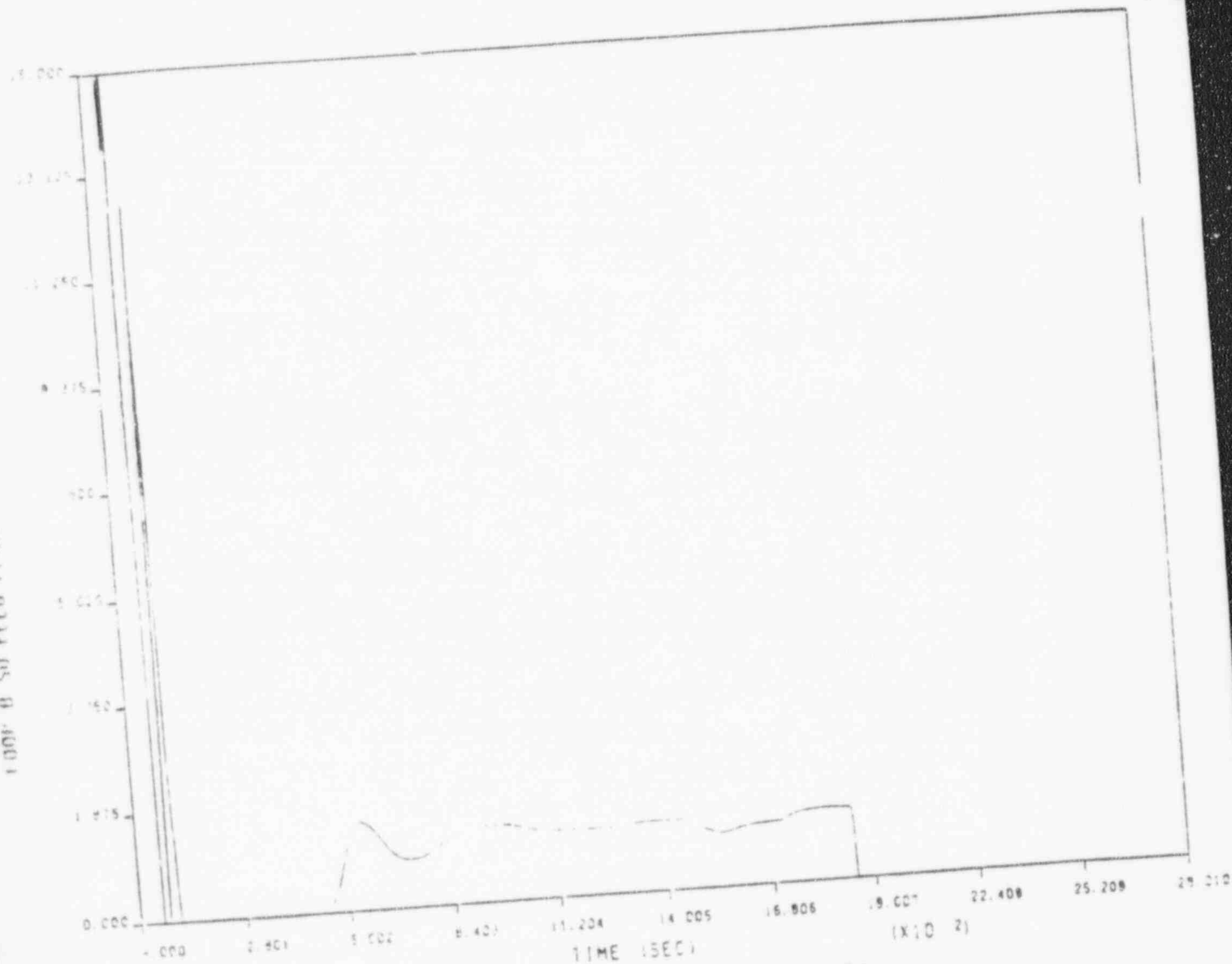

SMUD TEST (10/03/82)

FIGURE 9

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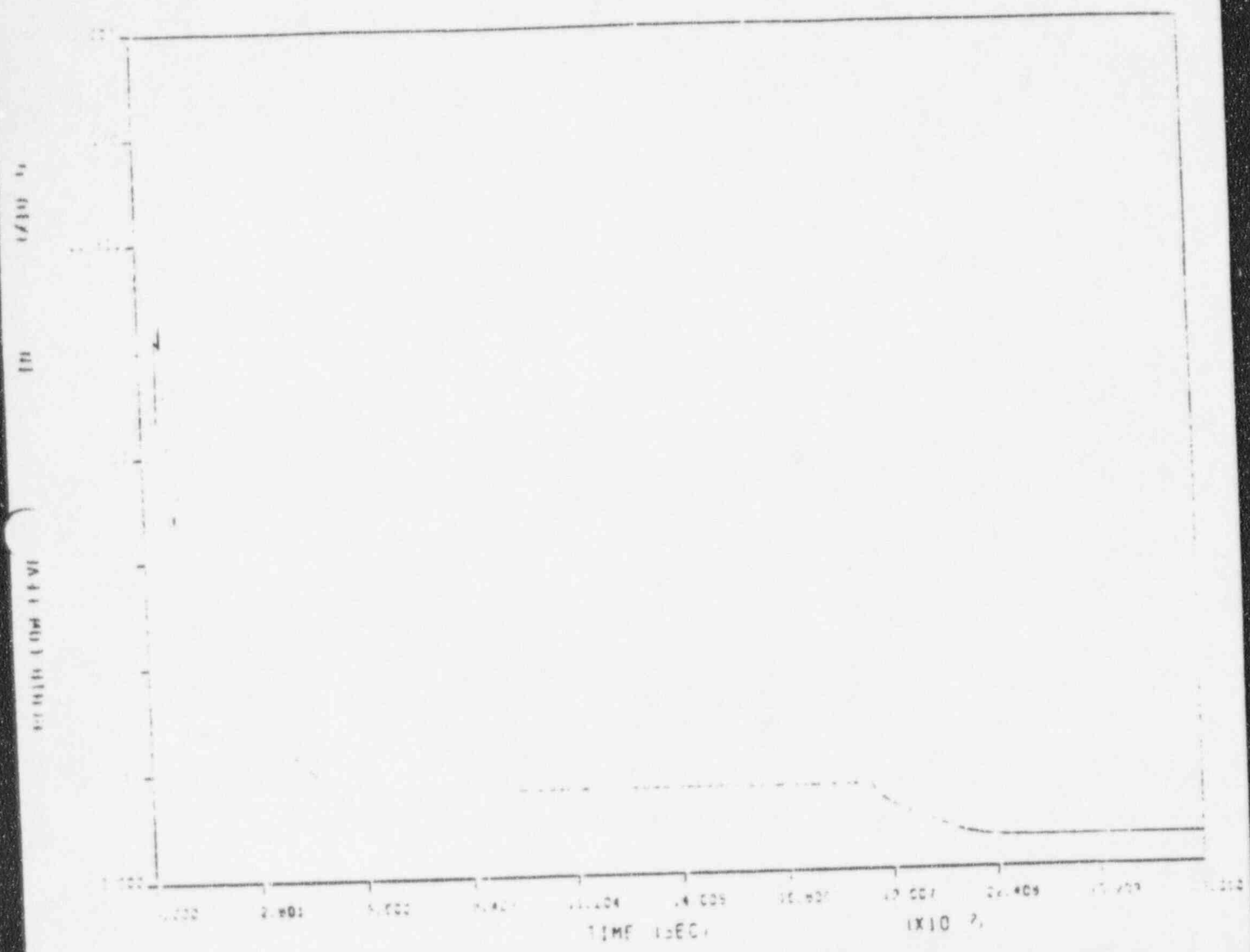

SMUD TEST (10/03/82)

FIGURE 10

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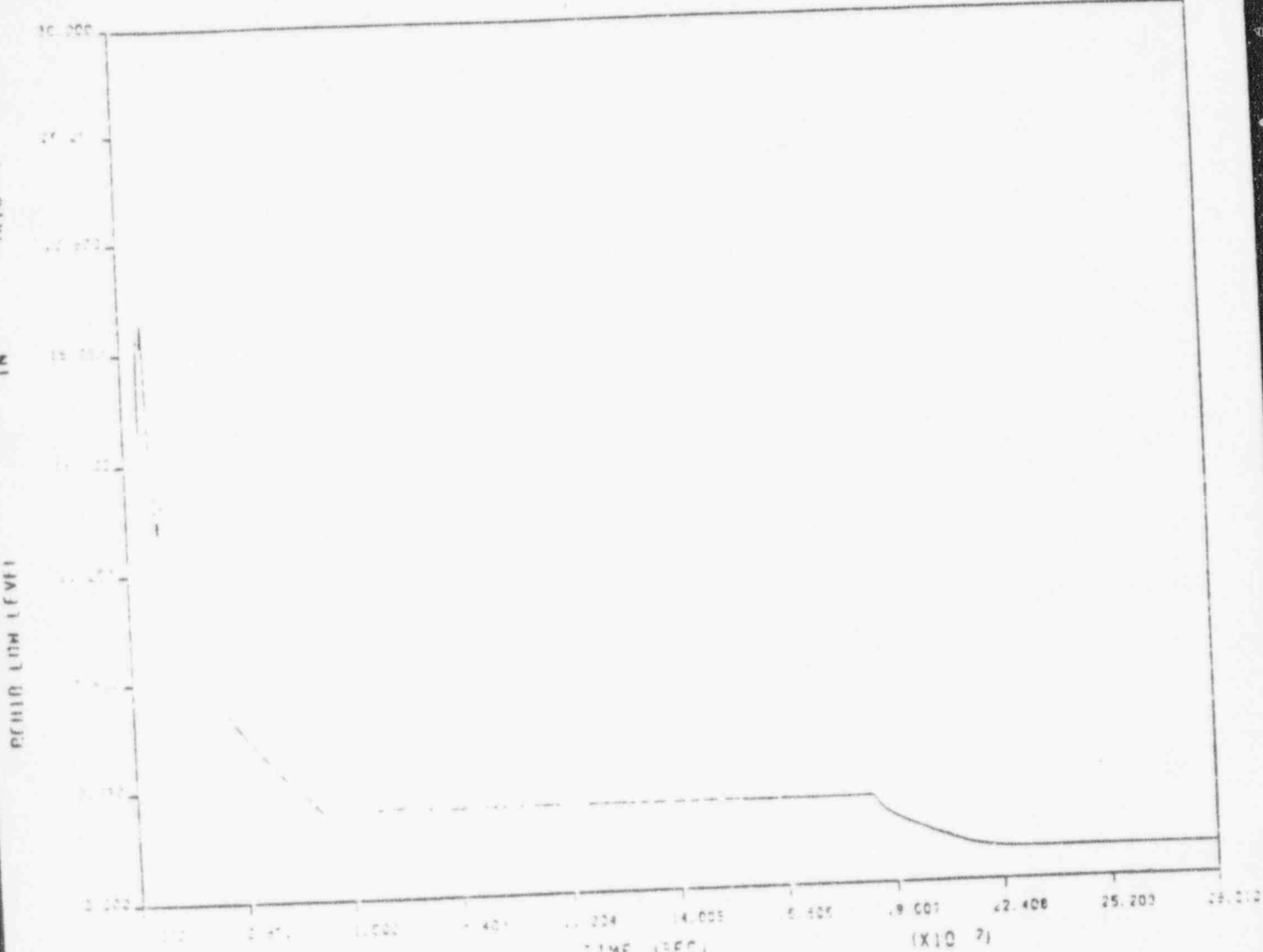

SMUD TEST (10/03/82)

FIGURE 11

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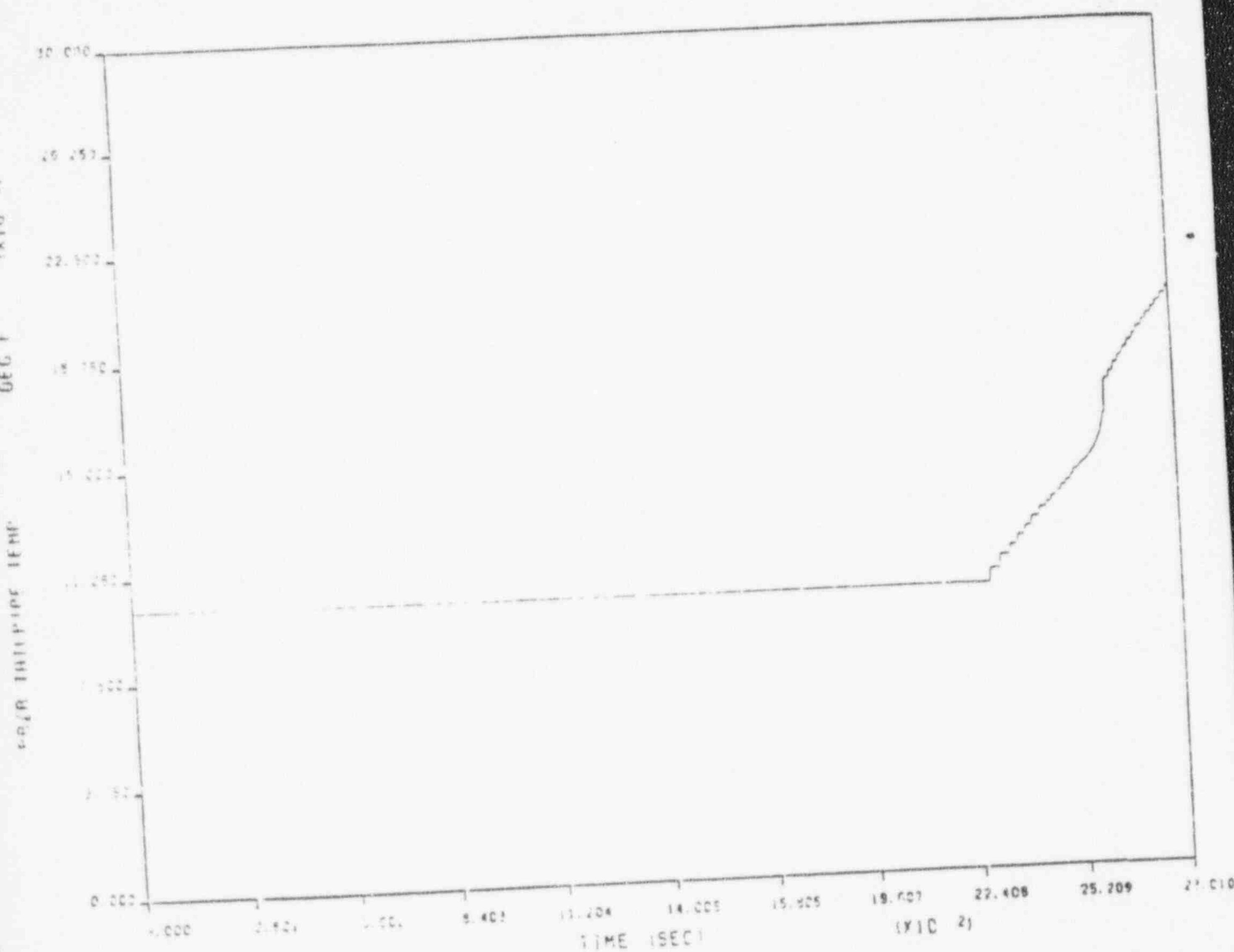

SMUD TEST (10/03/82)

FIGURE 12

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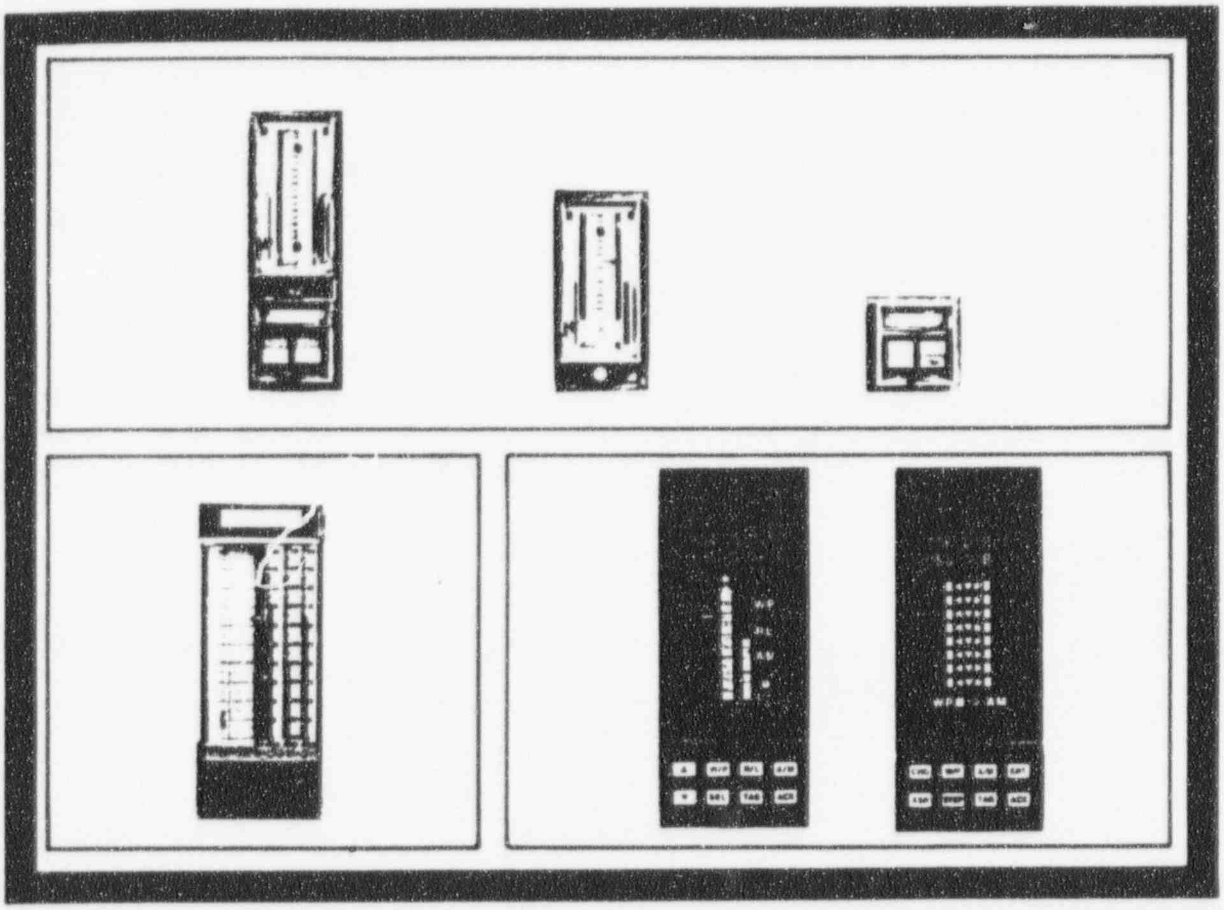

SPEC 200 DISPLAY STATIONS FOR NUCLEAR SERVICE

Subject to the qualification testing and stringent controls required for nuclear applications

NUCLEAR SERVICE QUALIFICATION

Nuclear-qualified display stations, while incorporating minor mechanical modifications, are virtually identical to the corresponding non-nuclear models. Testing and analysis per IEEE Standard 344-1975 demonstrates the capability of the SPEC 200 displays offered for Class II (structural integrity) qualification. Additional testing per IEEE standards 323-1974 and 344-1975 demonstrates the ability of products offered for Class 1E qualification to perform their required functions before, during, and after a specified Design Basis Event (DBE).

STRINGENT QUALITY ASSURANCE

The design, manufacture, and documentation of SPEC 200 nuclear-qualified equipment is strictly controlled. The Foxboro quality assurance program meets the requirements of 10CFR50, Appendix B; ANSI N45.2; ASME NQA-1 and CSA Z299.2. The program has been audited by the U.S. Nuclear Regulatory Commission and by a number of users in the nuclear power industry.

FOXBORO®

SEISMIC TESTING

Instruments for Class 1E qualification are type-tested for performance under the seismic vibration conditions shown in Figures 1 and 2. Five Operating Basis Earthquake (OBE) tests and one Safe Shutdown Earthquake (SSE) test are performed. These type tests are conducted with multi-frequency (random) input, biaxially, in each of four horizontal orientations. A shake table with 45-degree vectored drive is used. Test procedures and test reports are available from Foxboro.

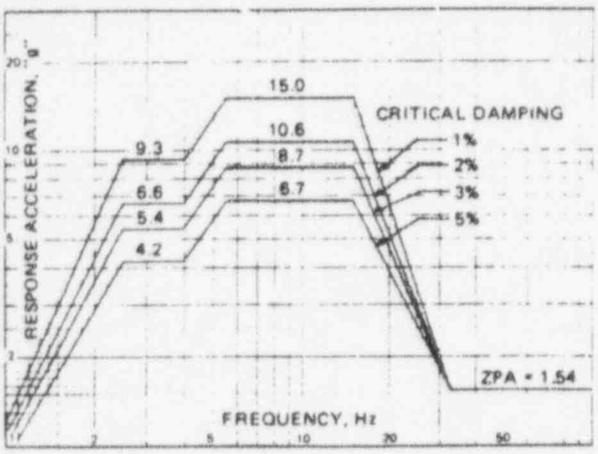

Figure 1. Generic OBE Response Spectra, Class 1E

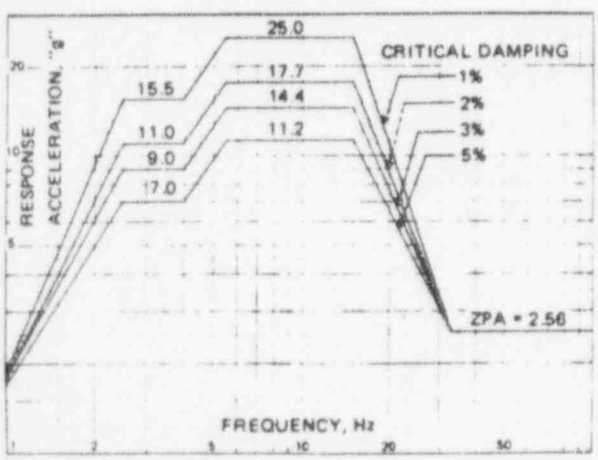

Figure 2. Generic SSE Response Spectra, Class 1E

The following equipment is qualified for Class 1E functional operation and structural integrity per IEEE Standards 323-1974 and 344-1975.

- **Recorders** N-E27R, N-227 Series
- **Control Display Stations** N-250H Series
- **Manual Display Stations** N-255H Series
- **SPEC 200 MICRO Display Stations** N-2CDA Series
- **Indicator Display Stations** N-257H Series
- **Output Stations** N-2AX + M Series
- **Mounting Equipment**
  N-2AX + H Series Housings
  N-202S Series Shelves

ENVIRONMENTAL CONDITIONS

Ambient Temperature Display stations are for use in control panels located in air-conditioned control rooms normally operating between 16 and 30°C (61 and 86°F). Limits of 5 and 50°C (40 and 120°F) are allowed in the event of air-conditioning failure. Testing to 57°C (135°F) is conducted to meet Qualification Class 1E requirements, thus providing a 7°C (15°F) margin over the maximum anticipated temperature of 50°C (120°F). Note that user must determine actual margin based on the application.

Humidity Display stations are tested between 50% relative humidity at 31°C (87°F) dry bulb temperature and 95% relative humidity at 31°C (87°F) dry bulb temperature.

Supply Voltage Nominal supply voltage values for specific models are listed in the model code tables on subsequent pages. Where applicable, 110% and 85% of nominal line voltage and 105% and 95% of nominal line frequency are applied at worst-case points during environmental testing. The worst-case points are chosen to provide minimum power dissipation at high humidity levels (to reduce drying effects) and maximum power dissipation at elevated temperature levels. Similarly, where applicable, 105% and 95% of the 15 V dc supplies are applied at worst-case points. The dc supplies do not vary more than 5% from the 15 V nominal when the mains fluctuate between 110% and 85% of nominal line voltage. Similarly, where applicable, 28 and 20 V ac are applied for the nominal 24 V ac supply at worst-case points during environmental testing.

RECORDER DISPLAY STATIONS

Two recorder families are available. The N-227 and N-E27R Series are designed for both Class 1E and Class II qualification.

N-227P and N-227S, Series Recorders accept input signals at the SPEC 200 system level of 0 to 10 V dc. Signals and power are brought to the recorder from a nest-mounted distribution component (Model N-2AX + DIO or N-2AX + DSP) over an N-2AK Series System Cable. N-227S recorders mount in an N-202S Series Shelf. Each N-227P recorder occupies an individual panel-mounted housing, Model N-2AX + HS1. N-227P Series Recorders conform to the DIN standard (72 mm wide by 144 mm high) format.

N-E27R Series Recorders can be specified for input signal levels of 1 to 5 V dc, 0 to 10 V dc, or 4 to 20 mA dc. They mount in an N-202S Series Shelf at a location where a power cord and signal terminal board provide electrical connections.

Each N-227S and N-E27R Series Recorder is nominally 75 x 150 mm (3 x 6 in) and requires one unit of shelf capacity. Each shelf location is individually configured for the particular model to be installed.

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CONTROL, MANUAL, AND INDICATOR DISPLAY STATIONS

The N-250 family includes control, manual, and indicator display stations. N-2AX + M Series Output Stations are offered for use in conjunction with N-250H Series stations or for independent use. All are designed for both Class 1E and Class II qualification.

N-250H, N-255H, and N-257H stations, with or without an output station, are panel-mounted by means of individual housings separately specified. Similarly, output stations used independently require individual housings. Up to ten housings of the same model number can occupy a single panel cutout. Further information on mounting is given in the section: "Housings, Models N-2AX + H048, N-2AX + H096, N-2AX + H144." All power and signal connections are made by plug-in cables of the N-2AK Series.

RECORDER DISPLAY STATIONS
N-227 Series

PERFORMANCE SPECIFICATIONS
(Under Reference Operating Conditions)

Indicating Accuracy ±0.5% of span

Repeatability 0.4% of span

Recording Accuracy ±0.75% of span after trim of zero and/or span to match chart rather than indicator scale

FUNCTIONAL SPECIFICATIONS

Number of Pens 1, 2, or 3, as specified

Nominal Pen Speed 5 s to travel from 0 to 100% of scale

Input Signal 0 to 10 V dc

Input Impedance 100 kΩ minimum

Chart
- **Type** Rectilinear, roll
- **Scale Length** 100 mm (4 in)
- **Speed** 20 mm/h, others optional
- **Initial Supply** One 30-day chart with each recorder

Ink
- **Reservoir** Disposable snap-in cartridge with fiber-tip pen provides a 915 mm (3000 ft) ink line (a nominal 3-month supply).
- **Initial Supply** 1 cartridge per pen

Ambient Temperature Influence Less than 0.5% of span for 28°C (50°F) change between 5 and 50°C (40 and 120°F)

Humidity Influence For a change of 50 to 95% relative humidity at maximum wet bulb temperature of 30°C (86°F)
- **Indication** ±0.3% of span
- **Record** +0.75 to −1.5% of span (chiefly chart paper variation)

Power Requirements
- **Supply Voltage** +15 and −15 V dc ±10%
- **Typical Current** 80 mA for 1 pen, 140 mA for 2 pens, 200 mA for 3 pens
- **Chart Drive Supply** 24 V, 50 or 60 Hz, 3 W, 4.2 VA

Supply Voltage Influence Less than 0.1% of span for ±5% change from nominal

Connections 30-pin receptacle for cable connector

Mounting
- **N-227S Series** Each recorder occupies one unit of capacity in an N-202S Series Shelf. Refer to the section "Shelves for Recorders."
- **N-227P Series** Each N-227P Series recorder resides in an individual panel-mounted Model N-2AX + HS1 Housing. The housing is retained in panel by top and bottom screw clamps. A hold-down bracket at rear is fastened to a horizontal framing member supplied by user.

Approximate Mass
- **1-pen Recorder** 2.9 kg (6.5 lb)
- **2-pen Recorder** 3.2 kg (7.0 lb)
- **3-pen Recorder** 3.4 kg (7.5 lb)

Model Codes

N-227P = Housing-mounted Recorder
N-227S = Shelf-mounted Recorder
Number of Pens
-1 = One pen
-2 = Two pens
-3 = Three pens
Supply Frequency
R5 = 50 Hz chart drive
R6 = 60 Hz chart drive

Example: N-227S-2R6

N-2AX + HS1 = Housing for 227P Series Recorder

Qualification Code

CS-N/SRC =	Type-tested for Class 1E qualification per IEEE Standards 323-1974 and 344-1975
CS-N/SRD =	Type-tested for Class II (structural integrity) qualification per IEEE Standard 344-1975

OPTIONAL FEATURE

Alternate Chart Speed 5 mm/h or 10 mm/h

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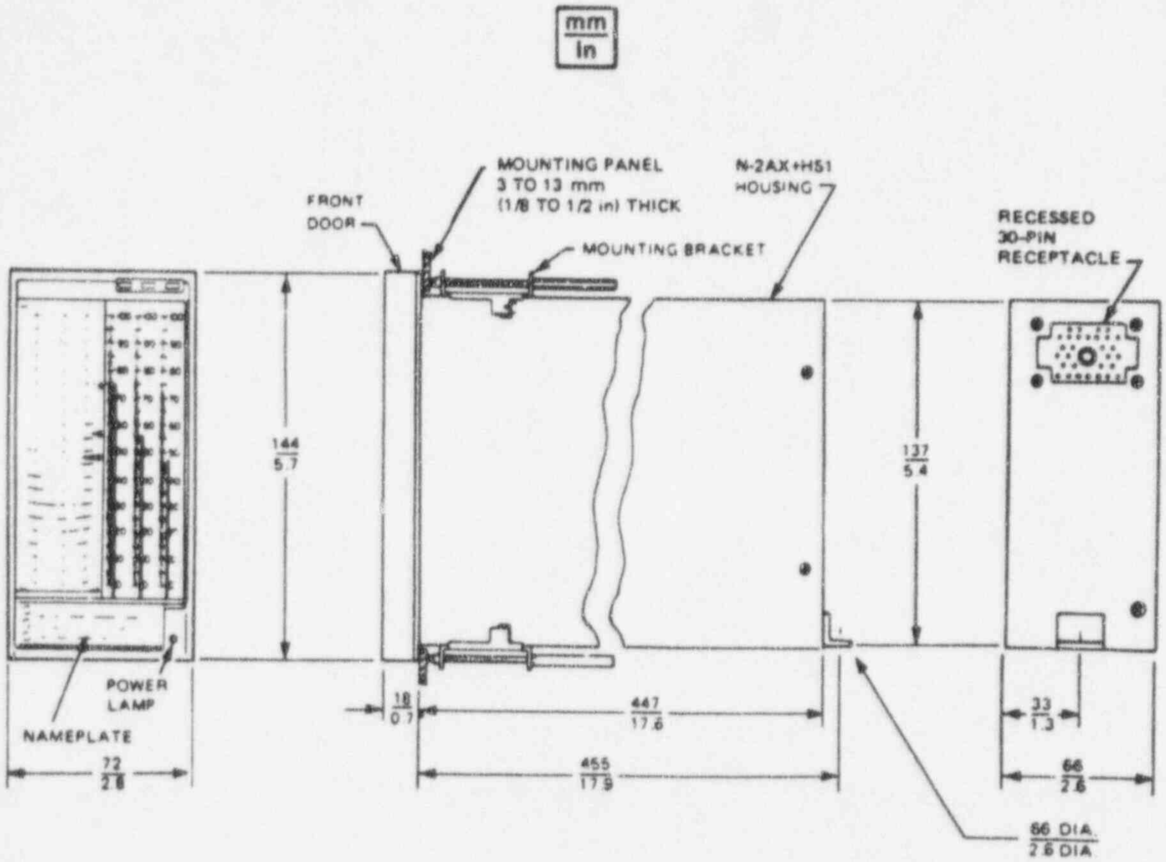
DIMENSIONS—NOMINAL
N-2AX + HS1 Housing for N-227P Series Recorder



ORDERING INSTRUCTIONS

Specify:

1. Model Number
2. Qualification Code
3. Optional Feature
4. Scale Range(s)
5. Chart Range and Number
6. Nameplate Data (2 lines, 21 characters or spaces per line)
7. Tag
8. Separate Items
   N-2AX + HS1 Housing (For N-227P Series)
   N-202S Series Shelf (For N-227S Series)
   Additional Recorder Supplies

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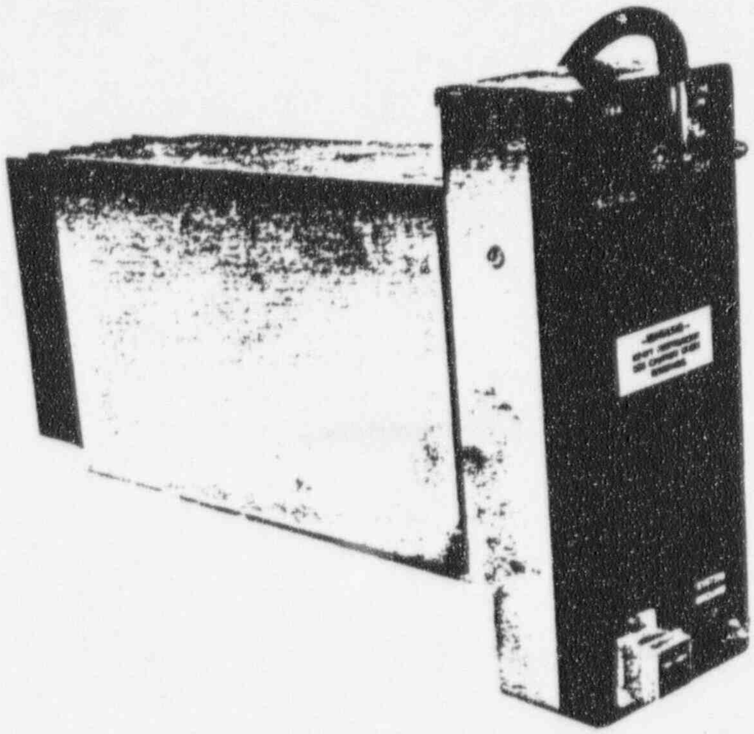
Technical Information



2AX + PS9 SERIES - STYLE B SINGLE NEST dc POWER SUPPLIES

Energize the SPEC 200 system components in one nest

These power supplies mount in a Model 2ANU-P Nest and provide up to 1.5 A of direct current at +15 and −15 V for SPEC 200 system components also mounted in the nest. When applicable, they provide power for transmitters and/or display stations connected to these components.

For high reliability, industrial grade components operated well below normal ratings are used. Overvoltage, overcurrent, and reverse polarity protection is incorporated. Also included are in-line filters for the suppression of radio frequency interference (RFI), voltage surge protection, and a power security turn-off circuit.

An on-off switch, fuse access, and indicating lamps are on the front panel. When the indicating lamps are lit, both the +15 and −15 V outputs are energized.

FOXBORO®

SPECIFICATIONS

Outputs +15 V (referred to common) at 1.5 A dc, and −15 V (referred to common) at 1.5 A dc

Regulation
Line 0.2% output voltage change for ±10% change from nominal line voltage
Load 1.5% output voltage change for load change from 50 to 100%
Frequency 0.1% output voltage change for frequency change from 47 to 63 Hz

Ripple 20 mV maximum

Power Requirements
Line Voltage 100, 120, 220, or 240 V ac +10% −15%, as specified.
Line Frequency 47 to 63 Hz
Maximum Consumption 100 W or 135 VA at full load

Warm-Up Time 30 minutes

Short Circuit Protection A continuous short circuit on either the +15 or −15 V output will not damage the supply. Upon removal of the short circuit, the power supply returns to normal operation.

Overvoltage Protection Both outputs are shut off if any power supply failure raises either output above 19 V.

Security Turn Off To assure the predictable response of connected loads, both outputs are shut off upon loss of either output.

Surge Voltage Protection The voltage surges described in IEEE Standard 472-1974 will not affect output if applied to the input power leads, and will not trigger the overvoltage protection circuits if applied to the output connections.

RFI Protection RFI typically produces less than 1% output voltage change for a field strength at the power supply of 15 V/m at frequencies between 410 and 512 MHz.

Electrical Classification Ordinary locations

Mounting Occupies two units of space in a Model 2ANU-P Nest; leaves nine units of space for other system components.

Ambient Temperature
Normal Operating Limits 5 and 50°C (40 and 120°F)
Influence Less than 0.5% output voltage change for 25°C (45°F) change within normal operating limits

Humidity
Normal Operating Limits 10 and 95% relative humidity with a maximum wet bulb temperature of 30°C (86°F)
Influence Less than 0.1% output voltage change for relative humidity changes within normal operating limits

PRINCIPLE OF OPERATION

As illustrated in Figure 1, two identical power supplies are connected to provide +15 V dc referred to common and −15 V dc referred to common. In each supply, a regulator amplifier varies the voltage drop across a series pass transistor as required to maintain output voltage. The desired value of output voltage is set by the voltage adjust circuit. The overcurrent circuit takes control of the regulator starting at 110% of rated output current. Overload or short circuit current from either output is limited to a value between 1.55 and 1.70 A. Upon removal of the overload or short circuit, normal operation is restored.

The overvoltage protection circuit consists of a zener diode overvoltage detector, a transistor driver, and a silicon controlled rectifier (SCR). The SCR, when fired by an overvoltage condition, shorts the power supply output to common. Shunt diodes protect against externally-applied reverse or forward transients above 20 V.

The +15, −15, and common leads to the power security turn-off circuit include RFI filters.

flow to the affected generator). This problem has been considered for the Consumers plant (see References 1, 2, and 3). In addition, work was done on the VEPCO plant (see Reference 4) which also showed that under certain conditions it is possible for the intact loop not to repressurize even for a large steam line break.

In order to avoid the problems mentioned above, it has been suggested that the FOGG logic be modified to include a differential pressure measurement. The modification would cause AFW to be terminated to one S.G. in a case in which both steam generators were below 600 psia and the pressure difference between the generators were greater than 150 psi. If these conditions exist, FOGG would direct AFW flow only to the higher pressure steam generator.

The purpose of this analysis was to:

(1) Determine whether the proposed modification to FOGG would cure the known problems.

(2) Identify any other possible scenarios which still would result in FOGG's inability to determine which was the intact loop (e.g., a case in which steam generator pressure difference is less than 150 psi), and

(3) Assess the consequences of any cases found under (2) above.

METHODS

The following cases were studied to determine whether the proposed modification would avoid any previously described FOGG related problems:

(1) Consumers FSAR Steam Line Break Spectrum Analysis

(2) 177 FA Overcooling Analysis cases (Reference 5)

(3) VEPCO FOGG Analysis (Reference 4)

ANALYSIS/CALCULATION

DOC ID # I-92-000B ATT # 4915 / 4120

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INSTRUCTION MANUAL

FOR

REGULATED POWER SUPPLIES

LCS-A SERIES

This manual applies to units bearing serial no. prefixes A-E

 All information contained herein applies to all LCS-A models unless otherwise specified.

LAMBDA ELECTRONICS MELVILLE, L.I., N.Y.

MAIN PLANT TELEPHONE: 516 MYrtle 4-4200

ANALYSIS/CALCULATION
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TABLE OF CONTENTS

SPECIFICATIONS AND FEATURES

Specifications apply for all models.

DC OUTPUT--Voltage regulated for line and load.

TABLE I

VOLTAGE AND CURRENT

RANGES

MODEL	VOLTAGE RANGE	MAXIMUM CURRENT (AMPS) AT AMBIENT TEMPERATURE			
		40°C	50°C	60°C	71°C
LCS-A-2	2±5%	3.0	2.5	2.0	1.4
LCS-A-3	3±5%	3.0	2.5	2.0	1.4
LCS-A-3P6	3.6±5%	2.9	2.4	1.9	1.3
LCS-A-4	4±5%	2.9	2.4	1.9	1.3
LCS-A-4P5	4.5±5%	2.8	2.3	1.8	1.2
LCS-A-5	5±5%	2.7	2.3	1.8	1.2
LCS-A-6	6±5%	2.6	2.2	1.8	1.2
LCS-A-8	8±5%	2.4	2.0	1.7	1.1
LCS-A-10	10±5%	2.1	1.8	1.5	1.0
LCS-A-12	12±5%	1.9	1.7	1.3	0.9
LCS-A-15	15±5%	1.8	1.5	1.2	0.9
LCS-A-18	18±5%	1.6	1.3	1.1	0.8
LCS-A-20	20±5%	1.4	1.2	1.0	0.8
LCS-A-24	24±5%	1.1	1.0	0.85	0.70
LCS-A-28	28±5%	1.0	0.9	0.75	0.60
LCS-A-36	36±5%	0.90	0.80	0.70	0.50
LCS-A-48	48±5%	0.60	0.55	0.50	0.45
LCS-A-100	100±5%	0.18	0.18	0.18	0.18
LCS-A-120	120±5%	0.15	0.15	0.15	0.15
LCS-A-150	150±5%	0.10	0.10	0.10	0.10

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TABLE I (Cont'd)

MODEL	VOLTAGE RANGE	MAXIMUM CURRENT (AMPS) AT AMBIENT TEMPERATURE			
		40°C	50°C	60°C	71°C
LCS-A-01	0-7	2.0	1.9	1.6	1.1
LCS-A-02	0-18	1.1	1.0	0.9	0.7
LCS-A-03	0-32	0.69	0.64	0.60	0.45
LCS-A-04	0-60	0.37	0.34	0.31	0.25
LCS-A-05	0-120	0.10	0.10	0.10	0.10

Current range must be chosen to suit the appropriate maximum ambient temperature. Current ratings apply for entire voltage range.

REGULATED VOLTAGE OUTPUT

Regulation (line) . . . . 0.01 percent plus 1.0 millivolt for input variations from 105-132 or 132-105 volts AC

Regulation (load) . . . . 0.01 percent plus 1.0 millivolt for load variations from no load to full load or full load to no load

Remote Programming

External Resistor . . . . Nominal 1000 ohms/ volt output

Programming Voltage . . . . . One-to-one voltage change

Ripple and Noise . . . . 250 microvolts rms; 1 millivolt peak to peak with 57-63 Hz input

Temperature Coefficient . . . . . Output change in voltage (0.01% + 0.3%mv)/°C using an external programming resistor, less than (0.015% + 0.3%mv)/°C with internal resistor

Remote Sensing . . . . Provision is made for remote sensing to eliminate effect of power output lead resistance on DC regulation

AC INPUT--105-132, 205-265 or 187-242 ("V" option) volts AC at 47-440 Hz. Maximum input power*: 80 Watts. Ratings apply for 57-63 Hz.; at 47-57 Hz input derate current 10% for each ambient temperature given in table I. For 63-440 Hz, consult factory for details of operation.

* With output loaded to full 40°C rating and input voltage 132 volts AC, 60 Hz.

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OVERLOAD PROTECTION

Electrical

External. . . . . Automatic electronic current limiting circuit, limits output current to a preset value less than 140% of 40°C current rating. Automatic current limiting protects the load and power supply when external overloads and direct shorts occur

Internal. . . . . Fuse F1 provides protection against internal circuit failure in conjunction with over-voltage protector option

OVERVOLTAGE PROTECTION*--Model LCS-A-5-OV includes a fixed built in overvoltage protection circuit which prevents damage to the load caused by excessive power supply output voltage. Overvoltage protection range varies between 6.4 and 6.8 volts D.C.

*Not applicable to units bearing serial no. prefixes A-D.

INPUT AND OUTPUT CONNECTIONS--Terminal block on rear of chassis.

OPERATING AMBIENT TEMPERATURE RANGE AND DUTY CYCLE--Continuous duty from -20°C to 71°C ambient with corresponding load current ratings for all modes of operation

STORAGE TEMPERATURE - (non-operating) -55°C to 85°C

CONTROLS

DC output control. . . . . Voltage adjust control permits adjustment of DC output voltage via access hole located in nameplate

PHYSICAL DATA

Size. . . . . 3-3/16" x 3-5/16" x 6-1/2"
Weight. . . . . 6 lbs. net ; 7 lbs. shipping wt.
Finish. . . . . Grey, FED STD 595 No. 26081

MOUNTING - Three surfaces, each with tapped mounting holes, can be utilized for mounting this unit. All LCS-A power supplies can be mounted with the Top, Front, or Right Side facing up. Top, Front, or Right Side must be in a horizontal plane. Refer to figure 12 for mounting details.

MODEL OPTIONS

Suffix "V" Input Option. . . . . Standard LCS-A power supplies can be obtained for 205-265 VAC, 47-440 Hz input or 187-242 VAC, 47-440 Hz input. See nameplate for AC input rating. See schematic diagram for rewiring of AC input. At 47-57 Hz input, derate current 10% for each ambient temperature given in Table I. For 63-440 Hz consult factory for details of operation.

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Suffix "S" Option . . . . Fixed voltage LCS-A power supplies, used
(LCS-A-3 through LCS-A-48 Only) in conjunction with Lambda Systems Power Sequencer or System Power Protector, must be specified with the "S" option.

ACCESSORIES

Rack Adapter . . . . Rack adapters LRA-8, LRA-10, LRA-11, LRA-12, or LRA-13 with or without chassis slides are available.

Overvoltage Protector . . . . . . Externally mounted, L-20-OV series overvoltage protectors are available for use with models LCS-A-5, -6, -12, -15, -20, -24, -28. On models LCS-A-2, -3, -3P6, -4, -4P5, -8, -10, -18, -36, -48; use overvoltage protectors LMOV-1, -2, -3. On models LCS-A-01 through LCS-A-04, use overvoltage protectors LHOV-4, -5, -6.

Control Panel . . . . All LCS-A power supplies may be obtained with a Systems Power Control Panel, SP-3 or SP-5. This unit, mounted on rack adapters LRA-8, LRA-10, or LRA-11, and used with a Systems Cable or Auxiliary Cable, provides an on-off switch, voltage control and pilot light.

Metering Panel . . . . A Systems Metering Panel, SMP-3 or SMP-5 may be used in conjunction with the LCS-A power supplies. The panel, mounted in rack adapters LRA-8, LRA-10, or LRA-11, and used with a Systems Cable contains a voltmeter and an ammeter, each with three ranges and a push button selector switch. The selector switch allows monitoring of the voltage and current of any of up to 8 outputs.

Metered and Non-Metered Panels . . Metered panels MP-3, MP-5 and non-metered panels P-3, P-5 are available for use with Lambda rack adapters LRA-4, LRA-6 or LRA-7.

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FISHER-ROSEMOUNT

Rosemount Nuclear Instruments, Inc.
12001 Technology Drive
Eden Prairie, MN 55344-3695
USA

DATE: March 16, 1995

PAGE(S) INCLUDING LEAD SHEET: 2

TO		FROM	
COMPANY:	FPC	**FAX NUMBER:**	(612) 828-8280
ATTENTION:	Richard Iwachow	**SENDER:**	Tim Layer
FAX NUMBER:	(813) 866-4984	**PHONE NUMBER:**	(612) 828-8240

SUBJECT: Model 1154 Series H Drift Specification

CC:

ANALYSIS/CALCULATION
DOC ID # I-92-0008 ATT # 3016
REV 1 SHEET 2 OF 2

Rosemount Nuclear Instruments

Rosemount Nuclear Instruments, Inc.
12001 Technology Drive
Eden Prairie, MN 55344 USA
Tel 1 (612) 828-8252
Fax 1 (612) 828-8280

March 16, 1995

Mr. Richard Iwachow
Florida Power Corporation
Fax: (813) 866-4984

Subj: Model 1154 Series H Transmitter Drift Specification

Dear Mr. Iwachow,

The Rosemount model 1154 Series H transmitter Drift Specification is published as ± 0.20% URL for 30 months. This specification will be included in all future revisions of Instruction Manual MAN 4631 and product literature PDS 4631.

Older revisions of model 1154 Series H transmitter product data sheets and instruction manuals indicated a drift specification for only 18 months. The reason was due to the publication date. When these documents were published, the drift specification test conducted by Rosemount to develop the 30 month specification was not yet complete.

The 30 month drift specification is based on a 36 month drift test completed by Rosemount. The results of the testing is published in Rosemount Report D8900126. Although the title of the report states applicability to Model 1152., 1153, and 1154 transmitters, this data is applicable to all Model 1154 Series H transmitters by similarity.

The Model 1154 Series H Transmitter utilizes the same Electronics Package and Sensor Module as the Model 1154 transmitter. Although there are differences in the physical design of the two model types, there are no differences between units which impact drift. Therefore, the results of the Drift Specification testing is directly applicable to the model 1154 Series H by similarity.

Sincerely,

T. J. Layer
Product Marketing Manager
Rosemount Nuclear Instruments, Inc.

TJL/

ANALYSIS/CALCULATION		
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REV 1	SHEET 1	OF 3

MODEL 1154 SERIES H

Product Data Sheet PDS 4631
Rev. 8/93

ALPHALINE® NUCLEAR PRESSURE TRANSMITTER

- *Tested per IEEE Std. 323-1974 and 344-1975*
- *1.1 x 10^8 rads TID gamma radiation*
- *8.5 g's ZPA seismic*
- *420° F (215.6° C) steam temperature*
- *0.25% accuracy*

Post-it® Fax Note 7671

Date	# of pages ▶ 3
To Rich Iwachow	From Jane Sandstrom
Co./Dept. FPC	Co. RNII
Phone #	Phone #
Fax # 813 866-4984	Fax #

FEATURES

Model 1154 Series H *Alphaline®* Pressure Transmitters* are designed for precision pressure measurements in nuclear applications requiring reliable performance and safety over an extended service life. These transmitters have been qualified to IEEE-323 and IEEE-344 to radiation levels of 110 megarads TID gamma radiation, seismic levels of 8.5 g's, and steam-pressure performance up to 420 °F. Stringent quality control during the manufacturing process includes traceability of pressure retaining parts, special nuclear cleaning, and hydrostatic testing.

Model 1154 Series H transmitters are of a design unique to Class 1E nuclear service while retaining the working concept and design parameters of the Model 1151 transmitters that have set industry standards for reliable service. Transmitters are available in sealed gage (S), differential (D), and high-line differential (H) configurations, with a variety of pressure range choices.

Direct electronic sensing with the completely sealed *δ-Cell™* capacitance sensing element eliminates mechanical force transfer and problems associated with shock and vibration. Installation and commissioning are simplified by the compact design and 2-wire system compatibility. Wiring terminals and electronics are in separate compartments, so the electronics remain sealed during installation.

OPERATION

The completely sealed *δ-Cell* capacitance sensing element is the key to the unequalled performance and reliability of the Model 1154 Series H transmitters. Its simple design concept is recognized as a landmark in transmitter engineering. Process pressure is transmitted through an isolating diaphragm and silicone oil fill fluid to a sensing diaphragm in the center of the *δ-Cell*. A reference pressure is transmitted in like manner to the other side of the sensing diaphragm. Displacement of the sensing diaphragm, a maximum motion of 0.004 inches (0.1 mm), is proportional to the pressure differential across it. The position of the sensing diaphragm is detected by capacitor plates on both sides. Differential capacitance between the sensing diaphragm and the capacitor plates is converted electronically to a 2-wire, 4-20 mA dc signal.

ROSEMOUNT®

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SPECIFICATIONS

Nuclear Specifications

Qualified to IEEE Std. 323-1974 and 344-1975 per Rosemount Report D8700096

Radiation

Accuracy within ±(0.2% of upper range limit + 0.2% of span) during first 30 minutes; ±(0.5% of upper range limit + 1.0% of span) after 55 megarads total integrated dosage (TID); ±(0.75% of upper range limit + 1.0% of span) after 110 megarads TID gamma radiation exposure.

Seismic

Accuracy within ±0.5% of upper range limit during and after a disturbance defined by a required response spectrum with a ZPA of 8.5 g's.

Steam Pressure/Temperature

Accuracy within ±(1.0% of upper range limit + 1.0% of span) for range codes 4-8: ±(2.0% of upper range limit +0.5% of span) for range code 9 during and after sequential exposure to steam at the following temperatures and pressures, concurrent with chemical spray for the first 24 hours.

420 °F (215.6 °C), 85 psig for 3 minutes
350 °F (176.6 °C), 85 psig for 7 minutes
320 °F (160 °C), 75 psig for 8 hours
265 °F (129.4 °C), 24 psig for 56 hours

Chemical Spray

Chemical spray composition is 0.28 molar boric acid, 0.064 sodium thiosulfate, and sodium hydroxide to make an initial pH of 11.0 and a subsequent pH ranging 8.5 to 11.0. Chemical spray is sprayed at a rate of 0.25 gal/min/ft².

Post DBE Operation

Accuracy at reference conditions shall be within ±2.5% of upper range limit for one year following DBE.

Quality Assurance Program

In accordance with NQA-1 and 10CFR50, Appendix B.

Nuclear Cleaning

To 1 ppm maximum chloride content.

Hydrostatic Testing

To 150% of maximum working pressure or 2000 psi (13.8 MPa), whichever is greater.

Traceability

In accordance with NQA-1 and 10CFR50, Appendix B; chemical and physical material certification of pressure retaining parts.

Qualified Life

Dependent on continuous ambient temperature at the installation site, illustrated in Figure 3. Replacement of amplifier and calibration circuit boards at the end of their qualified life permits extension of the transmitter's qualified life to the module's qualified life. See Rosemount Report D8700096.

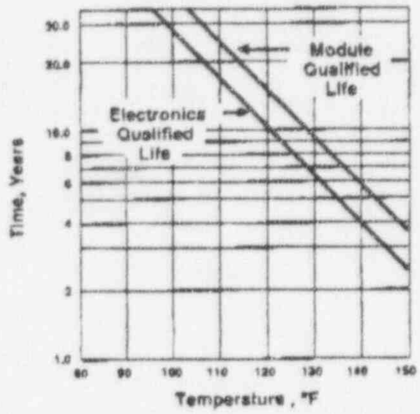

FIGURE 3. Qualified Life vs. Temperature

Performance Specifications

(Zero-based Spans, Reference Conditions)

Accuracy

±0.25% of calibrated span. Includes combined effects of linearity, hysteresis and repeatability.

Deadband

None.

Drift

±0.2% of upper range limit for thirty months.

Temperature Effect

±(0.15% of upper range limit + 0.35% span) per 50 °F (27.8 °C) ambient temperature change between 40 °F (4.4 °C) and 130 °F (54.4 °C).

±(0.75% upper range limit + 0.5% span) per 100 °F (55.6 °C) ambient temperature change between 40 °F (4.4 °C) and 200 °F (93.3 °C).

Overpressure Effect

Model 1154D: Maximum zero shift after 2,000 psi (13.8 MPa) overpressure:

Range 4: ±0.25% of upper range limit.
Range 5: ±1.0% of upper range limit.
Ranges 6 and 7: ±3.0% of upper range limit.
Range 8: ±6.0% of upper range limit.

Model 1154S: Maximum zero shift after 4,500 psi (31.0 MPa) overpressure:

Range 9: ±0.5% of upper range limit.

Model 1154H: Maximum zero shift after 3,000 psi (20.68 MPa) overpressure:

Range 4: ±1.0% of upper range limit.
Range 5: ±2.0% of upper range limit.
Ranges 6 and 7: ±5.0% of upper range limit.

Static Pressure Zero Effect

Model 1154D: ±0.2% of upper range limit per 1,000 psi (6.9 MPa) (ranges 4 and 5); ±0.5% of upper range limit per 1,000 psi (6.9 MPa) (ranges 6, 7 and 8).

Model 1154H: ±0.66% of upper range limit per 1,000 psi (6.9 MPa) for all ranges.

Static Pressure Span Effect

Effect is systematic and can be calibrated out for a particular pressure before installation. Correction uncertainty: ±0.5% of reading/1,000 psi.

Power Supply Effect

Less than 0.005% of output span/volt.

Load Effect

No load effect other than the change in voltage supplied to the transmitter.

Mounting Position Effect

No span effect. Zero shift of up to 1.5 inH_2O (372 Pa) for ranges 4 and 5, which can be calibrated out. For higher ranges, effect is superseded by accuracy specifications.

Response Time

Fixed time constant (63%) at 100 °F (37.8 °C) as follows:
Range 4: 0.5 seconds or less.
All other ranges: 0.2 seconds or less.

Adjustable damping option available through special N-Option.

Functional Specifications

Service

Liquid, gas, or vapor.

Output

4-20 mA dc.

Power Supply

Design limits as shown in **Figure 4**.

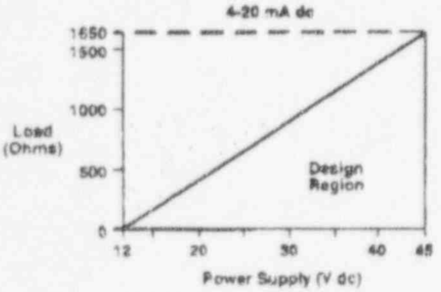

FIGURE 4. Load Limitations

Span and Zero

Continuously adjustable externally.

Zero Elevation and Suppression

Maximum zero elevation : 600% of calibrated span.
Maximum zero suppression : 500% of calibrated span.
Zero elevation and suppression must be such that neither the span nor the upper or lower range value exceeds 100% of the upper range limit.

Temperature Limits

Normal Operating Limits: 40 to 200 °F (4.4 to 93.3 °C).
Qualified Storage Limits: –40 to 120 °F (–40.0 to 48.9 °C).

Humidity Limits

0-100% relative humidity (NEMA 4X).

Volumetric Displacement

Less than 0.01 in^3 (0.16 cm^3).

Turn-On Time

Two seconds maximum. No warm-up required.

Model 1154D and 1154H

Codes/Ranges

(4) 0-25 to 0-150 inH_2O (0-6.22 to 0-37.50 kPa).
(5) 0-125 to 0-750 inH_2O (0-31.08 to 0-186.50 kPa).
(6) 0-17 to 0-100 psi (0-0.12 to 0-0.69 MPa).
(7) 0-50 to 0-300 psi (0-0.34 to 0-2.07 MPa).
(8) 0-170 to 0-1000 psi (D units only) (0-1.17 to 0-6.89 MPa).

Maximum Working Pressure

Static pressure limit.

Static Pressure and Overpressure Limits

Model 1154D: 0.5 psia to 2,000 psig (3.4 kPa to 13.8 MPa) maximum rated static pressure for operation within specifications. Overpressure limit is 2,000 psig (13.8 MPa) on either side without damage to the transmitter.

Model 1154H: 0.5 psia to 3,000 psig (3.4 kPa to 20.7 MPa) maximum rated static pressure for operation within specifications. Overpressure limit is 3,000 psig (20.7 MPa) on either side without damage to the transmitter.

Model 1154S

Codes/Ranges

(9) 0-500 to 0-3000 psig (0-3.45 to 0-20.68 MPa).

Maximum Working Pressure

Upper range limit.

Overpressure Limits

Operates within specifications from 0.5 psia (3.4 kPa) to upper range limit. Overpressure limit is 4500 psig (31.0 MPa) for range code 9, without damage to the transmitter.

ANALYSIS/CALCULATION

DOC ID # I-92-0008 ATT # 18

REV 1 SHEET 1 OF 14

ROSEMOUNT
Measurement
Control
Analytical
Valves

Rosemount Inc.
12001 Technology Drive
Eden Prairie, MN 55344 U.S.A.
Tel (612) 941-5560
Telex 4310012
Fax (612) 828-3088

October 23, 1991

Florida Power Corporation
P.O. Box 14042
St. Petersburg, FL 33733

Att: David Owen, M/C C2I

Dear Mr. Owen:

Enclosed please find a copy of Report 78212 as requested. This report will apply to the Model 1154 and 1154 Series H transmitters as well.

If you have any further questions please feel free to call me at (612) 828-3100.

Sincerely,

Neil P. Lien
Marketing Engineer
Rosemount Nuclear Products

enc: Report 78212

ANALYSIS/CALCULATION

DOC ID # I-92-0008 ATT # 18

REV 1 SHEET 2 OF 14

Rosemount

ROSEMOUNT INC., 12001 WEST 78th STREET / EDEN PRAIRIE, MINNESOTA 55344
Mailing Address: P.O. BOX 35129 / MINNEAPOLIS, MINNESOTA 55435
TEL: (612) 941-5560 TWX 910-576-3103 TELEX 29-0183

NUCLEAR OPERATIONS GROUP

INTERNAL THERMAL RESPONSE OF TRANSMITTER

HOUSINGS TO STEAM IMPINGEMENT

ROSEMOUNT MODELS 1153 SERIES B AND D

ROSEMOUNT REPORT 78212

REVISION A

Approved by Eng. [signature] Date 8/27/82

LYLE LOFGREN - Senior Engineer, Design

Approved by Eng. [signature] Date 8/30/82

CHUCK ODEGAARD - Manager, Nuclear Operations Group

Approved by Q.A. [signature] Date 9-14-82

MIKE POLLACK - Project Engineer, Quality

Approved by Q.A. [signature] Date 9-14-82

JERRY ANDERSON - Supervisor, Quality Assurance

REVISION STATUS

Rev	Page	Paragraph	Change Description	Eng. App.	Eng. Supv. App.	Mfg. Eng. App.	Q.A. App.	Env. Test Supv. App.	Cust. Data Coord. App.	Effectivity S/N or Date
A			Original Release	LEL	[illegible]	N/A	[illegible]	[illegible]	N/A	9/23/82

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INTERNAL THERMAL RESPONSE OF TRANSMITTER HOUSINGS TO STEAM IMPINGEMENT, ROSEMOUNT MODELS 1153 SERIES B AND D. ROSEMOUNT REPORT 78212.

1. SUMMARY.

Several previous reports have been written on the thermal response of Rosemount nuclear qualified and related transmitters to the temperature transients expected in a High Energy Line Break (HELB) accident (see refs. 2.1 through 2.6). However, none of the previous tests were conducted using high energy steam as the heat transfer medium. This report summarizes the results of recent tests of the internal temperature response of Rosemount Models 1153 Series B and Series D pressure transmitters when exposed to sudden high-temperature steam impingement.

2. REFERENCES.

2.1 Rosemount Report 47422. "Response of 1151 Transmitter to Transient Temperature Field." (1974).

2.2 Rosemount Report 1775C. "Temperature Transient Effect, Model 1152GP9A." (1975).

2.3 Rosemount Report 27718A. "Transient Response of 1151DP Transmitter to Rapid Changes in Temperature." (1977).

2.4 Rosemount Report 37718. "Effect of Elevated Temperatures on Pressure Transmitter Electronics for Aluminum and SST Housings." (1977).

2.5 Rosemount Report 17912B. "Temperature Transient Test Results for Rosemount Pressure Transmitter, Model 1153 Series A." (1979).

2.6 Rosemount Report 118017. "Thermal Time Constant Analysis for Stainless Steel Electronics Housings, Rosemount Model 1153 Series A and Series D." (1980).

2.7 Rosemount Report 48223C. "420 F Temperature Test Results, Model 1153 Series B." (1982).

2.8 Anderson, Norman A. "Step Analysis Method of Finding Time Constant." Instruments & Control Systems, 36 , 130 (1963).

2.9 Rosemount Report 67817. "Steam Chemical Facility for Nuclear Qualification Testing." (1978).

3. <u>TESTS CONDUCTED</u>.

The Rosemount Model 1153 Series B pressure transmitter uses

an aluminum electronics housing. Tests were conducted to establish if the unit could withstand short excursions to 420 F. The tests, described in ref. 2.7, were conducted in Rosemount's Steam chamber (ref. 2.9). As part of this test, a non-operating unit was placed in the chamber. It contained a thermocouple located on one of the screws holding the amplifier board in place. Since the amplifier board contains most of the sensitive components of the unit, the thermocouple readings give a good indication of the effect of external temperature transients on the unit.

A test series was subsequently run using the Rosemount Model 1153 Series D transmitter, which uses a housing made of 316 stainless steel. A similar non-operating unit with an internal thermocouple was used, and the output recorded during a simulated HELB transient to 350 F. The temperature inside the chamber, as determined by thermocouples placed close to the test housings, rose from room temperature to the desired temperature within approximately 30 seconds.

4. ANALYSIS.

Fig. 1 shows the steam temperature and internal housing temperature vs. time for the Series D (stainless steel housing). The steam temperature change is very close to a step function, and, if the housing behaves as a "one-time-constant system," the thermal time constant can be determined by measuring the time required for the internal

temperature to achieve 63.2% of its final temperature. As can be seen from Fig. 1, this is approximately 5 minutes.

A more precise analysis, however, can be made using a technique (called Step Analysis) described in ref. 2.8. The response of a one-time-constant system to a step input is given by 1-exp(-t/ θ), where t is elapsed time and θ is the time constant. If the response is calculated in terms of the percentage of the step response which has not yet appeared inside the system (% incomplete), this exponential function yields a straight line on semi-log paper, with the line intersecting t=0 at 100 % incomplete response. In a multi-time-constant system, however, a graph of % incomplete response vs. time will show a deviation from a straight line initially, with the data more closely resembling a straight line as time increases. A straight line through the data at large time values, when extended back to t=0, represents the time constant of the slowest responding thermal element of the system. This is shown by the solid line in fig. 2. The time constant of the slowest element can then be determined by noting the intersection of this line with t=0 (130% in this case), calculating the point at which this line would be 36.8% incomplete (=63.2% complete), and finding the time along the line at which this response would occur. The calculation shown on fig. 2 gives 4.8 minutes, which is very close to the 5 minute value determined from fig. 1. A calculation of the time constant of the next-slowest thermal element can be made by plotting the difference between the

unit's response and the straight line extrapolation. This is shown by the x's in fig. 2, with the dashed line being a straight line extrapolation through these points. The points follow a straight line all the way to t=0, so there are no other significant thermal elements involved between the steam outside and the amplifier board inside the housing. A calculation of 36.8% incomplete time on this line results in a second time constant of 1.4 minutes.

Fig. 3 shows the steam temperature input and response of the thermocouple inside the aluminum 1153 Series B housing, as replotted from ref. 2.7. The step function was held for only about 5 minutes, which is not long enough to plot a reliable time constant value from this graph. However, the Step Analysis technique, shown in fig. 4, still works. In this case, the Step Analysis technique must be repeated twice, resulting in calculated time constants of 3, 1.2 and 0.6 minutes. The 1.2 minute result here agrees quite closely with the 1.4 minute result of fig. 2. This indicates a common thermal element, probably the standoffs on which the amplifier board is mounted. The first time constant in each case is obviously due to the housing, resulting in a thermal time constant of 4.8 minutes for the Series D and 3 minutes for the Series B.

5. CONCLUSIONS.

The thermal time constant of the stainless steel housing of

the Model 1153 Series D is approximately 4.8 minutes. The time constant of the aluminum housing of the Model 1153 Series B is approximately 3 minutes. Although postulated HELB events usually specify a rise time of 10 seconds from room to HELB temperatures, this data shows that slower rise times can be used during testing without affecting results, as long as rise times are short compared with housing response. Thus, a 30-second rise time (16% of the time constant of the fastest unit) is an acceptable simulation, since the internal components see the same transient. Previous tests with very fast rise times, such as described in ref. 2.5, prove qualification of the external part of the housing for 10-second rise-time HELB events.

FIGURE 1 - THERMAL RESPONSE TEST, 1153 SERIES D HOUSING
Tested in conjunction with output Code R tests, group I, 6/12 - 6/14/82

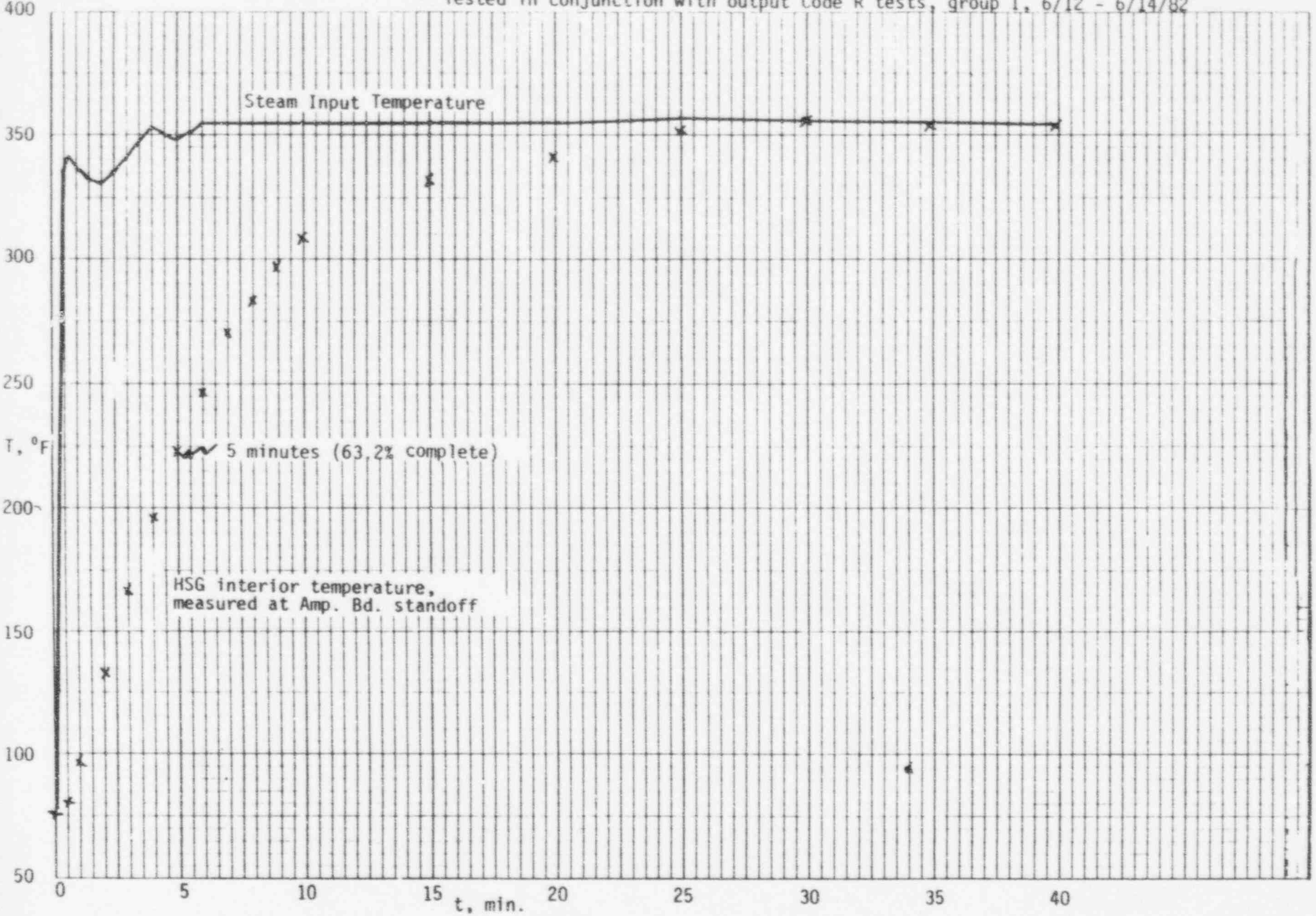

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FIGURE 2 - STEP ANALYSIS - THERMAL RESPONSE - 1153 SERIES D HOUSING

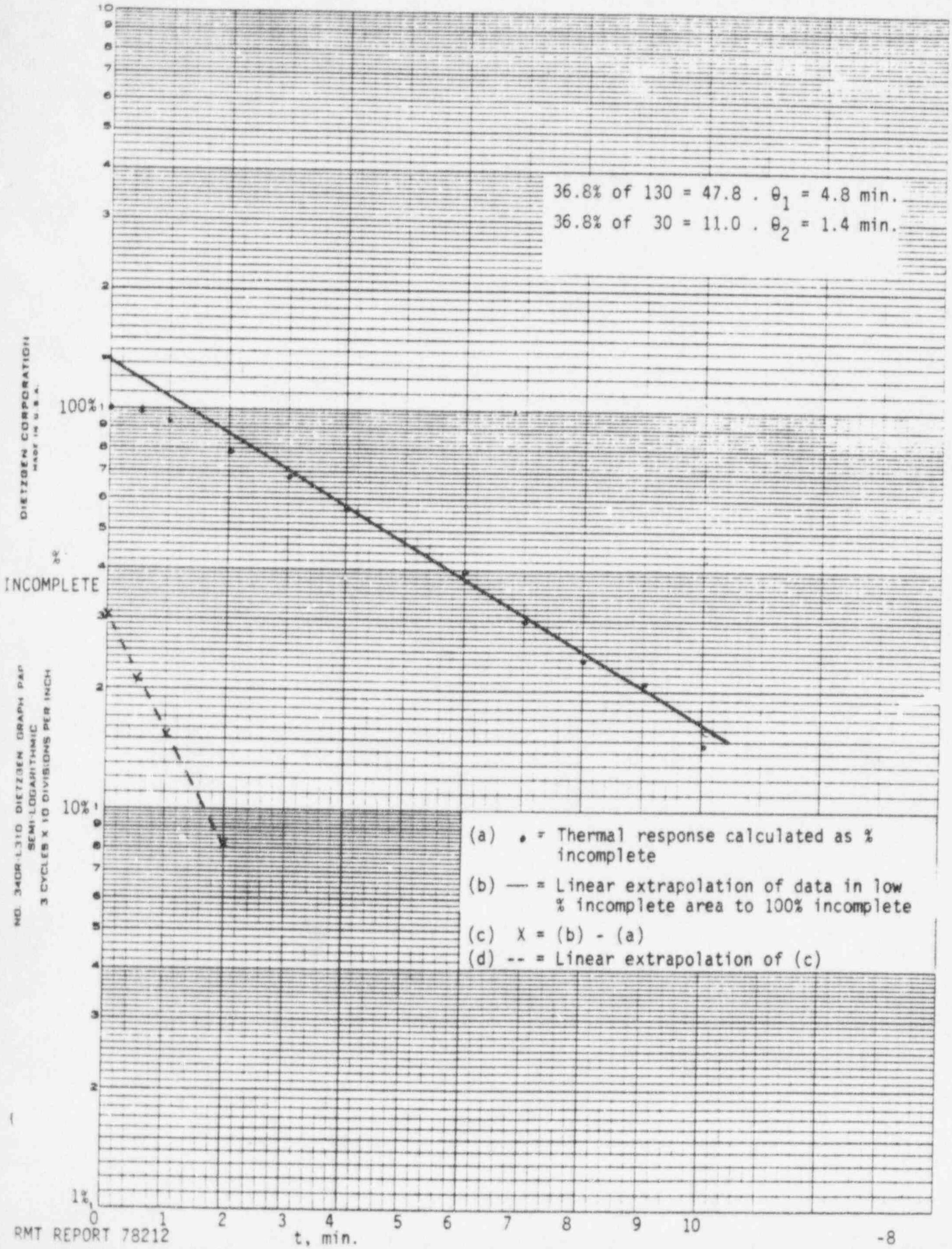

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FIGURE 3 - THERMAL RESPONSE, 1153 SERIES B HOUSING

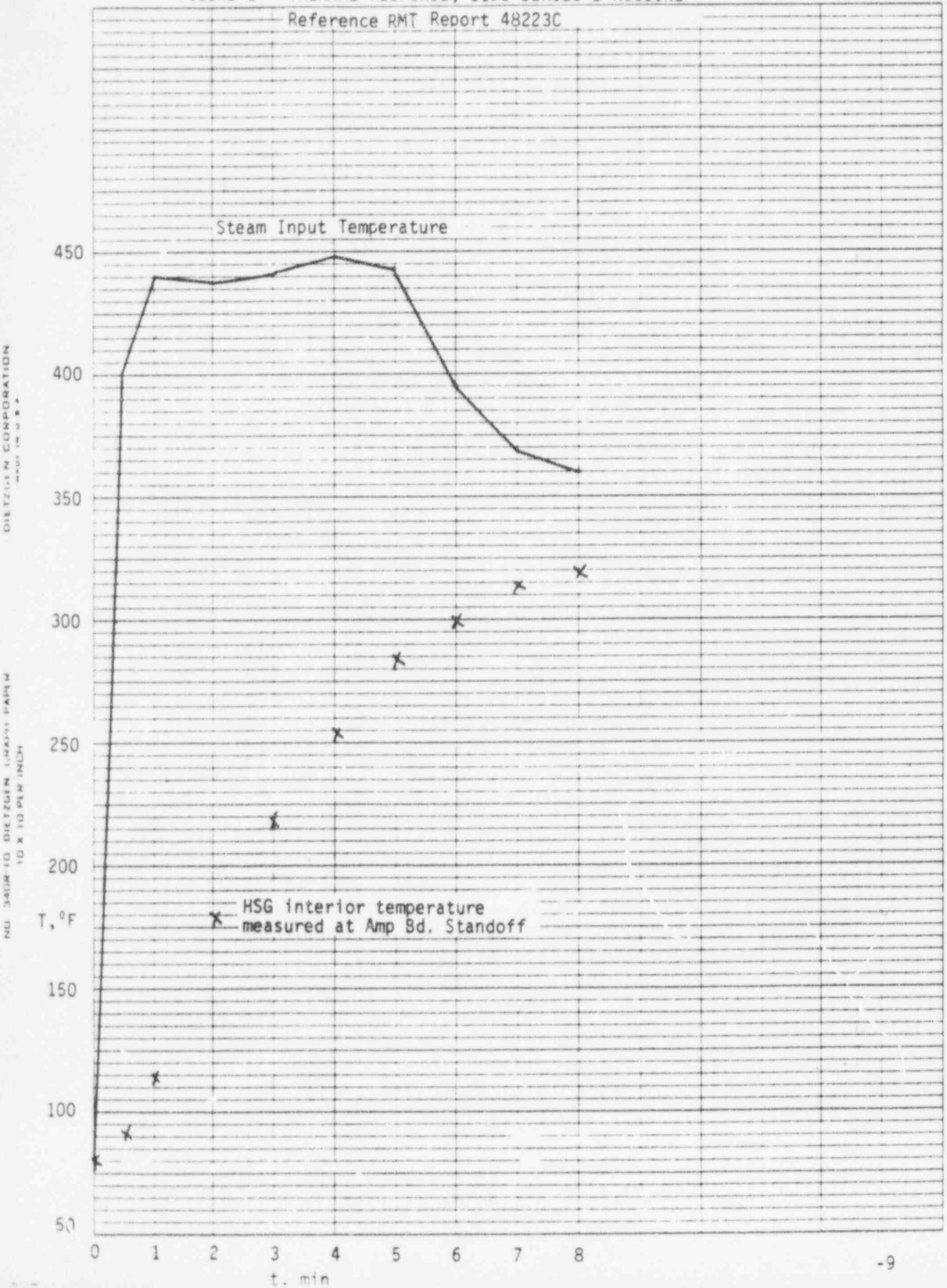

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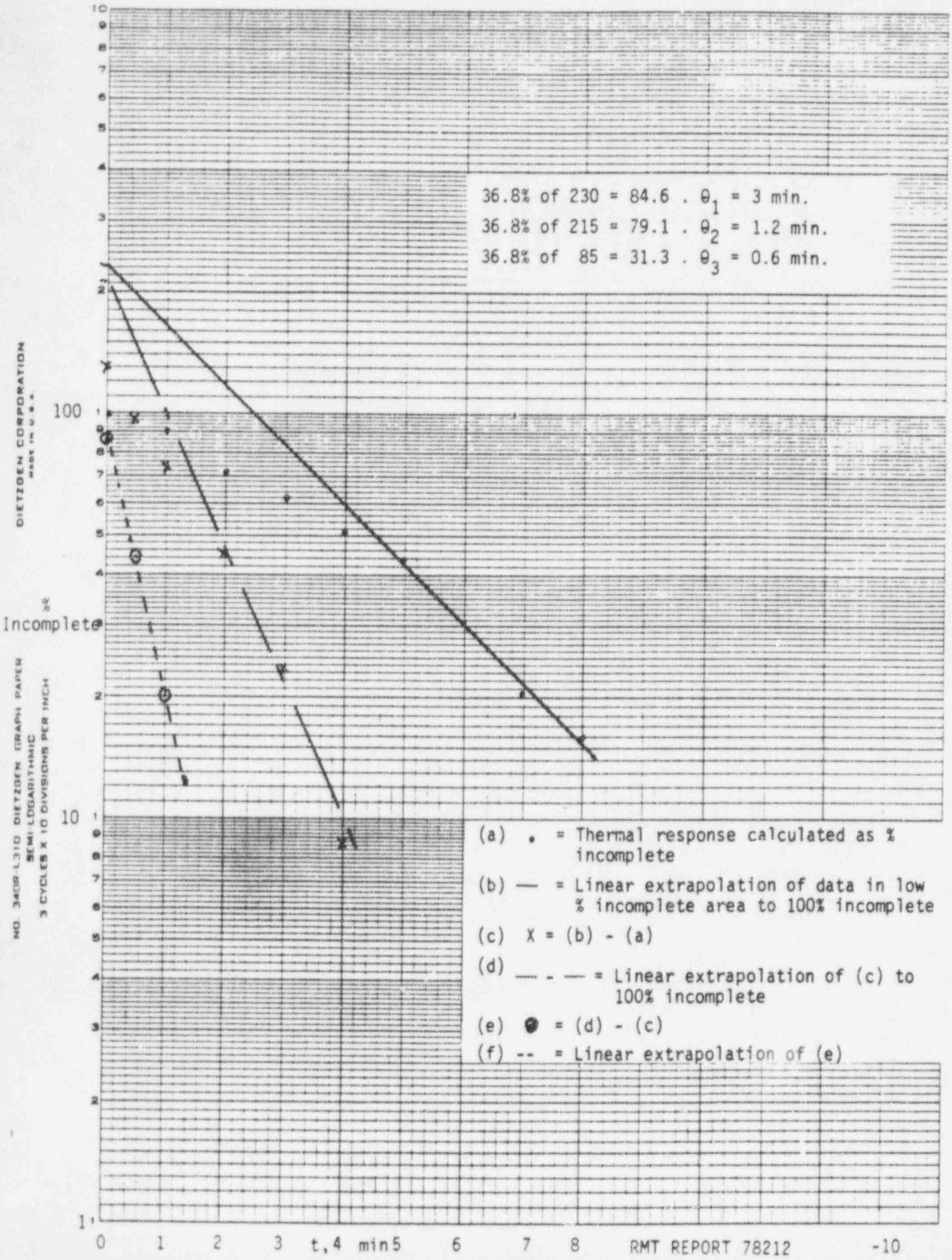
FIGURE 4 - STEP ANALYSIS - THERMAL RESPONSE - 1153 SERIES B HOUSING



RMT REPORT 78212

ATTACHMENT 19

Atmospheric Dump Valve
Control Valve Tuning Parameters

Prior to the advent of the Emergency Feedwater Initiation and Control (EFIC) system, the atmospheric dump valve (ADV) control logic was a part of the Integrated Control System (ICS). The ADV control circuitry was housed on modular cards which occupied cabinet positions 4-4-3 and 4-4-12 (Reference 50). The control function was removed from ICS and transferred to the EFIC control logic. Since no operational occurrences were experienced or identified with the ICS control valve tuning parameters, these same parameters were set-up for the EFIC control logic. The following tuning parameters as transferred from ICS and translated to binary setting for placement on the front panels of the EFIC control modules for the pressure control function (MSV-025-PC and MSV-026-PC).

a) Translation of Integral Rate.
Previously, ICS module 4-4-3 had an integral setting of 2 repeats/minute. To adjust this rate into the front panel, we set the 5 digit thumbwheel switch per the instructions outlined in the Vitro manual (Reference 36) on page 6-16.

To match the EFIC setting, the ICS values must be converted as:

$$A = B/60$$

where B = the ICS setting of repeats/minute
A = the EFIC setting of repeats/seconds

So then, the setting for the ADV repeat/second is 2 repeats/minute or

$$A = 2/60$$
$$A = 0.0333$$

the thumbwheel setting should be as " 00333 ".

b) The Proportional Band.
The proportional band setting in the in ICS module 4-4-12 had a " K " setting of " 5 ". To adjust this rate into the front panel, we set the digit thumbwheel switch per the instructions outlined in the Vitro manual (Reference 36) on page 6-16.

To match the EFIC setting, the ICS value of " 5 " is set as: **ADV K = 05000**