CALCULATION COVER SHEET

ABB
ASEA BROWN BOVERI
ABB IMPELL CORPORATION

CALCULATION NUMBER: (25-226-C004)

TITLE: Setpoint Calculation For LIS263-72A, B, C, D: Reactor Vessel Low-Low Water Level

CLIENT: BOSTON EDISON

PROJECT: SETPOINT CONTROL PROGRAM

PROJECT NUMBER(S): 25-226

SUMMARY DESCRIPTION:

REVISION	REVISION DESCRIPTION	APPROVED	DATE
0	INITIAL ISSUE	BORIS LOKSHIN	2/2/93
1	Calculation of Pma & Re effects were revised. All affected pages also revised	Boris Lokshin	4-1-93

TOTAL 126 PAGES INCLUDING ATTACHMENTS

Identify total number of pages, including attachments
Effective 4/92

D-2

REVISION 1 SUMMARY

This revision incorporates changes to the methodology for calculation Process Measurement Accuracy (Pma) and Radiation (Re) Effects. Since these changes affected most pages (e.g. Form 1, Form 2, Form 3, References, Assumptions, Methodology, etc.), a complete revision of the calculation was done. Note that the methodology changes incorporated into Revision 1 slightly modify the final results, however, they do not modify the conclusions associated with the status of the instrument setpoints.

					Setpoint Calculation		
					LIS263-72A, B, C, D : Reactor Vessel Low-Low Level		
1	JWR	4/1/93	TJD	4/1/93	ABB	JOB NO. 25-226	PAGE 2
0	JWR	1/28/93	TJD	2/1/93	ASEA BROWN BOVERI	CALC NO.	OF 87
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I. PURPOSE/BACKGROUND

A. PURPOSE

This calculation is being performed to support Pilgrim Nuclear Power Station (PNPS) Technical Specification changes required for a 24 month fuel cycle as described in NRC Generic Letter (GL) 91-04 (Reference 43).

The purpose of this calculation is to determine the setpoint and allowable value (Tech Spec value) required to support an increase in fuel cycle duration from 18 months to 24 months for Reactor Water Level Switches LIS263-72A, B, C, D.

B. BACKGROUND

The low-low Reactor vessel water level switches, LIS263-72A, B, C and D trip ESF functions RCIC and ADS and also start the Standby Diesel Generator at -46" vessel level. Core spray will also be initiated off these switches if Reactor pressure is less than 400 psig or after a thirteen minute time delay.

II. DESIGN INPUTS/ASSUMPTIONS

- See Detailed Calculation (Section IV) for design inputs

- Level Transmitters LT263-72, A, B, C, D are calibrated using maximum no adjust limits of ± 0.04 mA (± .25% of span) over a range of 4-20 mA (Reference 21, 22). All measuring and test equipment will be assumed to have a combined accuracy of ± .25% or better (Reference 46).

- Master trip units are calibrated using maximum no adjust limits of ± 0.02 mA (± 0.125% of span) over a range of 4-20 mA (Reference 23, 24). All measuring and test equipment will be assumed to have a combined accuracy of ± .13% or better (Reference 46).

- Calibration of Level Transmitters will be assumed to be conducted at a nominal frequency of every 24 months or better. However, a frequency of 30 months is used herein to be consistent with the Tech Spec (Reference 40) definition of surveillance frequency (U), which allows a maximum extension of 25% of the specified surveillance interval.

- Calibration of master trip units will be assumed to be conducted at a frequency of 3 months or better. However, a frequency of 4 months is used herein to be consistent with the Tech Spec (Reference 40) definition of surveillance frequency (U), which allows a maximum extension of 25% of the specified surveillance interval.

- Performance specifications are typically expressed in terms of % Upper Range Limit (URL), % of reading or % calibrated span. In this calculation, all results will be expressed in units of indicated water level height. The span of this indication is 100". The span of the differential pressure applied to the transmitter differs from the indicated water level. These values are 70.06"H_2O for the "A" Train transmitters, and 70.05"H_2O for the "B" Train transmitters.

- The effects of the accumulation of non-condensable gases in the reference leg, which can result in notching, are not considered in this calculation. BECo is addressing the issue separately via the BWR Owner's Group.

- Reference leg flashing is not considered in this calculation because flashing cannot occur above 100 psig. Operability Evaluation of the reactor water level system, Reference 66, shows that these water level setpoints are reached before reactor vessel pressure reaches 400 PSIG.

- Reactor and Turbine building normal temperatures are taken from FSAR Tables 10.9.1 & 10.9.2 (Reference 9), because the FSAR is the most recent, controlled document, reference source found with this information. The temperatures are assumed to be correct because they are the same as the temperatures identified in the Bechtel Design Basis Report 6498-HDBR-05 (Reference 60).

- A large break LOCA scenario is not evaluated for its effects on these level loops because the primary protective function for this event is provided by the High Drywell Pressure instruments (Reference 7).

III. REFERENCES

1. Vendor Manual V-0098, Rev. 9 (Rosemount Instruction Manual 4302, Rev. E), "Model 1153 Series B Alphaline Pressure Transmitters for Nuclear Service"

2. Vendor Manual V-0243, Rev. 3 (Rosemount Instruction Manual 4471-2, Rev. B), "Trip/Calibration System Model 710DU" (Operating Instructions)

3. Vendor Manual V-0243, Rev. 3 (Rosemount Instruction Manual 4471-1, Rev. A), "Trip/Calibration System Model 710DU" (Maintenance & Repair Instructions)

4. PNPS BECo Work Instruction Number NEDWI No. 394, Rev. 3, "Methodology for Calculation of Instrument Setpoints"

5. BECo Calc. No. I-N1-21, Rev. 1, "Rosemount Dp Transmitter Calibration Correction for High Static Pressure"

6. BECo Calc. No. I-N1-24, Rev. 0, "Reactor Water Level Instrument Calibration"

7. NEDC-31852P, PNPS Safer/GESTR-LOCA Loss-of-Coolant Analysis, September, 1990.

8. PNPS Procedure 2.2.80, Rev. 10, "Reactor Vessel Level, Temperature, and Internal Instrumentation"

9. PNPS FSAR, Rev, 14

10. BECo EQDF No. 329B, Rev. E2, "Analysis of Bechtel Calcs. E-504-1, E-524-2 and E-524-3 due to PBOC.

11. BECo NED No. 85-237, March 8, 1985, "Cable Spreading Room Environment"

12. BECo Dwg. M1001, Sh. 129, Rev. E1, "Nuclear Boiler System Reference Leg from Nozzle N15B to Penetration X-29C & X-82B"

13. BECo Dwg. M1001, Sh. 128, Rev. E1, "Nuclear Boiler System Reference Leg from Nozzle N15A to Penetration X-28C & X-82A"

14. BECo Dwg. M632, Sh. 20, Rev. E1, "Temperature & Pressure Pipe Break Outside Containment (PBOC)"

15. BECo Dwg. M632, Sh. 10, Rev. E4, "Temperature & Pressure Pipe Break Outside Containment (PBOC)"

16. BECo P&ID M253, Sh. 1, Rev. E24, "Nuclear Boiler Vessel Instrumentation"

17. BECo P&ID M253, Sh. 2, Rev. E15, "Nuclear Boiler Vessel Instrumentation"

18. BECo Elementary Diagram E727, Rev. E3, "ECCS Analog Trip Cabinet C2233A Section A"

19. BECo Elementary Diagram E729, Rev. E3, "ECCS Analog Trip Cabinet C2233B Section A"

20. PNPS Q-List, Rev. E50

21. PNPS Procedure 8.M.2-8.1, Rev. 5, "Calibration of ATS Transmitters Rack C2205"

22. PNPS Procedure 8.M.2-8.2, Rev. 7, "Calibration of ATS Transmitters Rack C2206"

23. PNPS Procedure 8.M.1-32.5, Rev. 13, "Analog Trip System - Trip Unit Calibration - Cabinet C2233A, Section A"

24. PNPS Procedure 8.M.1-32.7, Rev. 10, "Analog Trip System - Trip Unit Calibration - Cabinet C2233B, Section A"

25. BECo Dwg. M1002, Sh. 20, Rev. E2, "Reference Leg Piping to Instrument Racks 2205 and 2275"

26. BECo Dwg. MIP 312-3, Rev. E4, "Arrangement Drawing Reactor Protection System Instrument Rack C2205"

27. BECo Dwg. MIP-319-2, Rev. E3, "Rack 2206 Sh No. 4 Arrangement"

28. BECo Dwg. M1002, Sh. 16, Rev. E1, "Nuclear Boiler System Instrument Piping to C2206"

29. BECo Dwg. M1002, Sh. 19A, Rev. E1, "Nuclear Boiler System Reference Leg Piping from X-82A to C2251 & Capped Piping from X-28A"

30. BECo Dwg. M1002, Sh. 124, Rev. E0, "Nuclear Boiler System Reference Leg to Instrument Racks 2205, 2275 & 2251"

31. BECo Dwg. M1002, Sh. 125, Rev. E0, "Nuclear Boiler System Reference Leg to Instrument Racks 2206, 2276 & X82B"

32. BECo Electronic Analog Data Sheets

    a. M209A-DS-165-1, Rev. E1
    b. M209A-DS-165-2, Rev. E1
    c. M209A-DS-166-1, Rev. E0
    d. M209A-DS-166-2, Rev. E0
    e. M209A-DS-56, Rev. E0

f. M209A-DS-61, Rev. E0
g. M209A-DS-66, Rev. E0
h. M209A-DS-68, Rev. E0

33. BECo Nedorandum NAD #91-78, November 13, 1991 "Analytical Limit for Reactor Water Level Low-Low Setpoint"

34. GE Letter LLC-55-91, November 12, 1991 "PNPS Safety Evaluation for Changing the Analytical Limit for Low-Low Reactor Water Level" (Includes GE Attachment DRF A00-03983)

35. Rosemount Letter from T. Layer (Rosemount) to B. Rancourt (BECo), November 13, 1991, "Model 353C and 353C1 Performance Specs"

36. Crane Technical Paper No. 410, "Flow of Fluids through Valves, Fittings & Pipe"

37. SUDDS/RF #91-178 (GE Letter LLC-52-91, November 15, 1991 "Analytical Limits for Scram Water Level and HPCI/RCIC Water Level Trip for Pilgrim")

38. BECo Nedorandum PS&MC 91-176, October 11, 1991 "Reactor Vessel Thermal Growth Effect on Reactor Instrumentation"

39. Rosemount Letter from T. Layer (Rosemount) to B. Rancourt (BECo), August 8, 1989, "Rosemount Nuclear Specifications"

40. PNPS Technical Specifications, Rev. No. 161

41. Environmental Qualification Evaluation Sheets:

    a. LT263-72A, Rev. 1
    b. LT263-72B, Rev. 1
    c. LT263-72C, Rev. 1
    d. LT263-72D, Rev. 1

42. Rosemount Report D8600063, EQDF No. 394, Rev. A, "Low Level Radiation Dose Rate Test Small Break LOCA Test - Rosemount Nuclear Pressure Transmitter Model 1153 Series B"

43. NRC Generic Letter (GL) 91-04, April 2, 1991, "Changes in Technical Specification Surveillance Intervals to Accommodate a 24 month Fuel Cycle"

44. ABB Impell Project Instruction 25-226-PI-001, Rev. 2, "Data Collection and Analysis"

45. ABB Impell Project Instruction 25-226-PI-002, Rev. 1, "Setpoint Calculations"

46. PNPS Procedure 1.3.36, Rev. 12, "Measuring and Test Equipment"

47. Safety Evaluation SE2279, Rev. 0, "Modification of Control Room High Efficiency Air Filtration System Heater Controls (CRHEAFS)

48. BECO Calc. No. I-N1-23, Rev. 1, "ECCS/RPS Analog Trip Panel Current Drain"

49. GE NEDO-21617-A, December 1978, Licensing Topical Report "Analog Transmitter/Trip Unit System for Engineered Safeguards Sensor Trip Units"

50. BECO Dwg. M292, Rev. E14, "Control & Cable Spreading Room, Intake Structure, Access Control, Warehouse & Machine Shop Air Flow Diagrams"

51. Specification E-536, Rev. 1, "Environmental Parameters for use in the Environmental Qualification of Electrical Equipment (per 10CFR50.49)"

52. Vendor Manual V-0098, Rev. 8 (Rosemount Product Data Sheet 2302, Rev. 6/90)

53. BECo EQDF #389, Rev. E0, "30 Month Stability Specification for Rosemount Model 1152, 1153 and 1154 Pressure Transmitters. Rosemount Report D8900126"

54. BECo NED Procedure 3.05, "Design Calculations"

55. ABB Impell Quality Assurance Manual Procedure QP-3.4, Rev. 6, "Calculations"

56. Rosemount Report 78212, Rev. A (EQDF #395), "Internal Thermal Response of Transmitter Housings to Steam Impingement"

57. ASME Steam Tables, 5th edition

58. Environmental Qualification Data File (EQDF) Ref. 4, "ERHS 82-34, Finalized I.E. Bulletin 79-01B Equipment Qualification Radiation Exposure Levels, Worst Case, For Various Code Areas Within the Reactor Building (40 Year Normal Operation + a HELB Accident Scenario, With & Without Core Damage)

59. GE Report GEK-83395, March 1984, "Voltage Converter Operation & Maintenance Instructions - 147D8661P1"

60. Bechtel Report 6498-HDBR-05, Rev. 1, " Design Basis Report Control Room, Cable Spreading and Computer Room Air Conditioning System", Enclosure in Bechtel Letter 17322-GBLE-91/002, Dated 6/28/91, S.Veale (Bechtel) to R. Fairbank (BECo).

61. BECo Drawings M209A5 Sheets 1-5, Rev. E0, "Meter Face Illustrations RPS/PCIS & ECCS Analog Trip Rosemount Model 710DU Master Trip Unit"

62. PNPS Procedure No. 2.1.15, Rev. 92, "Daily Surveillance Log (Tech Specs and Regulatory Agencies)"

63. ANSI/ASME PTC 19.1-1985, "Part 1, Measurement Uncertainty"

64. PNPS Equipment Qualification Master List (EQML), Rev. E29

65. BECo Dwg. M23, Rev. E6, "Equipment Location Section D-D & L-L"

66. Engineering Operability Evaluation, Reactor Water Level System, Rev. 0, ORC #92-72

67. Rosemount Procedure D8700142, Rev. A (EQDF #396) "Beta Contribution During Radiation Exposure Model 1153B Transmitter"

68. BECo EQDF #394A (ABB Impell Letter 25-226-037), March 16, 1993, "Evaluation of Rosemount Test Report D8600063 for Applicability to BECo Setpoint Control Program Project"

Note: Additional references are located in Note 14, Transient Analysis of Reference Leg Heatup.

IV. DETAILED CALCULATION

A. METHODOLOGY

This calculation is performed per ABB Impell Project Instruction No. 25-226-PI-002 (Reference 45), BECo NEDWI No. 394 (Reference 4), and NRC GL 91-04 (Reference 43). The format of this calculation has been specifically modified to meet the content requirements identified in BECo NED Procedure 3.05 (Reference 54) and ABB Impell Quality Assurance Procedure QP-3.4 (Reference 55).

This calculation utilizes a new analytical limit for Reactor water low-low water level (-56.9 inches from instrument zero) provided by GE in GE Letter No. LLC-55-91 (Reference 34). The new limit lowers the existing limit and provides room for loop measurement uncertainty. The goal of this calculation is to maintain the existing Reactor low-low water level field setpoint, while accounting for loop measurement uncertainty.

As found/as-left instrument calibration data is statistically analyzed to calculate 95%/95% probability and confidence level values for LIS263-72A, B, C, D. The values are derived in accordance with ABB Impell Project Instruction 25-226-PI-001 (Reference 44), are presented in Attachment 6 and used in the setpoint calculation. The value determined in this process is considered to include the effects of measurement and test equipment (M&TE), reference or basic component accuracy and component drift. Therefore, values will not be entered in this calculation for Rca (M&TE contributions) or Rea (rack basic accuracy). The rack and sensor setting tolerances (St and Ret) are retained. This approach is consistent with the proposed Instrument Society of America (ISA) Recommended Practice. For Rosemount trip units, Rea (repeatability) is N/A, because Rosemount includes repeatability in the drift specification.

The 95%/95% probability and confidence level is taken from the second outlier column on the spreadsheet printout (Attachment 6). For Rosemount trip units, the worst case 95%/95% drift value is used for all four loops.

The manufacturer's drift specification is used for transmitters LT263-72A, B, C, D, because there are not enough data points for a valid statistical analysis at this time.

This calculation covers four redundant loops. Where individual loop values differ, the values for each train are compared and the worst case train is used for conservatism. If a loop is required to function during one or more accident scenarios, then the uncertainty effects due to each accident are calculated and compared and the single worst accident scenario is used in calculating total loop uncertainty. The individual switch safety function determines if the loop must function during an accident scenario.

Pma is calculated for normal operation and two post-accident scenarios. The normal operation Pma is due to temperature variations inside the drywell and Reactor building which affect the density of the reference leg column of water as well as static offset due to the difference between the actual condensate pot elevation and that used in the scaling calculation I-N1-24. The two

post-accident scenarios, PBOC-2T break inside the Reactor building and a SB LOCA inside the drywell, consider the temperature effects on the reference leg as well as dimensional changes to the Reactor vessel. Maximum and minimum temperature during normal operation were obtained from Reference 9. Maximum temperatures and maximum or minimum Reactor vessel pressures were obtained from References 7, 14, 15 and 51.

The 95%/95% probability and confidence level values for the four level switches have been statistically analyzed to determine if the data sets are normal or bounded by a normal curve. See Note 13 for the results of the statistical analysis. Histograms, scatter plots and SYSTAT printouts are included in Attachment 7. The results show that none of the data exhibited time dependency and sufficient data is bounded by the 95% probability/95% confidence values to establish that they are valid estimates of instrument drift.

All errors identified in this calculation are individually evaluated to determine whether they are random or biases. In the context of instrument uncertainty, it is accepted within the industry that random uncertainties are those uncertainties that a manufacturer specifies as having a ∓ magnitude. Random uncertainties are combined using the root sum of the squares (RSS) technique in accordance with NEDWI 394. Biases are expressed with either a + or a - sign and are added together separately according to sign. Individual component error terms which contain both a bias and a random value (for example, -0.95 ∓ 0.5 inches) may be split up so that the random part (∓ 0.5) is combined with other component error terms by the RSS method and the biases (-0.95) added to other component bias terms of the same sign. Both random and bias terms are added together to determine Total Loop Uncertainty (TLU). A random or bias term can also be further classified as being dependent or independent. Two error terms are classified as dependent if they possess a significant correlation, for whatever cause, known or unknown. Instrument proximity or physical connections alone do not cause dependency, because the sign of the error term is determined solely by that instrument's measured response to the stimulus (temperature, pressure, etc.). Dependent errors are summed algebraically to form independent errors.

IV. DETAILED CALCULATION

B. LOOP DIAGRAM

See Attached Loop Diagram, Page 15

					Setpoint Calculation		
					LIS263-72A, B, C, D : Reactor Vessel Low-Low Level		
1	JWR	4/1/93	JFD	4/1/93	ABB	JOB NO. 25-226	PAGE 14
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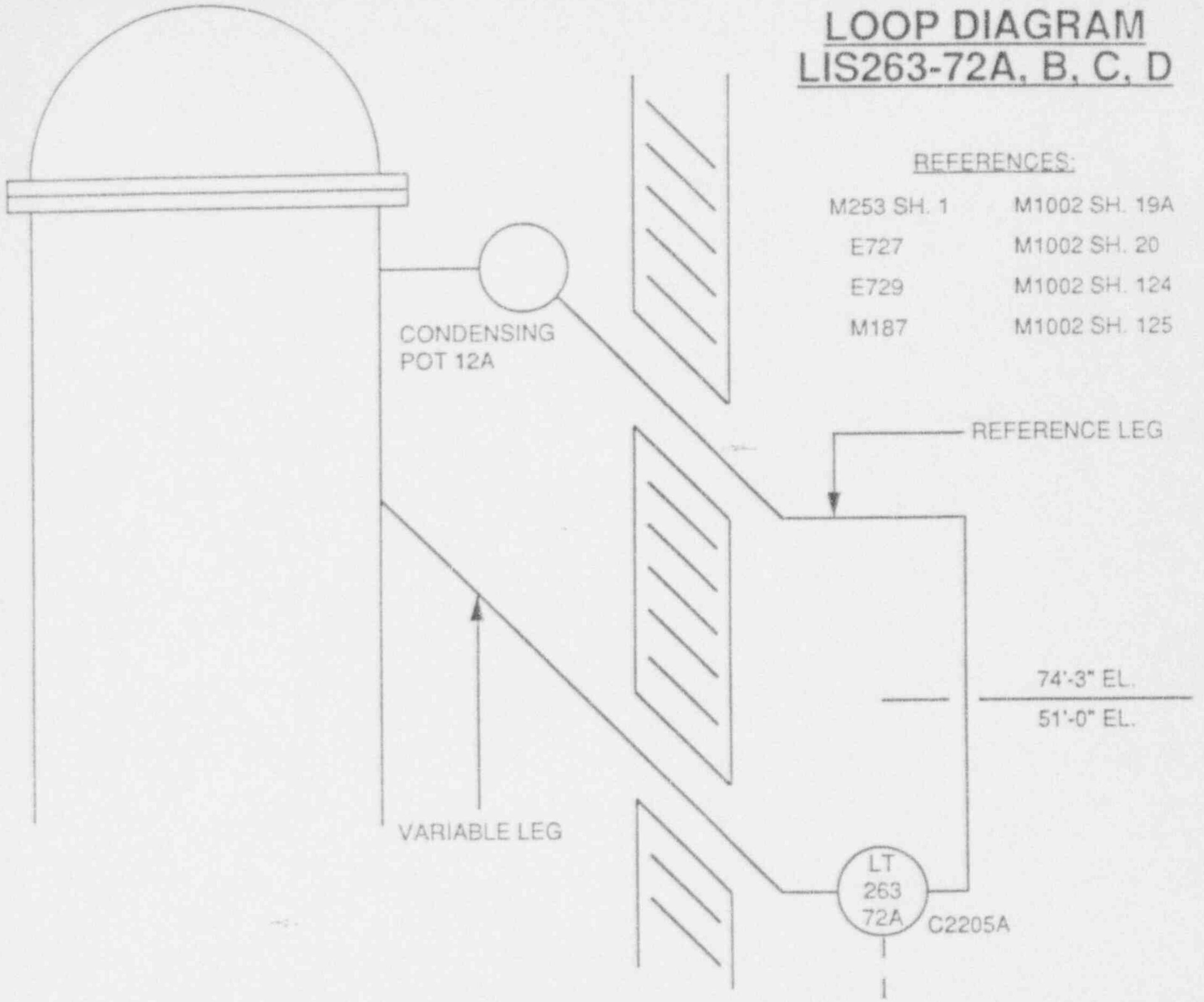
LOOP DIAGRAM
LIS263-72A, B, C, D

REFERENCES:

M253 SH. 1	M1002 SH. 19A
E727	M1002 SH. 20
E729	M1002 SH. 124
M187	M1002 SH. 125



CONDENSING POT	LT		LIS	
	NUMBER	LOCATION	NUMBER	LOCATION
12A	LT263-72A	C2205A	LIS263-72A	C2233A
12B	LT263-72B	C2206A	LIS263-72B	C2233B
12A	LT263-72C	C2205A	LIS263-72C	C2233A
12B	LT263-72D	C2206A	LIS263-72D	C2233B

REV.	BY	DATE	CHECKED	DATE
1	JWR	4/1/93	JFD	4/1/93
0	JWR	1/28/93	TJD	2/1/93

Setpoint Calculation

LIS263-72A, B, C, D : Reactor Vessel Low-Low Level

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IV. DETAILED CALCULATION

C. CALCULATION

See Attached Calculation, Pages 17 through 84

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0	JWR	1/28/93	TJD	2/1/93
1	JFR	4/1/93	JFD	4/1/93

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Setpoint Calculation
LIS263-72A, B, C, D : Reactor Vessel Low-Low Level

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Instrument Number A) LT263 - 72A, B, C, D : B) LIS263 - 72A, B, C, D

FORM 1 INSTRUMENT DATA

TITLE		DESCRIPTION/ VALUE	REFERENCE	REMARKS
GENERAL INFORMATION	INSTRUMENT NUMBER	A) LT263-72A, B, C, D B) LIS263-72A, B, C, D	M253, SH.1	The A) & B) used throughout this data form is used to distinguish between the transmitter & the master trip unit.
	SERVICE DESCRIPTION	Reactor Low-Low Water Level	M209A-DS-165-1, 2 M209A-DS-166-1, 2 M209A-DS-56, 61, 66, 68	—
	QUALITY CATEGORY	A) Q B) Q (cabinet C2233 A, B)	BECo Q-List	—
	ENVIRONMENTAL QUALIFICATION	YES	EQML, p. 2-45-1	transmitters only
	SAFETY FUNCTION (IF APPLICABLE)	at Rx low-low water level, initiate RCIC, Auto Blowdown & Core Spray; start standby diesel.	M253 SH.1	—
	TECHNICAL SPECIFICATION (IF APPLICABLE)	-49"	PNPS Tech Spec., Amend No. 139 Table 3.2.A	existing Tech Spec is at or above -49" indicated level.
	MANUFACTURER	A) Rosemount B) Rosemount	M209A-DS-165-1, 2 M209A-DS-166-1, 2 M209A-DS-56, 61, 66, 68	—
	MODEL NUMBER	A) 1153DB4RCN0012 B) 710DU10TT4506B	M209A-DS-165-1, 2 M209A-DS-166-1, 2 M209A-DS-56, 61, 66, 68	—

Instrument Number A) LT263- 72A, B, C, D : B) LIS263- 72A, B, C, D

FORM 1 INSTRUMENT DATA

TITLE			DESCRIPTION/ VALUE	REFERENCE	REMARKS
INSTRUMENT SETPOINT DATA	ANALYTICAL LIMIT (AL)		-56.9"	• NAD memo 91-78 • BLIDDS/RF # 91-178	• See Attachment 3 • See Note 1
	ALLOWABLE VALUE (AV)		-46.32"	Form 3 PAGE 3 (THIS CALC)	N/A
	SETPOINT	TRIP	-46.14"	FORM 3 PAGE 2 (THIS CALC)	N/A
		RESET	-42" (5.28 mA)	PNPS Procedures 8.M.2-8.1, 8.2	See Note 10
	NORMAL OPERATION UPPER LIMIT (NUL)		+40"	PNPS Procedure 2.2.80, Rev. 10, p. 24, 25	—
	NORMAL OPERATION LOWER LIMIT (NLL)		+20"	PNPS Procedure 2.2.80, Rev. 10, p. 24, 25	—
	PROCESS CALIBRATED RANGE		A) 113.01 - 42.95" H_2O A) 113.09 - 43.04" H_2O B) -50 to 50" (NOTE: span = 100")	A) M209A-DS-165-1, -166-1 A) M209A-DS-165-2, -166-2 B) M209A-DS-56, 61, 66, 68	A) LT 72A, C (A Train) A) LT 72B, D (B Train) B) LIS 72A, B, C, D
	OPERATING MARGIN (OM)*		66"	Form 3, PAGE 3 this calc.	N/A

*Note: Adequate Operating Margin is required between the setpoint and the Normal Operation Upper Limit or Lower Limit, as applicable, to avoid inadvertent trips due to process noise, transients and measurement uncertainties.

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0	JWR	1/28/93	TJD	2/1/93
1	JWR	4/1/93	JFD	4/1/93

Setpoint Calculation

LIS263-72A, B, C, D : Reactor Vessel Low-Low Level

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Instrument Number A) LT263-72A, B, C, D ; B) LIS263-72A, B, C, D

FORM 1 INSTRUMENT DATA

TITLE		DESCRIPTION/ VALUE	REFERENCE	REMARKS
INSTRUMENT SETPOINT DATA (CONT)	ADJUSTABLE RANGE	0-150" H_2O (URL) 0-25" H_2O (LRL)	• Rosemount Product Data Sheet 2302	*URL: Upper Range Limit. *1153DB4 implies Range Code 4 which has 150" H_2O URL. *LRL: Lower Range Limit
	INPUT SIGNAL FROM	LT263-72A, B, C, D	M253 SH.1 E727 E729	—
	INPUT SIGNAL CALIBRATED RANGE	4-20 mA (span = 16 mA)	M209A-DS-165-1,2 M204A-DS-166-1,2 M204A-DS-56,61,66,68	LTs see a reverse acting range setting of about 113" H_2O - ~43" H_2O. This corresponds to an input signal from 4-20 mA
	OUTPUT SIGNAL TO	CSCS Logic 14A-K51A, B, C, D	M253 SH.1 E727 E729	N/A
	OUTPUT SIGNAL CALIBRATED RANGE	CONTACT POSITION CHANGE	E727 E729	N/A
	SETPOINT CALIBRATION FREQUENCY (NOMINAL)	A) 24 months B) 3 months	A) NRC GL 91-04 B) See Design Input/ Assumptions Section, this calc.	Will require a PNPS Tech Spec change.

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0	JWR	1/28/93	TJD	2/1/93
1	JWR	4/1/93	JFD	4/1/93

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Setpoint Calculation
LIS263-72A, B, C, D : Reactor Vessel Low-Low Level

JOB NO. 25-226
CALC NO. (25-226-C004)

Instrument Number A) LT263-72A,B,C,D ; B) LIS263-72A,B,C,D

FORM 1 INSTRUMENT DATA

TITLE		DESCRIPTION/ VALUE	REFERENCE	REMARKS
ENVIRONMENTAL ALLOWANCE (EA) FORM 3 STEP 1	TEMPERATURE EFFECT (Te)	N/A	—	Sensor temp effect (Ste) accounts for Te. See Note 5
	RADIATION EFFECT (Re)	±0.71"	• EQDF #394, 394A • EQDF #4 • EQDF #396	SEE Note 4
	STEAM/CHEMICAL SPRAY EFFECT (S/Ce)	N/A	—	only applicable to components located in drywell. Effects due to a PBOC in Rx bldg. are negligible.
	PRESSURIZATION (EXTERNAL) EFFECT (Pe)	N/A	M632 SH. 10 EQML (EQ Areas 1.11, 1.12)	short term pressure transient (15.26 psia for 5.1 sec) has no effect on Dp LT.
	SEISMIC EFFECT (Se)	N/A	• Rosemount Rpt. DB300131 (EQDF #296)	analysis does not have to consider PBOC and seismic together. Worst case is PBOC.
CIRCUIT LEAKAGE ALLOWANCE (LA) FORM 3 STEP 2	CABLE LEAKAGE (Cl)	-.172% span =(.172%)(100") = -0.172"	• EQDF #329B	.172% is LT-72A. This was the largest error ∴ the most conservative assumption (See Note 3)
	TERMINAL BLOCK LEAKAGE (Tl)	N/A	E727 E729 EQDF 329B,	loop does not have any terminal blocks located in harsh environments. Applicable only to accident environments.
	PENETRATION LEAKAGE (Pl)	N/A	E727 E729	occurs only at drywell pens. in harsh environments. This loop does not have any circuits which penetrate the drywell.

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0	JWR	1/28/93	TJD	2/1/93
1	JRB	4/1/93	JFD	4/1/93

Setpoint Calculation

LIS263-72A, B, C, D : Reactor Vessel Low-Low Level

ABB ASEA BROWN BOVERI
ABB IMPELL CORPORATION

JOB NO. 25-226

CALC NO. (25-226-C004)

Instrument Number A) LT263-72A, B, C, D : B) LIS263-72A, B, C, D

FORM 1 INSTRUMENT DATA

TITLE		DESCRIPTION/ VALUE	REFERENCE	REMARKS
CIRCUIT LEAKAGE ALLOWANCE (LA) (CONTINUED)	SPLICE LEAKAGE (Sl)	N/A	• EQDF 329R • E727 • E729	qualified heat shrink splices are used and ∴ does not contribute to leakage concerns
	SEALING DEVICE LEAKAGE (Dl)	N/A	Rosemount letter from T. Layer to B. Rancourt (11/15/91) - Ref. 55	"(the applicable) conduit seals will not add any performance degradation to transmitter performance" over design condition range of ≤200°F.
PROCESS ALLOWANCE (PA) FORM 3 STEP 3	PROCESS MEASUREMENT ACCURACY (Pma)	+7.56" (PBOC) +0.27" (SB LOCA) +.60 ± .93" (Normal Op.)	• BECo calc. I-N1-24 • FS/MC memo 91-176 • ASME Steam Tables	see Note 8
	PRIMARY ELEMENT ACCURACY (Pea)	N/A	M253, Sh. 1	No primary element
CALIBRATION ALLOWANCE (CA) FORM 3 STEP 4	SENSOR CALIBRATION ACCURACY (Sca)	±.25% accuracy = (.25%)(100") = ±0.25" (Sca = Sa)	• Rosemount 2302, 6/90 (V-0098) • PNPS Procedure 1.1.36	"calibration equipment to be as accurate as instrumentation" (see Note 2)
	RACK EQUIPMENT CALIBRATION ACCURACY (Rca)	0	See methodology section this calc. (ABB Impell Statistical Analysis)	included in 95/95 Red value. (see Attachment 6)

REV	BY	DATE	CHECKED	DATE
0	JWP	1/28/93	TJD	2/1/93
1	WR	4/1/93	JFD	4/1/93

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Setpoint Calculation

LIS263-72A, B, C, D: Reactor Vessel Low-Low Level

JOB NO. 25-226

CALC NO. (25-226-C004)

Instrument Number A) LT263-72A, B, C, D : B) LIS263-72A, B, C, D

FORM 1 INSTRUMENT DATA

TITLE		DESCRIPTION/ VALUE	REFERENCE	REMARKS
RACK EQUIPMENT ALLOWANCE (RA) FORM 3 STEP 5	RACK EQUIPMENT ACCURACY (Rea)	N/A	• Vendor manual V-0243, p. 99 (Rosemount 4471-1, Rev. A) • Section IV.A, Methodology	• Trip unit accuracy is included in repeatability (see Rea) • For M&TE accuracy, use Rosemount's specified repeatability value of ±0.13% span
	RACK TEMPERATURE EFFECTS (Rte)	± .20% span/100°F $= \frac{(.002)(100")(130-90)°F}{100°F}$ ±0.08"	• Vendor Manual V0243, p. 99 (Rosemount 4471-1)	see Note 7 (master unit only)
	RACK POWER SUPPLY EFFECTS (Rps)	N/A	—	see Note 6
	RACK EQUIPMENT MISCELLANEOUS EFFECTS (Rme)	N/A	–	–

REV	BY	DATE	CHECKED	DATE
0	JWR	1/28/93	TJD	2/1/93
1	JMR	4/1/93	JFD	4/1/93

Setpoint Calculation

LIS263-72A, B, C, D : Reactor Vessel Low-Low Level

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ABB IMPELL CORPORATION

JOB NO. 25-226

CALC NO. (25-226-C004)

Instrument Number A) LT263-72A, B, C, D ; B) LIS263-72A, B, C, D

FORM 1 INSTRUMENT DATA

TITLE		DESCRIPTION/ VALUE	REFERENCE	REMARKS
SENSOR ALLOWANCE (SA) FORM 3 STEP 6	SENSOR BASIC ACCURACY (Sa)	±.25 % span = .25% (100") = ±0.25"	Rosemount 2302, 6/90 (V-0098)	See also Sca
	SENSOR STATIC PRESSURE SPAN SHIFT (Ssps)	+.157 ± .91 (PBOC) -1.03 ± .12 (SB LOCA) ±.81" (Normal Op)	• BECo Calc. I-N1-21 • Rosemount 4302 • GE NEDC-31852P, 9/90	SEE Note 9
	SENSOR STATIC PRESSURE ZERO SHIFT (Sspz)	±.2% URL / 1000 psig OR ±.48" (1125 psig) - PBOC ±0.064" (150 psig) - SB LOCA ± .43" (Normal Op.)	Rosemount 4302, p. 4-3	SEE Note 9
	SENSOR TEMPERATURE EFFECTS (Ste)	±0.95" (normal op.) ±2.53" (post-PBOC)	• Rosemount 4302, Rev. E p. 4-1, 4-2 (V-0098) • FSAR Table 10.9-1, 10.9-2 • Rosemount Letter from T. Layer to B. Rancourt (8/9/89)	See Note 5
	SENSOR POWER SUPPLY EFFECTS (Spse)	±.005% span/Volt OR [.005% (28-23.5 V)(100)]/100% = ±0.02"	• Rosemount 2302, 6/90 (V-0098) • GE GEK-83395, 3/84	—
	SENSOR MISCELLANEOUS EFFECTS (Sme)	N/A	—	—

REV	BY	DATE	CHECKED	DATE
0	JWR	1/28/93	TJD	2/1/93
1	JFR	4/1/93	JFD	4/1/93

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Setpoint Calculation
LIS263-72A, B, C, D: Reactor Vessel Low-Low Level

JOB NO. 25-226
CALC NO. (25-226-C004)

Instrument Number A) LT263-72A, B, C, D ; B) LIS263-72A, B, C, D

FORM 1 INSTRUMENT DATA

TITLE		DESCRIPTION/ VALUE	REFERENCE	REMARKS
DRIFT ALLOWANCE (DA) FORM 3 STEP 7	SENSOR DRIFT (Sd)	±.2% URL/30 months OR ±(.002)(150" H_2O) = ±.3" H_2O or $\frac{(.3" H_2O)(100")}{70.06}$ = ±.43"	EQDF 389	See section IV A, Methodology
	RACK EQUIPMENT DRIFT (Red)	±.13% span = (.0013)(100") = ±.13"	• ABB Impell Statistical Analysis (see Attachment 6)	* Worst case calculated value is for 72B LIS, ±.13% span/4 months. Note that this value has 95%/95% probability & confidence level.
TOLERANCE ALLOWANCE (TA) FORM 3 STEP 8	SENSOR TOLERANCE (St)	No Adjust Limit: ±.04mA Span: 16 mA No Adjust Limit (% span) = $\pm\frac{.04mA}{16mA}$ = ±.25% = (±.0025)(100") = ±.25" Note: (±.0025)(16mA) = ±.04mA	PNPS Procedures 8.M1.2-8.1, 8.2	PNPS No Adjust Limits not to exceed this value.
	RACK EQUIPMENT TOLERANCE (Ret)	No Adjust Limit: ±.02mA Span: 16 mA No Adjust Limit (% span) = $\pm\frac{.02mA}{16mA}$ = ±0.13" = (±.0013)(100") = ±0.13" Note: (±.0013)(16mA) = ±.02mA	PNPS Procedures 8.M1-32.5, 32.7	PNPS No Adjust Limits not to exceed this value.

REV	BY	DATE	CHECKED	DATE
0	JWR	11/28/93	TJD	2/1/93
1	JKR	4/1/93	JFP	4/1/93

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Setpoint Calculation
LIS263-72A, B, C, D: Reactor Vessel Low-Low Level
JOB NO. 25-226
CALC NO. (25-226-C004)
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Instrument Number A) LT263-72A, B, C, D : B) LIS263-72A, B, C, D

FORM 1 INSTRUMENT DATA

TITLE	DESCRIPTION/ VALUE	REFERENCE	REMARKS
N/A			

REV	BY	DATE	CHECKED	DATE
0	JWR	1/28/93	TJD	2/1/93
1	JWR	4/1/93	JFD	4/1/93

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Setpoint Calculation

LIS263-72A, B, C, D : Reactor Vessel Low-Low Level

JOB NO. 25-226

CALC NO. (25-226-C004)

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FORM 2B. CALCULATION SHEET (DECREASING SETPOINT)

Instrument Number LT263-72A, B, C, D : LIS263-72A, B, C, D

PARAMETER	DESCRIPTION	ABBREVIATION/VALUE*	COMMENTS
NORMAL OPERATION UPPER LIMIT		NUL = 40"	
	NORMAL OPERATING BAND		
NORMAL OPERATION LOWER LIMIT		NLL = 20"	
RESET VALUE		RV = -42"	Trip setpoint does not need to be changed therefore Reset value will remain the same
	OPERATING MARGIN	OM = 66	
TRIP SETPOINT		Tsp** = -46.14"	
DRIFT ALLOWANCE (DA)	SENSOR DRIFT	Sd = ±.43"	
	RACK EQUIPMENT DRIFT	Red = ±.13"	
TOLERANCE ALLOWANCE (TA)	SENSOR TOLERANCE	St = ±.25"	
	RACK EQUIPMENT TOLERANCE	Ret = ±.13"	
ALLOWABLE VALUE		AV** = -46.32"	
ENVIRONMENTAL ALLOWANCE (EA)	TEMPERATURE EFFECT	Te = N/A	
	RADIATION EFFECT	Re = ±0.71"	see Note 11
	STEAM/CHEM SPRAY EFFECT	S/Ce = N/A	
	PRESSURIZATION (EXT.) EFFECT	Pe = N/A	
	SEISMIC EFFECT	Se = N/A	
CIRCUIT LEAKAGE ALLOWANCE (LA)	CABLE LEAKAGE	Cl = -.172"	
	TERMINAL BLOCK LEAKAGE	Tl = N/A	
	PENETRATION LEAKAGE	Pl = N/A	
	SPLICE LEAKAGE	Sl = N/A	
	SEALING DEVICE LEAKAGE	Dl = N/A	
PROCESS ALLOWANCE (PA)	PROCESS MEASUREMENT ACCURACY	Pma = +7.56"	see Note 11
	PRIMARY ELEMENT ACCURACY	Pea = N/A	
CALIBRATION ALLOWANCE (CA)***	SENSOR CALIBRATION ACCURACY	Sca = ±.25"	
	RACK EQUIPMENT CALIBRATION ACCURACY	Rca = 0	
RACK EQUIPMENT ALLOWANCE (RA)	RACK EQUIPMENT ACCURACY	Rea = N/A	
	RACK TEMPERATURE EFFECT	Rte = ±.08"	
	RACK POWER SUPPLY EFFECT	Rps = N/A	
	RACK EQUIPMENT MISC EFFECT	Rme = N/A	
SENSOR ALLOWANCE (SA)	SENSOR BASIC ACCURACY	Sa = ±.25"	
	SENSOR STATIC PRESSURE SPAN SHIFT	Ssps = ±.157" ±.91"	see Note 11
	SENSOR STATIC PRESSURE ZERO SHIFT	Sspz = ±0.48"	see Note 11
	SENSOR TEMPERATURE EFFECTS	Ste = ±2.53"	see Note 5
	SENSIR POWER SUPPLY EFFECTS	Spse = ±.02"	
	SENSOR MISC EFFECTS	Sme = N/A	
ANALYTICAL LIMIT		AL = -56.9"	

TOTAL LOOP UNCERTAINTY

REV	BY	DATE	CHECKED	DATE		
					Setpoint Calculation	
					LIS263-72A, B, C, D : Reactor Vessel Low-Low Level	
1	JWR	4/1/93	JFD	4/1/93	ABB	JOB NO. 25-226 — PAGE 26
0	JWP	1/28/93	TJD	2/1/93	ASEA BROWN BOVERI ABB IMPELL CORPORATION	CALC NO. (25-226-C004) — OF 87

* NOTE: VALUES ARE IDENTIFIED FOR MAGNITUDE ONLY AND ARE IN ACCORDANCE WITH THE EQUATIONS ON FORM 3

** NOTE: CALCULATED VALUE FROM FORM 3

FORM 3. CALCULATION SHEET | SHEET NO. 1 OF 4

INSTRUMENT NUMBER LT263-72A, B, C, D : LIS263-72A, B, C, D

1. ENVIRONMENTAL ALLOWANCE (EA) (see Note 11)

$$EA = \sqrt{(Te)^2 + (Re)^2 + (S/Ce)^2 + (Pe)^2 + (Se)^2}$$

$$EA = \sqrt{(N/A)^2 + (\pm.71")^2 + (N/A)^2 + (N/A)^2 + (N/A)^2} = \pm.71"$$

2. CIRCUIT LEAKAGE ALLOWANCE (LA)

$$LA = Cl + Tl + Pl + Sl + Dl$$

$$LA = -.172" + N/A + N/A + N/A + N/A = -.172"$$

3. PROCESS ALLOWANCE (PA)

$$PA = \sqrt{(P\not{m}a)^2 + (Pea)^2} + Pma_{bias}(PBoc)$$

$$PA = \sqrt{(\,-\,)^2 + (N/A)^2} + 7.56" = +7.56"$$ (see Note 11)

4. CALIBRATION ALLOWANCE (CA)

$$CA = \sqrt{(Sca)^2 + (Rca)^2}$$

$$CA = \sqrt{(\pm.25")^2 + (0)^2} = \pm.25"$$

5. RACK EQUIPMENT ALLOWANCE (RA)

$$RA = \sqrt{(Rea)^2 + (Rte)^2 + (Rps)^2 + (Rme)^2}$$

$$RA = \sqrt{(N/A)^2 + (\pm.08)^2 + (N/A)^2 + (N/A)^2} = \pm.08"$$

6. SENSOR ALLOWANCE (SA)

$$SA = \sqrt{(Sa)^2 + (Ssps + Sspz)^2 + (Ste)^2 + (Spse)^2 + (Sme)^2} + SSps_{bias}(PBoc)$$

$$SA = \sqrt{(\pm.25")^2 + (\pm.91" + \pm.48")^2 + (\pm2.53")^2 + (\pm.02)^2 + (N/A)^2} + .157$$

$$SA = \pm2.90 + .157$$

(See Note 11)

REV	BY	DATE	CHECKED	DATE		
					Setpoint Calculation	
					LIS263-72A, B, C, D : Reactor Vessel Low-Low Level	
1	JWR	4/1/93	JFD	4/1/93	ABB ASEA BROWN BOVERI ABB IMPELL CORPORATION	JOB NO. 25-226; PAGE 27 OF 87
O	JWR	1/28/93	TJD	2/1/93		CALC NO. (25-226-C004)

7. DRIFT ALLOWANCE (DA)

$DA = \sqrt{(Sd)^2 + (Red)^2}$

$DA = \sqrt{(\pm .43'')^2 + (\pm .13'')^2}$ $= \pm .45''$

8. TOLERANCE ALLOWANCE (TA)

$TA = \sqrt{(St)^2 + (Ret)^2}$

$TA = \sqrt{(\pm .25'')^2 + (\pm .13'')^2}$ $= \pm .28''$

9. TOTAL LOOP UNCERTAINTY ALLOWANCE (TLU)

$TLU = LA \pm \sqrt{(EA)^2 + (PA)^2 + (CA)^2 + (RA)^2 + (SA)^2 + (DA)^2 + (TA)^2} + SA^{PBoc}_{bias} + PA^{PBoc}_{bias}$

$TLU = -.172'' \pm \sqrt{(\pm .71)^2 + (-)^2 + (\pm .25)^2 + (\pm .08)^2 + (\pm 2.90)^2 + (\pm .45)^2 + (\pm .28)^2}$

$+ 0 + 7.56'' + .157'' = \pm 3.04'' + 7.72 - .172$

$TLU = +10.76'', -3.21$

10. TRIP SETPOINT (TSp) IN PROCESS UNITS

10A. FOR INCREASING SETPOINT - FORM 2A: (ENTER N/A IF DECREASING SETPOINT)

TSp = AL - TLU

TSp = N/A - N/A = N/A

10B. FOR DECREASING SETPOINT - FORM 2B: (ENTER N/A IF INCREASING SETPOINT)

TSp = AL + TLU

TSp = $-56.9'' + 10.76'' = -46.14''$

The actual value implemented at PNPS is conservative compared to this value (See Figure 1)

REV	BY	DATE	CHECKED	DATE	
					Setpoint Calculation
					LIS263-72A, B, C, D : Reactor Vessel Low-Low Level
1	JWR	4/1/93	JFD	4/1/93	ABB ASEA BROWN BOVERI ABB IMPELL CORPORATION — JOB NO. 25-226 — PAGE 28
0	JWR	1/28/93	TJD	2/1/93	CALC NO. (25-226-C004) — OF 87

11. ALLOWABLE VALUE (AV)

11A. FOR INCREASING SETPOINT - FORM 2A: (ENTER N/A IF DECREASING SETPOINT)

$AV = TSp + \sqrt{(DA)^2 + (TA)^2}$

AV = N/A + √(N/A)² + (N/A)²

AV = N/A

11B. FOR DECREASING SETPOINT - FORM 2B: (ENTER N/A IF INCREASING SETPOINT)

~~$AV = TSp - \sqrt{(DA)^2 + (TA)^2}$~~ $AV = T_{sp} - \sqrt{(R_{et})^2 + (R_{ea})^2}$

AV = -46.14" - √(±.13")² + (±.13")² (only portion of loop which is being tested)

AV = -46.32"

12. OPERATING MARGIN (OM)

12A. FOR INCREASING SETPOINT - FORM 2A: (ENTER N/A IF DECREASING SETPOINT)

OM = TSp - NUL

OM = N/A - N/A = N/A

12B. FOR DECREASING SETPOINT - FORM 2B: (ENTER N/A IF INCREASING SETPOINT)

OM = NLL - TSp

-46" is the PNPS implemented value

OM = 20" - -46" = 66"

13. RESET VALUE (RV)

13A. FOR INCREASING SETPOINT - FORM 2A: (ENTER N/A IF DECREASING SETPOINT)

RV > NUL

RV = N/A

N/A

NUL = N/A

13B. FOR DECREASING SETPOINT - FORM 2B: (ENTER N/A IF INCREASING SETPOINT)

RV < NLL

RV = -42" (see Next Page)

NLL = 20"

					Setpoint Calculation
					LIS263-72A, B, C, D : Reactor Vessel Low-Low Level
1	JWR	4/1/93	JFP	4/1/93	ABB — JOB NO. 25-226 — PAGE 27
0	JWR	1/28/93	TJD	2/1/93	CALC NO. (25-226-C004) — OF 81
REV	BY	DATE	CHECKED	DATE	ASEA BROWN BOVERI ABB IMPELL CORPORATION

14. TRIP SETPOINT (TSp) IN PROCESS UNITS

TSs = TSp MODIFIED BY THE FACTORS ACCOUNTING FOR CONVERSION FROM PROCESS UNITS TO SIGNAL UNITS (VOLTS, AMPS, COUNTS, etc.)

TSs = 4.64 mAdc (NOTE: SEE PAGE below FOR CONVERSION)

$TS_s = \left(\text{output span} * \frac{T_{sp}}{\text{input span}}\right) + 4\text{mAdc}$

$TS_s = \left[16 * \frac{-46'' - (-50)''}{(50 - (-50))''}\right] + 4\text{mAdc} = 4.64\text{ mAdc}$

No Adjust Tolerance

4.62 to 4.66 mAdc

(see Note 11)

RESET: RESET WILL BE SET AT 4% OF SPAN above trip setpoint

RESET = 4% OF SPAN = 0.04 * 100" = 4" above trip setpoint

Reset Value: -46" + 4" = -42"

$\therefore \left(16\text{mAdc} * \frac{8''}{100''}\right) + 4\text{mAdc} = 5.28\text{mAdc}$

No Adjust Tolerance

5.12 to 5.44 mA

(see Note 10)

This reset value is acceptable because:

- Reset occurs at 4% span, which falls within the manufacturer's specification of 0.5% to 7.5% of the input span (Ref. 2)
- Reset occurs before the process normal operation limit is reached (See Figure 1)

REV	BY	DATE	CHECKED	DATE	
1	JWR	4/1/93	JFD	4/1/93	
0	JWR	1/28/93	TJD	2/1/93	

Setpoint Calculation

LIS263-72A, B, C, D : Reactor Vessel Low-Low Level

ABB — ASEA BROWN BOVERI — ABB IMPELL CORPORATION

JOB NO. 25-226

CALC NO. (25-226-C004)

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Notes:

1. PNPS LOCA Analysis (NEDC-31852P, Sept., 1990) also indicates Reactor low-low water level as 425.6" measured from vessel zero. Vessel zero is indicated as 482.5" on M253 Sh. 1, Rev. E24. Therefore 425.6" from vessel zero corresponds to (482.5 - 425.6) or -56.9".

2. Measurement and Test Equipment utilized for calibration shall have an accuracy equal to or better than the device being calibrated (Reference 46). According to manufacturer's data, the transmitter's accuracy is ±0.25% and the master trip unit's accuracy is ±0.13%.

3. Leakage from conductor to conductor is considered as the primary leakage path, which results in increased signal current at the rack electronics. For a given level in the Reactor vessel, increased current results in a lower indicated level, hence the minus sign for CI.

4. Radiation Effect:

From Equipment Qualification Evaluation Sheets for LT263-72A, B, C, D (Reference 41)

"A" Train normal radiation dose : 1.662×10^3R
"B" Train normal radiation dose : 4.455×10^3R

Worst Case: "B" Train (LT263-72B, D)

Normal Radiation (30 months) $= [4.455 \times 10^3\text{R} * (2.5 \text{ years})]/40 \text{ years}$
$= 2.78 \times 10^2$R

Under accident conditions, radiation dose will be the normal radiation dose plus the radiation dose for 5 hours due to an accident (i.e. required operating time for transmitters is 5 hours - Reference 41).

Normal radiation dose (30 months) : 2.78×10^2R
Gamma accident radiation dose : 2.8×10^5R (Reference 58)
Beta accident radiation dose : 3.5×10^3R (Reference 58)

Only 1.6% of the beta dose will be converted to high energy gamma and will affect the transmitter (EQDF #396, Rev. E0 - Reference 67)

Therefore net beta dose $= (0.016) * (3.5 \times 10^3\text{R}) = 56\text{R}$

Total 5 hour accident radiation $= (56\text{R}) + (2.8 \times 10^5\text{R}) = (2.8 \times 10^5\text{R})$

Total radiation dose $= (2.78 \times 10^2\text{R}) + (2.8 \times 10^5\text{R}) = (2.8 \times 10^5\text{R})$

In accordance with ABB Impell memorandum dated March 10, 1993 contained in Reference 68, a bounding radiation uncertainty is:

Re $= \pm$ (.408 + .14$\log_{10}$(TID [MRad])) %URL
$= \pm$ (.408 + .14$\log_{10}$(.28)) %URL
$= \pm$ .33%URL
Therefore Total Radiation Effect = $\pm$(0.0033)*(150'H_2O)(100"/70.06"H_2O)
= $\pm$0.71"

5. Sensor Temperature Effect (Ste):

Two values for the sensor temperature effect will be determined, one for normal operation and one for post-PBOC operation. The normal operation sensor temperature effect is determined using the temperature sensitivity from Reference 1 as follows:

Ste = $\pm$(0.75%URL + 0.5% span)*(Max ambient temp. - Min Calibration temp.)/100^{0}F

From Reference 9, Table 10.9-1 (Design Temperature - Winter)
Minimum Cailbibration Temperature = 60^{0}F

From Reference 9, Table 10.9-2 (Design Temperature - Summer)
Maximum Ambient Temperature (Operating) = 105^{0}F

For a Range Code 4 transmitter URL = 150"H_2O
For the subject transmitters: Span = 70.06"H_2O

Therefore:

Ste $= \pm$ (0.0075*150"H_2O + 0.005*70.06"H_2O)[[105^{0}F - 60^{0}F]/100^{0}F]
$= \pm$ (1.475"H_2O)(45^{0}F/100^{0}F)
$= \pm$ (0.66"H_2O)
and converting "H_2O to indicated inches :
$= \pm$ (0.66"H_2O)(100"/70.06"H_2O)
$= \pm$ 0.95" (Normal Operation)

BECo Dwg. M632 Sh. 10 (Reference 15) depicts a temperature profile during a PBOC and the highest temperature at transmitter locations.

Rosemount indicates a thermal response time constant of 3 minutes (Report 78212, Rev. A - Reference 56), i.e., the transmitter amplifier board will achieve 63.2% of a step temperature increase 3 minutes after the step increase in temperature is applied. Therefore, temperature as a 3 minute interval from Reference 15 will be used to determine the transmitter's post-PBOC temperature. From Reference 15:

Time	Reactor Bldg Ambient Temperature
0+	212^0F
3 min	190^0F
6 min	180^0F

Assuming the PBOC occurs after calibration at the Winter minimum temperature of 60°F, the initial step increase is 152°F and the transmitter temperature after 1 time constant is:

$$T_{transmitter} = T_{transmitter,\ initial} + 0.632\Delta T.$$
$$T_{transmitter} = 60^0F + 0.632*152^0F = 156.1^0F.$$

At the beginning of the second time constant (3-6 minutes post-PBOC), the temperature difference is (190 - 156.1)°F or 33.9°F, and the transmitter temperature after the second time constant is

$$T_{transmitter} = T_{transmitter,\ initial} + 0.632\Delta T.$$
$$T_{transmitter} = 156.1^0F + 0.632*33.9^0F = 177.5^0F.$$

At the beginning of the third time constant (6-9 minutes post-PBOC), the temperature difference is (180 - 177.5)°F or 2.5°F. It will be assumed the transmitter temperature does not exceed 180°F.

Now using the sensor temperature sensitivity from Reference 1, and the URL and span values from above:

Ste $= \pm\ (0.0075*150"H_2O + 0.005*70.06"H_2O)[[180^0F - 60^0F]/100^0F]$
$= \pm\ (1.475"H_2O)(120^0F/100^0F)$
$= \pm\ (1.77"H_2O)$

and converting $"H_2O$ to indicated inches:

$= \pm\ (1.77"H_2O)(100"/70.06"H_2O)$
$= \pm\ 2.53"$

According to Rosemount (Reference 39), the sensitivities provided in Reference 1 are 3σ values. Conversion of a standard deviation to 95/95 values require use of a multiplier of 3 for samples of 12 or fewer. Since the number of transmitters tested is not known, the entire value calculated above will be used.

Ste (Normal Operation)	= ±0.95"
Ste (SB LOCA)	= ±0.95"
Ste (PBOC)	= ±2.53"

6. Rack Power Supply Effect (Rps):

Rps error is considered negligible and N/A is entered on Form 1 for the following reasons:

A. Rack Power Supply Error

Vendor Manual V-0243 (Reference 2) identifies the power supply voltage requirements for the card file as 22.0 to 28.0 Vdc. This is the electrical specification for power at each master and slave trip unit.

GE NEDO-21617-A (Reference 49) Figure 2.21 provides a graph of power supply output voltage vs. current. The poorest regulation occurs at 0% current, where the voltage range can vary from 23.5 to 28 Vdc. Thus, under the worst case, the voltage at the card file is well within the electrical specification for the unit. This is the most conservative case, because the figure shows that at points above 20% rated power supply current, the regulation improves from 23.5 to 26.5 Vdc.

BECo Calc. I-N1-23 (Reference 48) indicates that ECCS Cabinet C2233A has a current load of 16.0775A and that is typical for C2233B. Each cabinet has two 24Vdc, 20A power supplies connected in parallel. In each cabinet, one power supply is fed from the appropriate divisional AC source, and the other power supply is fed from the appropriate divisional 125Vdc battery. Thus, under normal conditions, the percent load in these cabinets is approximately:

$$[(16.0775A)/(20A)](100\%) = 80\%$$

Therefore, under most conditions, the analog trip system load will be within the 23.5 to 26.5 Vdc portion of the curve.

The card file power input requirements conservatively overlap the output specifications of the cabinet power supply. Thus, the card file should be unaffected even with a drastic out of spec variation in the cabinet power supplies.

B. Degraded Voltage Considerations

The cabinet power supplies require a minimum input voltage of 102 Vac per NED-21617-A (Reference 49) Section 2.3.1.2. ECCS (CSCS) Analog Trip System Cabinets C2233A, B each have two power supplies. One is fed from the appropriate divisional AC source and the other is fed from the appropriate 125 Vdc battery. In the event of a degraded voltage condition, the battery fed power supply will automatically assume the cabinet load before the 102 Vac minimum is reached. Thus, the card file will not be affected by a degraded voltage situation.

7. Control Room and Cable Spreading Room Temperature

Per FSAR Table 10.9-2 (Reference 9), the Control Room design maximum temperature in the summer is 78°F. The winter design temperature is 75°F based on Dwg. M292 (Reference 50), Note 1. The Control Room HVAC thermostat is assumed to control within ±2°F of the design temperature, which is typical for HVAC systems. Thus, under normal conditions, the Control Room temperature is assumed to range between the lower winter temperature limit of 73°F (22.8°C) and the upper summer temperature limit of 80°F (26.7°C).

Since the Control Room is classified as a mild environment, there are no calculated temperatures for accident conditions. However, since an accident with loss of offsite power causes load shedding of the Control Room HVAC trains, it is probable that the Control Room temperatures will move out of the normal operating range of 73°F - 80°F. Therefore, for purposes of this calculation, the Control Room general area temperature range during an accident is conservatively assumed to range from 60°F (15.6°C) to 114°F (45.6°C). 60°F is conservative because the Control Room High Efficiency Air Filtration System (CRHEAFS) will maintain Control Room temperatures above 60°F at the ambient design lower limit of 10°F as described in Safety Evaluation SE2279 (Reference 47). 114°F is identified in FSAR Section 7.1.8 as the equilibrium Control Room temperature at the ambient design upper limit of 90°F when normal AC and ventilation is lost and only CRHEAFS is operating. For enclosed panels and cabinets, an additional 16°F is allowed for internal panel temperature rise. Thus, the internal panel temperature range during accident conditions is conservatively assumed to range from 60°F (15.6°C) to 130°F (54.4°C). This is consistent with the value identified in Specification E536 (Reference 51), which identifies an accident temperature of <130°F.

The Cable Spreading Room has the same temperature profile as the Control Room during normal and accident conditions.

For the purposes of this calculation, it is conservatively assumed that the Rosemount analog trip system master and slave trip units will experience temperatures between 60°F and 130°F. The repeatability parameter provided by Rosemount in Vendor Manual V-0243 (Reference 3) is valid over a range of 60°F to 90°F. Repeatability is included in the rack drift value (Red) and is not included in Rte. Therefore, only the 40°F temperature band between 90°F and 130°F needs to be considered in the Rte value.

Thus, for master trip units: Rte = ±0.20%(40°F/100°F) = ±0.08% span

For slave units (Note : Includes uncertainty associated with both master trip unit & slave - See Attachment 5): Rte = ±0.35%(40°F/100°F) = ±0.14% span

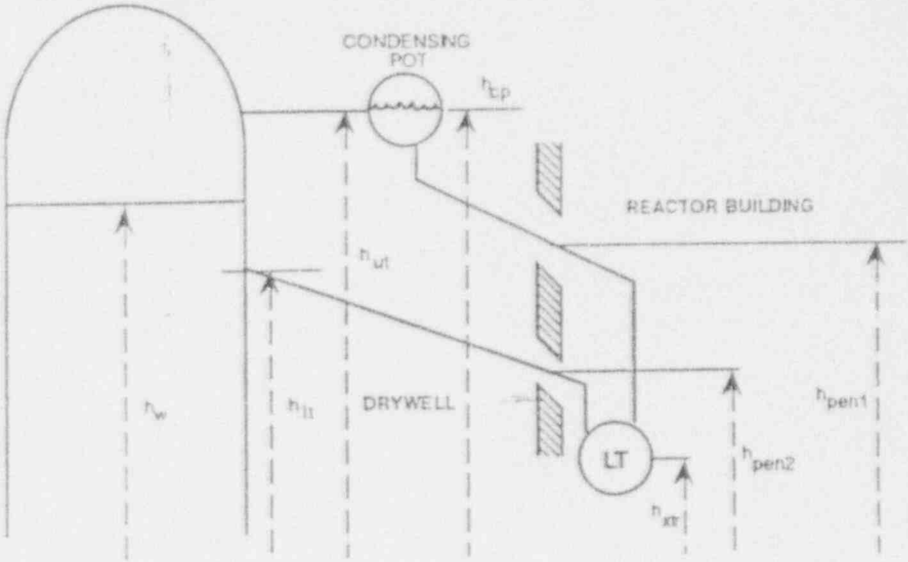
8. Process Measurement Accuracy (Pma):

The process measurement accuracy accounts for errors in the differential pressure applied to the level transmitters due to accident temperature changes affecting the reference legs, Reactor thermal growth and changes in the steam and water densities inside the Reactor vessel.

The accident scenarios (SB LOCA and PBOC) assume a concurrent loss of offsite power and use of the emergency diesel generator for power to the safety related loads. The reduced HVAC will result in increased temperatures in both the Reactor building and the drywell. Positive values for Pma are of concern for a decreasing setpoint, the limiting accident, then, is a PBOC. For this accident, the reference drywell temperature of 135°F will be used instead of an elevated temperature because the reduced density of the warmer water would reduce the value of the density variation portion of Pma. (The density variation affects both the reference and variable leg piping inside the drywell, since there is a larger vertical run on the variable leg, the net effect is to decrease Pma (density)).

The results derived in this note for Pma are valid for Normal Operation and Post-Accident conditions. The Pma value for the PBOC accident is based on a maximum temperature of 207.2°F. The density of water (ρ_w) at 207°F is 60.188 lbm/ft^3 (specific volume (v) = 0.01662 ft3/lbm). The question has been raised whether, when the Reactor vessel is depressurized to either 500 psig or 150 psig, ρ_w could be less than this value and hence introduce even greater error than has been accounted for. Recalling that $v = 1/\rho$ a lower ρ would correspond to a larger v. According to the ASME Steam Tables, 5th edition, at a pressure of 500 psig, the temperature would have to be greater than 200°F for the v to be larger than 0.01662 ft^3/lbm. Similarly, at a pressure of 150 psig, the temperature would have to be greater than 198°F. According to the simulations in Note 14, there is a maximum difference between the water column temperature and the ambient temperature of 5.5°F. Thus the ambient temperature must be less than 192.5°F. According to the environmental profile for this area (Reference 15), the temperature is below 192°F three minutes into the transient. It is not considered possible to depressurize within this time frame. Subsequently, ρ_w will be greater than the value used here, and the error will be less.

Consider the following Reactor vessel water level measurement loop:



$P_{stm}^{RV} =$	pressure of steam in Reactor vessel dome (typically ≈ 1000 psig)
$\rho_w^{RV,\,CAL} =$	density of water in the Reactor vessel assumed in determining the differential pressures at the transmitter for calibration
$\rho_{stm}^{RV,\,CAL} =$	density of steam in the Reactor vessel assumed in determining the differential pressures at the transmitter for calibration
$\rho_w^{DW,\,CAL} =$	density of water in the drywell portion of the reference or variable leg assumed in determining the differential pressures at the transmitter for calibration
$\rho_w^{RB,\,CAL} =$	density of water in the Reactor building portion of the reference or variable leg assumed in determining the differential pressures at the transmitter for calibration
$h_w =$	height of water inside the Reactor vessel

Then the differential pressure seen at the transmitter at calibration is given by:

$$\Delta P_{transmitter} = P_{Reference\ Leg} - P_{Variable\ Leg}$$

$$P_{Reference\ Leg} = P_{stm}^{RV} + \left(h_{cp}^{CAL} - h_{pen1}\right)\rho_w^{DW,CAL} + \left(h_{pen1} - h_{xtr}\right)\rho_w^{RB,CAL}$$

$$P_{Variable\ Leg} = P_{stm}^{RV} + \left(h_{cp}^{CAL} - h_{ut}^{CAL}\right)\rho_{stm}^{RV,CAL} + \left(h_{ut}^{CAL} - h_w\right)\rho_{stm}^{RV,CAL} + \left(h_w - h_{lt}^{CAL}\right)\rho_w^{RV,CAL} + \left(h_{lt}^{CAL} - h_{pen2}\right)\rho_w^{DW,CAL} + \left(h_{pen2} - h_{xtr}\right)\rho_w^{RB,CAL}$$

$$\Delta P_{transmitter} = \left[\left(h_{cp}^{CAL} - h_{pen1}\right) - \left(h_{lt}^{CAL} - h_{pen2}\right)\right] * \rho_w^{DW,CAL} + \left(h_{pen1} - h_{pen2}\right) * \rho_w^{RB,CAL} - \left(h_{cp}^{CAL} - h_{ut}^{CAL}\right) * \rho_{stm}^{RV,CAL} - \left(h_{ut}^{CAL} - h_w^{CAL}\right) * \rho_{stm}^{RV,CAL} - \left(h_w^{CAL} - h_{lt}^{CAL}\right) * \rho_w^{RV,CAL}$$

(Equation 1)

According to M1001 Sh. 128 & 129, the condensing pot is attached to the Reactor vessel via a 2" schedule 80 pipe. Equation 1 can be simplified:

$$\Delta P_{transmitter} = \left[\left(h_{cp}^{CAL} - h_{lt}^{CAL}\right) - \left(h_{pen1} - h_{pen2}\right)\right] * \rho_w^{DW,CAL} + \left(h_{pen1} - h_{pen2}\right) * \rho_w^{RB,CAL} - \left(h_{cp}^{CAL} - h_w^{CAL}\right) * \rho_{stm}^{RV,CAL} - \left(h_w^{CAL} - h_{lt}^{CAL}\right) * \rho_w^{RV,CAL}$$

(Equation 2)

In normal or accident conditions, the following terms from Equation 2 can differ from their calibration values:

$$h_{lt}^{ACT} = h_{lt}^{CAL} + e_{lt}$$ (thermal growth of vessel)

$$\rho_w^{DW,\,ACT} = \rho_w^{DW,\,CAL} + e_{\rho,\,w}^{DW}$$

$$\rho_w^{RB,\,ACT} = \rho_w^{RB,\,CAL} + e_{\rho,\,w}^{RB}$$

$$\rho_w^{RV,\,ACT} = \rho_w^{RV,\,CAL} + e_{\rho,\,w}^{RV}$$

$$\rho_{stm}^{RV,\,ACT} = \rho_{stm}^{RV,\,CAL} + e_{\rho,stm}^{RV}$$

$$h_{cp}^{ACT} = h_{cp}^{CAL} + e_{cp}$$ (Since $h_{cp} = h_{ut}$, growth of upper tap = shift in h_{cp})

where $e_{cp} = e_{ut}$ (thermal growth) + e_{offset}

$e_{offset} = h_{cp}^{ACT,\,Cold} - h_{cp}^{CAL}$ (assumed)

$$h_w = h_w^{CAL} + e_{h,w}$$

The equation for the actual differential pressure in terms of the calibration conditions is:

$$\Delta P_{transmitter} = \left[\left(h_{cp}^{CAL} + e_{cp} - h_{lt}^{CAL} - e_{lt}\right) - \left(h_{pen1} - h_{pen2}\right)\right] * \left(\rho_w^{DW,CAL} + e_{\rho,w}^{DW}\right)$$
$$+ \left(h_{pen1} - h_{pen2}\right) * \left(\rho_w^{RB,CAL} + e_{\rho,w}^{RB}\right) - \left(h_{cp}^{CAL} + e_{cp} - h_w^{CAL} - e_{h,w}\right) * \left(\rho_{stm}^{RV,CAL} + e_{\rho,stm}^{RV}\right)$$
$$- \left(h_w + e_{h,w} - h_{lt}^{CAL} - e_{lt}\right) * \left(\rho_w^{RV,CAL} + e_{\rho,w}^{RV}\right)$$

(Equation 3)

If we define the error as:

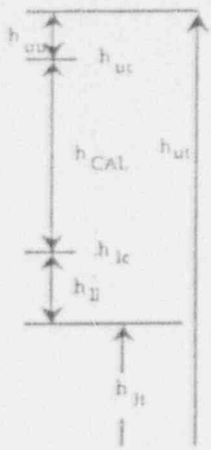
$$\Delta P_{error} = \Delta P_{transmitter}\text{ (calibration)} - \Delta P_{transmitter}\text{ (actual)}$$ **(Equation 4)**

...then a $\Delta P_{transmitter}$ (actual) less than a $\Delta P_{transmitter}$ (calibrated) will result in a positive ΔP_{error} which correlates with the positive (higher than actual) indication error. Substituting equations (2) and (3) into (4) yields:
(products of two errors are considered negligible and are dropped):

$$\Delta P_{error} = -\left(e_{cp} - e_{lt}\right) * \rho_w^{DW,CAL} - \left[\left(h_{cp}^{CAL} - h_{lt}^{CAL}\right) - \left(h_{pen1} - h_{pen2}\right)\right] * e_{\rho,w}^{DW}$$
$$- \left(h_{pen1} - h_{pen2}\right) * e_{\rho,w}^{RB} + \left(e_{cp} - e_{h,w}\right) * \rho_{stm}^{RV,CAL} + \left(h_{cp}^{CAL} - h_w^{CAL}\right) * e_{\rho,stm}^{RV}$$
$$+ \left(e_{h,w} - e_{lt}\right) * \rho_w^{RV,CAL} + \left(h_w^{CAL} - h_{lt}^{CAL}\right) * e_{\rho,w}^{RV}$$

(Equation 5)

If we do not calibrate the transmitter over the entire distance between the upper and lower taps (such as shown below), then:



• $h_{CAL} = h_{uc} - h_{lc}$

• $h_{ll} = h_{lc} - h^{CAL}_{lt}$

• $h_{uu} = h^{CAL}_{ut} - h_{uc}$

Note that $e_{h,w}$ in Equations (3) and (5) must satisfy the following constraints:

$$e_{h,w} = e_{lt} \quad \text{when} \quad h_w^{CAL} = h_{lt}^{CAL}$$
$$e_{h,w} = e_{ut} \quad \text{when} \quad h_w^{CAL} = h_{ut}^{CAL}$$

Therefore $e_{h,w}$ can be expressed as:

$$e_{h,w} = e_{lt} + \frac{h_w^{CAL} - h_{lt}^{CAL}}{h_{ut}^{CAL} - h_{lt}^{CAL}} (e_{ut} - e_{lt}) \qquad \text{(Equation 6)}$$

Define h'_w as follows:

$$h'_w = \frac{h_w^{CAL} - h_{lc}^{CAL}}{h_{CAL}} \qquad (0 \le h'_w \le 1) \qquad \text{(Equation 7)}$$

then Equation (6) becomes:

$$e_{h,w} = e_{lt} + \frac{h_{ll} + h'_w h_{CAL}}{h_{ut}^{CAL} - h_{lt}^{CAL}} (e_{ut} - e_{lt}) \qquad \text{(Equation 8)}$$

Note also that:

$$h_{w}^{CAL} - h_{lt}^{CAL} = h_{ll} + h'_{w}h_{CAL} \quad \text{(Equation 9)}$$

$$h_{cp}^{CAL} - h_{w}^{CAL} = h_{cp}^{CAL} - h_{lt}^{CAL} - h_{ll} - h'_{w}h_{CAL} \quad \text{(Equation 10)}$$

$$e_{h,w} - e_{lt} = \frac{h_{ll} + h'_{w}h_{CAL}}{h_{ut}^{CAL} - h_{lt}^{CAL}}(e_{ut} - e_{lt}) \quad \text{(Equation 11)}$$

$$e_{cp} - e_{h,w} = e_{offset} + \left\{1 - \left(\frac{h_{ll} + h'_{w}h_{CAL}}{h_{ut}^{CAL} - h_{lt}^{CAL}}\right)\right\}(e_{ut} - e_{lt}) \quad \text{(Equation 12)}$$

Substituting equations (9) through (12) into Equation (5) and rearranging terms yields:

$$\Delta P_{error} = -\left[\left(h_{cp}^{CAL} - h_{lt}^{CAL}\right) - \left(h_{pen1} - h_{pen2}\right)\right] e_{\rho,w}^{DW} - \left(h_{pen1} - h_{pen2}\right) e_{\rho,w}^{RB} - \left(e_{offset} + e_{ut} - e_{lt}\right) \rho_{w}^{DW,CAL} +$$

$$\left[e_{offset} + \left(1 - \frac{\left(h_{ll} + h'_{w}\, h_{CAL}\right)}{h_{ut}^{CAL} - h_{lt}^{CAL}}\right)(e_{ut} - e_{lt})\right] \rho_{stm}^{RV,CAL} + \frac{\left(h_{ll} + h'_{w}\, h_{CAL}\right)}{h_{ut}^{CAL} - h_{lt}^{CAL}}(e_{ut} - e_{lt})\, \rho_{w}^{RV,CAL}$$

$$+ \left(h_{cp}^{CAL} - h_{lt}^{CAL} - h_{ll} - h'_{w}h_{CAL}\right) e_{\rho,stm}^{RV} + \left(h_{ll} + h'_{w}\, h_{CAL}\right) e_{\rho,w}^{RV}$$

(Equation 13)

This error equation can be divided into three parts according to whether the error is due to Reference Leg Variations (RLV), dimensional changes on the vessel (DC) or changes in the densities of steam and water inside the vessel ($\Delta\rho$). Let:

$$\Delta P_{error,RLV} = -\left[\left(h_{cp}^{CAL} - h_{lt}^{CAL}\right) - \left(h_{pen1} - h_{pen2}\right)\right] e_{\rho,w}^{DW} - \left(h_{pen1} - h_{pen2}\right) e_{\rho,w}^{RB} \quad \text{(Equation 14)}$$

$$\Delta P_{error,DC} = \left[\rho_{stm}^{RV,CAL} + \frac{h_{ll} + h'_{w}h_{CAL}}{h_{ut}^{CAL} - h_{lt}^{CAL}}\left(\rho_{w}^{RV,CAL} - \rho_{stm}^{RV,CAL}\right) - \rho_{w}^{DW,CAL}\right](e_{ut} - e_{lt}) - e_{offset} * \left(\rho_{w}^{DW,CAL} - \rho_{stm}^{RV,CAL}\right)$$

(Equation 15)

Note: $e_{ut} - e_{lt}$ is the relative thermal growth of the upper tap elevation to the lower tap elevation.

$$\Delta P_{error,\Delta\rho} = \left(h_{cp}^{CAL} - h_{lt}^{CAL}\right) e_{\rho,stm}^{RV} + \left(h_{ll} + h'_{w}h_{CAL}\right)\left(e_{\rho,w}^{RV} - e_{\rho,stm}^{RV}\right) \quad \text{(Equation 16)}$$

According to BECo, GE has already considered the $\Delta P_{error,\Delta\rho}$ contribution when they determined the analytical limit of -56.9" - Reference 37, Attachment 6. Therefore, this term will not be further analyzed.

According to BECo Calc. I-N1-24, Reference 6, the normal operation conditions for calibration of the transmitter are:

T_{RV} = 546.5°F
T_{DW} = 135°F
T_{RB} = 80°F
P_{RV} = 1000 psig

From the ASME Steam Tables, 5th edition (Reference 57), the following densities are obtained:

Reactor Vessel Pressure = 1000 psig:

$\rho_{rb,w}$ (@ 80°F) = 62.4220 lb/ft^3
$\rho_{dw,w}$ (@ 135°F) = 61.6523 lb/ft^3
$\rho_{rv,w}$ (@ 546.5°F) = 46.2028 lb/ft^3
$\rho_{rv,stm}$ (@ 546.5°F) = 2.2806 lb/ft^3

According to BECo calculation I-N1-24, the following elevations relative to the bottom of the Reactor vessel were assumed to exist at calibration:

	"A" Train Level	"B" Train Level
h_{cp}^{CAL}	548.5	548.5
h_{ut}	547"	547"
h_{lt}	425.5"	425.5"
h_{pen2}	404.3125"	398.3125"
h_{pen1}	534.375"	535.75"
h_{ic}	432.5"	432.5"
h_{CAL}	100"	100"

The distance from the bottom of the Reactor vessel to the bottom of the inside of the pipe from the Reactor vessel to the condensing pot for each train is calculated below. Note, this should correspond to the water level in the condensing pot.

	"A" Train Level	"B" Train Level	Reference
Top of Pipe	83' 9.3125" (1005.3125")	83' 9.375" (1005.375")	M1001 Sh. 128, 129
Reactor Zero Elevation	-37' 11 1/4" (-455.25")	-37' 11 1/4" (-455.25")	M23
Internal diameter 2" Sch. 80 Pipe + Wall Thickness	-2.157"	-2.157"	M1001 Sh. 128, 129 (Detail 1)
h_{cp}^{ACTUAL}	547.91"	547.97"	-

Thermal growth, according to FS&MC memo 91-176 (Reference 38 - Attachment 6), is 7.3 x 10^{-6} in/in/°F and the cold distance between the upper and lower taps is 121.5". Assuming a cold temperature of 60°F:

$\Delta l = 0.88695 \times 10^{-3}$" (T-60°F)

Using T = Tsat (1000 psig) = 546.5°F, Δl = 0.431"

Now Equations (14) and (15) become:

Reference Leg Error

"A" Train:

$$\Delta P_{error, RLV} = -[(548.5-425.5) - (534.375-404.3125)] * \epsilon_{\rho, w}^{DW} - (534.375-404.3125) * \epsilon_{\rho, w}^{RB}$$
$$= -(123.0 - 130.0625) * \epsilon_{\rho, w}^{DW} - 130.0625 * \epsilon_{\rho, w}^{RB}$$
$$= 7.0625 * \epsilon_{\rho, w}^{DW} - 130.0625 * \epsilon_{\rho, w}^{RB} \qquad \text{(Equation 17)}$$

"B" Train :

$$\Delta P_{error, RLV} = -[(548.5-425.5) - (535.75-398.3125)] * \epsilon_{\rho, w}^{DW} - (535.75-398.3125) * \epsilon_{\rho, w}^{RB}$$
$$= -(123.0 - 137.4375) * \epsilon_{\rho, w}^{DW} - 137.4375 * \epsilon_{\rho, w}^{RB}$$
$$= 14.4375 * \epsilon_{\rho, w}^{DW} - 137.4375 * \epsilon_{\rho, w}^{RB} \qquad \text{(Equation 18)}$$

Dimensional Change Error

"A" Train:

$$\Delta P_{error, DC} = [2.2806 + (7 + h'_w * 100)/121.5) * (46.2028-2.2806) - 61.6523] * (e_{ut} - e_{lt}) - (61.6523 - 2.2806) e_{offset}$$
$$= [2.2806 + 2.5305 + 36.15 h'_w - 61.6523] * (e_{ut} - e_{lt}) - 59.3717 e_{offset}$$
$$= (-56.84 + 36.15 h'_w) * (e_{ut} - e_{lt}) - 59.3717 e_{offset}$$

"B" Train:

$\Delta P_{error, DC} = [2.2806 + ((7 + h'_w * 100)/121.5) * (46.2028 - 2.2806) - 61.6523] * (e_{ut} - e_{lt}) - (61.6523 - 2.2806)\, e_{offset}$

$= [2.2806 + 2.5305 + 36.15\, h'_w - 61.6523] * (e_{ut} - e_{lt}) - 59.3717 e_{offset}$

$= (-56.84 + 36.15\, h'_w) * (e_{ut} - e_{lt}) - 59.3717 e_{offset}$

$e_{offset} = h_{cp}^{ACTUAL} - h_{cp}^{CAL} = 547.91" - 548.5" = -0.59"$ ("A" Train)

$e_{offset} = h_{cp}^{ACTUAL} - h_{cp}^{CAL} = 547.97" - 548.5" = -0.53"$ ("B" Train)

Now $\Delta p_{error, DC} = (-56.84 + 36.15 h'_w) * (e_{ut} - e_{lt}) + 35.03$ ("A" Train)

$= (-56.84 + 36.15 h'_w) * (e_{ut} - e_{lt}) + 31.47$ ("B" Train)

(Equation 19)

Consider the following post-accident conditions:

SB LOCA (inside drywell)	PBOC	Normal Operation Variation
P_{RV} = 150 psig	1125 psig	1000 psig
T_{RV} = 363.6°F	560.7°F	546.5°F
T_{DW} = 330°F	135°F	125°F - 145°F
T_{RB} = 80°F	207°F*	60°F - 105°F

* Peak Reference Leg Temperature per Heat Transient Analysis - See Note 14

Using the ASME Steam Tables, 5th edition, (Reference 57), the following densities were obtained:

ρ_w (@ 1000 psig & 60°F) = 62.5783 lbm/ft^3
ρ_w (@ 1000 psig & 105°F) = 62.1118 lbm/ft^3
ρ_w (@ 1000 psig & 125°F) = 61.8104 lbm/ft^3
ρ_w (@ 1000 psig & 145°F) = 61.4818 lbm/ft^3
ρ_w (@ 1125 psig & 135°F) = 61.6713 lbm/ft^3
ρ_w (@ 1125 psig & 207°F) = 60.188 lbm/ft^3
ρ_w (@ 150 psig & 330°F) = 56.3063 lbm/ft^3
ρ_w (@ 150 psig & 80°F) = 62.2665 lbm/ft^3
ρ_w (@ 1125 psig & 330°F) = 56.5611 lbm/ft^3
ρ_w (@ 1125 psig & 60°F) = 62.5782 lbm/ft^3

Now the values for $e^{DW}_{\rho,w}$ & $e^{RB}_{\rho,w}$ are:

	SB LOCA	PBOC	Normal Op. Variation
$e^{DW}_{\rho,w}$	56.3063 - 61.6523 = -5.3460	61.6713 - 61.6523 = 0.0190	61.8104 - 61.6523 = 0.1581 61.4818 - 61.6523 = -0.1705
$e^{RB}_{\rho,w}$	62.2665 - 62.4220 = -0.1555	60.188 - 62.4220 = -2.234	62.5783 - 62.422 = 0.1563 62.1118 - 62.422 = -0.3102

Using the Reactor vessel temperatures above, the elongation error for the SB LOCA and the PBOC are calculated as follows:

Δl (@ 1125 psig) = 0.8869x10^{-3} " * (560.7 - 60)°F = 0.444"

Δl (@ 150 psig) = 0.8869x10^{-3} " * (363.7 - 60)°F = 0.269"

and:

$(e_{ut} - e_{lt})_{PBOC}$ = Δl (@ 1125 psig) = 0.444"

$(e_{ut} - e_{lt})_{SB\ LOCA}$ = Δl (@ 150 psig) = 0.269"

Substituting the values for $e^{DW}_{\rho,w}$ & $e^{RB}_{\rho,w}$ and $(e_{ut} - e_{lt})$ into Equations 17, 18 & 19 yields:

	SB LOCA	PBOC	Normal Op. Variation
$\Delta P_{error, RLV}$ (A)⇒ (B)⇒	-37.76 - (-20.22) = -17.54 -77.18 - (-21.37) = -55.81	0.134 - (-290.56) = 290.69 0.274 - (-307.04) = 307.31	-19.2 (A:Min), + 39.14 (A:Max) -19.2 (B:Min), + 40.17 (B:Max)
$\Delta P_{error, DC}$ $(f_w = 1)$	29.46 (A), 25.90 (B)	25.84 (A), 22.28 (B)	26.11 (A), 22.55 (B)

The quantities determined through Equations 17, 18 and 19 have units of inch*(lbm/ft^3). In order to convert them into inches of water ("H_2O), a conversion factor equal to the density assumed at calibration, 62.2462 lbm/ft^3, times 1"/1" H_2O must be applied.

Therefore, the largest Pma (Normal Operation) is a Bias of:

[26.11 in lbm/ft^3]/[62.2462 in lbm/ft^3/"H_2O] = +0.42"H_2O

and a Random term of:

[40.17 in lbm/ft^3]/[62.2462 in lbm/ft^3/"H_2O] = 0.65"H_2O

...and the largest Pma (Accident) is:

[329.59 in lbm/ft^3]/[62.2462 in lbm/ft^3/"H_2O] = 5.29"H_2O (PBOC)
[11.92 in lbm/ft^3]/[62.2462 in lbm/ft^3/"H_2O] = 0.19"H_2O (SB LOCA)

Converting these differential pressures into Reactor vessel indication yields:

Pma (Normal Operation, Bias) = 0.42"H_2O * (100"/70.06"H_2O) = +0.60"
Pma (Normal Operation, Random Term) = 0.65"H_2O * (100"/70.06"H_2O) = ± 0.93"
Pma (Post-Accident : PBOC) = 5.29"H_2O * (100"/70.06"H_2O) = + 7.56"
Pma (Post-Accident : SB LOCA) = (0.19)"H_2O * (100"/70.06"H_2O) = +0.27"

The normal operation Pma is bounded by the ±0.65"H_2O or ±0.93" water level variation. It will be treated as a random variable since the exact combination of drywell and Reactor building temperatures can not be predicted.

An additional contribution to Process measurement accuracy is the possibility of hydrogen coming out of solution in the reference leg which would result in indications above the actual level in the Reactor vessel. This issue is being addressed by the GE Owners Group and will not be addressed in this calculation.

9. Sensor Static Pressure Effect

The sensor static pressure effect is partially correctable, i.e. a correction factor is determined for normal operating conditions. The error in the correction consists of a random value as well as a bias. We will calculate the biases first.

According to NEDC-81852P (Reference 7), the Reactor vessel operating pressure varies between 150 psig and 1125 psig. The maximum differential pressure applied to the "A" Train transmitters is 113.86"H_2O and to the "B" Train transmitters is 113.95"H_2O. (BECo Calc. I-N1-24 - Reference 6)

According to the Rosemount Vendor Manual for the 1153 Series B transmitters (Reference 1), the static pressure correction factor is:

CF = -0.75% of reading (applied pressure/1000 psig)

At normal operating pressure of 1000 psig:

CF = -0.75% of reading
= -0.0075(113.86)"H_2O
= -0.85"H_2O ("A" Train)

= -0.0075(113.95)"H_2O
= -0.85"H_2O ("B" Train)

at the maximum Reactor vessel pressure (PBOC conditions):

CF = -0.75% of reading (1125 psig/1000 psig)
= -0.844% of reading

= -0.00844(113.86)"H_2O
= -0.96"H_2O ("A" Train)

= -0.00844(113.95)"H_2O
= -0.96"H_2O ("B" Train)

at the minimum Reactor vessel pressure (SB LOCA conditions):

CF = -0.75% of reading (150 psig/1000 psig)
= -0.113% of reading
= -0.00113(113.86)"H_2O
= -0.128"H_2O ("A" Train)

= -0.00113(113.95)"H_2O
= -0.128"H_2O ("B" Train)

Error in the correction factor is given by:

PBOC

E_{CF} = CF_{1000} - CF_{1125}
= -0.85 - (-0.96)"H_2O
= 0.11"H_2O * (100"/70.06"H_2O)
= 0.157" ("A" Train)

= -0.85 - (-0.96)"H_2O
= 0.11"H_2O * (100"/70.05"H_2O)
= 0.157" ("B" Train)

SB LOCA

E_{CF} = CF_{1000} - CF_{150}
= -0.85 - (-0.128)"H_2O
= -0.722"H_2O * (100"/70.06"H_2O)
= -1.03" ("A" Train)

= -0.85 - (-0.128)"H_2O
= -0.722"H_2O * (100"/70.05"H_2O)
= -1.03" ("B" Train)

Random Terms

Static Pressure Span Effect

According to Rosemount Vendor Manual 4302 (Reference 1):

Ssps = ±0.5% of reading/1000 psig

During normal operation P_{RV} = 1000 psig and the maximum Ssps is:

Ssps = ±0.5% of reading
= ±0.005(113.86)"H_2O
= ±0.569"H_2O*(100"/70.06"H_2O)
= ±0.81" ("A" Train)

= ±0.005(113.95)"H_2O
= ±0.570"H_2O*(100"/70.05"H_2O)
= ±0.81" ("B" Train)

Post PBOC, P_{RV} = 1125 psig and:

Ssps = ±0.5% of reading (1125 psig/1000 psig)
= ±0.56% of reading
= ±0.0056(113.86)"H_2O
= ±0.638"H_2O*(100"/70.06"H_2O)
= ±0.91" ("A" Train)

= ±0.0056(113.95)"H_2O
= ±0.638"H_2O*(100"/70.05"H_2O)
= ±0.91" ("B" Train)

Post SB LOCA, P_{RV} = 150 psig and:

Ssps = ±0.5% of reading (150 psig/1000 psig)
= ±0.075% of reading
= ±0.00075(113.86)"H_2O
= ±0.0854"H_2O*(100"/70.06"H_2O)
= ±0.12" ("A" Train)

= ±0.00075(113.95)"H_2O
= ±0.0855"H_2O*(100"/70.05"H_2O)
= ±0.12" ("B" Train)

Static Pressure Zero Effect, Sspz

According to the Rosemount Vendor Manual 4302 (Reference 1), Sspz is determined by:

Sspz = ±0.2% URL/1000 psig

At normal operating conditions, P_{RV} = 1000 psig and the maximum Sspz is:

Sspz = ±0.002(150"H_2O)
= ±0.3"H_2O * (100"/70.05"H_2O)
= ±0.43" ("A" & "B" Trains)

At post-PBOC conditions, P_{RV} = 1125 psig and the maximum Sspz is:

Sspz $= \pm 0.002(150"H_2O)*(1125 \text{ psig}/1000 \text{ psig})$
$= \pm 0.00225(150"H_2O)$
$= \pm 0.338"H_2O * (100"/70.05"H_2O)$
$= \pm 0.482"$ ("A" & "B" Trains)

At post-SB LOCA conditions, P_{RV} = 150 psig and the maximum Sspz is:

Sspz $= \pm 0.002(150"H_2O)*(150 \text{ psig}/1000 \text{ psig})$
$= \pm 0.0003(150"H_2O)$
$= \pm 0.045"H_2O * (100"/70.05"H_2O)$
$= \pm 0.064"$ ("A" & "B" Trains)

10. The No Adjust Limits (Instrument Tolerance) and Reset values will be based on the existing settings utilized. These values are based on the accuracy of the device as stated by the manufacturer and are shown in PNPS Procedures 8.M.1-32.5 & 8.M.1-32.7.

11. Combining Terms

Three cases are being considered. These are SB LOCA inside drywell, a pipe break in the Reactor Building (PBOC), and normal operation. These results are summarized in the table below.

BIASES

Bias	Normal Operation	SB LOCA	PBOC	Reference (Source of Value)
Pma	+0.60"	+0.27"	+7.56"	Note 8
Ssps (Correction Factor)	-	-1.03"	+.157"	Note 9
CI	-	-	-.172"	Form 1

RANDOM TERMS

Random Terms	Normal Operation	SB LOCA	PBOC	Reference (Source of Value)
Re	-	±0.71"	±0.71"	Note 4
Pma	±0.93"	-	-	Note 8
Sca	±0.25"	±0.25"	±0.25"	Form 1
Rte	±0.08"	±0.08"	±0.08"	Form 1
Sa	±0.25"	±0.25"	±0.25"	Form 1
Ssps	±0.81"	±0.12"	±0.91"	Note 9
Sspz	±0.43"	±0.064"	±0.48"	Note 9
Ste	±0.95"	±0.95"	±2.53"	Note 5
Spse	±0.02"	±0.02"	±0.02"	Form 1
Sd	±0.43"	±0.43"	±0.43"	Form 1
Red	±0.13"	±0.13"	±0.13"	Attachment 6
St	±0.25"	±0.25"	±0.25"	Form 1
Ret	±0.13"	±0.13"	±0.13"	Form 1
EA	0	±0.71"	±0.71"	
LA	0	0	-0.172"	
PA	+0.60±0.93"	+0.27"	+7.56"	
CA	±0.25"	±0.25"	±0.25"	
RA	±0.08"	±0.08"	±0.08"	
SA	±1.58"	-1.03±1.0"	+0.157"±2.90"	
DA	±0.45"	±0.45"	±0.45"	
TA	±0.28"	±0.28"	±0.28"	

COMBINED TERMS

	Normal Operation	SB LOCA	PBOC
Combined Biases	+0.60"	+0.27", -1.03"	+7.72", -0.172"
Combined Random Terms	±1.92"	±1.36"	±3.04"
TLU	-1.92", +2.52"	-2.39", +1.63"	-3.22", +10.76"

12. Channel Cross Check

Channel cross check criteria is intended to be used by BECo operators to determine when a channel may be malfunctioning based on a comparison of its indicated value for a plant

parameter versus the value displayed by the other channels displaying the same parameter. It is intended that this comparison will be performed during plant normal operation.

1. Methodology

A. Total Loop Uncertainty for Cross Check

The TLU used for cross check purposes is defined as:

$$TLU_{CROSS\ CHECK} = \sqrt{(PA)^2 + (CA)^2 + (RA)^2 + (SA)^2 + (DA)^2 + (TA)^2}$$

where:

$PA = Pea$

$CA^2 = Sca^2 + Rca^2$

Note: Rca includes the readability of the meter (1/2 minimum gradation)

$RA^2 = Rea^2 + Rte\,[N.O.]^2 + Ma^2$

Note: Rte [N.O.] is the error due to temperature difference between calibration and Normal Operation temperature. Ma is the master trip unit analog meter accuracy.

$SA^2 = Sa^2 + (Ssps + Sspz)^2 + Ste[N.O.]^2$

Note: Ste[N.O.] is the error due to temperature difference between calibration and Normal Operation temperature.

$DA^2 = Sd^2 + Red^2$

$TA^2 = St^2 + Ret^2$

Note: Ret is the "As Left" setting tolerance of the meter indication.

The following terms from the equation for TLU in NEDWI 394 are not considered for the following reasons:

EA and its constituent terms Te, Re, S/Ce, Pe and Se are not considered since these errors are associated with Post Accident conditions and the cross check is performed only during Normal Operation. Similar reasoning is why LA and its constituents Cl, Tl, Pl, Sl, and Dl are not considered.

The process measurement accuracy, Pma, constituent of PA is not considered since it would equally affect all channels.

The sensor and rack power supply effects, Spse and Rps, are not considered because minor voltage variations on the 120 Vac buses are well within the regulation capability of the individual sensor and rack power supplies. Also, a severe degraded voltage condition is not considered, because this is not a normal plant operating condition.

For differential pressure transmitters in pressurized applications, the static pressure span and zero error terms, Ssps and Sspz, consist only of the random portion of the error. They account for the uncertainty in the correction actually applied and are still applicable.

B. Development of Channel Cross Check Criteria

The purpose of this section is to discuss the derivation of the channel cross check methodology to be used at the Pilgrim Nuclear Power Station (PNPS). The purpose of the cross check process is to detect when a channel's performance begins to deviate from within analyzed bounds and is performed by comparing an individual channel's indication against some criteria.

An ideal test would be to compare the channel indication against the actual value of the parameter being monitored. In this case the criteria would be that **"the difference between the indicated and the actual value must be less than the uncertainty established for the channel indication"**.

However, the actual value of a parameter is never known with absolute certainty. From a statistical standpoint, reduced uncertainty in the value of a parameter can be achieved by making a series of repeated independent measurements.

From Section 2, "Fundamental Considerations", of ASME PTC 19.1 - 1985 (Reference 63), "Part 1 Measurement Uncertainty", if a series of independent measurements (readings) are made, then the mean value of the series is given by $\left(\sum_{i=1}^{N} (x_i) / N\right)$.

From the same document, the uncertainty associated with the mean value of a series of independent readings is related to the uncertainty in each of the measurements in the series used to calculate the mean value. This uncertainty is given by $s_{Mean} = s_{Series} / \sqrt{N}$

where $s_{Series} = \left(\sum_{i=1}^{N} (s_i)^2 / N\right)^{1/2}$ and s_i = uncertainty associated with the ith measurement.

If the measurement uncertainties are the same (all $s_i = s_{Measurement}$) then $s_{Series} = s_{Measurement}$ and

$s_{Mean} = s_{Series}/\sqrt{N} = s_{Measurement}/\sqrt{N}$.

This indicates that if you are estimating the actual value of a parameter by averaging several measurements, then the uncertainty in your estimate decreases as the number of measurements in the average increases.

If one were to compare the indication of a single channel with the mean indication of several channels monitoring the same parameter, what would be an appropriate comparison criteria. The criteria proposed is that **"the difference between the indication of a single channel and the mean indication of several channels monitoring the same parameter must be less than the uncertainty established for the channel indication plus the uncertainty established for the mean value"**. Mathematically, the criteria is expressed as follows:

$$\left| Reading_{Channel\,i} - \left(\sum_{i=1}^{N} \left(Reading_{Channel\,i} \right) / N_{Channels} \right) \right| < S_{Channel} + S_{Mean}$$

$$\left| Reading_{Channel\,i} - \left(\sum_{i=1}^{N} \left(Reading_{Channel\,i} \right) / N_{Channels} \right) \right| < S_{Channel} + \frac{S_{Channel}}{\sqrt{N_{Channels}}}$$

The criteria is based on the fact that the first uncertainty is that of the reading being compared and the second uncertainty is that of the standard being compared against. In the limiting case of N = 1, i.e. comparing two readings to each other, the criteria states that the difference must be less than twice the established channel indication uncertainty. In the limiting case of $N \rightarrow \infty$, the uncertainty associated with the mean value approaches zero and the criteria reverts to the ideal case above.

Using the above equation and substituting $TLU_{Cross\ Check}$ for $s_{Channel}$ and simplifying yields:

$$\left| \text{Channel i Reading - Average Channel Reading} \right| < \left(1 + \frac{1}{\sqrt{N}} \right) * TLU_{Cross\ Check}$$

Tabulated below are values for $(1 + 1/\sqrt{N})$

N (No. of channels)	$(1 + 1/\sqrt{N})$ $TLU_{Cross\ Check}$ Multiplier (M)
2	1.707
3	1.577
4	1.500
7	1.378
8	1.354

The current PNPS channel cross check procedure is performed by comparing two readings to each other, which is the limiting case of N=1 described above. Therefore, the calculation presented in Part 2 will consider both the cross check between channels (limiting case of N=1) and the cross check against the average.

C. Application of Cross Check Criteria

Round off the calculated cross check value to the nearest readable value. Compare the calculated value of the cross check criteria to the existing value taken from PNPS Procedures. If the existing value is larger than the calculated value, coordinate with BECo NED concerning reducing the existing cross check criteria to the calculated value. If not, use the existing value. Identify the cross check value in Section V, Results and Conclusions.

2. CALCULATION

$$TLU_{CROSS\ CHECK} = \sqrt{(PA)^2 + (CA)^2 + (RA)^2 + (SA)^2 + (DA)^2 + (TA)^2}$$

where:

(PA) = N/A

(CA) = ±1.03", where $CA^2 = Sca^2 + Rca^2$

Sca = ±0.25" (See Note 11)

$Rca = \sqrt{(Rca_{Form\ 1})^2 + (Readability)^2} = 1"$

where: $Rca_{Form\ 1}$ =N/A (See Form 1)
Readability = 1/2 (2") = 1" (See Reference 61)

(RA) = ±3.00, where $RA^2 = Rea^2 + Rte^2 + Ma^2$ and Rea = N/A, see Form 1.

The cable spreading room Normal Operating Temperature is 73° F- 80° F. The repeatability parameter provided by Rosemount in vendor manual V-0243 (Reference 2) is valid over a range of 60° F-90° F. Therefore, repeatability is included in the Rack Drift value (Red) and is not included in (Rte). See Note 7.

Ma = ±3% of Full Scale (Reference 2)
= ±(0.03)(100")
= ±3.00"

$(SA) = \pm 1.58''$, where $SA^2 = Sa^2 + (Ssps + Sspz)^2 + Ste^2$
$Sa = \pm 0.25''$ (See Note 11)
$Ssps = \pm 0.81''$ (See Note 11)
$Sspz = \pm 0.43''$ (See Note 11)
$Ste = \pm 0.95''$ where $Ste = \pm$ (.75%URL + .5% of Span) Per 100° F (See Form 1)

Since the Reactor Building Normal Temperature range is 60° F- 105° F (See Note 5), the Maximum Normal Temperature variance is 105° F- 60° F = 45° F.

Therefore, Ste $= \pm(.0075 * 150''H_2O + .005 * 70.06''H_2O) * 45^\circ F/100^\circ F$
$= \pm 0.66''H_2O*(100''/70.06''H_2O)$
$= \pm 0.95''$

$(DA) = \pm 0.45''$ (See Note 11)
$(TA) = \pm 0.28''$ (See Note 11). Since there is no meter adjustment possible, the setting tolerance for the master trip unit and the setting tolerance for the sensor will be used to calculate TA.

Therefore,

$$TLU_{Cross\ Check} = \sqrt{(0)^2 + (1.03)^2 + (3.00)^2 + (1.58)^2 + (0.45)^2 + (0.28)^2}$$

$$TLU_{Cross\ Check} = 3.58''$$

$$TLU_{Cross\ Check\ Mean} = \frac{TLU_{Cross\ Check}}{\sqrt{N}} \quad \text{(where N = Number of Channels)}$$

Case 1 Comparison to an average of the four channels:

$$TLU_{Cross\ Check\ Mean} = \frac{3.58''}{\sqrt{4}} = 1.79''$$

From Section B, all channel readings must satisfy the relationship:

$$|\text{Channel i Reading - Average Channel Reading}| < TLU_{Cross\ Check\ Mean} + TLU_{Cross\ Check}$$

which, after substituting 1.79" for $TLU_{Cross\ Check\ Mean}$ & 3.58" for $TLU_{Cross\ Check}$:

$$|\text{Channel i Reading - Average Channel Reading}| < 1.79'' + 3.58'' = 5.37''$$

5.37" will be rounded off to the nearest 1", therefore, will equal 5", which is less than the 6" value in BECo Procedure 2.1.15 (Ref. 62).

Case 2 Comparison between any two channels (i and j):

$$TLU_{Cross\ Check\ Mean} = \frac{3.58"}{\sqrt{1}} = 3.58"$$

$$|\text{Channel i Reading - Channel j Reading}| < 3.58" + 3.58" = 7.16"$$

Since the calculated value is larger than the existing value in BECo Procedure 2.1.15 (Ref. 62), the existing value is conservative and can continue to be used.

13. Evaluation of Statistics for Calculation 25-226-C004

1. The mean and standard deviation computed after the second outlier check with Microsoft Excel (Attachment 6) and computed by SYSTAT (Attachment 7) are approximately the same. The mean and standard deviations are expressed in units of % Calibrated Span.

2. Since the largest mean was less than 0.1% CS (See Attachments 6 & 7), no bias is assumed to exist and the absolute value of the mean will be added to the standard deviation and that quantity used to determine the 95/95 tolerance level.

3. The skewness (3rd moment of the data) test is used to determine how uniformly the data is distributed about the mean value. The results (Attachment 7) indicate that there is moderate skewing of the data. This will be discussed further when the histogram and probability plots are discussed.

4. The kurtosis (4th moment of the data) is used to determine if the data is bunched close to the mean or at the tails of the distribution, i.e. peaked or flat distribution. A kurtosis value of close to zero indicates a distribution close to a normal distribution. The results (Attachment 7) indicate that the master trip unit data has some peaking of the data close to the mean value.

5. The data was plotted on a bar histogram and the normal probability density function superimposed. Ideally the bars would follow the curvature of the density function and the height of the bars would be close to the height of the curve.

   A review of the master trip unit drift data histograms (Attachment 7) shows a peaking of the data at -0.0625%, 0.000% and +0.0625%. This corresponds to -1, 0 and +1 Least Significant Digit (LSD) on the digital multimeter used to read that test results. This excess of data appears to also be the cause of the Skewness and Kurtosis values discussed above.

6. Finally, a Probability Plot (P-Plot) was generated for each set of data. This is a plot of the data's cumulative probability distribution on a special scale such that if the data is normally distributed, the data will lie along a straight line. The SYSTAT program draws

the straight line corresponding to a normal distribution with mean and standard deviation of the plotted data.

A review of the master trip unit data P-Plots (Attachment 7) shows that the peaking of the data close to zero, as discussed above with respect to the histograms, results in the presence of a bow in the data's cumulative probability distribution. If the comparison is limited to data outside the region between -.0625% and +0.0625%, it appears to more closely match the normal distribution.

7. To test for time dependency, the data sets were regressed against the time interval. Based on Reference 44, the criteria is that if the squared multiple R value is less than 0.4, then the data is not time dependent. From Attachment 7, the squared multiple R value ranged from 0.001 to 0.035, which indicates no time dependency. Since there was no correlation to the time interval, no further evaluation of the data concerning time dependency was performed.

8. Attachment 7 contains plots of the drift data with the 95/95% tolerance values superimposed on them. These are used to demonstrate visually that 95% of the data is actually encompassed by the tolerance values.

9. The result of the review of the master trip unit data's statistics is to determine that the data consists of two distributions, a normal distribution of drift plus a uniform distribution of digital multimeter error corresponding to 0, ± 1 LSD. This tends to result in a larger standard deviation value than the drift distribution by itself. Therefore the standard deviation and 95%/95% values from the master trip unit data conservatively encompass the master trip unit drift and M&TE errors. Greater than 98% of all Master trip unit test data is encompassed by the 95%/95% tolerances.

SECTION I INTRODUCTION

The purpose of this calculation is to determine the transient response of the portion of the reactor vessel reference leg located in the reactor building to a 2T pipe break inside the reactor building. The Reference Leg will be modeled as three lumped masses. The stainless steel pipe will be modeled as two concentric masses and the water column will be modeled as a single mass. Heat transfer on the exterior of the reference leg pipe is via condensation during the steam break until the temperature on the surface of the pipe reaches the ambient temperature. After this, the heat transfer mechanism changes to convective heat transfer. Heat transfer on the exterior of the steel pipe will be via natural convection. Heat transfer within the pipe will be via conduction, from the pipe to the water column will be via conduction.

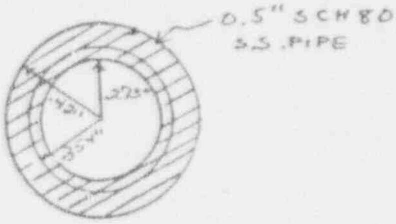
Since the condensation coefficient is much larger than the convective coefficient and the dew point temperature is closer to the reactor building bulk temperature, it is conservative to assume that the time averaged heat transfer coefficient can be represented by the condensation heat transfer coefficient. The value of "h" used in the analysis will be four (4) times the Uchida heat transfer coefficient. This is consistent with the guidance given in Appendix B of NUREG 0588, Reference A.1, for heat transfer coefficients during the condensing phase of main steam line breaks. Values for Uchida heat transfer coefficients are given in NUREG 0800, Reference A.2, and are reproduced below:

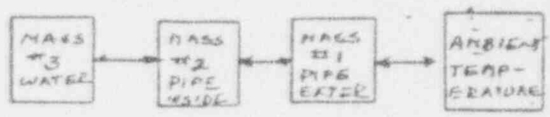
TABLE 1
UCHIDA HEAT TRANSFER COEFFICIENTS

Mass Ratio Coeff (lbm air/lbm steam)	Heat Transfer Coeff (BTU/hr-ft^2-°F)	4XHeat Transfer (BTU/hr-ft^2-°F)
50	2	8
10	14	56
5	21	84
3	29	116
1.8	46	184
0.8	98	392
0.5	140	560
0.166	215	860
0.1	280	1120

These coefficients are based on mass ratios of air to steam. Let R equal the steam mass divided by the air mass (m_{steam}/m_{air}), one over the values listed above. Analyses will be performed for R values of 6 (h = 215, 4h = 860 BTU/Hr-ft^2-°F) and 10 (h = 280, 4h = 1120 BTU/Hr-ft^2-°F). These are reasonable because they correspond to steam partial pressures six and ten times the atmospheric partial pressure, which is extremely conservative.

According to BECo Isometric drawing M-1002, sheet 125, Reference A.3, the reference leg inside the reactor building is 0.5" Schedule 80 A316 Stainless steel pipe. A sketch of the pipe/water column along with the three lumped mass model are shown below. Dimensions are from Crane Technical Paper No. 410, Reference A.4.





The heat capacity, c_{Water}, for water was obtained from Hollman, "Heat Transfer", 3rd Edition, Reference A.5.

c_{Water} = 0.9975 BTU/lbm-°F @ 85 °F
= 1.0058 BTU/lbm-°F @ 212 °F

A value for c_{Water} of 1.000 BTU/lbm-°F will be used.

Table 3, "Properties of Superheated Steam and Compressed Water (Temperature and Pressure)" from the ASME Steam Tables, Fifth Edition, Reference A.6, provides specific volume (1/density) values at 85 °F and 210 °F:

Temperature (°F, 1125 PSIG)	Specific Volume (ft^3/lbm)	Density (lbm/ft^3)
85	.016031	62.3733
210	.016640	60.0456

From the Mechanical Engineering Handbook, Section 10-Heat Transfer, Appendix A, "Properties of Metals", Reference A.7.

Density of SS = 488 lbm/ft^3
k_{ss} = 8.00 BTU/hr-ft-°F @ 32 °F
= 9.40 BTU/hr-ft-°F @ 212 °F
c_{ss} = 0.11 BTU/lbm-°F

The following environmental profile data applicable to the 2T break was obtained from BECo Dwg M632, Sheet 10, "EQ Areas 1.11 & 1.12", Reference A.8.

Time	Ambient Temperature (°F)	Ambient Pressure (PSIA)
0 sec	85	14.7
27 sec	212	15.26
30 sec	210.5	15.10
1 min	203	15.0
2 min	195	14.9

Note: The Ambient Pressure data was not used to determine the steam/air ratios. Instead, the limiting values from ref. A.2 were used.

Section II HEAT BALANCE EQUATIONS

From Reference A.6, the basic heat balance equation for each mass is:

heat flux into a mass - heat flux leaving the mass = rate of change in thermal energy of the mass **Eq. 1**

The thermal energy of a mass is given by $\rho_{mass} c_{mass} V_{mass} T_{mass}$. The rate of change of the thermal energy within a mass is given by:

$$\rho_{mass} c_{mass} V_{mass} dT_{mass}/d\tau \qquad \text{Eq. 2}$$

For the four masses used in this analysis equation 2 becomes:

$$\rho_{Pipe} c_{Pipe} V_{PipeE} dT_{PipeE}/d\tau \qquad \text{Eq. 2A}$$
$$\rho_{Pipe} c_{Pipe} V_{PipeI} dT_{PipeI}/d\tau \qquad \text{Eq. 2B}$$
$$\rho_{Water} c_{Water} V_{Pipe} dT_{Water}/d\tau \qquad \text{Eq. 2C}$$

Next, the heat transfer mechanisms for each mass will be defined. The heat flux into the exterior pipe wall is given by:

$$4h_{UC} * A_{PipeE} * (T_{Ambient} - T_{PipeE}) \qquad \text{Eq. 3}$$

Th heat conducted from the exterior pipe mass to the interior pipe mass is given by:

$$[2\pi k_{SS}/\ln(r_{PipeE}/r_{PipeI})]*(T_{PipeE} - T_{PipeI})*L \qquad \text{Eq. 4}$$

This heat flux is the leaving heat flux for the exterior pipe mass and the entering heat flux for the interior pipe mass. The heat flux leaving the interior portion pipe mass and entering the water mass is given by:

$$[2\pi k_{SS}/\ln(r_{PipeI}/r_{WaterE})]*(T_{PipeI} - T_{Water})*L \qquad \text{Eq. 5}$$

where:

A_{PipeE} = Surface area of the exterior of the pipe (ft^2)
ρ_{Pipe} = density of the pipe (lbm/ft^3)
ρ_{Water} = density of the water column
c_{Pipe} = heat capacity of the pipe (BTU/lbm-°F)
c_{Water} = heat capacity of the water colum
h_{UC} = UCHIDA Heat Transfer coefficient (BTU/hr-ft^2-°F)
k_{SS} = thermal conductivity of the stainless steel pipe (BTU/hr-ft-°F)
$T_{Ambient}$ = Ambient bulk temperature (°F)
T_{PipeE} = Temperature of the exterior pipe mass (°F)
T_{PipeI} = Temperature of the interior pipe mass (°F)
T_{Water} = Temperature of the exterior water mass (°F)
V_{PipeE} = Volume of the exterior pipe mass (ft^3)
V_{PipeI} = Volume of the interior pipe mass (ft^3)
V_{WaterE} = Volume of the exterior Water mass (ft^3)

Using equations 2A, 2B, 2C, 3, 4 and 5, the heat balance equation for each mass can now be written. For the exterior pipe mass:

$$\rho_{Pipe}c_{Pipe}V_{PipeE}dT_{PipeE}/d\tau = 4h_{UC}*A_{PipeE}*(T_{Ambient} - T_{PipeE}) - [2\pi k_{SS}/\ln(r_{PipeE}/r_{PipeI})]*(T_{PipeE} - T_{PipeI})* \qquad \text{Eq. 6}$$

For the interior pipe mass:

$$\rho_{Pipe}c_{Pipe}V_{PipeI}dT_{PipeI}/d\tau = [2\pi k_{SS}/\ln(r_{PipeE}/r_{PipeI})]*(T_{PipeE} - T_{PipeI})*L - [2\pi k_{SS}/\ln(r_{PipeI}/r_{WaterE})]*(T_{PipeI} - T_{WaterE})*L \qquad \text{Eq. 7}$$

For the water mass:

$\rho_{Water} c_{Water} V_{Pipe} dT_{Water}/d\tau = [2\pi k_{SS}/\ln(r_{PipeI}/r_{WaterE})]*(T_{PipeI} - T_{WaterE})*L$ Eq. 8

These can be simplified by defining the following time constants:

$\tau_{PETA} = \rho_{Pipe} c_{Pipe} V_{PipeE}/4h_{UC}*A_{PipeE}$ Eq. 9

$\tau_{PEPI} = \rho_{Pipe} c_{Pipe} V_{PipeE}/[2\pi k_{SS}/\ln(r_{PipeE}/r_{PipeI})]*L$ Eq. 10

$\tau_{PIPE} = \rho_{Pipe} c_{Pipe} V_{PipeI}/[2\pi k_{SS}/\ln(r_{PipeE}/r_{PipeI})]*L$ Eq. 11

$\tau_{PIW} = \rho_{Pipe} c_{Pipe} V_{PipeI}/[2\pi k_{SS}/\ln(r_{PipeI}/r_{Water})]*L$ Eq. 12

$\tau_{WPI} = \rho_{Water} c_{Water} V_{Water}/[2\pi k_{SS}/\ln(r_{PipeI}/r_{Water})]*L$ Eq. 13

Then equations 6, 7 and 8 now become:

$dT_{PipeE}/d\tau = \tau_{PETA}^{-1}*(T_{Ambient} - T_{PipeE}) - \tau_{PEPI}^{-1}*(T_{PipeE} - T_{PipeI})$ Eq. 14

$dT_{PipeI}/d\tau = \tau_{PIPE}^{-1}*(T_{PipeE} - T_{PipeI}) - \tau_{PIW}^{-1}*(T_{PipeI} - T_{Water})$ Eq. 15

$dT_{Water}/d\tau = \tau_{WPI}^{-1}*(T_{PipeI} - T_{Water})$ Eq. 16

Replacing the differential $dT/d\tau$ with the difference $(T_N - T_{N-1})/\Delta t$ and solving for T_N yields:

$T_{PipeE,N} = T_{PipeE,N-1} + \Delta t/\tau_{PETA}*(T_{Ambient,N-1} - T_{PipeE,N-1}) - \Delta t/\tau_{PEPI}*(T_{PipeE,N-1} - T_{PipeI,N-1})$ Eq. 17

$T_{PipeI,N} = T_{PipeI,N-1} + \Delta t/\tau_{PIPE}*(T_{PipeE,N-1} - T_{PipeI,N-1}) - \Delta t/\tau_{PIWE}*(T_{PipeI,N-1} - T_{Water,N-1})$ Eq. 18

$T_{Water,N} = T_{Water,N-1} + \Delta t/\tau_{WPI}*(T_{PipeI,N-1} - T_{Water,N-1})$ Eq. 19

SECTION III SOLVING FOR TIME CONSTANTS

The pipe will be divided into two masses of equal volume. The equation for the volume of a pipe is:

$V = \pi(r_o^2 - r_i^2)L$ where r_o is the outside radius and r_i is the inside radius.

For the two pipe masses to be of equal volume, this equates to:

$(r_{PipeE}^2 - r_{PipeI}^2) = (r_{PipeI}^2 - r_{Water}^2)$

solving for r_{PipeI} yields:

$r_{PipeI} = \sqrt{((r_{PipeE}^2 + r_{Water}^2)/2)}$ Eq. 20

					Setpoint Calculation		
					LIS263-72A, B, C, D : Reactor Vessel Low-Low Level		
1	JWR	4/1/93	JFD	4/1/93	ABB	JOB NO. 25-226	PAGE 62
0	JWR	1/28/93	TJD	2/1/93		CALC NO.	OF 87
REV	BY	DATE	CHECKED	DATE	ASEA BROWN BOVERI ABB IMPELL CORPORATION	(25-226-C004)	

Substituting, $r_{PipeE} = 0.84"/2 = 0.42"$ and $r_{Water} = 0.546"/2 = 0.273"$ yields:

$$r_{PipeI} = \sqrt{((r_{PipeE}^2 + r_{Water}^2)/2)} = \sqrt{(.2509/2)} = 0.354"$$

Solving for τ_{PETA} using equation 9 yields

$$\begin{aligned}
\tau_{PETA} &= \rho_{Pipe}C_{Pipe}V_{PipeE}/4h_{UC}*A_{PipeE} \\
&= 488*(0.11)*[\pi(R_{PipeE}^2 - R_{PipeI}^2)L/4*(2\pi R_{PipeE}L)]/h_{UC}) \\
&= 53.68*[(.42^2 - .354^2)/(12)^2*8*(.42/12)]/h_{UC} \\
&= 68.0106/1000*h_{UC}\ (hr) \\
&= 68.0106/1000*h_{UC}*3600sec/hr = 244.838/h_{UC}\ (sec) \qquad \text{Eq. 21}
\end{aligned}$$

Solving for τ_{PEPI} using equation 10 yields:

$$\begin{aligned}
\tau_{PEPI} &= \rho_{Pipe}C_{Pipe}V_{PipeE}/[2\pi k_{SS}/\ln(r_{PipeE}/r_{PipeI})]*L \\
&= 488*(0.11)[\pi(r_{PipeE}^2 - r_{PipeI}^2)L/(2\pi L/\ln(r_{PipeE}/r_{PipeI}))]/k_{SS} \\
&= 53.68*[(r_{PipeE}^2 - r_{PipeI}^2)*\ln(r_{PipeE}/r_{PipeI})/2]/k_{SS} \\
&= 53.68*[(0.42^2 - 0.354^2)*\ln(0.42/0.354)/2*(12)^2]/k_{SS} \\
&= 1.6278/1000*k_{SS}\ (hr) \\
&= (1.6278/1000*k_{SS})*3600sec/hr = 5.86/k_{SS}\ (sec) \qquad \text{Eq. 22}
\end{aligned}$$

Solving for τ_{PIPE} using equation 11 yields:

$$\begin{aligned}
\tau_{PIPE} &= \rho_{Pipe}C_{Pipe}V_{PipeI}/[2\pi k_{SS}/\ln(r_{PipeE}/r_{PipeI})]*L \\
&= 488*(.11)*[(\pi(r_{PipeI}^2 - r_{Water}^2)L/(2\pi*L/\ln(r_{PipeE}/r_{PipeI}))]/k_{SS} \\
&= 53.68*[(r_{PipeI}^2 - r_{Water}^2)*\ln(r_{PipeE}/r_{PipeI})/2]/k_{SS} \\
&= 53.68*[(0.354^2 - 0.273^2)*\ln(0.42/0.354)/2*(12)^2]/k_{SS} \\
&= 1.6183/1000*k_{SS}\ (hr) \\
&= 1.6183/1000*k_{SS}*3600sec/hr = 5.8259/k_{SS}\ (sec) \qquad \text{Eq. 23}
\end{aligned}$$

Solving for τ_{PIW} using equation 12 yields:

$$\begin{aligned}
\tau_{PIWE} &= \rho_{Pipe}C_{Pipe}V_{PipeI}/[2\pi k_{SS}/\ln(r_{PipeI}/r_{Water})]*L \\
&= 488*(0.11)*[(\pi(r_{PipeI}^2 - r_{Water}^2)L/(2\pi*L/\ln(r_{PipeI}/r_{Water}))]/k_{SS} \\
&= 53.68*[(r_{PipeI}^2 - r_{Water}^2)*\ln(r_{PipeI}/r_{Water})/2]/k_{SS} \\
&= 53.68*[(0.354^2 - 0.273^2)*\ln(.354/.273)/2*(12)^2]/k_{SS} \\
&= 2.4595/1000*k_{SS}\ (hr) \\
&= 2.4595/1000*k_{SS}*3600sec/hr = 8.8543/k_{SS}\ (sec) \qquad \text{Eq. 24}
\end{aligned}$$

Solving for τ_{WPI} using equation 13 yields:

$$\begin{aligned}\tau_{WEPI} &= \rho_{Water} c_{Water} V_{Water} / [2\pi k_{SS} / \ln(r_{PipeI}/r_{Water})]*L \\ &= \rho_{Water}*(1.)*[(\pi r_{Water}^2)*L/(2\pi*L/\ln(r_{PipeI}/r_{WaterE}))]/k_{SS} \\ &= \rho_{Water}*[(r_{Water}^2)*\ln(r_{PipeI}/r_{Water})/2]/k_{SS} \\ &= [(.273^2)*\ln(.354/.273)/2*(12)^2]*(\rho_{Water}/k_{SS}) \\ &= 6.7238/100,000*(\rho_{Water}/k_{SS}) \text{ (hrs)} \\ &= 2.4206(\rho_{Water}/10*k_{SS}) \text{ (sec)} \qquad \text{Eq. 25}\end{aligned}$$

The equations for the temperatures of the four masses can now be written as follows:

$$T_{PipeE,N} = T_{PipeE,N-1} + (h_{UC}/244.838)*\Delta t*(T_{Ambient,N-1} - T_{PipeE,N-1}) - (k_{SS}/5.86)*\Delta t*(T_{PipeE,N-1} - T_{PipeI,N-1}) \qquad \text{Eq. 26}$$

$$T_{PipeI,N} = T_{PipeI,N-1} + (k_{SS}/5.826)*\Delta t*(T_{PipeE,N-1} - T_{PipeI,N-1}) - (k_{SS}/8.8543)*\Delta t*(T_{PipeI,N-1} - T_{Water,N-1}) \qquad \text{Eq. 27}$$

$$T_{Water,N} = T_{Water,N-1} + (4.1313*k_{SS}/\rho_{Water})*\Delta t*(T_{PipeI,N-1} - T_{Water,N-1}) \qquad \text{Eq. 28}$$

The pipe's thermal conductivity, k_{SS}, is assumed to vary linearly with temperature between the two values stated on page two, then for pipe temperatures between 85°F and 210°F:.

$$\begin{aligned}k_{SS} &= 8.7 \text{ BTU/hr-ft-°F} \quad T_{PipeAverage} \le 147.5 \text{ °F} \\ &= 9.1 \text{ BTU/hr-ft-°F} \quad T_{PipeAverage} > 147.5 \text{ °F} \qquad \text{Eq. 29}\end{aligned}$$

Equations 26 through 29 represent the model which will be used to analyze the response of the reference leg to the steam transient. A water density of 61.3346 (s.v. 0.016304) corresponding to a T_{Water} of 158 °F will be used. This results in less than 2% error in actual denisty.

For the first case, the Uchida heat transfer coefficient, h_{UC},, will start at 25 and ramp to 210 in the initial ten seconds and remain at that value until the pipe external temperature, T_{PipeE}, equals the ambient temperature, $T_{Ambient}$. The conversion from condensation heat transfer to convection heat transfer will be modeled by reducing the value of h_{UC} from 215 to 25. This will be modeled as follows:

135 at end of 1st time step,
95 at end of 2nd time step,
75 at end of 3rd time step

					Setpoint Calculation		
					LIS263-72A, B, C, D : Reactor Vessel Low-Low Level		
1	JWR	4/1/93	JFD	4/1/93	ABB	JOB NO. 25-226	PAGE 64
0	JWR	1/28/93	TJD	2/1/93		CALC NO. (25-226-C004)	OF 87
REV	BY	DATE	CHECKED	DATE	ASEA BROWN BOVERI ABB IMPELL CORPORATION		

65 at end of 4th time step
55 at end of 5th time step
45 at end of 6th time step
35 at end of 7th time step
25 at end of 8th time step

For the second case, the Uchida heat transfer coefficient, h_{UC}, will start at 25 and ramp to 280 in the initial ten seconds and remain at that value until the pipe external temperature, T_{PipeE}, equals the ambient temperature, $T_{Ambient}$. The conversion from condensation heat transfer to convection heat transfer will be modeled by reducing the value of h_{UC} from 280 to 25. This will be modeled as follows:

180 at end of 1st time step,
130 at end of 2nd time step,
105 at end of 3rd time step
85 at end of 4th time step
65 at end of 5th time step
50 at end of 6th time step
35 at end of 7th time step
25 at end of 8th time step

SECTION IV RESULTS

The results of the transient analysis of the reactor vessel reference leg to a steam break in the reactor building using the detailed three mass model were as follows:

h_{UC} = 215 BTU/hr-ft^2-°F T_{Water}(Peak) = 206.5°F @ 47 sec.

h_{UC} = 280 BTU/hr-ft^2-°F T_{Water}(Peak) = 207.2°F @ 45 sec.

The simulation using h_{UC} = 215 BTU/hr-ft^2-°F was run until t = 120 sec. The simulation using h_{UC} = 280 BTU/hr-ft^2-°F was run until t = 150 sec. This allowed establishment of the long term lag between the reference leg water temperature and the ambient temperature. The data from the last simulation (h_{UC} = 280 BTU/hr-ft^2-°F) was:

time	$(T_{Water} - T_{Ambient})$	Rate of increase
60	3.483°F	
90	4.44°F	1.83°F/min
120	4.87°F	0.86°F/min
150	5.06°F	0.38°F/min

Assuming the slope continues to decrease in the same proportion as above, $(T_{Water} - T_{Ambient})_{Stady\ State} = 5.5°F$.

SECTION V REFERENCES

A.1 USNRC NUREG 0588, "Interim Saff Position on Environmental Qualification of Safety-Related Electrical Equipment", Revision 1

A.2 USNRC NUREG 0800, "Standard Review Plan, Section 6.2.1.5 - Minimum Containment Pressure Analysis for Emergency Core Cooling System Performance Capability Studies", Revision 2, July 1981

A.3 BECo Isometric Dwg. M-1002, Sheet 1245, "Nuclear Boiler System, Reference Leg to Instrument racks 2206, 2276 and 2252 from X82B", Revision E0

A.4 Crane Technical Paper No. 410, "Flow of Fluids through Valves, Fittings and Pipe"

A.5 Hollman, "Heat Transfer", 3rd Edition

A.6 ASME Steam Tables, Fifth Edition

A.7 Mechanical Engineering Review Manual, Seventh edition, 1984, Section 10, "Heat Transfer"

A.8 BECo Dwg. M632 Sheet 10, Environmental Temperature and Pressure Profiles, Reactor Building (General Area), EQ Area:1.11, 1.12 El. 51'-0"

N	time	Δ TIME	Tambient	h(Uchida)	TpipeExt	TpipeInt	k(ss)	Twater
0	0.0		85	25.00	85.000	85.000	8.7	85.000
1	0.3	0.25	86.176	29.75	85.000	85.000	8.7	85.000
2	0.5	0.25	87.352	34.50	85.036	85.000	8.7	85.000
3	0.8	0.25	88.528	39.25	85.104	85.013	8.7	85.000
4	1.0	0.25	89.704	44.00	85.208	85.044	8.7	85.002
5	1.3	0.25	90.88	48.75	85.349	85.095	8.7	85.008
6	1.5	0.25	92.056	53.50	85.530	85.168	8.7	85.021
7	1.8	0.25	93.232	58.25	85.752	85.267	8.7	85.042
8	2.0	0.25	94.408	63.00	86.017	85.393	8.7	85.075
9	2.3	0.25	95.584	67.75	86.325	85.548	8.7	85.122
10	2.5	0.25	96.76	72.50	86.677	85.733	8.7	85.184
11	2.8	0.25	97.936	77.25	87.073	85.951	8.7	85.265
12	3.0	0.25	99.112	82.00	87.514	86.201	8.7	85.365
13	3.3	0.25	100.288	86.75	87.998	86.486	8.7	85.488
14	3.5	0.25	101.464	91.50	88.525	86.805	8.7	85.634
15	3.8	0.25	102.64	96.25	89.096	87.160	8.7	85.806
16	4.0	0.25	103.816	101.00	89.708	87.550	8.7	86.004
17	4.3	0.25	104.992	105.75	90.362	87.976	8.7	86.230
18	4.5	0.25	106.168	110.50	91.056	88.438	8.7	86.486
19	4.8	0.25	107.344	115.25	91.789	88.936	8.7	86.772
20	5.0	0.25	108.52	120.00	92.561	89.470	8.7	87.089
21	5.3	0.25	109.696	124.75	93.369	90.039	8.7	87.438
22	5.5	0.25	110.872	129.50	94.213	90.643	8.7	87.819
23	5.8	0.25	112.043	134.25	95.091	91.282	8.7	88.233
24	6.0	0.25	113.224	139.00	96.002	91.955	8.7	88.679
25	6.3	0.25	114.4	143.75	96.944	92.661	8.7	89.159
26	6.5	0.25	115.576	148.50	97.916	93.400	8.7	89.672
27	6.8	0.25	116.752	153.25	98.918	94.170	8.7	90.218
28	7.0	0.25	117.928	158.00	99.946	94.972	8.7	90.797
29	7.3	0.25	119.104	162.75	101.001	95.804	8.7	91.409
30	7.5	0.25	120.28	167.50	102.080	96.664	8.7	92.053
31	7.8	0.25	121.456	172.25	103.183	97.553	8.7	92.728
32	8.0	0.25	122.632	177.00	104.307	98.470	8.7	93.435
33	8.3	0.25	123.808	181.75	105.453	99.412	8.7	94.173
34	8.5	0.25	124.984	186.50	106.617	100.380	8.7	94.940
35	8.8	0.25	126.16	191.25	107.800	101.372	8.7	95.737
36	9.0	0.25	127.336	196.00	109.000	102.388	8.7	96.563
37	9.3	0.25	128.512	200.75	110.215	103.425	8.7	97.416
38	9.5	0.25	129.688	205.50	111.446	104.484	8.7	98.297
39	9.8	0.25	130.864	210.25	112.690	105.563	8.7	99.203
40	10.0	0.25	132.04	215.00	113.946	106.661	8.7	100.135
41	10.3	0.25	133.216	215.00	115.215	107.778	8.7	101.091

h(Uchida) = 215

N	time	Δ TIME	Tambient	h(Uchida)	TpipeExt	TpipeInt	k(ss)	Twater
42	10.5	0.25	134.392	215.00	116.406	108.912	8.7	102.071
43	10.8	0.25	135.568	215.00	117.573	110.029	8.7	103.073
44	11.0	0.25	136.744	215.00	118.723	111.137	8.7	104.092
45	11.3	0.25	137.92	215.00	119.864	112.238	8.7	105.124
46	11.5	0.25	139.096	215.00	120.997	113.338	8.7	106.166
47	11.8	0.25	140.272	215.00	122.128	114.436	8.7	107.217
48	12.0	0.25	141.448	215.00	123.256	115.534	8.7	108.274
49	12.3	0.25	142.624	215.00	124.384	116.634	8.7	109.338
50	12.5	0.25	143.8	215.00	125.511	117.735	8.7	110.407
51	12.8	0.25	144.976	215.00	126.640	118.838	8.7	111.480
52	13.0	0.25	146.152	215.00	127.770	119.943	8.7	112.558
53	13.3	0.25	147.328	215.00	128.900	121.051	8.7	113.640
54	13.5	0.25	148.504	215.00	130.032	122.161	8.7	114.726
55	13.8	0.25	149.68	215.00	131.166	123.273	8.7	115.815
56	14.0	0.25	150.856	215.00	132.301	124.388	8.7	116.908
57	14.3	0.25	152.032	215.00	133.437	125.504	8.7	118.003
58	14.5	0.25	153.208	215.00	134.575	126.623	8.7	119.102
59	14.8	0.25	154.384	215.00	135.714	127.744	8.7	120.204
60	15.0	0.25	155.56	215.00	136.855	128.868	8.7	121.309
61	15.3	0.25	156.736	215.00	137.997	129.993	8.7	122.416
62	15.5	0.25	157.912	215.00	139.140	131.120	8.7	123.526
63	15.8	0.25	159.088	215.00	140.284	132.249	8.7	124.639
64	16.0	0.25	160.264	215.00	141.430	133.379	8.7	125.754
65	16.3	0.25	161.44	215.00	142.576	134.511	8.7	126.871
66	16.5	0.25	162.616	215.00	143.724	135.645	8.7	127.990
67	16.8	0.25	163.792	215.00	144.873	136.781	8.7	129.112
68	17.0	0.25	164.968	215.00	146.023	137.918	8.7	130.235
69	17.3	0.25	166.144	215.00	147.174	139.057	8.7	131.361
70	17.5	0.25	167.32	215.00	148.326	140.196	8.7	132.488
71	17.8	0.25	168.496	215.00	149.478	141.338	8.7	133.617
72	18.0	0.25	169.672	215.00	150.632	142.480	8.7	134.748
73	18.3	0.25	170.848	215.00	151.786	143.624	9.1	135.881
74	18.5	0.25	172.024	215.00	152.802	144.822	9.1	137.068
75	18.8	0.25	173.2	215.00	153.924	145.946	9.1	138.256
76	19.0	0.25	174.376	215.00	155.058	147.085	9.1	139.434
77	19.3	0.25	175.552	215.00	156.204	148.233	9.1	140.607
78	19.5	0.25	176.728	215.00	157.357	149.386	9.1	141.775
79	19.8	0.25	177.904	215.00	158.515	150.543	9.1	142.942
80	20.0	0.25	179.08	215.00	159.677	151.703	9.1	144.106
81	20.3	0.25	180.256	215.00	160.841	152.865	9.1	145.270
82	20.5	0.25	181.432	215.00	162.007	154.028	9.1	146.434
83	20.8	0.25	182.608	215.00	163.174	155.192	9.1	147.598

h(Uchida) = 215

N	time	Δ TIME	Tambient	h(Uchida)	TpipeExt	TpipeInt	k(ss)	Twater
84	21.0	0.25	183.784	215.00	164.342	156.358	9.1	148.762
85	21.3	0.25	184.96	215.00	165.510	157.524	9.1	149.926
86	21.5	0.25	186.136	215.00	166.680	158.690	9.1	151.090
87	21.8	0.25	187.312	215.00	167.849	159.857	9.1	152.255
88	22.0	0.25	188.488	215.00	169.019	161.025	9.1	153.420
89	22.3	0.25	189.664	215.00	170.190	162.192	9.1	154.585
90	22.5	0.25	190.84	215.00	171.360	163.361	9.1	155.751
91	22.8	0.25	192.016	215.00	172.531	164.529	9.1	156.917
92	23.0	0.25	193.192	215.00	173.702	165.698	9.1	158.083
93	23.3	0.25	194.368	215.00	174.873	166.867	9.1	159.250
94	23.5	0.25	195.544	215.00	176.045	168.036	9.1	160.417
95	23.8	0.25	196.72	215.00	177.216	169.206	9.1	161.585
96	24.0	0.25	197.896	215.00	178.388	170.376	9.1	162.753
97	24.3	0.25	199.072	215.00	179.560	171.546	9.1	163.921
98	24.5	0.25	200.248	215.00	180.732	172.716	9.1	165.089
99	24.8	0.25	201.424	215.00	181.905	173.887	9.1	166.258
100	25.0	0.25	202.6	215.00	183.077	175.058	9.1	167.427
101	25.3	0.25	203.776	215.00	184.250	176.228	9.1	168.596
102	25.5	0.25	204.952	215.00	185.422	177.400	9.1	169.766
103	25.8	0.25	206.128	215.00	186.595	178.571	9.1	170.936
104	26.0	0.25	207.304	215.00	187.768	179.743	9.1	172.106
105	26.3	0.25	208.48	215.00	188.941	180.914	9.1	173.276
106	26.5	0.25	209.656	215.00	190.114	182.086	9.1	174.446
107	26.8	0.25	210.832	215.00	191.288	183.258	9.1	175.617
108	27.0	0.25	212.008	215.00	192.461	184.430	9.1	176.788
109	27.3	0.25	211.883	215.00	193.634	185.603	9.1	177.959
110	27.5	0.25	211.758	215.00	194.522	186.775	9.1	179.130
111	27.8	0.25	211.633	215.00	195.298	187.836	9.1	180.302
112	28.0	0.25	211.508	215.00	195.987	188.814	9.1	181.456
113	28.3	0.25	211.383	215.00	196.610	189.725	9.1	182.584
114	28.5	0.25	211.258	215.00	197.180	190.579	9.1	183.678
115	28.8	0.25	211.133	215.00	197.708	191.383	9.1	184.735
116	29.0	0.25	211.008	215.00	198.200	192.145	9.1	185.754
117	29.3	0.25	210.883	215.00	198.661	192.867	9.1	186.733
118	29.5	0.25	210.758	215.00	199.095	193.554	9.1	187.673
119	29.8	0.25	210.633	215.00	199.504	194.207	9.1	188.574
120	30.0	0.25	210.508	215.00	199.891	194.828	9.1	189.437
121	30.3	0.25	210.4455	215.00	200.256	195.420	9.1	190.264
122	30.5	0.25	210.383	215.00	200.615	195.984	9.1	191.054
123	30.8	0.25	210.3205	215.00	200.962	196.526	9.1	191.809
124	31.0	0.25	210.258	215.00	201.294	197.046	9.1	192.532
125	31.3	0.25	210.1955	215.00	201.613	197.545	9.1	193.224

h(Uchida) = 215

REV	BY	DATE	CHECKED	DATE
1	JWR	4/1/93	JFD	4/1/93
0	JWR	1/28/93	TJD	2/1/93

SETPOINT CALCULATION

LIS263-72A, B, C, D: Reactor Vessel Low-Low Level

ABB
ASEA BROWN BOVERI
ABB Impell Corporation

JOB NO. 25-226

CALC NO. (25-226-C00?)

N	time	Δ TIME	Tambient	h(Uchida)	TpipeExt	TpipeInt	k(ss)	Twater
126	31.5	0.25	210.133	215.00	201.918	198.023	9.1	193.886
127	31.8	0.25	210.0705	215.00	202.209	198.481	9.1	194.520
128	32.0	0.25	210.008	215.00	202.488	198.919	9.1	195.127
129	32.3	0.25	209.9455	215.00	202.753	199.338	9.1	195.708
130	32.5	0.25	209.883	215.00	203.006	199.739	9.1	196.264
131	32.8	0.25	209.8205	215.00	203.247	200.122	9.1	196.797
132	33.0	0.25	209.758	215.00	203.477	200.488	9.1	197.306
133	33.3	0.25	209.6955	215.00	203.696	200.838	9.1	197.794
134	33.5	0.25	209.633	215.00	203.903	201.172	9.1	198.260
135	33.8	0.25	209.5705	215.00	204.101	201.490	9.1	198.706
136	34.0	0.25	209.508	215.00	204.288	201.794	9.1	199.133
137	34.3	0.25	209.4455	215.00	204.466	202.084	9.1	199.541
138	34.5	0.25	209.383	215.00	204.634	202.361	9.1	199.930
139	34.8	0.25	209.3205	215.00	204.794	202.624	9.1	200.303
140	35.0	0.25	209.258	215.00	204.945	202.875	9.1	200.659
141	35.3	0.25	209.1955	215.00	205.088	203.114	9.1	200.998
142	35.5	0.25	209.133	215.00	205.224	203.341	9.1	201.322
143	35.8	0.25	209.0705	215.00	205.351	203.558	9.1	201.632
144	36.0	0.25	209.008	215.00	205.471	203.763	9.1	201.927
145	36.3	0.25	208.9455	215.00	205.585	203.958	9.1	202.208
146	36.5	0.25	208.883	215.00	205.691	204.144	9.1	202.476
147	36.8	0.25	208.8205	215.00	205.791	204.320	9.1	202.732
148	37.0	0.25	208.758	215.00	205.885	204.486	9.1	202.975
149	37.3	0.25	208.6955	215.00	205.973	204.644	9.1	203.207
150	37.5	0.25	208.633	215.00	206.055	204.794	9.1	203.427
151	37.8	0.25	208.5705	215.00	206.131	204.935	9.1	203.636
152	38.0	0.25	208.508	215.00	206.202	205.068	9.1	203.835
153	38.3	0.25	208.4455	215.00	206.268	205.194	9.1	204.024
154	38.5	0.25	208.383	215.00	206.329	205.313	9.1	204.204
155	38.8	0.25	208.3205	215.00	206.386	205.425	9.1	204.374
156	39.0	0.25	208.258	215.00	206.437	205.530	9.1	204.535
157	39.3	0.25	208.1955	215.00	206.485	205.629	9.1	204.687
158	39.5	0.25	208.133	215.00	206.528	205.721	9.1	204.831
159	39.8	0.25	208.0705	215.00	206.567	205.808	9.1	204.968
160	40.0	0.25	208.008	215.00	206.602	205.888	9.1	205.096
161	40.3	0.25	207.9455	215.00	206.634	205.964	9.1	205.218
162	40.5	0.25	207.883	215.00	206.662	206.034	9.1	205.332
163	40.8	0.25	207.8205	215.00	206.686	206.099	9.1	205.440
164	41.0	0.25	207.758	215.00	206.707	206.159	9.1	205.541
165	41.3	0.25	207.6955	215.00	206.725	206.214	9.1	205.635
166	41.5	0.25	207.633	215.00	206.740	206.265	9.1	205.724
167	41.8	0.25	207.5705	215.00	206.751	206.311	9.1	205.807

h(Uchida) = 215

REV	BY	DATE	CHECKED	DATE		
1	JWR	4/1/93	JFD	4/1/93	ABB Impell Corporation	SETPOINT CALCULATION LIS263-72A, B, C, D; Reactor Vessel Low-Low Level JOB NO. 25-226 CALC NO. (25-226-2004) PAGE 70 OF 83
0	JWR	1/28/93	TJD	2/1/93		

N	time	Δ TIME	Tambient	h(Uchida)	TpipeExt	TpipeInt	k(ss)	Twater
168	42.0	0.25	207.508	215.00	206.760	206.354	9.1	205.884
169	42.3	0.25	207.4455	215.00	206.767	206.392	9.1	205.956
170	42.5	0.25	207.383	215.00	206.770	206.426	9.1	206.023
171	42.8	0.25	207.3205	215.00	206.771	206.457	9.1	206.085
172	43.0	0.25	207.258	215.00	206.770	206.484	9.1	206.142
173	43.3	0.25	207.1955	215.00	206.766	206.508	9.1	206.194
174	43.5	0.25	207.133	215.00	206.760	206.528	9.1	206.242
175	43.8	0.25	207.0705	215.00	206.752	206.545	9.1	206.286
176	44.0	0.25	207.008	215.00	206.742	206.559	9.1	206.326
177	44.3	0.25	206.9455	215.00	206.729	206.570	9.1	206.361
178	44.5	0.25	206.883	215.00	206.715	206.579	9.1	206.393
179	44.8	0.25	206.8205	215.00	206.699	206.584	9.1	206.422
180	45.0	0.25	206.758	215.00	206.681	206.587	9.1	206.447
181	45.3	0.25	206.6955	215.00	206.662	206.588	9.1	206.468
182	45.5	0.25	206.633	215.00	206.640	206.586	9.1	206.487
183	45.8	0.25	206.5705	135.00	206.618	206.582	9.1	206.502
184	46.3	0.5	206.4455	95.00	206.577	206.569	9.1	206.526
185	46.8	0.5	206.3205	75.00	206.545	206.553	9.1	206.539
186	47.3	0.5	206.1955	65.00	206.517	206.540	9.1	206.544
187	47.8	0.5	206.0705	55.00	206.492	206.524	9.1	206.542
188	48.3	0.5	205.9455	45.00	206.469	206.508	9.1	206.537
189	48.8	0.5	205.8205	35.00	206.452	206.493	9.1	206.528
190	49.3	0.5	205.6955	25.00	206.438	206.479	9.1	206.517
191	49.5	0.25	205.633	25.00	206.435	206.473	9.1	206.511
192	50.0	0.5	205.508	25.00	206.423	206.463	9.1	206.500
193	50.5	0.5	205.383	25.00	206.407	206.451	9.1	206.488
194	51.0	0.5	205.258	25.00	206.389	206.436	9.1	206.477
195	51.5	0.5	205.133	25.00	206.368	206.420	9.1	206.464
196	52.0	0.5	205.008	25.00	206.345	206.402	9.1	206.451
197	52.5	0.5	204.883	25.00	206.321	206.383	9.1	206.436
198	53.0	0.5	204.758	25.00	206.296	206.362	9.1	206.420
199	53.5	0.5	204.633	25.00	206.269	206.340	9.1	206.402
200	54.0	0.5	204.508	25.00	206.240	206.316	9.1	206.383
201	54.5	0.5	204.383	25.00	206.211	206.291	9.1	206.362
202	55.0	0.5	204.258	25.00	206.180	206.265	9.1	206.341
203	55.5	0.5	204.133	25.00	206.148	206.237	9.1	206.317
204	56.0	0.5	204.008	25.00	206.115	206.209	9.1	206.293
205	56.5	0.5	203.883	25.00	206.080	206.179	9.1	206.267
206	57.0	0.5	203.758	25.00	206.044	206.147	9.1	206.240
207	57.5	0.5	203.633	25.00	206.007	206.115	9.1	206.211
208	58.0	0.5	203.508	25.00	205.969	206.081	9.1	206.182
209	58.5	0.5	203.383	25.00	205.930	206.046	9.1	206.151

h(Uchida) = 215

REV	BY	DATE	CHECKED	DATE		
					SETPOINT CALCULATION	
					LIS263-72A, B, C, D: Reactor Vessel Low-Low Level	
1	JWR	4/1/93	JPD	4/1/93	ABB Impell Corporation	JOB NO. 25-226 — PAGE 71
0	JWR	1/28/93	TJD	2/1/93		CALC NO. (25-226-C004) — OF 87

N	time	Δ TIME	Tambient	h(Uchida)	TpipeExt	TpipeInt	k(ss)	Twater
210	59.0	0.5	203.258	25.00	205.890	206.009	9.1	206.119
211	59.5	0.5	203.133	25.00	205.848	205.972	9.1	206.085
212	60.0	0.5	203.008	25.00	205.806	205.934	9.1	206.050
213	60.5	0.5	202.9414	25.00	205.762	205.894	9.1	206.015
214	61.0	0.5	202.8748	25.00	205.720	205.853	9.1	205.978
215	61.5	0.5	202.8082	25.00	205.678	205.813	9.1	205.939
216	62.0	0.5	202.7416	25.00	205.637	205.772	9.1	205.901
217	62.5	0.5	202.675	25.00	205.594	205.732	9.1	205.862
218	63.0	0.5	202.6084	25.00	205.552	205.691	9.1	205.822
219	63.5	0.5	202.5418	25.00	205.510	205.650	9.1	205.782
220	64.0	0.5	202.4752	25.00	205.467	205.608	9.1	205.741
221	64.5	0.5	202.4086	25.00	205.424	205.567	9.1	205.701
222	65.0	0.5	202.342	25.00	205.381	205.524	9.1	205.660
223	65.5	0.5	202.2754	25.00	205.337	205.482	9.1	205.618
224	66.0	0.5	202.2088	25.00	205.293	205.439	9.1	205.576
225	66.5	0.5	202.1422	25.00	205.249	205.396	9.1	205.534
226	67.0	0.5	202.0756	25.00	205.204	205.352	9.1	205.492
227	67.5	0.5	202.009	25.00	205.159	205.308	9.1	205.449
228	68.0	0.5	201.9424	25.00	205.114	205.264	9.1	205.406
229	68.5	0.5	201.8758	25.00	205.069	205.220	9.1	205.362
230	69.0	0.5	201.8092	25.00	205.023	205.175	9.1	205.319
231	69.5	0.5	201.7426	25.00	204.977	205.130	9.1	205.275
232	70.0	0.5	201.676	25.00	204.931	205.085	9.1	205.230
233	70.5	0.5	201.6094	25.00	204.884	205.039	9.1	205.186
234	71.0	0.5	201.5428	25.00	204.837	204.993	9.1	205.141
235	71.5	0.5	201.4762	25.00	204.790	204.947	9.1	205.096
236	72.0	0.5	201.4096	25.00	204.743	204.901	9.1	205.050
237	72.5	0.5	201.343	25.00	204.695	204.854	9.1	205.004
238	73.0	0.5	201.2764	25.00	204.648	204.807	9.1	204.958
239	73.5	0.5	201.2098	25.00	204.600	204.760	9.1	204.912
240	74.0	0.5	201.1432	25.00	204.551	204.713	9.1	204.866
241	74.5	0.5	201.0766	25.00	204.503	204.665	9.1	204.819
242	75.0	0.5	201.01	25.00	204.454	204.617	9.1	204.772
243	75.5	0.5	200.9434	25.00	204.405	204.569	9.1	204.724
244	76.0	0.5	200.8768	25.00	204.356	204.521	9.1	204.677
245	76.5	0.5	200.8102	25.00	204.306	204.472	9.1	204.629
246	77.0	0.5	200.7436	25.00	204.256	204.423	9.1	204.581
247	77.5	0.5	200.677	25.00	204.206	204.374	9.1	204.532
248	78.0	0.5	200.6104	25.00	204.156	204.325	9.1	204.484
249	78.5	0.5	200.5438	25.00	204.106	204.275	9.1	204.435
250	79.0	0.5	200.4772	25.00	204.055	204.225	9.1	204.386
251	79.5	0.5	200.4106	25.00	204.005	204.175	9.1	204.337

h(Uchida) = 215

REV	BY	DATE	CHECKED	DATE	SETPOINT CALCULATION LIS263-72A, B, C, D: Reactor Vessel Low-Low Level
1	JWR	4/1/93	JFD	4/1/93	ABB — ABB Impell Corporation
0	JWR	1/28/93	TJD	2/1/93	JOB NO. 25-226; CALC NO. (25-226-C004)

N	time	Δ TIME	Tambient	h(Uchida)	TpipeExt	TpipeInt	k(ss)	Twater
252	80.0	0.5	200.344	25.00	203.954	204.125	9.1	204.287
253	80.5	0.5	200.2774	25.00	203.902	204.075	9.1	204.238
254	81.0	0.5	200.2108	25.00	203.851	204.024	9.1	204.188
255	81.5	0.5	200.1442	25.00	203.799	203.973	9.1	204.137
256	82.0	0.5	200.0776	25.00	203.748	203.922	9.1	204.087
257	82.5	0.5	200.011	25.00	203.696	203.871	9.1	204.036
258	83.0	0.5	199.9444	25.00	203.643	203.819	9.1	203.986
259	83.5	0.5	199.8778	25.00	203.591	203.767	9.1	203.935
260	84.0	0.5	199.8112	25.00	203.538	203.715	9.1	203.883
261	84.5	0.5	199.7446	25.00	203.486	203.663	9.1	203.832
262	85.0	0.5	199.678	25.00	203.433	203.611	9.1	203.780
263	85.5	0.5	199.6114	25.00	203.380	203.559	9.1	203.728
264	86.0	0.5	199.5448	25.00	203.326	203.506	9.1	203.676
265	86.5	0.5	199.4782	25.00	203.273	203.453	9.1	203.624
266	87.0	0.5	199.4116	25.00	203.219	203.400	9.1	203.572
267	87.5	0.5	199.345	25.00	203.165	203.347	9.1	203.519
268	88.0	0.5	199.2784	25.00	203.111	203.294	9.1	203.466
269	88.5	0.5	199.2118	25.00	203.057	203.240	9.1	203.413
270	89.0	0.5	199.1452	25.00	203.003	203.186	9.1	203.360
271	89.5	0.5	199.0786	25.00	202.948	203.132	9.1	203.307
272	90.0	0.5	199.012	25.00	202.894	203.078	9.1	203.253
273	90.5	0.5	198.9454	25.00	202.839	203.024	9.1	203.200
274	91.0	0.5	198.8788	25.00	202.784	202.970	9.1	203.146
275	91.5	0.5	198.8122	25.00	202.729	202.915	9.1	203.092
276	92.0	0.5	198.7456	25.00	202.674	202.860	9.1	203.038
277	92.5	0.5	198.679	25.00	202.618	202.806	9.1	202.983
278	93.0	0.5	198.6124	25.00	202.563	202.751	9.1	202.929
279	93.5	0.5	198.5458	25.00	202.507	202.695	9.1	202.874
280	94.0	0.5	198.4792	25.00	202.451	202.640	9.1	202.819
281	94.5	0.5	198.4126	25.00	202.395	202.585	9.1	202.764
282	95.0	0.5	198.346	25.00	202.339	202.529	9.1	202.709
283	95.5	0.5	198.2794	25.00	202.283	202.473	9.1	202.654
284	96.0	0.5	198.2128	25.00	202.226	202.417	9.1	202.599
285	96.5	0.5	198.1462	25.00	202.170	202.361	9.1	202.543
286	97.0	0.5	198.0796	25.00	202.113	202.305	9.1	202.487
287	97.5	0.5	198.013	25.00	202.056	202.249	9.1	202.432
288	98.0	0.5	197.9464	25.00	201.999	202.192	9.1	202.375
289	98.5	0.5	197.8798	25.00	201.942	202.136	9.1	202.319
290	99.0	0.5	197.8132	25.00	201.885	202.079	9.1	202.263
291	99.5	0.5	197.7466	25.00	201.828	202.022	9.1	202.207
292	100.0	0.5	197.68	25.00	201.770	201.965	9.1	202.150
293	100.5	0.5	197.6134	25.00	201.713	201.908	9.1	202.093

h(Uchida) = 215

N	time	Δ TIME	Tambient	h(Uchida)	TpipeExt	TpipeInt	k(ss)	Twater
294	101.0	0.5	197.5468	25.00	201.655	201.851	9.1	202.037
295	101.5	0.5	197.4802	25.00	201.597	201.793	9.1	201.980
296	102.0	0.5	197.4136	25.00	201.539	201.736	9.1	201.923
297	102.5	0.5	197.347	25.00	201.481	201.678	9.1	201.865
298	103.0	0.5	197.2804	25.00	201.423	201.621	9.1	201.808
299	103.5	0.5	197.2138	25.00	201.365	201.563	9.1	201.751
300	104.0	0.5	197.1472	25.00	201.307	201.505	9.1	201.693
301	104.5	0.5	197.0806	25.00	201.248	201.447	9.1	201.635
302	105.0	0.5	197.014	25.00	201.190	201.389	9.1	201.578
303	105.5	0.5	196.9474	25.00	201.131	201.330	9.1	201.520
304	106.0	0.5	196.8808	25.00	201.072	201.272	9.1	201.462
305	106.5	0.5	196.8142	25.00	201.013	201.213	9.1	201.403
306	107.0	0.5	196.7476	25.00	200.954	201.155	9.1	201.345
307	107.5	0.5	196.681	25.00	200.895	201.096	9.1	201.287
308	108.0	0.5	196.6144	25.00	200.836	201.037	9.1	201.228
309	108.5	0.5	196.5478	25.00	200.777	200.978	9.1	201.170
310	109.0	0.5	196.4812	25.00	200.717	200.919	9.1	201.111
311	109.5	0.5	196.4146	25.00	200.658	200.860	9.1	201.052
312	110.0	0.5	196.348	25.00	200.598	200.801	9.1	200.993
313	110.5	0.5	196.2814	25.00	200.539	200.742	9.1	200.934
314	111.0	0.5	196.2148	25.00	200.479	200.682	9.1	200.875
315	111.5	0.5	196.1482	25.00	200.419	200.623	9.1	200.816
316	112.0	0.5	196.0816	25.00	200.359	200.563	9.1	200.757
317	112.5	0.5	196.015	25.00	200.299	200.503	9.1	200.697
318	113.0	0.5	195.9484	25.00	200.239	200.444	9.1	200.638
319	113.5	0.5	195.8818	25.00	200.179	200.384	9.1	200.578
320	114.0	0.5	195.8152	25.00	200.118	200.324	9.1	200.519
321	114.5	0.5	195.7486	25.00	200.058	200.264	9.1	200.459
322	115.0	0.5	195.682	25.00	199.998	200.203	9.1	200.399
323	115.5	0.5	195.6154	25.00	199.937	200.143	9.1	200.339
324	116.0	0.5	195.5488	25.00	199.877	200.083	9.1	200.279
325	116.5	0.5	195.4822	25.00	199.816	200.023	9.1	200.219
326	117.0	0.5	195.4156	25.00	199.755	199.962	9.1	200.159
327	117.5	0.5	195.349	25.00	199.694	199.902	9.1	200.098
328	118.0	0.5	195.2824	25.00	199.633	199.841	9.1	200.038
329	118.5	0.5	195.2158	25.00	199.572	199.780	9.1	199.978
330	119.0	0.5	195.1492	25.00	199.511	199.719	9.1	199.917
331	119.5	0.5	195.0826	25.00	199.450	199.658	9.1	199.857
332	120.0	0.5	195.016	25.00	199.389	199.598	9.1	199.796

h(Uchida) = 215

REV	BY	DATE	CHECKED	DATE
1	JWR	4/1/93	JFD	4/1/93
0	JWR	1/28/93	TJD	2/1/93

SETPOINT CALCULATION

LIS263-72A, B, C, D: Reactor Vessel Low-Low Level

ABB
ASEA BROWN BOVERI
ABB Impell Corporation

JOB NO 25-226

CALC NO (25-226-C004)

N	time	Δ TIME	Tambient	h(Uchida)	TpipeExt	TpipeInt	k(ss)	Twater
0	0.0		85.000	25	85.000	85.000	8.7	85.000
1	0.3	0.25	86.176	31.375	85.000	85.000	8.7	85.000
2	0.5	0.25	87.352	37.75	85.038	85.000	8.7	85.000
3	0.8	0.25	88.528	44.125	85.113	85.014	8.7	85.000
4	1.0	0.25	89.704	50.5	85.230	85.048	8.7	85.002
5	1.3	0.25	90.880	56.875	85.393	85.105	8.7	85.009
6	1.5	0.25	92.056	63.25	85.605	85.189	8.7	85.023
7	1.8	0.25	93.232	69.625	85.867	85.303	8.7	85.047
8	2.0	0.25	94.408	76	86.181	85.451	8.7	85.085
9	2.3	0.25	95.584	82.375	86.549	85.634	8.7	85.138
10	2.5	0.25	96.760	88.75	86.969	85.853	8.7	85.211
11	2.8	0.25	97.936	95.125	87.442	86.112	8.7	85.305
12	3.0	0.25	99.112	101.5	87.968	86.410	8.7	85.423
13	3.3	0.25	100.288	107.875	88.545	86.749	8.7	85.568
14	3.5	0.25	101.464	114.25	89.172	87.129	8.7	85.741
15	3.8	0.25	102.640	120.625	89.848	87.551	8.7	85.944
16	4.0	0.25	103.816	127	90.571	88.014	8.7	86.180
17	4.3	0.25	104.992	133.375	91.339	88.518	8.7	86.448
18	4.5	0.25	106.168	139.75	92.151	89.063	8.7	86.752
19	4.8	0.25	107.344	146.125	93.005	89.648	8.7	87.090
20	5.0	0.25	108.520	152.5	93.899	90.273	8.7	87.465
21	5.3	0.25	109.696	158.875	94.830	90.937	8.7	87.876
22	5.5	0.25	110.872	165.25	95.796	91.638	8.7	88.325
23	5.8	0.25	112.048	171.625	96.797	92.377	8.7	88.810
24	6.0	0.25	113.224	178	97.829	93.151	8.7	89.333
25	6.3	0.25	114.400	184.375	98.891	93.959	8.7	89.892
26	6.5	0.25	115.576	190.75	99.980	94.801	8.7	90.488
27	6.8	0.25	116.752	197.125	101.096	95.675	8.7	91.120
28	7.0	0.25	117.928	203.5	102.235	96.580	8.7	91.787
29	7.3	0.25	119.104	209.875	103.397	97.514	8.7	92.489
30	7.5	0.25	120.280	216.25	104.579	98.476	8.7	93.225
31	7.8	0.25	121.456	222.625	105.781	99.465	8.7	93.995
32	8.0	0.25	122.632	229	107.000	100.479	8.7	94.796
33	8.3	0.25	123.808	235.375	108.235	101.517	8.7	95.628
34	8.5	0.25	124.984	241.75	109.484	102.579	8.7	96.491
35	8.8	0.25	126.160	248.125	110.747	103.661	8.7	97.383
36	9.0	0.25	127.336	254.5	112.022	104.764	8.7	98.303
37	9.3	0.25	128.512	260.875	113.308	105.887	8.7	99.249
38	9.5	0.25	129.688	267.25	114.603	107.027	8.7	100.222
39	9.8	0.25	130.864	273.625	115.908	108.184	8.7	101.219
40	10.0	0.25	132.040	280	117.220	109.356	8.7	102.239
41	10.3	0.25	133.216	280	118.538	110.544	8.7	103.282

h(Uchida) = 280

REV	BY	DATE	CHECKED	DATE	
1	JWR	4/1/93	JED	4/1/93	SETPOINT CALCULATION
0	JWR	1/28/93	TJD	2/1/93	LIS263-72A, B, C, D; Reactor Vessel Low-Low Level

ABB
ASEA BROWN BOVERI
ABB Impell Corporation

JOB NO. 25-226
CALC NO. (25-226-C004)

N	time	Δ TIME	Tambient	h(Uchida)	TpipeExt	TpipeInt	k(ss)	Twater
42	10.5	0.25	134.392	280	119.767	111.744	8.7	104.346
43	10.8	0.25	135.568	280	120.971	112.922	8.7	105.430
44	11.0	0.25	136.744	280	122.157	114.086	8.7	106.527
45	11.3	0.25	137.920	280	123.332	115.242	8.7	107.635
46	11.5	0.25	139.096	280	124.500	116.394	8.7	108.749
47	11.8	0.25	140.272	280	125.664	117.542	8.7	109.869
48	12.0	0.25	141.448	280	126.826	118.690	8.7	110.993
49	12.3	0.25	142.624	280	127.987	119.837	8.7	112.121
50	12.5	0.25	143.800	280	129.147	120.984	8.7	113.251
51	12.8	0.25	144.976	280	130.306	122.132	8.7	114.384
52	13.0	0.25	146.152	280	131.466	123.280	8.7	115.519
53	13.3	0.25	147.328	280	132.627	124.430	8.7	116.656
54	13.5	0.25	148.504	280	133.788	125.580	8.7	117.795
55	13.8	0.25	149.680	280	134.949	126.732	8.7	118.936
56	14.0	0.25	150.856	280	136.111	127.884	8.7	120.078
57	14.3	0.25	152.032	280	137.273	129.038	8.7	121.221
58	14.5	0.25	153.208	280	138.436	130.192	8.7	122.367
59	14.8	0.25	154.384	280	139.600	131.348	8.7	123.513
60	15.0	0.25	155.560	280	140.764	132.504	8.7	124.661
61	15.3	0.25	156.736	280	141.928	133.661	8.7	125.810
62	15.5	0.25	157.912	280	143.093	134.819	8.7	126.960
63	15.8	0.25	159.088	280	144.259	135.977	8.7	128.111
64	16.0	0.25	160.264	280	145.425	137.137	8.7	129.264
65	16.3	0.25	161.440	280	146.591	138.297	8.7	130.417
66	16.5	0.25	162.616	280	147.758	139.458	8.7	131.571
67	16.8	0.25	163.792	280	148.925	140.619	8.7	132.727
68	17.0	0.25	164.968	280	150.093	141.781	8.7	133.883
69	17.3	0.25	166.144	280	151.261	142.944	9.1	135.040
70	17.5	0.25	167.320	280	152.287	144.161	9.1	136.251
71	17.8	0.25	168.496	280	153.430	145.302	9.1	137.463
72	18.0	0.25	169.672	280	154.582	146.462	9.1	138.665
73	18.3	0.25	170.848	280	155.744	147.629	9.1	139.859
74	18.5	0.25	172.024	280	156.912	148.802	9.1	141.050
75	18.8	0.25	173.200	280	158.084	149.977	9.1	142.238
76	19.0	0.25	174.376	280	159.258	151.154	9.1	143.424
77	19.3	0.25	175.552	280	160.434	152.333	9.1	144.608
78	19.5	0.25	176.728	280	161.611	153.512	9.1	145.[illegible]92
79	19.8	0.25	177.904	280	162.789	154.691	9.1	146.975
80	20.0	0.25	179.080	280	163.966	155.870	9.1	148.157
81	20.3	0.25	180.256	280	165.144	157.050	9.1	149.339
82	20.5	0.25	181.432	280	166.322	158.230	9.1	150.521
83	20.8	0.25	182.608	280	167.500	159.409	9.1	151.702

h(Uchida) = 280

SETPOINT CALCULATION

LIS263-72A, B, C, D; Reactor Vessel Low-Low Level

REV	BY	DATE	CHECKED	DATE
1	JWB	4/1/93	JFD	4/1/93
0	JWR	1/28/93	TJS	2/1/93

ABB — ASEA BROWN BOVERI — ABB Impell Corporation

JOB NO. 25-226

CALC NO. (25-226-C004)

N	time	Δ TIME	Tambient	h(Uchida)	TpipeExt	TpipeInt	k(ss)	Twater
84	21.0	0.25	183.784	280	168.678	160.588	9.1	152.883
85	21.3	0.25	184.960	280	169.856	161.768	9.1	154.064
86	21.5	0.25	186.136	280	171.034	162.947	9.1	155.244
87	21.8	0.25	187.312	280	172.212	164.126	9.1	156.425
88	22.0	0.25	188.488	280	173.390	165.305	9.1	157.605
89	22.3	0.25	189.664	280	174.568	166.484	9.1	158.785
90	22.5	0.25	190.840	280	175.745	167.662	9.1	159.964
91	22.8	0.25	192.016	280	176.923	168.841	9.1	161.144
92	23.0	0.25	193.192	280	178.100	170.019	9.1	162.323
93	23.3	0.25	194.368	280	179.278	171.197	9.1	163.503
94	23.5	0.25	195.544	280	180.455	172.376	9.1	164.682
95	23.8	0.25	196.720	280	181.632	173.554	9.1	165.861
96	24.0	0.25	197.896	280	182.810	174.732	9.1	167.040
97	24.3	0.25	199.072	280	183.987	175.910	9.1	168.218
98	24.5	0.25	200.248	280	185.164	177.088	9.1	169.397
99	24.8	0.25	201.424	280	186.341	178.265	9.1	170.575
100	25.0	0.25	202.600	280	187.518	179.443	9.1	171.754
101	25.3	0.25	203.776	280	188.695	180.621	9.1	172.932
102	25.5	0.25	204.952	280	189.872	181.798	9.1	174.110
103	25.8	0.25	206.128	280	191.049	182.976	9.1	175.288
104	26.0	0.25	207.304	280	192.226	184.153	9.1	176.466
105	26.3	0.25	208.480	280	193.403	185.330	9.1	177.644
106	26.5	0.25	209.656	280	194.579	186.508	9.1	178.822
107	26.8	0.25	210.832	280	195.756	187.685	9.1	180.000
108	27.0	0.25	212.008	280	196.933	188.862	9.1	181.177
109	27.3	0.25	211.883	280	198.110	190.039	9.1	182.355
110	27.5	0.25	211.758	280	198.914	191.216	9.1	183.532
111	27.8	0.25	211.633	280	199.598	192.248	9.1	184.710
112	28.0	0.25	211.508	280	200.185	193.181	9.1	185.865
113	28.3	0.25	211.383	280	200.703	194.036	9.1	186.986
114	28.5	0.25	211.258	280	201.168	194.828	9.1	188.067
115	28.8	0.25	211.133	280	201.592	195.567	9.1	189.103
116	29.0	0.25	211.008	280	201.981	196.259	9.1	190.093
117	29.3	0.25	210.883	280	202.340	196.909	9.1	191.038
118	29.5	0.25	210.758	280	202.674	197.521	9.1	191.938
119	29.8	0.25	210.633	280	202.985	198.099	9.1	192.793
120	30.0	0.25	210.508	280	203.275	198.643	9.1	193.606
121	30.3	0.25	210.445	280	203.545	199.158	9.1	194.378
122	30.5	0.25	210.383	280	203.814	199.643	9.1	195.110
123	30.8	0.25	210.320	280	204.073	200.107	9.1	195.805
124	31.0	0.25	210.258	280	204.320	200.550	9.1	196.464
125	31.3	0.25	210.195	280	204.554	200.972	9.1	197.090

h(Uchida) = 280

REV	BY	DATE	CHECKED	DATE
1	JWR	4/1/93	JFD	4/1/93
0	JWR	1/28/93	TJD	2/1/93

SETPOINT CALCULATION

LIS263-72A, B, C, D: Reactor Vessel Low-Low Level

ABB
ABEA BROWN BOVERI
ABB Impell Corporation

JOB NO. 25-226

CALC NO. (25-226-C004)

N	time	Δ TIME	Tambient	h(Uchida)	TpipeExt	TpipeInt	k(ss)	Twater
126	31.5	0.25	210.133	280	204.776	201.374	9.1	197.685
127	31.8	0.25	210.070	280	204.987	201.755	9.1	198.250
128	32.0	0.25	210.008	280	205.185	202.116	9.1	198.787
129	32.3	0.25	209.945	280	205.373	202.460	9.1	199.298
130	32.5	0.25	209.883	280	205.549	202.785	9.1	199.782
131	32.8	0.25	209.820	280	205.715	203.093	9.1	200.242
132	33.0	0.25	209.758	280	205.871	203.384	9.1	200.679
133	33.3	0.25	209.695	280	206.017	203.660	9.1	201.094
134	33.5	0.25	209.633	280	206.154	203.921	9.1	201.487
135	33.8	0.25	209.570	280	206.282	204.167	9.1	201.860
136	34.0	0.25	209.508	280	206.401	204.400	9.1	202.213
137	34.3	0.25	209.445	280	206.513	204.620	9.1	202.548
138	34.5	0.25	209.383	280	206.616	204.827	9.1	202.866
139	34.8	0.25	209.320	280	206.712	205.022	9.1	203.166
140	35.0	0.25	209.258	280	206.802	205.205	9.1	203.451
141	35.3	0.25	209.195	280	206.884	205.378	9.1	203.719
142	35.5	0.25	209.133	280	206.960	205.540	9.1	203.974
143	35.8	0.25	209.070	280	207.030	205.692	9.1	204.214
144	36.0	0.25	209.008	280	207.094	205.835	9.1	204.440
145	36.3	0.25	208.945	280	207.152	205.968	9.1	204.654
146	36.5	0.25	208.883	280	207.205	206.093	9.1	204.855
147	36.8	0.25	208.820	280	207.253	206.209	9.1	205.045
148	37.0	0.25	208.758	280	207.296	206.318	9.1	205.223
149	37.3	0.25	208.695	280	207.334	206.419	9.1	205.391
150	37.5	0.25	208.633	280	207.368	206.512	9.1	205.548
151	37.8	0.25	208.570	280	207.397	206.599	9.1	205.696
152	38.0	0.25	208.508	280	207.423	206.679	9.1	205.834
153	38.3	0.25	208.445	280	207.444	206.752	9.1	205.964
154	38.5	0.25	208.383	280	207.462	206.820	9.1	206.085
155	38.8	0.25	208.320	280	207.475	206.882	9.1	206.197
156	39.0	0.25	208.258	280	207.487	206.938	9.1	206.302
157	39.3	0.25	208.195	280	207.494	206.989	9.1	206.400
158	39.5	0.25	208.133	280	207.498	207.035	9.1	206.490
159	39.8	0.25	208.070	280	207.500	207.076	9.1	206.573
160	40.0	0.25	208.008	280	207.498	207.112	9.1	206.650
161	40.3	0.25	207.945	280	207.494	207.144	9.1	206.721
162	40.5	0.25	207.883	280	207.487	207.172	9.1	206.786
163	40.8	0.25	207.820	280	207.478	207.196	9.1	206.845
164	41.0	0.25	207.758	280	207.467	207.216	9.1	206.899
165	41.3	0.25	207.695	280	207.453	207.232	9.1	206.948
166	41.5	0.25	207.633	280	207.437	207.245	9.1	206.991
167	41.8	0.25	207.570	280	207.418	207.255	9.1	207.030

h(Uchida) = 280

REV	BY	DATE	CHECKED	DATE
1	JWR	4/1/93	JFD	4/1/93
0	JWR	1/28/93	TJD	2/1/93

SETPOINT CALCULATION

LIS263-72A, B, C, D; Reactor Vessel Low-Low Level

ABB Impell Corporation

JOB NO. 25-226

CALC NO. (25-226-C004)

N	time	Δ TIME	Tambient	h(Uchida)	TpipeExt	TpipeInt	k(ss)	Twater
168	42.0	0.25	?207.508	280	207.398	207.261	9.1	207.065
169	42.3	0.25	207.445	280	207.376	207.264	9.1	207.095
170	42.5	0.25	207.383	280	207.353	207.264	9.1	207.121
171	42.8	0.25	207.320	280	207.327	207.262	9.1	207.143
172	43.0	0.25	207.258	280	207.300	207.257	9.1	207.161
173	43.5	0.5	207.133	180	207.242	207.241	9.1	207.190
174	44.0	0.5	207.008	130	207.201	207.216	9.1	207.206
175	44.5	0.5	206.883	105	207.161	207.199	9.1	207.209
176	45.0	0.5	206.758	85	207.131	207.175	9.1	207.206
177	45.5	0.5	206.633	65	207.100	207.157	9.1	207.196
178	46.0	0.5	206.508	50	207.082	207.133	9.1	207.184
179	46.5	0.5	206.383	35	207.063	207.120	9.1	207.169
180	47.0	0.5	206.258	25	207.058	207.100	9.1	207.154
181	47.5	0.5	206.133	25	207.050	207.095	9.1	207.137
182	48.0	0.5	206.008	25	207.038	207.082	9.1	207.124
183	48.5	0.5	205.883	25	207.019	207.069	9.1	207.111
184	49.0	0.5	205.758	25	207.000	207.052	9.1	207.098
185	49.5	0.5	205.633	25	206.977	207.035	9.1	207.084
186	50.0	0.5	205.508	25	206.954	207.015	9.1	207.069
187	50.5	0.5	205.383	25	206.927	206.995	9.1	207.053
188	51.0	0.5	205.258	25	206.901	206.972	9.1	207.035
189	51.5	0.5	205.133	25	206.872	206.949	9.1	207.016
190	52.0	0.5	205.008	25	206.843	206.923	9.1	206.995
191	52.5	0.5	204.883	25	206.811	206.898	9.1	206.973
192	53.0	0.5	204.758	25	206.780	206.869	9.1	206.950
193	53.5	0.5	204.633	25	206.746	206.841	9.1	206.925
194	54.0	0.5	204.508	25	206.712	206.810	9.1	206.899
195	54.5	0.5	204.383	25	206.676	206.779	9.1	206.872
196	55.0	0.5	204.258	25	206.639	206.746	9.1	206.844
197	55.5	0.5	204.133	25	206.600	206.713	9.1	206.814
198	56.0	0.5	204.008	25	206.562	206.677	9.1	206.783
199	56.5	0.5	203.883	25	206.521	206.641	9.1	206.750
200	57.0	0.5	203.758	25	206.480	206.603	9.1	206.717
201	57.5	0.5	203.633	25	206.437	206.565	9.1	206.682
202	58.0	0.5	203.508	25	206.393	206.525	9.1	206.646
203	58.5	0.5	203.383	25	206.348	206.484	9.1	206.609
204	59.0	0.5	203.258	25	206.303	206.442	9.1	206.571
205	59.5	0.5	203.133	25	206.255	206.399	9.1	206.531
206	60.0	0.5	203.008	25	206.208	206.355	9.1	206.491
207	60.5	0.5	202.941	25	206.159	206.310	9.1	206.449
208	61.0	0.5	202.875	25	206.112	206.263	9.1	206.406
209	61.5	0.5	202.808	25	206.064	206.219	9.1	206.363

h(Uchida) = 280

					SETPOINT CALCULATION		
					LIS263-72A, B, C, D: Reactor Vessel Low-Low Level		
1	JWR	4/1/93	JFD	4/1/93	ABB	JOB NO. 25-226	PAGE 77
0	JWR	1/28/93	TJD	2/1/93	ABB Impell Corporation	CALC NO. (25-226-C004)	OF 87
REV	BY	DATE	CHECKED	DATE			

N	time	Δ TIME	Tambient	h(Uchida)	TpipeExt	TpipeInt	k(ss)	Twater
210	62.0	0.5	202.742	25	206.018	206.172	9.1	206.318
211	62.5	0.5	202.675	25	205.970	206.127	9.1	206.274
212	63.0	0.5	202.608	25	205.924	206.080	9.1	206.229
213	63.5	0.5	202.542	25	205.876	206.034	9.1	206.183
214	64.0	0.5	202.475	25	205.829	205.987	9.1	206.137
215	64.5	0.5	202.409	25	205.780	205.941	9.1	206.091
216	65.0	0.5	202.342	25	205.733	205.893	9.1	206.045
217	65.5	0.5	202.275	25	205.684	205.846	9.1	205.998
218	66.0	0.5	202.209	25	205.636	205.798	9.1	205.952
219	66.5	0.5	202.142	25	205.587	205.750	9.1	205.905
220	67.0	0.5	202.076	25	205.538	205.702	9.1	205.857
221	67.5	0.5	202.009	25	205.488	205.654	9.1	205.810
222	68.0	0.5	201.942	25	205.439	205.605	9.1	205.762
223	68.5	0.5	201.876	25	205.389	205.556	9.1	205.714
224	69.0	0.5	201.809	25	205.339	205.507	9.1	205.665
225	69.5	0.5	201.743	25	205.289	205.458	9.1	205.617
226	70.0	0.5	201.676	25	205.239	205.408	9.1	205.568
227	70.5	0.5	201.609	25	205.188	205.358	9.1	205.519
228	71.0	0.5	201.543	25	205.137	205.308	9.1	205.470
229	71.5	0.5	201.476	25	205.086	205.258	9.1	205.420
230	72.0	0.5	201.410	25	205.035	205.207	9.1	205.370
231	72.5	0.5	201.343	25	204.984	205.157	9.1	205.320
232	73.0	0.5	201.276	25	204.932	205.106	9.1	205.270
233	73.5	0.5	201.210	25	204.880	205.055	9.1	205.220
234	74.0	0.5	201.143	25	204.828	205.003	9.1	205.169
235	74.5	0.5	201.077	25	204.776	204.952	9.1	205.118
236	75.0	0.5	201.010	25	204.724	204.900	9.1	205.067
237	75.5	0.5	200.943	25	204.671	204.848	9.1	205.016
238	76.0	0.5	200.877	25	204.618	204.796	9.1	204.965
239	76.5	0.5	200.810	25	204.565	204.744	9.1	204.913
240	77.0	0.5	200.744	25	204.512	204.691	9.1	204.861
241	77.5	0.5	200.677	25	204.459	204.639	9.1	204.809
242	78.0	0.5	200.610	25	204.405	204.586	9.1	204.757
243	78.5	0.5	200.544	25	204.352	204.533	9.1	204.704
244	79.0	0.5	200.477	25	204.298	204.480	9.1	204.652
245	79.5	0.5	200.411	25	204.244	204.426	9.1	204.599
246	80.0	0.5	200.344	25	204.190	204.373	9.1	204.546
247	80.5	0.5	200.277	25	204.135	204.319	9.1	204.493
248	81.0	0.5	200.211	25	204.081	204.265	9.1	204.440
249	81.5	0.5	200.144	25	204.026	204.211	9.1	204.386
250	82.0	0.5	200.078	25	203.972	204.157	9.1	204.332
251	82.5	0.5	200.011	25	203.917	204.102	9.1	204.279

h(Uchida) = 280

REV	BY	DATE	CHECKED	DATE
1	JWR	4/1/93	JFD	4/1/93
0	JWA	1/28/93	TJD	2/1/93

SETPOINT CALCULATION

LIS263-72A, B, C, D: Reactor Vessel Low-Low Level

ABB — ASEA BROWN BOVERI — ABB Impell Corporation

JOB NO. 25-226

CALC NO. (25-226-C004)

N	time	Δ TIME	Tambient	h(Uchida)	TpipeExt	Tpipeint	k(ss)	Twater
252	83.0	0.5	199.944	25	203.861	204.048	9.1	204.225
253	83.5	0.5	199.878	25	203.806	203.993	9.1	204.170
254	84.0	0.5	199.811	25	203.751	203.938	9.1	204.116
255	84.5	0.5	199.745	25	203.695	203.883	9.1	204.062
256	85.0	0.5	199.678	25	203.639	203.828	9.1	204.007
257	85.5	0.5	199.611	25	203.584	203.773	9.1	203.952
258	86.0	0.5	199.545	25	203.528	203.717	9.1	203.897
259	86.5	0.5	199.478	25	203.471	203.662	9.1	203.842
260	87.0	0.5	199.412	25	203.415	203.606	9.1	203.787
261	87.5	0.5	199.345	25	203.359	203.550	9.1	203.731
262	88.0	0.5	199.278	25	203.302	203.494	9.1	203.676
263	88.5	0.5	199.212	25	203.246	203.438	9.1	203.620
264	89.0	0.5	199.145	25	203.189	203.381	9.1	203.564
265	89.5	0.5	199.079	25	203.132	203.325	9.1	203.508
266	90.0	0.5	199.012	25	203.075	203.268	9.1	203.452
267	90.5	0.5	198.945	25	203.018	203.212	9.1	203.396
268	91.0	0.5	198.879	25	202.960	203.155	9.1	203.339
269	91.5	0.5	198.812	25	202.903	203.098	9.1	203.283
270	92.0	0.5	198.746	25	202.845	203.041	9.1	203.226
271	92.5	0.5	198.679	25	202.788	202.983	9.1	203.169
272	93.0	0.5	198.612	25	202.730	202.926	9.1	203.112
273	93.5	0.5	198.546	25	202.672	202.868	9.1	203.055
274	94.0	0.5	198.479	25	202.614	202.811	9.1	202.998
275	94.5	0.5	198.413	25	202.556	202.753	9.1	202.941
276	95.0	0.5	198.346	25	202.497	202.695	9.1	202.883
277	95.5	0.5	198.279	25	202.439	202.637	9.1	202.826
278	96.0	0.5	198.213	25	202.381	202.579	9.1	202.768
279	96.5	0.5	198.146	25	202.322	202.521	9.1	202.710
280	97.0	0.5	198.080	25	202.263	202.463	9.1	202.652
281	97.5	0.5	198.013	25	202.205	202.404	9.1	202.594
282	98.0	0.5	197.946	25	202.146	202.346	9.1	202.536
283	98.5	0.5	197.880	25	202.087	202.287	9.1	202.478
284	99.0	0.5	197.813	25	202.028	202.229	9.1	202.419
285	99.5	0.5	197.747	25	201.968	202.170	9.1	202.361
286	100.0	0.5	197.680	25	201.909	202.111	9.1	202.302
287	100.5	0.5	197.613	25	201.850	202.052	9.1	202.244
288	101.0	0.5	197.547	25	201.790	201.993	9.1	202.185
289	101.5	0.5	197.480	25	201.731	201.933	9.1	202.126
290	102.0	0.5	197.414	25	201.671	201.874	9.1	202.067
291	102.5	0.5	197.347	25	201.611	201.815	9.1	202.008
292	103.0	0.5	197.280	25	201.551	201.755	9.1	201.949
293	103.5	0.5	197.214	25	201.492	201.695	9.1	201.889

h(Uchida) = 280

REV	BY	DATE	CHECKED	DATE
1	JWR	4/1/93	JFD	4/1/93
0	JWR	1/28/93	TJD	2/1/93

SETPOINT CALCULATION

LIS263-72A, B, C, D: Reactor Vessel Low-Low Level

ABB Impell Corporation

JOB NO. 25-226

CALC NO. (25-226-C004)

PAGE 81 OF 87

N	time	Δ TIME	Tambient	h(Uchida)	TpipeExt	TpipeInt	k(ss)	Twater
294	104.0	0.5	197.147	25	201.431	201.636	9.1	201.830
295	104.5	0.5	197.081	25	201.371	201.576	9.1	201.770
296	105.0	0.5	197.014	25	201.311	201.516	9.1	201.711
297	105.5	0.5	196.947	25	201.251	201.456	9.1	201.651
298	106.0	0.5	196.881	25	201.191	201.396	9.1	201.591
299	106.5	0.5	196.814	25	201.130	201.336	9.1	201.532
300	107.0	0.5	196.748	25	201.070	201.276	9.1	201.472
301	107.5	0.5	196.681	25	201.009	201.215	9.1	201.412
302	108.0	0.5	196.614	25	200.948	201.155	9.1	201.351
303	108.5	0.5	196.548	25	200.887	201.094	9.1	201.291
304	109.0	0.5	196.481	25	200.827	201.034	9.1	201.231
305	109.5	0.5	196.415	25	200.766	200.973	9.1	201.171
306	110.0	0.5	196.348	25	200.705	200.913	9.1	201.110
307	110.5	0.5	196.281	25	200.644	200.852	9.1	201.050
308	111.0	0.5	196.215	25	200.583	200.791	9.1	200.989
309	111.5	0.5	196.148	25	200.521	200.730	9.1	200.928
310	112.0	0.5	196.082	25	200.460	200.669	9.1	200.867
311	112.5	0.5	196.015	25	200.399	200.608	9.1	200.807
312	113.0	0.5	195.948	25	200.337	200.547	9.1	200.746
313	113.5	0.5	195.882	25	200.276	200.485	9.1	200.685
314	114.0	0.5	195.815	25	200.214	200.424	9.1	200.624
315	114.5	0.5	195.749	25	200.153	200.363	9.1	200.562
316	115.0	0.5	195.682	25	200.091	200.301	9.1	200.501
317	115.5	0.5	195.615	25	200.029	200.240	9.1	200.440
318	116.0	0.5	195.549	25	199.967	200.178	9.1	200.379
319	116.5	0.5	195.482	25	199.905	200.116	9.1	200.317
320	117.0	0.5	195.416	25	199.843	200.055	9.1	200.256
321	117.5	0.5	195.349	25	199.781	199.993	9.1	200.194
322	118.0	0.5	195.282	25	199.719	199.931	9.1	200.132
323	118.5	0.5	195.216	25	199.657	199.869	9.1	200.071
324	119.0	0.5	195.149	25	199.595	199.807	9.1	200.009
325	119.5	0.5	195.083	25	199.533	199.745	9.1	199.947
326	120.0	0.5	195.016	25	199.471	199.683	9.1	199.885
327	120.5	0.5	194.949	25	199.408	199.621	9.1	199.823
328	121.0	0.5	194.883	25	199.346	199.559	9.1	199.761
329	121.5	0.5	194.816	25	199.283	199.497	9.1	199.699
330	122.0	0.5	194.750	25	199.221	199.434	9.1	199.637
331	122.5	0.5	194.683	25	199.158	199.372	9.1	199.575
332	123.0	0.5	194.616	25	199.096	199.309	9.1	199.513
333	123.5	0.5	194.550	25	199.033	199.247	9.1	199.450
334	124.0	0.5	194.483	25	198.970	199.184	9.1	199.388
335	124.5	0.5	194.417	25	198.907	199.122	9.1	199.326

h(Uchida) = 280

REV	BY	DATE	CHECKED	DATE
1	INR	4/1/93	JFD	4/1/93
0	JWR	1/20/93	TJD	2/1/93

SETPOINT CALCULATION

LIS263-72A, B, C, D: Reactor Vessel Low-Low Level

ABB ASEA BROWN BOVERI

ABB Impell Corporation

JOB NO. 25-226

CALC NO. (25-226-C004)

N	time	Δ TIME	Tambient	h(Uchida)	TpipeExt	TpipeInt	k(ss)	Twater
336	125.0	0.5	194.350	25	198.845	199.059	9.1	199.263
337	125.5	0.5	194.283	25	198.782	198.996	9.1	199.201
338	126.0	0.5	194.217	25	198.719	198.934	9.1	199.138
339	126.5	0.5	194.150	25	198.656	198.871	9.1	199.075
340	127.0	0.5	194.084	25	198.593	198.808	9.1	199.013
341	127.5	0.5	194.017	25	198.530	198.745	9.1	198.950
342	128.0	0.5	193.950	25	198.466	198.682	9.1	198.887
343	128.5	0.5	193.884	25	198.403	198.619	9.1	198.824
344	129.0	0.5	193.817	25	198.340	198.556	9.1	198.761
345	129.5	0.5	193.751	25	198.277	198.493	9.1	198.698
346	130.0	0.5	193.684	25	198.214	198.430	9.1	198.635
347	130.5	0.5	193.617	25	198.150	198.367	9.1	198.572
348	131.0	0.5	193.551	25	198.087	198.303	9.1	198.509
349	131.5	0.5	193.484	25	198.023	198.240	9.1	198.446
350	132.0	0.5	193.418	25	197.960	198.177	9.1	198.383
351	132.5	0.5	193.351	25	197.896	198.113	9.1	198.320
352	133.0	0.5	193.284	25	197.833	198.050	9.1	198.257
353	133.5	0.5	193.218	25	197.769	197.987	9.1	198.193
354	134.0	0.5	193.151	25	197.706	197.923	9.1	198.130
355	134.5	0.5	193.085	25	197.642	197.860	9.1	198.067
356	135.0	0.5	193.018	25	197.578	197.796	9.1	198.003
357	135.5	0.5	192.951	25	197.514	197.732	9.1	197.940
358	136.0	0.5	192.885	25	197.451	197.669	9.1	197.876
359	136.5	0.5	192.818	25	197.387	197.605	9.1	197.813
360	137.0	0.5	192.752	25	197.323	197.541	9.1	197.749
361	137.5	0.5	192.685	25	197.259	197.477	9.1	197.685
362	138.0	0.5	192.618	25	197.195	197.414	9.1	197.622
363	138.5	0.5	192.552	25	197.131	197.350	9.1	197.558
364	139.0	0.5	192.485	25	197.067	197.286	9.1	197.494
365	139.5	0.5	192.419	25	197.003	197.222	9.1	197.430
366	140.0	0.5	192.352	25	196.939	197.158	9.1	197.366
367	140.5	0.5	192.285	25	196.875	197.094	9.1	197.303
368	141.0	0.5	192.219	25	196.811	197.030	9.1	197.239
369	141.5	0.5	192.152	25	196.747	196.966	9.1	197.175
370	142.0	0.5	192.086	25	196.682	196.902	9.1	197.111
371	142.5	0.5	192.019	25	196.618	196.838	9.1	197.047
372	143.0	0.5	191.952	25	196.554	196.774	9.1	196.983
373	143.5	0.5	191.886	25	196.490	196.709	9.1	196.919
374	144.0	0.5	191.819	25	196.425	196.645	9.1	196.855
375	144.5	0.5	191.753	25	196.361	196.581	9.1	196.790
376	145.0	0.5	191.686	25	196.297	196.517	9.1	196.726
377	145.5	0.5	191.619	25	196.232	196.452	9.1	196.662

h(Uchida) = 280

N	time	Δ TIME	Tambient	h(Uchida)	TpipeExt	TpipeInt	k(ss)	Twater
378	146.0	0.5	191.553	25	196.168	196.388	9.1	196.598
379	146.5	0.5	191.486	25	196.103	196.324	9.1	196.534
380	147.0	0.5	191.420	25	196.039	196.259	9.1	196.469
381	147.5	0.5	191.353	25	195.974	196.195	9.1	196.405
382	148.0	0.5	191.286	25	195.910	196.130	9.1	196.341
383	148.5	0.5	191.220	25	195.845	196.066	9.1	196.276
384	149.0	0.5	191.153	25	195.780	196.001	9.1	196.212
385	149.5	0.5	191.087	25	195.716	195.937	9.1	196.147
386	150.0	0.5	191.020	25	195.651	195.872	9.1	196.083

h(Uchida) = 280

REV	BY	DATE	CHECKED	DATE	SETPOINT CALCULATION LIS263-72A, B, C, D: Reactor Vessel Low-Low Level
1	JWR	4/1/93	JFD	4/1/93	ABB — ABB Impell Corporation; JOB NO. 25-226
0	JWR	1/28/93	TJD	2/1/93	CALC NO. (25-226-C004); PAGE 84 OF 87

V. RESULTS AND CONCLUSIONS

PLANT IMPACT

Parameter	Instrument	
	LT263-72A, B, C, D	LIS263-72A, B, C, D
Surveillance Interval	24 Months	3 Months
Combined Measurement & Test Equipment Accuracy	±0.25% span or ±0.25" in	±0.13% span or ±0.02 mAdc
No Adjust Limits	±0.04mAdc	±0.02 mAdc (trip) ±0.16 mAdc (reset)

SETPOINT DATA

	Current Value	24 Month Fuel Cycle Value
Field Trip Setpoint	-46" (4.64mAdc)	-46.14" (4.62mAdc)
Field Reset	-42" (5.28mAdc)	N/A
Notify Watch Engineer Value	-49" (4.16 mAdc)	-46.37" (4.58mAdc)

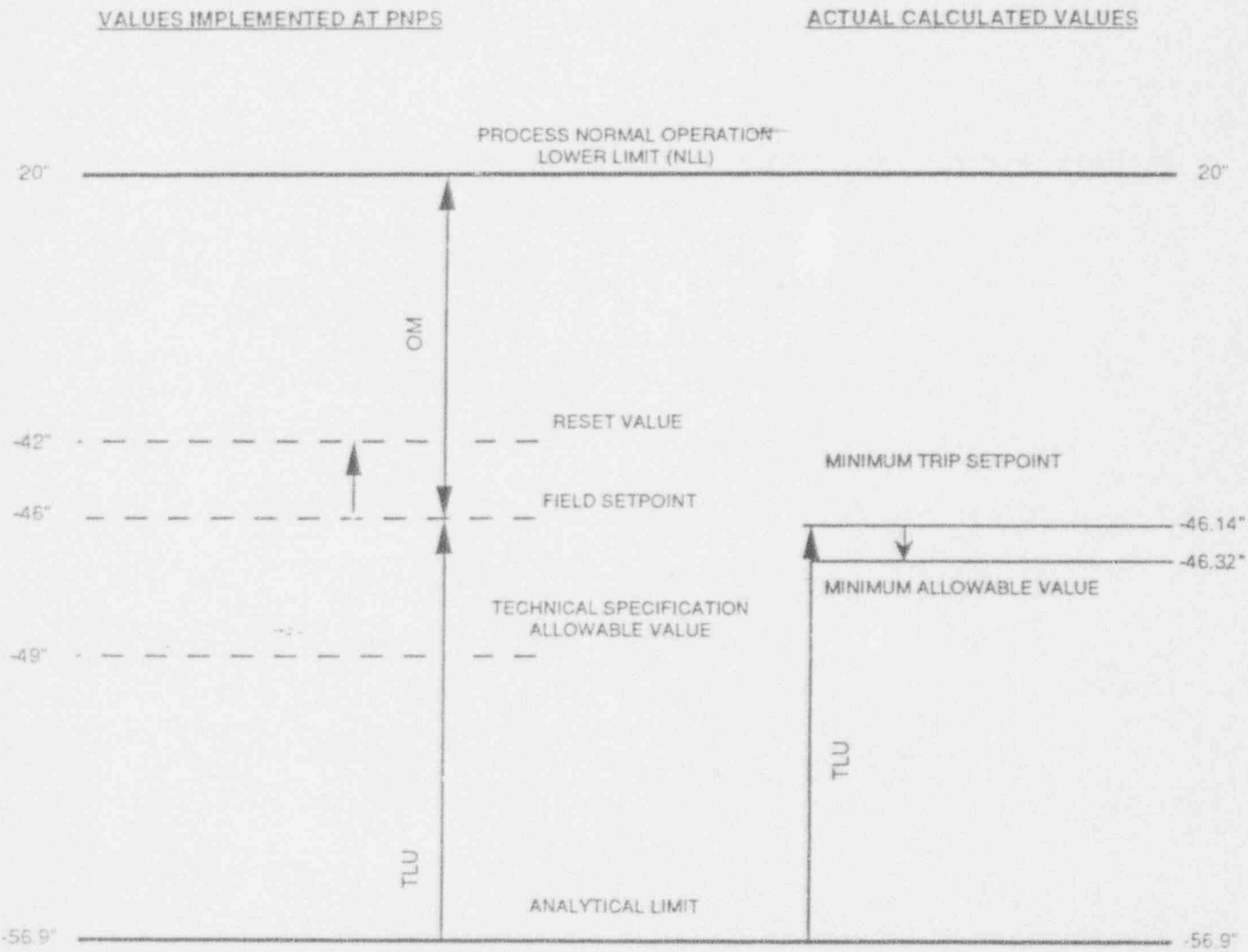
Channel Cross Check Value = 6"

The field setpoint value now implemented at PNPS is conservative with respect to the calculated trip setpoint, however, the calculated allowable value is less than the existing allowable value now implemented at PNPS (See Figure 1). Therefore, there is negative margin. Please note that existing setpoints implemented at PNPS have a different technical basis from the values determined from this calculation. Therefore, an allowable value change will be necessary when the 24 month fuel cycle is adopted.

This calculation has demonstrated that 0.14" margin exists in the setpoint. Following recalibration of the transmitter, this value can be increased to >0.72" by using the actual reference leg elevation in the scaling calculation. An additional +0.42" of margin can be achieved if Rosemount tested more than 34 transmitters to establish temperature sensitivities.

FIGURE 1
CALCULATED LIMITS AND SETPOINT RELATIONSHIP

(DECREASING SETPOINT)



REV	BY	DATE	CHECKED	DATE		
					SETPOINT CALCULATION	
					LS263-72A, B, C, D : Reactor Vessel Low-Low Level	
1	JWR	4/1/93	JFD	4/1/93	ABB ASEA BROWN BOVERI ABB IMPELL CORPORATION	JOB NO. 25-226
0	JWR	1/28/93	TJD	2/1/93		CALC NO. (25-226-C004)

VI. ATTACHMENTS

1. Rosemount Letter from T. Layer (Rosemount) to B. Rancourt (BECo), November 13, 1991, "Model 353C and 353C1 Performance Specs"

2. Rosemount Letter from T. Layer (Rosemount) to B. Rancourt (BECo), August 8, 1989, "Rosemount Nuclear Specifications"

3. BECo Nedorandum NAD #91-78, November 13, 1991 "Ar alytical Limit for Reactor Water Level Low-Low Setpoint"

4. B.?Co Nedorandum FS&MC 91-176, October 11, 1991 "Reactor Vessel Thermal Growth Effect on Reactor Instrumentation"

5. Record of Conversation from W. Hill (ABB Impell) to J. Sanderstrom (Rosemount) dated 1/20/93, "Rosemount 710DU Slave Trip Unit Repeatability"

6. Results from ABB Impell's Statistical Analysis of VISIrecords (As-found/As-left Data) to calculate 95%/95% Probability and Confidence Levels for Reactor Water Level Instrumentation. Done on Microsoft Excel Software.

7. Results from ABB Impell's Graphical Statistical Analysis, including histograms and scatter plots, using SYSTAT software.

Eden Prairie, MN 55344 USA
Tel (612) 941-5560
Telex 4310012
Fax (612) 828-3088

November 13, 1991

CALC. 25-226-C004
ATT. 1
p. 1 of 1

Mr. Bruce Rancourt
Boston Edison Co.
Pilgrim Generating Station
Edison Access Road
Plymouth, MA 02360

Re: Model 353C and 353C1 Performance Specifications

Dear Mr. Rancourt,

Per our discussion, the following information summarizes the performance specifications for the Model 353C and 353C1 Conduit Seal over normal operating temperature ranges.

The Model 353C and 353C1 Conduit Seals will not add any performance degradation to the pressure transmitter performance over the design temperature range of 40 to 220 Degree F. and up to 100% RH. Please note; the pressure transmitter design temperature range is 40 to 200 Degree F and up to 100% RH for normal operation.

The application at BECO utilizes a 1153 Series B Transmitter with the Model 353C Conduit Seal where a 212 Degree F HELB is possible. The Conduit Seal will add no additional performance degradation when exposed to this condition.

The above statement is valid based on the Insulation Resistance (IR) measurements expected at these temperature ranges. The measure IR for the conduit seal at the temperature range of 40 to 220 Degree F with 0-100% RH will not change enough for any measurable performance degradation.

For temperatures above the design temperature of 220 Degree F. one should use the 420 Degree F. LOCA Specification for the Model 353C Conduit Seal referenced in the Qualification Report D8300152.

Sincerely,

Timothy J. Layer
Marketing Engineer
Rosemount Nuclear Products

TJL

ROSEMOUNT INC.
12001 Technology Drive
Eden Prairie, MN 55344 U.S.A.
(612) 941-5560
TWX 4310012 or 4310024
FAX (612) 828-3088

CALC. 25-226-C004
ATT. 2
p. 1 of 1

Rosemount

August 9, 1989

Boston Edison Co.
Pilgrim Generating Station
Edison Access Road
Plymouth, MA 02350

Attention: Bruce Rancort
Subject: Rosemount Nuclear Specifications

Dear Mr. Rancort,

Rosemount publishes nuclear and performance specifications per Rosemount Qualification Reports or through testing of large sample sizes.

The nuclear specifications for qualified pressure transmitters and 710DU Trip/Calibration Systems are based on the applicable qualification report which itemizes a limited sample size and have a confidence factor of 2-Sigma.

The performance specifications for the above instrumentation are based on large sample sizes and have a confidence factor of 3-Sigma.

Sincerely,

Timothy J. Layer
Applications Engineer
Rosemount Nuclear Products

TJL:lbc

Calc. 25-226-C004
Att. 3
p. 1 of 4

BOSTON
EDISON

MEDORANDUM
NAD #91-78

TO: S. Dasgupta FROM: J. W. Gosnell DATE: November 13, 1991

Subject: Analytical Limit for Reactor Water Level Low-Low Setpoint

Reference: Ltr, L. L. Chi to Jim Gosnell, "PNPS Safety Evaluation for Changing the Analytical Limit for Low-Low Reactor Water Level", LLC-55-91, November 12, 1991

Replies To: N/A

Reply Requested: N/A

Requested Date: N/A

Message:

The referenced letter presents GE's assessment of lowering the analytical limit for low-low (L2) reactor water level from -49 inches to -57 inches. The current LOCA analysis (SAFER/GESTR) for PNPS considers an analytical limit of -56.9 inches. Thus, the analytical limit for this setpoint can be considered -56.9 inches relative to the reference 0 for reactor water level instrumentation. A final report will be available in 2 weeks time.

Distribution:

D. Richard
R. Kirven
P. Antonopoulos

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Calc. 25-226-C004
Att. 3
p. 2 of 4

GE Nuclear Energy

General Electric Company
175 Curtner Avenue, San Jose, CA 95125

LLC-55-91
November 12, 1991

Dr. Jim Gosnell
Boston Edison Company
25 Braintree Hill Office Park
Braintree, MA 02184

SUBJECT: Pilgrim Nuclear Power Station
Safety Evaluation for Changing the Analytical Limit
for Low-Low Reactor Water Level

REFERENCE: Telephone conversation between Petros Antonopolis, Jim Gosnell and Larry Chi, November 8, 1991.

Dear Dr. Gosnell:

In response to an urgent request from BECo, attached is a summary report for the justification for changing the analytical limit for low-low water level from its current -49 inches from instrument zero to -57 inches from instrument zero.

If you need further assistance on this subject, please call me at 408-925-3874.

Yours truly,

L. L. Chi, Principal Engineer
Plant Performance Engineering

General Electric Company
175 Curtner Avenue, San Jose, CA 95125

SUMMARY REPORT FOR JUSTIFICATION
TO LOWER THE ANALYTICAL LIMIT
FOR LOW-LOW WATER LEVEL
FOR PILGRIM NUCLEAR POWER STATION
(DRF A00-03983)

INTRODUCTION

This document provides a summary of the safety evaluation performed to justify lowering the analytical limit for the reactor low-low water level signal for Pilgrim Nuclear Power Station from its current -49 inches to -57 inches from instrument zero. The low-low reactor water level is used to provide the following safety functions:

a. Initiation of HPCI and RCIC systems.

b. Initiation of emergency diesel generators, LPCI and core spray systems.

c. Initiation of MSIV closure and isolation valves for drywell equipment drain.

d. Initiation of ADS bypass timer and contribute for ADS initiation.

e. Initiation of recirculation pump trip.

The impact of the changes in the analytical limits for the above functions for transients, LOCA, and other events are summarized as follows.

EVALUATION RESULTS

a. Transient Events - The proposed change would not have any adverse impact on the HPCI/RCIC initiation on the reactor low-low water level during a transient event. This is because the core will still be adequately covered and this change will not affect the MCPR of the fuel previously analyzed for Pilgrim. The recirculation pump trip at low-low water level is for equipment protection only. Therefore, the new analytical limit is not considered as a safety impact for this function.

b. LOCA Events - The effect of the new analytical limit for the low-low water level was evaluated in NEDC-31852P and the analysis results show that the delay in the ECCS/LOCA related functions, i.e., diesel generators, LPCI, core spray, MSIV isolation, and ADS for breaks inside primary containment will not have any impact on plant safety. The PCTs for the analyzed events are significantly lower than the Appendix K limit of 2200°F.

c. Breaks Outside Primary Containment - For breaks outside primary containment, the initiation of the ADS bypass timer on the low-low water level will be required. The impact of the new analytical limit for the low-low water level signal on the design basis event for the bypass timer, i.e., RWCU line break outside containment, has been evaluated and found to have an insignificant impact on the PCT. The 15 minute bypass timer is still valid for meeting the regulatory requirements.

d. Containment isolation functions - The change in the analytical limit for the other containment isolation functions, i.e., drywell equipment drain, will not have any adverse impact on plant safety. There will not be any increase in the radiological release because the isolation function will still occur with the core fully covered.

Therefore, it is concluded that the proposed change in the analytical limit for the low-low reactor water level will not have any adverse impact on plant safety.

Prepared by: [signature] 11/12/91
L. K. Chi, Principal Engineer
Plant Performance Engineering

Verified by: [signature]
K. Faynshtein, Engineer
Plant Performance Engineering

Approved by: C. H. Stoll for G. L. Sozzi
G. L. Sozzi, Manager
Plant Performance Engineering

BOSTON EDISON

NEDORANDUM

B.E.Co. Form X6604

w/plug/ Also w/ 90% G. McLaison input

To S. Dasgupta From W. Riggs Date 10/11/91

Subject: Reactor Vessel Thermal Growth Effect on Reactor Instrumentation

Replies to: N/A

CALC. 25-226-C004
ATT. 4
p. 1 of 4

References: I&CS #91-259

Reply Requested: No

Requested Date: N/A

Message: (Use attached sheets if required)

The maximum elevation change is less than a 1/2" increase of N15A&B above N16A&B for the conditions in the referenced memo. Actual changes for the different conditions are shown in the attachments. Results will be formalized in an FS&MC calculation.

Distribution:

FS&MC 91-176

☐ Nuclear Engineering Manager
☐ Field Engineering Section Manager
☒ Design Section Manager
☐ Licensing and Analysis Section Manager
(Specify others - NED only)

INFORMATION ONLY

Reactor Vessel Inlet Nozzle - Effect of Thermal Growth on Elevation

$\Delta L = \alpha \Delta T L$

El of Vessel Skirt Bottom = -15 7/8"
Ref Dwg E 232-334 from Combustion Vessel Report

El N15A+D = 547"
El N16A+B = 425 1/2"

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ATT. 4
p. 2 of 4

Ambient Min Temp = 60°F

Vessel Mat'l in ASTM A533 B-1
per Combustion Vessel Report
Ni Steel ≈ 8% Ni.

α = 7.3x10^-6 in/in/°F (4.9) for 10% Ni
Ref Table 12 Marks Handbook ~~7th Edition~~

Relative Growth 547-425.5
= 121.5"

73'-6 1/4" - 73'-4 3/4"
= 121.5"

ΔT_N 550 − 60 = 490 °F

ΔT_{AT_1} 570 − 60 = 510 °F

ΔT_{AT_2} 590 − 60 = 530 °F

$\Delta L_N = (490°)(121.5")(7.3 \times 10^{-6})$

= .435"

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ATT. 4
p. 3 of 4

$\Delta L_{AT_1} = (510)(121.5)(7.3 \times 10^{-6})$

= .452"

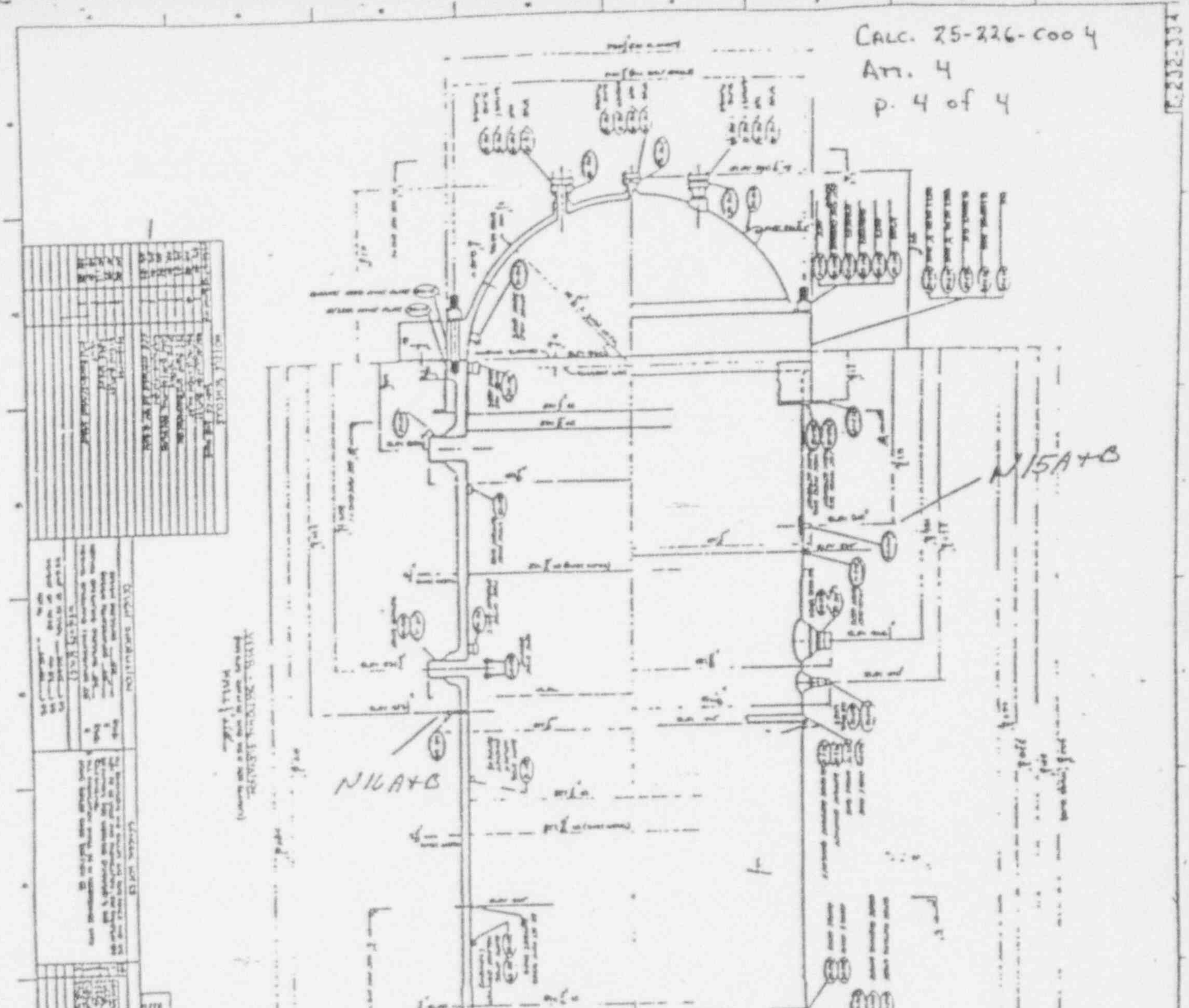
$\Delta L_{AT_2} = (530)(121.5)(7.3 \times 10^{-6})$

= .470"

Say 1/2" el increase of upper nozzle over lower nozzle due to thermal growth for worst case conditions

INFORMATION ONLY

CALC. 25-226-C004
Att. 4
p. 4 of 4



INFORMATION ONLY

ABB
ASEA BROWN BOVERI

Record of Conversation

File: 25-226

Copy: B. LOKSHIN

☒ Telephone ☐ Meeting ☐ Other

To: Jane Sanderstrom

From: Warren Hill (ABB Impell) WAH

Company: Rosemount

Phone No.: (612) 828-3286

Date: 1/20/93

Subject: Rosemount 710DU Slave Trip Unit Repeatability

Summary of Conversation:

Jane Sanderstrom provided the following clarification for the slave trip unit output repeatability formula provided in BECo Vendor Manual V-0243, Table 8 (Rosemount Instruction Manual 4471-1).

Per Table 8, the formula for slave trip unit repeatability is:

$$\text{Repeatability} = \pm 0.20\% (60^0 \text{ to } 90^0F) \pm 0.35\%/100^0F$$

The slave trip unit value includes the effect of the master trip unit, because the test signal passes through the normal master/slave trip unit signal processing configuration. Therefore, these values are used for the slave units, and no additional term for the master trip unit is required.

D-100

DATE	DATA STATUS	CAL. DATA "D"	CAL. DATA "I"	INT	REMARKS	RAW DATA SUM. "D"	RAW DATA SUM. "I"	1ST OUT. SUM. "D"	1ST OUT. SUM. "I"	2ND OUT. SUM. "D"	2ND OUT. SUM. "I"
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	AS LEFT	4.62									
9/5/87	AS FOUND	N/A		65	NO DATA						
	AS LEFT	N/A									
9/9/87	AS FOUND	4.64		4							
	AS LEFT	4.64									
10/16/87	AS FOUND	4.64		37							
	AS LEFT	4.64									
11/18/87	AS FOUND	4.65		139		0.1875%		OUTLIER		OUTLIER	
	AS LEFT	4.65									
11/30/87	AS FOUND	4.64		12							
	AS LEFT	4.64									
1/3/88	AS FOUND	4.65		116		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.65									
2/2/88	AS FOUND	4.65		109		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.65									
2/29/88	AS FOUND	4.64		103		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.64									
4/4/88	AS FOUND	4.64		126		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
5/3/88	AS FOUND	4.65		121		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.65									
6/1/88	AS FOUND	4.65		120		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.65									
8/18/88	AS FOUND	4.64		107		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.64									
9/22/88	AS FOUND	4.66		113		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.66									
10/21/88	AS FOUND	4.65		29							
	AS LEFT	4.65									
11/23/88	AS FOUND	4.65		33							
	AS LEFT	4.65									
12/23/88	AS FOUND	4.63		127		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.63									
1/22/89	AS FOUND	4.65		122		-0.0625%		-0.0625%		-0.0625%	

PREPARED BY: Richard D Georato 1/28/93

DATE	DATA STATUS	CAL. DATA "D"	CAL. DATA "I"	INT	REMARKS	RAW DATA SUM. "D"	RAW DATA SUM. "I"	1ST OUT. SUM. "D"	1ST OUT. SUM. "I"	2ND OUT. SUM. "D"	2ND OUT. SUM. "I"
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2/23/89	AS FOUND	4.64		125		-0.0625%		-0.0625%		-0.0625%	
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3/26/89	AS FOUND	4.64		123		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.64									
5/1/89	AS FOUND	4.64		129		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.64									
5/29/89	AS FOUND	4.64		127		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.64									
7/3/89	AS FOUND	4.64		130		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
8/4/89	AS FOUND	4.64		131		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
8/31/89	AS FOUND	4.64		122		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
10/4/89	AS FOUND	4.65		128		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.65									
10/31/89	AS FOUND	4.64		120		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
12/4/89	AS FOUND	4.65		122		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.65									
1/1/90	AS FOUND	4.65		123		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.65									
2/2/90	AS FOUND	4.64		121		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.64									
3/6/90	AS FOUND	4.65		126		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.65									
3/29/90	AS FOUND	4.65		115		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.65									
4/30/90	AS FOUND	4.65		119		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.65									
5/30/90	AS FOUND	4.65		117		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.65									
6/28/90	AS FOUND	4.65		114		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.65									

D-101

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9/1/90	AS FOUND	4.65		124		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.65									
10/2/90	AS FOUND	4.64		125		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.64									
11/1/90	AS FOUND	4.65		126		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.65									
12/5/90	AS FOUND	4.64		132		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.64									
1/4/91	AS FOUND	4.64		125		-0.0625%		-0.0625%		-0.0625%	
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2/6/91	AS FOUND	4.65		127		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.65									
3/12/91	AS FOUND	4.64		131		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.64									
4/11/91	AS FOUND	4.64		127		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
5/18/91	AS FOUND	4.64		134		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
6/18/91	AS FOUND	4.64		132		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.64									
7/24/91	AS FOUND	4.64		134		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
8/25/91	AS FOUND	4.64		138		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
9/13/91	AS FOUND	4.64		118		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
10/17/91	AS FOUND	4.65		121		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.65									
11/25/91	AS FOUND	4.64		124		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
12/10/91	AS FOUND	4.65		107		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.65									
1/14/92	AS FOUND	4.66		123		0.1250%		0.1250%		0.1250%	

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2/25/92	AS FOUND	4.64		131		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.64									
3/25/92	AS FOUND	4.64		121		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
4/29/92	AS FOUND	4.65		141		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.65									
5/28/92	AS FOUND	4.64		135		-0.1250%		-0.1250%		-0.1250%	
	AS LEFT	4.64									
6/19/92	AS FOUND	4.64		115		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
7/22/92	AS FOUND	4.65		119		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.65									
8/20/92	AS FOUND	4.64		113		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.64									
					AVERAGE	0.0012%		-0.0024%		-0.0024%	
					STD DEV.	0.0581%		0.0525%		0.0525%	
					COUNT	53		52		52	
					% OF ORIGINAL DATA POINTS			98%		98%	
					95%/95% TOL. INT. AS % CS			0.13%		0.13%	
					BIAS FLAG			NO BIAS		NO BIAS	

D-103

DATE	DATA STATUS	CAL. DATA "D"	CAL. DATA "I"	INT	REMARKS	RAW DATA SUM. "D"	RAW DATA SUM. "I"	1ST OUT. SUM. "D"	1ST OUT. SUM. "I"	2ND OUT. SUM. "D"	2ND OUT. SUM. "I"
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	AS LEFT	4.62									
9/6/87	AS FOUND	N/A		62	NO DATA						
	AS LEFT	N/A									
9/11/87	AS FOUND	4.64		67							
	AS LEFT	4.64									
10/20/87	AS FOUND	4.64		39							
	AS LEFT	4.64									
11/19/87	AS FOUND	4.64		136		0.1250%		0.1250%		0.1250%	
	AS LEFT	4.64									
12/14/87	AS FOUND	4.64		25							
	AS LEFT	4.64									
1/4/88	AS FOUND	4.64		115		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
2/4/88	AS FOUND	4.64		107		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
3/6/88	AS FOUND	4.65		108		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.65									
4/6/88	AS FOUND	4.64		114		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
5/5/88	AS FOUND	4.65		122		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.65									
6/8/88	AS FOUND	4.64		125		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
7/20/88	AS FOUND	N/A		42	NO DATA						
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8/8/88	AS FOUND	4.64		124		0.0000%		0.0000%		0.0000%	
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9/7/88	AS FOUND	4.64		125		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.64									
10/16/88	AS FOUND	4.64		130		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
11/17/88	AS FOUND	4.64		32							
	AS LEFT	4.64									
12/16/88	AS FOUND	4.64		130		0.0000%		0.0000%		0.0000%	

D-104

PREPARED BY: Richard D. Geronto 1/28/93

CHECKED BY: John W. Rill 1/28/93

DATE	DATA STATUS	CAL. DATA "D"	CAL. DATA "I"	INT	REMARKS	RAW DATA SUM. "D"	RAW DATA SUM. "I"	1ST OUT. SUM. "D"	1ST OUT. SUM. "I"	2ND OUT. SUM. "D"	2ND OUT. SUM. "I"
	AS LEFT	4.64									
1/14/89	AS FOUND	4.64		129		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
2/14/89	AS FOUND	4.65		121		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.65									
3/14/89	AS FOUND	4.64		117		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
4/22/89	AS FOUND	4.64		127		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
5/24/89	AS FOUND	4.64		130		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
6/21/89	AS FOUND	4.63		127		-0.1250%		-0.1250%		-0.1250%	
	AS LEFT	4.63									
7/24/89	AS FOUND	4.64		132		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
8/28/89	AS FOUND	4.64		128		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
9/29/89	AS FOUND	4.64		128		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
10/17/89	AS FOUND	4.64		118		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.64									
11/21/89	AS FOUND	4.65		120		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.65									
1/23/90	AS FOUND	4.64		148		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
3/24/90	AS FOUND	4.64		123		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.64									
5/25/90	AS FOUND	4.64		122		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
6/27/90	AS FOUND	4.64		33							
	AS LEFT	4.64									
7/26/90	AS FOUND	4.64		124		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
2/4/91	AS FOUND	4.64		193		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									

D-105

DATE	DATA STATUS	CAL. DATA "D"	CAL. DATA "I"	INT	REMARKS	RAW DATA SUM. "D"	RAW DATA SUM. "I"	1ST OUT. SUM. "D"	1ST OUT. SUM. "I"	2ND OUT. SUM. "D"	2ND OUT. SUM. "I"
3/7/91	AS FOUND	4.65		31							
	AS LEFT	4.65									
4/9/91	AS FOUND	4.63		33							
	AS LEFT	4.63									
5/8/91	AS FOUND	4.63		29							
	AS LEFT	4.63									
6/17/91	AS FOUND	4.63		133		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.63									
7/24/91	AS FOUND	4.63		139		-0.1250%		-0.1250%		-0.1250%	
	AS LEFT	4.63									
8/25/91	AS FOUND	4.64		138		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.64									
9/23/91	AS FOUND	4.63		138		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.63									
10/24/91	AS FOUND	4.63		129		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.63									
11/29/91	AS FOUND	4.64		128		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.64									
12/20/91	AS FOUND	4.64		117		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
1/23/92	AS FOUND	4.63		122		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.63									
2/28/92	AS FOUND	4.64		127		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.64									
3/27/92	AS FOUND	4.63		119		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.63									
4/30/92	AS FOUND	4.64		132		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
6/3/92	AS FOUND	4.64		132		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.64									
6/24/92	AS FOUND	4.64		117		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
7/20/92	AS FOUND	4.64		115		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.64									
8/20/92	AS FOUND	4.63		112		-0.0625%		-0.0625%		-0.0625%	

D-106

LIS263-72B 120 DAY DRIFT DATA (SLIDING FILTER)

DATE	DATA STATUS	CAL. DATA "D"	CAL. DATA "I"	INT	REMARKS	RAW DATA SUM. "D"	RAW DATA SUM. "I"	1ST OUT. SUM. "D"	1ST OUT. SUM. "I"	2ND OUT. SUM. "D"	2ND OUT. SUM. "I"
	AS LEFT	4.63									
9/22/92	AS FOUND	4.63		111		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.63									
10/20/92	AS FOUND	4.63		118		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.63									
					AVERAGE	0.0014%		0.0014%		0.0014%	
					STD DEV.	0.0513%		0.0513%		0.0513%	
					COUNT	44		44		44	
					% OF ORIGINAL DATA POINTS			100%		100%	
					95%/95% TOL. INT. AS % CS			0.13%		0.13%	
					BIAS FLAG			NO BIAS		NO BIAS	

D-107

LIS263-72C 120 DAY DRIFT DATA (SLIDING FILTER)

DATE	DATA STATUS	CAL. DATA "D"	CAL. DATA "I"	INT	REMARKS	RAW DATA SUM. "D"	RAW DATA SUM. "I"	1ST OUT. SUM. "D"	1ST OUT. SUM. "I"	2ND OUT. SUM. "D"	2ND OUT. SUM. "I"
7/2/87	AS FOUND	N/A			INITIAL CALIBRATION						
	AS LEFT	4.65									
9/5/87	AS FOUND	N/A		65	NO DATA						
	AS LEFT	N/A									
9/9/87	AS FOUND	4.64		69							
	AS LEFT	4.64									
10/17/87	AS FOUND	4.63		38							
	AS LEFT	4.63									
11/18/87	AS FOUND	4.64		139		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.64									
12/1/87	AS FOUND	4.63		13							
	AS LEFT	4.63									
1/3/88	AS FOUND	4.64		116		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
2/2/88	AS FOUND	4.65		108		0.1250%		0.1250%		0.1250%	
	AS LEFT	4.65									
3/1/88	AS FOUND	4.64		104		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
4/4/88	AS FOUND	4.64		125		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.64									
5/3/88	AS FOUND	4.65		121		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.65									
6/1/88	AS FOUND	4.63		120		-0.1250%		-0.1250%		-0.1250%	
	AS LEFT	4.63									
8/18/88	AS FOUND	4.64		136		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
9/22/88	AS FOUND	4.65		142		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.65									
10/21/88	AS FOUND	4.64		142		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.64									
11/23/88	AS FOUND	4.64		33							
	AS LEFT	4.64									
12/23/88	AS FOUND	4.63		127		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.63									
1/22/89	AS FOUND	4.65		122		0.0000%		0.0000%		0.0000%	

PREPARED BY: Richard D. Georote 1/28/93

CHECKED BY: John W. Riell 1/28/93

DATE	DATA STATUS	CAL. DATA "D"	CAL. DATA "I"	INT	REMARKS	RAW DATA SUM. "D"	RAW DATA SUM. "I"	1ST OUT. SUM. "D"	1ST OUT. SUM. "I"	2ND OUT. SUM. "D"	2ND OUT. SUM. "I"
	AS LEFT	4.65									
2/23/89	AS FOUND	4.64		125		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
3/26/89	AS FOUND	4.64		123		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
5/1/89	AS FOUND	4.64		129		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.64									
5/29/89	AS FOUND	4.63		127		-0.1250%		-0.1250%		-0.1250%	
	AS LEFT	4.63									
7/3/89	AS FOUND	4.64		130		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
8/4/89	AS FOUND	4.64		131		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
8/31/89	AS FOUND	4.64		122		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
10/4/89	AS FOUND	4.64		128		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.64									
10/31/89	AS FOUND	4.64		120		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
12/4/89	AS FOUND	4.64		122		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
1/1/90	AS FOUND	4.64		123		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
2/2/90	AS FOUND	4.64		121		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
3/6/90	AS FOUND	4.64		126		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
3/29/90	AS FOUND	4.64		115		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
4/30/90	AS FOUND	4.64		119		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
5/30/90	AS FOUND	4.64		117		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
6/28/90	AS FOUND	4.64		114		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									

DATE	DATA STATUS	CAL. DATA "D"	CAL. DATA "I"	INT	REMARKS	RAW DATA SUM. "D"	RAW DATA SUM. "I"	1ST OUT. SUM. "D"	1ST OUT. SUM. "I"	2ND OUT. SUM. "D"	2ND OUT. SUM. "I"
7/26/90	AS FOUND	4.64		119		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
9/1/90	AS FOUND	4.64		124		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
10/2/90	AS FOUND	4.63		125		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.63									
11/1/90	AS FOUND	4.64		126		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
12/5/90	AS FOUND	4.63		132		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.63									
1/4/91	AS FOUND	4.63		125		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.63									
2/6/91	AS FOUND	4.64		127		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.64									
3/12/91	AS FOUND	4.63		131		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.63									
4/11/91	AS FOUND	4.63		127		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.63									
5/18/91	AS FOUND	4.63		134		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.63									
6/16/91	AS FOUND	4.64		130		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
7/24/91	AS FOUND	4.63		134		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.63									
8/25/91	AS FOUND	4.63		136		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.63									
9/13/91	AS FOUND	4.63		118		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.63									
10/17/91	AS FOUND	4.63		123		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.63									
11/25/91	AS FOUND	4.64		124		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.64									
12/10/91	AS FOUND	4.64		107		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.64									
1/14/92	AS FOUND	4.65		123		0.1250%		0.1250%		0.1250%	

LIS263-72C 120 DAY DRIFT DATA (SLIDING FILTER)

DATE	DATA STATUS	CAL. DATA "D"	CAL. DATA "I"	INT	REMARKS	RAW DATA SUM. "D"	RAW DATA SUM. "I"	1ST OUT. SUM. "D"	1ST OUT. SUM. "I"	2ND OUT. SUM. "D"	2ND OUT. SUM. "I"
	AS LEFT	4.65									
1/23/92	AS FOUND	4.64		9							
	AS LEFT	4.64									
2/24/92	AS FOUND	4.63		130		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.63									
3/25/92	AS FOUND	4.64		121		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
4/29/92	AS FOUND	4.64		141		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
5/28/92	AS FOUND	4.64		135		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.64									
6/19/92	AS FOUND	4.64		116		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.64									
7/22/92	AS FOUND	4.63		119		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.63									
8/20/92	AS FOUND	4.64		113		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
					AVERAGE	0.0000%		0.0000%		0.0000%	
					STD DEV.	0.0501%		0.0501%		0.0501%	
					COUNT	54		54		54	
					% OF ORIGINAL DATA POINTS			100%		100%	
					95%/95% TOL. INT. AS % CS			0.12%		0.12%	
					BIAS FLAG			NO BIAS		NO BIAS	

D-111

DATE	DATA STATUS	CAL. DATA "D"	CAL. DATA "I"	INT	REMARKS	RAW DATA SUM. "D"	RAW DATA SUM. "I"	1ST OUT. SUM. "D"	1ST OUT. SUM. "I"	2ND OUT. SUM. "D"	2ND OUT. SUM. "I"
7/6/87	AS FOUND	N/A			INITIAL CALIBRATION						
	AS LEFT	4.61									
9/6/87	AS FOUND	N/A		62	NO DATA						
	AS LEFT	N/A									
9/11/87	AS FOUND	4.62		67							
	AS LEFT	4.63									
10/21/87	AS FOUND	4.64		40							
	AS LEFT	4.64									
11/19/87	AS FOUND	4.64		29							
	AS LEFT	4.64									
12/14/87	AS FOUND	4.64		25							
	AS LEFT	4.64									
1/4/88	AS FOUND	4.64		115		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.64									
2/4/88	AS FOUND	4.64		106		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
3/6/88	AS FOUND	4.63		108		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.63									
4/6/88	AS FOUND	4.63		114		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.63									
5/6/88	AS FOUND	4.64		123		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
6/8/88	AS FOUND	4.64		125		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
7/20/88	AS FOUND	N/A		42	NO DATA						
	AS LEFT	N/A									
8/8/88	AS FOUND	4.64		124		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.64									
9/7/88	AS FOUND	4.64		124		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
10/16/88	AS FOUND	4.64		130		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
11/18/88	AS FOUND	4.64		33							
	AS LEFT	4.64									
12/16/88	AS FOUND	4.64		130		0.0000%		0.0000%		0.0000%	

D-112

PREPARED BY: Richard D. Georato 1/28/93
CHECKED BY: John W. Riell 1/28/93

DATE	DATA STATUS	CAL. DATA "D"	CAL. DATA "I"	INT	REMARKS	RAW DATA SUM. "D"	RAW DATA SUM. "I"	1ST OUT. SUM. "D"	1ST OUT. SUM. "I"	2ND OUT. SUM. "D"	2ND OUT. SUM. "I"
	AS LEFT	4.64									
1/14/89	AS FOUND	4.64		129		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
2/14/89	AS FOUND	4.63		121		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.63									
3/17/89	AS FOUND	4.64		119		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
4/22/89	AS FOUND	4.64		127		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
5/24/89	AS FOUND	4.64		130		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
6/21/89	AS FOUND	4.64		127		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.64									
7/24/89	AS FOUND	4.64		129		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
8/28/89	AS FOUND	4.64		128		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
9/29/89	AS FOUND	4.63		128		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.63									
10/18/89	AS FOUND	4.63		119		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.63									
11/23/89	AS FOUND	4.63		122		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.63									
12/21/89	AS FOUND	4.64		115		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
1/23/90	AS FOUND	4.63		116		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.63									
2/24/90	AS FOUND	4.64		129		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.64									
3/25/90	AS FOUND	4.63		122		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.63									
4/8/90	AS FOUND	N/A		14	NO DATA						
	AS LEFT	N/A									
4/25/90	AS FOUND	4.64		125		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									

D-113

D-114

DATE	DATA STATUS	CAL. DATA "D"	CAL. DATA "I"	INT	REMARKS	RAW DATA SUM. "D"	RAW DATA SUM. "I"	1ST OUT. SUM. "D"	1ST OUT. SUM. "I"	2ND OUT. SUM. "D"	2ND OUT. SUM. "I"
5/25/90	AS FOUND	4.63		122		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.63									
6/27/90	AS FOUND	4.64		123		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
7/26/90	AS FOUND	4.63		123		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.63									
8/28/90	AS FOUND	4.64		125		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
9/29/90	AS FOUND	4.63		127		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.63									
10/29/90	AS FOUND	4.63		124		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.63									
11/28/90	AS FOUND	4.64		125		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.64									
1/2/91	AS FOUND	4.62		127		-0.1250%		-0.1250%		-0.1250%	
	AS LEFT	4.62									
2/4/91	AS FOUND	4.64		128		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.64									
3/7/91	AS FOUND	4.64		129		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.64									
4/9/91	AS FOUND	4.63		132		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.63									
5/8/91	AS FOUND	4.63		126		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.63									
6/17/91	AS FOUND	4.63		133		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.63									
7/25/91	AS FOUND	4.62		140		-0.1250%		-0.1250%		-0.1250%	
	AS LEFT	4.62									
8/25/91	AS FOUND	4.64		138		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.64									
9/23/91	AS FOUND	4.63		138		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.63									
10/24/91	AS FOUND	4.63		129		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.63									
11/29/91	AS FOUND	4.63		127		0.0625%		0.0625%		0.0625%	

DATE	DATA STATUS	CAL. DATA "D"	CAL. DATA "I"	INT	REMARKS	RAW DATA SUM. "D"	RAW DATA SUM. "I"	1ST OUT. SUM. "D"	1ST OUT. SUM. "I"	2ND OUT. SUM. "D"	2ND OUT. SUM. "I"
	AS LEFT	4.63									
12/20/91	AS FOUND	4.64		117		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
1/23/92	AS FOUND	4.63		122		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.63									
2/28/92	AS FOUND	4.64		127		0.0625%		0.0625%		0.0625%	
	AS LEFT	4.64									
3/27/92	AS FOUND	4.63		119		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.63									
4/30/92	AS FOUND	4.63		132		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.63									
6/3/92	AS FOUND	4.63		132		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.63									
6/24/92	AS FOUND	4.64		117		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.64									
7/20/92	AS FOUND	4.63		115		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.63									
8/21/92	AS FOUND	4.63		113		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.63									
9/22/92	AS FOUND	4.63		111		0.0000%		0.0000%		0.0000%	
	AS LEFT	4.63									
10/20/92	AS FOUND	4.63		118		-0.0625%		-0.0625%		-0.0625%	
	AS LEFT	4.63									
					AVERAGE	-0.0045%		-0.0045%		-0.0045%	
					STD DEV.	0.0464%		0.0464%		0.0464%	
					COUNT	55		55		55	
					% OF ORIGINAL DATA POINTS			100%		100%	
					95%/95% TOL. INT. AS % CS			0.11%		0.11%	
					BIAS FLAG			NO BIAS		NO BIAS	

D-115

LIS263-72A

THU 1/14/93 11:37:15 AM C:\SYSTATW5\BECO1ST\LIS72A3.SYS
OCESSING C:\SYSTATW5\CMD1ST\C004.CMD

TOTAL OBSERVATIONS: 52

	DRIFT
N OF CASES	52
MINIMUM	-0.1250
MAXIMUM	0.1250
MEAN	-0.0024
STANDARD DEV	0.0525
SKEWNESS(G1)	0.0719
KURTOSIS(G2)	-0.5818

THU 1/14/93 11:37:18 AM C:\SYSTATW5\BECO1ST\LIS72A3.SYS
PROCESSING C:\SYSTATW5\CMD1ST\C004.CMD

DEP VAR: DRIFT N: 52 MULTIPLE R: 0.193 SQUARED MULTIPLE R: 0.037
ADJUSTED SQUARED MULTIPLE R: .018 STANDARD ERROR OF ESTIMATE: 0.0520

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	0.1557	0.1140	0.0000	.	1.3664	0.1779
INT	-0.0013	0.0009	-0.1929	1.0000	-1.3903	0.1706

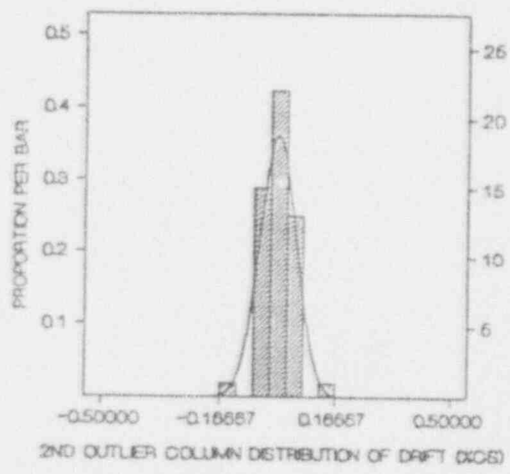
ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.0052	1	0.0052	1.9329	0.1706
RESIDUAL	0.1351	50	0.0027		

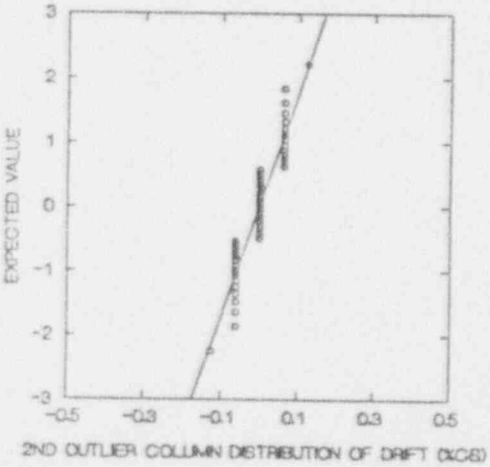
PREPARED BY: Richard D. Georato 1/28/93

CHECKED BY: John W. Riell 1/28/93

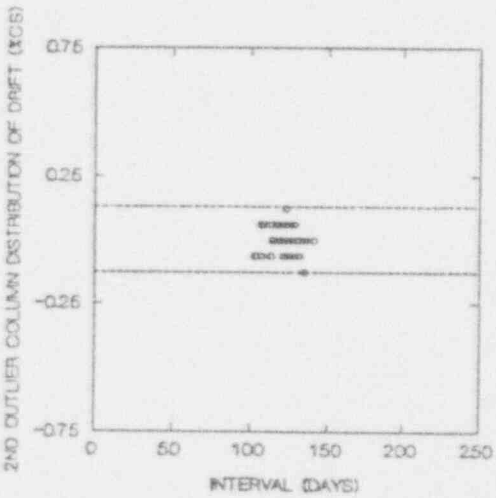
LIS263-72A CALIBRATION HISTOGRAM



LIS263-72A PROBABILITY PLOT



LIS263-72A CALIBRATION POINT 95/95% TOL. INT.



LIS263-72B

THU 1/14/93 11:41:48 AM C:\SYSTATW5\BECO1ST\LIS72B3.SYS
PROCESSING C:\SYSTATW5\CMD1ST\C004.CMD

TOTAL OBSERVATIONS: 44

	DRIFT
N OF CASES	44
MINIMUM	-0.1250
MAXIMUM	0.1250
MEAN	0.0014
STANDARD DEV	0.0513
SKEWNESS(G1)	-0.2967
KURTOSIS(G2)	0.4346

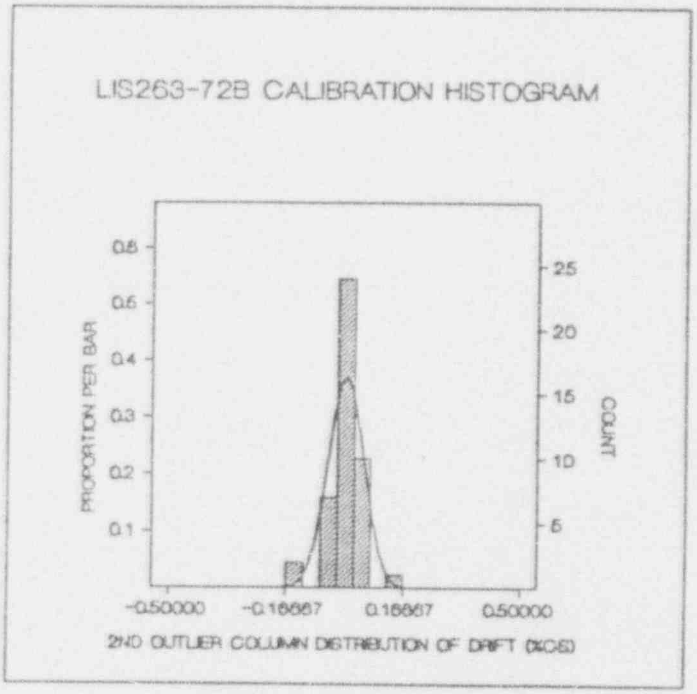
THU 1/14/93 11:41:51 AM C:\SYSTATW5\BECO1ST\LIS72B3.SYS
PROCESSING C:\SYSTATW5\CMD1ST\C004.CMD

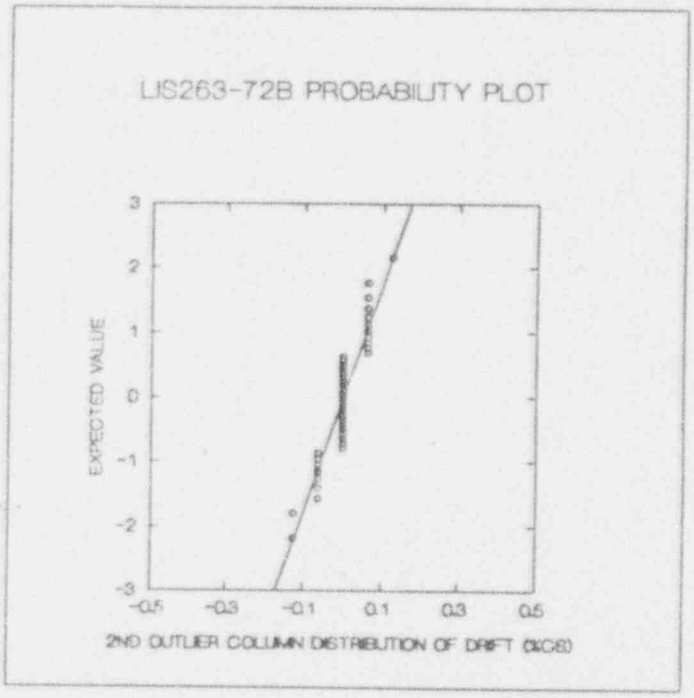
DEP VAR: DRIFT N: 44 MULTIPLE R: 0.004 SQUARED MULTIPLE R: 0.000
ADJUSTED SQUARED MULTIPLE R: .000 STANDARD ERROR OF ESTIMATE: 0.0519

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	-0.0005	0.0745	0.0000	.	-0.0062	0.9951
INT	0.0000	0.0006	0.0039	1.0000	0.0254	0.9799

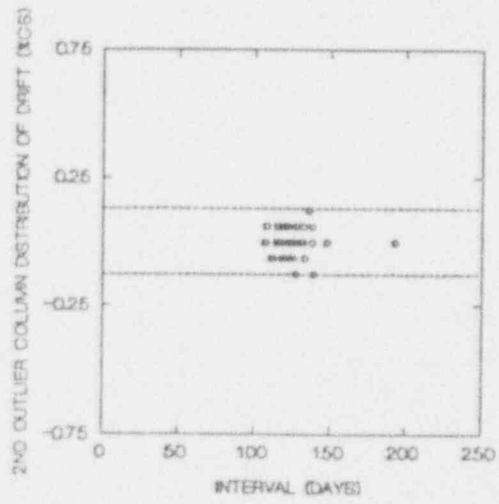
ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.0000	1	0.0000	0.0006	0.9799
RESIDUAL	0.1132	42	0.0027		


LIS263-72B CALIBRATION HISTOGRAM
0.6
0.5
0.4
0.3
0.2
0.1
PROPORTION PER BAR
25
20
15
10
5
COUNT
-0.50000
-0.16667
0.16667
0.50000
2ND OUTLIER COLUMN DISTRIBUTION OF DRIFT (%CS)


LIS263-72B PROBABILITY PLOT
EXPECTED VALUE
3
2
1
0
-1
-2
-3
-0.5
-0.3
-0.1
0.1
0.3
0.5
2ND OUTLIER COLUMN DISTRIBUTION OF DRIFT (%CS)

LIS263-72B CALIBRATION POINT 95/95% TOL. INT.



LIS263-72C

THU 1/14/93 11:47:00 AM C:\SYSTATW5\BECO1ST\LIS72C3.SYS
OCESSING C:\SYSTATW5\CMD1ST\C004.CMD

TOTAL OBSERVATIONS: 54

	DRIFT
N OF CASES	54
MINIMUM	-0.1250
MAXIMUM	0.1250
MEAN	0.0000
STANDARD DEV	0.0501
SKEWNESS(G1)	0.0000
KURTOSIS(G2)	0.8304

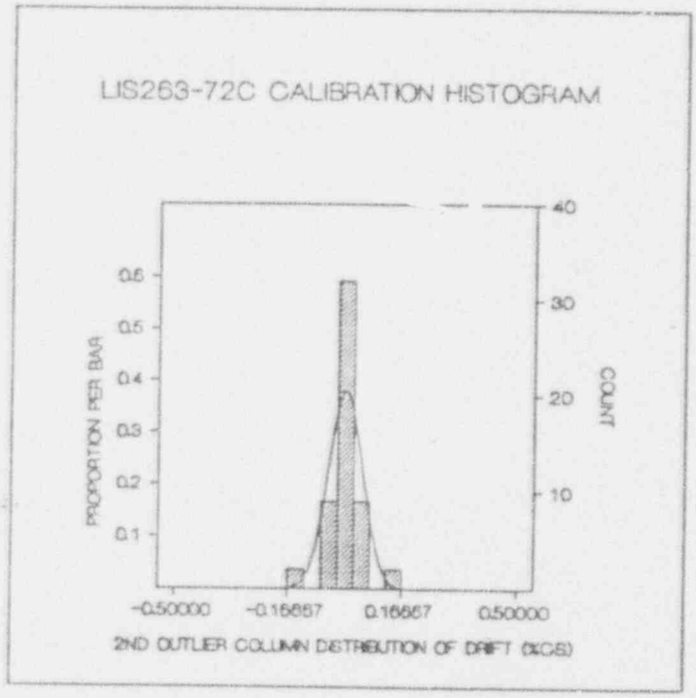
THU 1/14/93 11:47:03 AM C:\SYSTATW5\BECO1ST\LIS72C3.SYS
PROCESSING C:\SYSTATW5\CMD1ST\C004.CMD

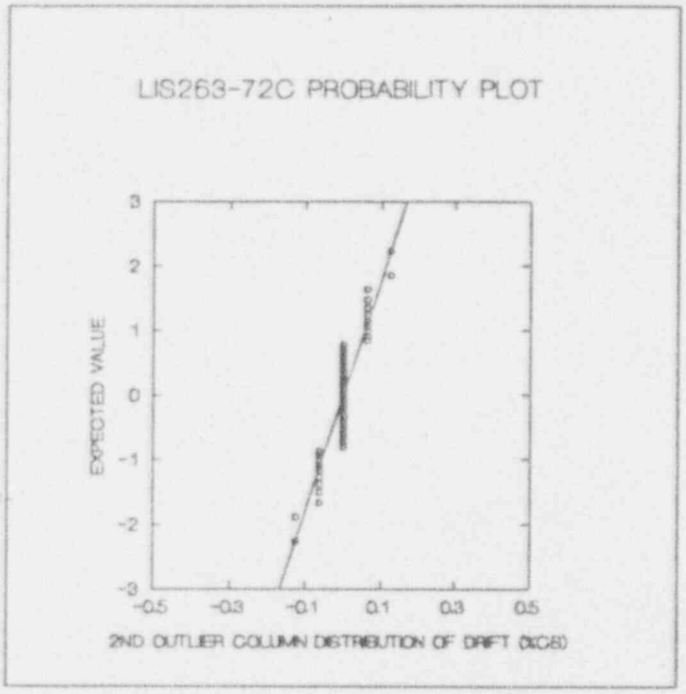
DEP VAR: DRIFT N: 54 MULTIPLE R: 0.194 SQUARED MULTIPLE R: 0.038
ADJUSTED SQUARED MULTIPLE R: .019 STANDARD ERROR OF ESTIMATE: 0.0496

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
ONSTANT	0.1448	0.1017	0.0000	.	1.4244	0.1603
INT	-0.0012	0.0008	-0.1942	1.0000	-1.4275	0.1594

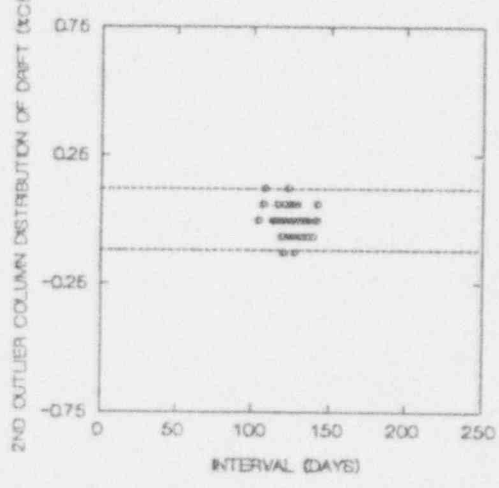
ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.0050	1	0.0050	2.0378	0.1594
RESIDUAL	0.1278	52	0.0025		


LIS263-72C CALIBRATION HISTOGRAM
PROPORTION PER BAR
0.1
0.2
0.3
0.4
0.5
0.6
COUNT
10
20
30
40
-0.50000
-0.16667
0.16667
0.50000
2ND OUTLIER COLUMN DISTRIBUTION OF DRIFT (%CS)


LIS263-72C PROBABILITY PLOT
EXPECTED VALUE
2ND OUTLIER COLUMN DISTRIBUTION OF DRIFT (%CS)
3
2
1
0
-1
-2
-3
-0.5
-0.3
-0.1
0.1
0.3
0.5

LIS263-72C CALIBRATION POINT 95/95% TOL. INT.



LIS263-72D

THU 1/14/93 11:52:16 AM C:\SYSTATW5\BECO1ST\LIS72D3.SYS
ROCESSING C:\SYSTATW5\CMD1ST\C004.CMD

TOTAL OBSERVATIONS: 55

	DRIFT
N OF CASES	55
MINIMUM	-0.1250
MAXIMUM	0.0625
MEAN	-0.0045
STANDARD DEV	0.0464
SKEWNESS(G1)	-0.4349
KURTOSIS(G2)	0.1339

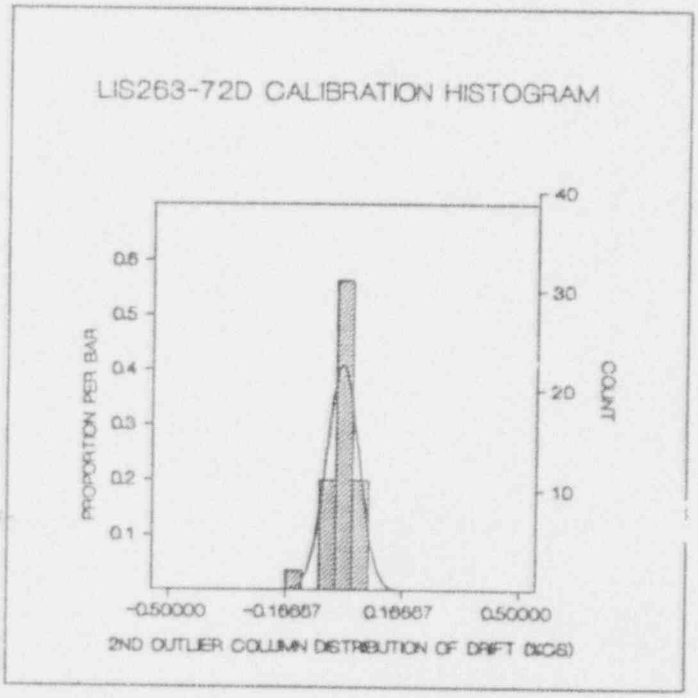
THU 1/14/93 11:52:18 AM C:\SYSTATW5\BECO1ST\LIS72D3.SYS
PROCESSING C:\SYSTATW5\CMD1ST\C004.CMD

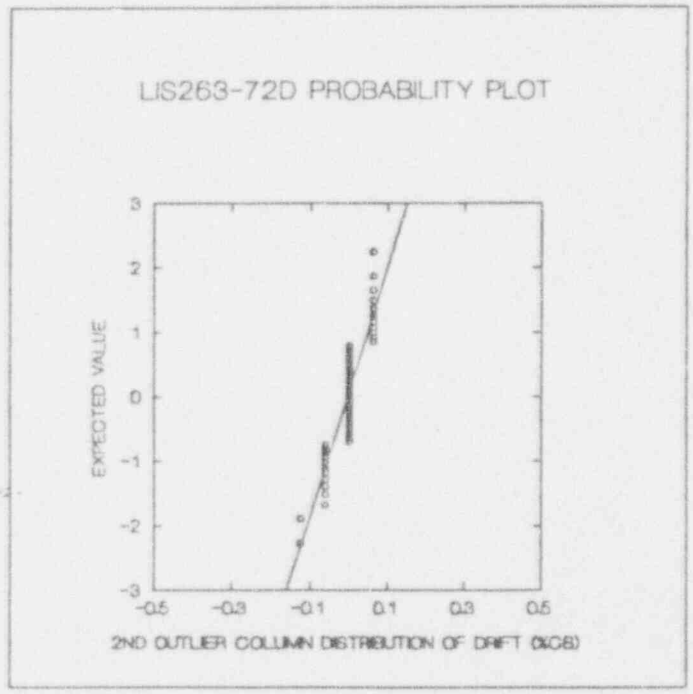
DEP VAR: DRIFT N: 55 MULTIPLE R: 0.022 SQUARED MULTIPLE R: 0.000
ADJUSTED SQUARED MULTIPLE R: .000 STANDARD ERROR OF ESTIMATE: 0.0468

VARIABLE	COEFFICIENT	STD ERROR	STD COEF	TOLERANCE	T	P(2 TAIL)
CONSTANT	-0.0221	0.1103	0.0000	.	-0.2004	0.8419
INT	0.0001	0.0009	0.0219	1.0000	0.1595	0.8739

ANALYSIS OF VARIANCE

SOURCE	SUM-OF-SQUARES	DF	MEAN-SQUARE	F-RATIO	P
REGRESSION	0.0001	1	0.0001	0.0254	0.8739
RESIDUAL	0.1160	53	0.0022		


LIS263-72D CALIBRATION HISTOGRAM
PROPORTION PER BAR
COUNT
2ND OUTLIER COLUMN DISTRIBUTION OF DRIFT (%CS)


LIS263-72D PROBABILITY PLOT
EXPECTED VALUE
3
2
1
0
-1
-2
-3
-0.5
-0.3
-0.1
0.1
0.3
0.5
2ND OUTLIER COLUMN DISTRIBUTION OF DRIFT (%CS)

LIS263-72D CALIBRATION POINT 95/95% TOL. INT.