ATTACHMENT

Additional Information Supporting the Request for License Amendment
Related to 24-Month Fuel Cycle

Appendix B

Clinton Power Station
Setpoint Calculation IP-C-0059

CALCULATION COVER SHEET

C	NSED	IP-C-0059	0	---	A
DEPT	DIV	CALCULATION NO	REVISION	ADDENDUM	VOLUME

TITLE: SETPOINT CALCULATION FOR RPV LEVEL 3 AND LEVEL 8 (NR); TRANSMITTER 1B21N095A,B

SIGNATURE BLOCK

PREPARED BY C. W. HALLETT (PRINT) Assignment Card
7/18/01 (DATE) [signature] 2001-07-01 (SIGNATURE)

CHECKED BY J. M. ASHCRAFT (PRINT) Assignment Card
7/18/01 (DATE) [signature] 2001-05-02 (SIGNATURE)

REVIEWED BY J. M. ASHCRAFT (PRINT) Assignment Card
7/18/01 (DATE) [signature] 2001-05-02 (SIGNATURE)

APPROVED BY P. R. MARCUM (PRINT)
7/18/01 (DATE) [signature] (SIGNATURE)

OWNER'S REVIEW NON-CPS CALC

REVIEWED BY ______ (PRINT)
__/__/__ (DATE) N/A (SIGNATURE)

CORP PREPARED THIS CALC: CPS — QUALITY RELATED: YES ✓ NO ☐

CONFIRMATION REQUIRED

YES/NO: NO — PAGE NO(S): ______ — CONFIRMED: ☐

Field Work To Be Performed Per ECN Listed Below

ECN NO	DESIGN RELEASED DATE	CID UPDATED
~~333801~~ and 12263		
AR 400278-01-02		
AR 78721-01		

ECN's listed above shall include "Volume Report" as Affected Documents.

READY FOR INCORPORATION

YES/NO/(N/A): NO — ASSIGNED TO: A — DATE RFI: ______

COMMENTS:
AR 400278-01-02 is to delete LDI 99-02
AR 78721-01 is to revise the ORM

NF-161.01-1 R/0 (02/99)

ACN 1/1

CALCULATION BATCH LIST

(May use computer print out and attach it with cover sheet or specify it's location if provided elsewhere in the calculation.)

IS THIS A PARENT CALC: YES ✓ NO ☐

DEPENDENT CALCULATIONS (Enter either a Parent, Revision, Alias, Addendum or Volume in the relationship column)

#	RELATIONSHIP	DEPT	DIV	CALCULATION NO	REV	ADD	VOL	STATUS BEFORE	STATUS AFTER
1	PARENT	C	NSED	IP-C-0059	0	---	---	U	A

IMPACTED CALCULATIONS (Enter either an Input, Output, Supplements, or Supersedes in the relationship column)

#	RELATIONSHIP	DEPT	DIV	CALCULATION NO	REV	ADD	VOL	STATUS BEFORE	STATUS AFTER
1	INPUT	C	NSED	IP-C-0089	0	---	---	A	A

REFERENCED CALCULATIONS (Not included as Dependent or Impacted Calculations. Enter Referenced in the relationship column)

ACN 1/1

#	RELATIONSHIP	DEPT	DIV	CALCULATION NO	REV	ADD	VOL

CALCULATION COVER SHEET (Continued)

DEPT	DIV	CALCULATION NO	REVISION	ADDENDUM	VOLUME
C	NSED	IP-C-0059	0	---	A

System Code(s) (or NA): NB

Equipment Identification No. (EINs) (or NA): 1B21N095A,B; 1B21N693A,B; 1B21N695A,B

Support Number(s) (or NA): NA Location (Bldg/Elev/Area (or NA): NA

Historic ☐ Microfiche Attached: Yes ☐ No ☑ Topic Code: M98

Temporary: ☐

ACN 1/1

NON-CALC INPUTS/OUTPUTS/REFERENCES

(Specify the Location, if provided elsewhere in the calculation)
(Identify in Relationship Column)

#	DOC TYPE	DOC NO	SHT NO	REV NO	DATE	DESCRIPTION	Relation-ship (I,O,R)
						SECTION 4	I
						SECTION 5	O
						SECTION 6	R

REVISION HISTORY

C NSED IP-C-0059 0 --- A

DEPT DIV CALCULATION NO REVISION ADDENDUM VOLUME

REVISION OBJECTIVE: ORIGINAL CALCULATION

WHAT INITIATED CHANGE: NA

AFFECTED PAGES: NA

Note: Preparer provide explicit instructions for volume/Addendum Calculations to be Incorporated using "Administrative Revisions".

NF-161.01-4 R/0 (02/99)

TABLE OF CONTENTS

1.0 OBJECTIVE

1.1 Determine the instrument uncertainty, setpoint and Allowable Value for the Reactor Pressure Vessel (RPV) Level Narrow Range (NR) instrumentation. This includes transmitters 1B21N095A,B: Level 3 & Level 8 trip units 1B21N695A,B: and 1B21N693A,B respectively.

1.2 This calculation evaluates the adequacy of the current setpoints in relationship to the results of 1.1 above.

1.3 The setpoint for RPV Level 3 was originally calculated in GE letter IP-3040 (Input 4.8). GE letter IP-3040 provided CPS specific setpoint information in the absence of a formal CPS calculation. Now that this calculation is in place, these results shall be used in lieu of GE letter IP-3040 results for the parameters covered by this calculation.

2.0 ASSUMPTIONS

2.1 Published instrument vendor specifications are considered to be 2σ values unless specific information is available to indicate otherwise (Ref. 6.1, Section 4.1.3.4).

2.2 Temperature, humidity, power supply, and ambient pressure errors have been incorporated when provided by the manufacturer. Otherwise, these errors are assumed to be included in the manufacturer's accuracy or repeatability specifications (Ref. 6.1, Section 4.3.1 and Appendix A, Section A.2.1).

2.3 Changes in ambient humidity are assumed to have a negligible effect on the uncertainty of the instruments used in these loops (Ref. 6.1, Appendix I, Section I.2).

2.4 Normal radiation induced errors have been incorporated when provided by the manufacturer. Otherwise, these errors are assumed to be small and capable of being adjusted out each time the instrument is calibrated. Therefore, unless specifically provided, normal radiation errors can be assumed to be included within the instrument drift errors (Ref. 6.1, Appendix I, Section I.1).

2.5 This analysis assumes that the instrument power supply stability (PSS) is within ±5% (±1.2 Vdc) of a nominal 24 Vdc (Ref. 6.1, App. I, Section I.11).

2.6 The Drift Effect will be determined with the assumption of a 30-month calibration interval (24 month nominal plus 25%). Drift will be determined using vendor provided data. Where vendor data is unavailable, drift will be determined in accordance with Reference 6.1.

2.7 It is assumed that the M&TE listed in Section 7.0 of the calibration procedures is calibrated to the required manufacturer's recommendations and within the manufacturer's required environmental conditions. Temperature related errors are based on the difference between the manufacturer's specific calibration temperature and the worst case temperature at which the device is used (Reference 6.5, Reference 6.1 Appendix H.1).

2.8 Per Reference 6.1, it is assumed that the reference standards used for calibrating M&TE or Calibration tools shall have an uncertainty requirement of not more than ¼ of the accuracy of the equipment being calibrated. A greater uncertainty may be acceptable as limited by "State of the Art". It is generally accepted that the published vendor accuracy of the M&TE or Calibration tool includes the uncertainty of the calibration standard M&TE when the 4:1 accuracy standard is satisfied. Hence, Calibration Standard uncertainty is considered negligible to the overall calibration error term and can be ignored. This assumption is based primarily upon inherent M&TE conservatism built into the calculation.

2.9 Review of historical maintenance work request for the loop indicates the effects associated with EMI and RFI have not resulted in equipment failure or degraded performance during the life of the plant. In addition, vendor performance specifications and qualification test reports do not provide an instrument error specification for the effects of EMI and RFI. As such, any effect related to EMI and RFI are assumed to be negligible. (Ref. 6.1, Section 4.3.1 and Appendix A, Section A.2.1).

2.10 Reference 6.1, Section C.3.14, states, "There are no realistic, identifiable events which would result in a pipe break inside containment of the magnitude required to cause a loss-of-coolant accident coincident with safe shutdown earthquake." Therefore, this calculation considers the effects of a seismic event and loss-of-coolant accident independently to establish the worst case scenario for the instrumentation being evaluated. Consideration has been given to the accident that this equipment is required to mitigate.

2.11 Per Reference 6.1, Section 4.1.2.2, CPS assumes that functions associated with setpoints will function in their first trip during an event, the point in time when they and they alone, are most relied upon for plant safety. Worst case environmental conditions, that assume failure of protective equipment, or conditions that would only exist after the point of time where manual operator action is expected, are not applicable to the automatic trip functions that are expected or relied upon to occur in the early part of an event.

Per Reference 6.4, the RPV Level 3 trip function is not required post accident. Harsh radiation levels are assumed not to occur prior to Level 8 trip operation because increasing water inventory in the reactor vessel following ECCS actuation demonstrates that the core has not been uncovered. Therefore, increasing radiation levels of the magnitude following fuel failure will not be present. This assumption is validated by Input 4.8, which considers an accident radiation level of zero for level 8 trips.

In steam environments the insulation resistance of cables, terminal blocks and other devices may be reduced, producing larger than expected leakage currents, which degrade signals. Pertaining to the Harsh Environment (HE), Reference 6.4, Section 1.2.1, states "From the standpoint of establishing setpoints, Harsh Environment does not apply. This distinction is made to avoid confusion between the long-term functional requirements for the devices, which includes post-trip operation, and the operation requirements during the initial period leading to the first trip. The error introduced by such Harsh Environment effects is referred to as Insulation Resistance Accuracy (IRA) error. In current loop instrumentation, the increased current flow in the instrument cable due to decreased cable resistance always results in a higher than actual process indication. Input 4.8 states that both Harsh Environment and Radiation Effect are not applicable. It is therefore assumed that no degradation of the insulation has occurred and the positive IRA bias does not exist prior to first trip.

2.12 ASME Steam Tables software was used to determine properties of water and steam used in this calculation. This software is provided with the ASME Steam Tables and represented as the computer code utilized to generate the actual tables. Software greatly reduces interpolation errors, and it is assumed the calculation reviewer will validate the accuracy of the program output by checking against Reference 6.6

2.13 This calculation assumes that the cold calibrated span for the level transmitters are greater than 41.70 inwc. This assumption provides a reasonable approximation of turn-down ratio. Attachment 1 of this calculation determines head correction and cold calibration values specific to each of the level transmitters addressed by this calculation. Attachment 1 validates this assumption.

3.0 METHODOLOGY

This calculation will determine the instrument uncertainty associated with the RPV Level differential pressure transmitters. The Evaluation will determine the loop setpoints and Allowable Values for the Level 3 and 8 Functions. Instrument uncertainty will be determined in accordance with Reference 6.1, CI-01.00, "Instrument Setpoint Calculation Methodology." The evaluation will then compare the current setpoint and Allowable Values with the results determined by this calculation.

Section 2.1.3 of Reference 6.1, CI-01.00, "Instrument Setpoint Calculation Methodology" states the standard provides flexibility in the precise method in which a setpoint is determined.

As stated in Section 2.1.4 of CI-01.00, the setpoint methodology is based on the industry standard ANSI/ISA S67.04 (Reference 6.8). Recommended Practice ANSI/ISA S67.04.02-2000 (Reference 6.9) provides a detailed methodology for implementing Reference 6.8. CI-01.00 uses Method 1 of Recommended Practice (Ref. 6.9, Section 7), to establish the relationship between the Analytical Limit (AL), Allowable Value (AV) and Nominal Trip Setpoint (NTSP). The Recommended Practice details two other acceptable methods.

Use of the CI-01.00 standard methodology results in Level 3 & 8 NTSPs which would decrease plant operating margin (i.e., a setpoint closer to the operational RPV level range than the current field setpoint). methodology results in a more conservative approximation of loop uncertainty than the methodology of Reference 6.9. This extra conservatism comes as a result of effectively algebraically adding the Square Root Sum of the Squares (SRSS) of A_L, PMA & PEA to the SRSS of C_L & D_L, the sum of which, depending upon trip direction, is appropriately added or subtracted from the AL to determine the NTSP.

$$NTSP_{(INC)} = AL - [\,(A_L^2 + PMA^2 + PEA^2)^{1/2} + (C_L^2 + D_L^2)^{1/2}\,].$$

$$NTSP_{(DEC)} = AL + [\,(A_L^2 + PMA^2 + PEA^2)^{1/2} + (C_L^2 + D_L^2)^{1/2}\,].$$

Combining the same error terms entirely by the SRSS method, per Reference 6.9 Methods 2 & 3, yields a smaller error term and an NTSP which demonstrates the current RPV level 3 & 8 setpoints are conservative.

$$NTSP_{(INC)} = AL - (A_L^2 + C_L^2 + D_L^2 + PMA^2 + PEA^2)^{1/2}$$

$$NTSP_{(DEC)} = AL + (A_L^2 + C_L^2 + D_L^2 + PMA^2 + PEA^2)^{1/2}$$

Removing unnecessary conservatism, through use of an alternative industry standard method, eliminates negative impact upon plant operation and costs necessary to implement a setpoint change.

Method 3 of the Recommended Practice provides for calculation of the Allowable value by summing the uncertainties of drift (D_L), calibration uncertainty (C_L), and "uncertainties during normal operation."

The CI-01.00 method of determining AFT_L determines the SRSS of C_L and D_L.

The methodology used in this calculation to determine AV will be to appropriately sum AFT_L with NTSP.

$$AV_{(inc)} = NTSP + AFT_L$$
$$AV_{(dec)} = NTSP - AFT_L$$

M&TE error will be determined from the results of Calculation IP-C-0089 (Input 4.6.1) which uses building temperature minimum and maximums to develop the uncertainty, and review of the corresponding loop and device calibration procedure (Input 4.12.1).

Per Reference 6.1, Head Correction is determined by evaluating either drawings, survey data, and/or walk down data as applicable. However for this calculation, head correction associated with these transmitters will be determined using survey data.

This calculation requires an appreciation of the relationship between cold calibration span, and process span. Cold calibration span refers to the difference between the minimum and maximum pressures applied to the transmitter during calibration to simulate the differential pressure under normal operating pressure and temperature (NOP/NOT) that correspond with a vessel water level of 0% and 100%. Therefore, the relationship between cold calibration span and process span are equivalent for vessel water level of 0% and 100%. Per Assumption 2.13 cold calibration span is 41.70 inwc and per Input 4.9.1 process span is 60 inches.

4.0 INPUTS

4.1 P&IDs
- 4.1.1 M05-1071, Sheet 1, Rev. AB, "Nuclear Boiler (NB)".
- 4.1.2 M05-1071, Sheet 2, Rev. Y, "Nuclear Boiler (NB)".

4.2 Technical Manuals
- 4.2.1 K2801-0091, Tab 2, Rev. 9, "Rosemount Model 1153 Series B Alphaline Transmitters for Nuclear Service"

4.3 System Design Criteria
- 4.3.1 DC-ME-09-CP, Rev. 11, "Equipment Environmental Design Conditions Design Criteria", (Zone Code H-26, Map Code C.3.1, HCU Modules El. 755'-0", page 72; Zone Code M-24, Map Code D.6.2, Main Control Room & Electric Panel Room, El. 800'-0", page 49).
- 4.3.2 DL851E382AC, Rev. 25, "RCIC System"
- 4.3.3 DL851E713AC, Rev. 20, "ADS System"

4.4 CPS Drawings
- 4.4.1 Not Used
- 4.4.2 E02-1NB99 Sheet 104, Rev. E, "Nuclear Boiler System (NB) Automatic Depressurization System (NSPS)".
- 4.4.3 E02-1NB99 Sheet 107, Rev. D, "Nuclear Boiler System (NB) Automatic Depressurization System (NSPS)".
- 4.4.4 E02-1NB99 Sheet 108, Rev. E, "Nuclear Boiler System (NB) Automatic Depressurization System (NSPS)".
- 4.4.5 E02-1RI99 Sheet 9, Rev. K, "Reactor Core Isolation System (RI)(NSPS)".
- 4.4.6 E02-1RI99 Sheet 12, Rev. K, "Reactor Core Isolation System (RI)(NSPS)".
- 4.4.7 E03-1P661 Sheet 606, Rev D, "Internal Wiring Diagram, NSPS Div. 1 Cabinet 1H13-P661".
- 4.4.8 E03-1P662 Sheet 606, Rev C, "Internal Wiring Diagram, NSPS Div. 2 Cabinet 1H13-P662".
- 4.4.9 NB-910, Rev. 6, "Containment Bldg. Nuclear Boiler Piping"
- 4.4.10 NB-942, Rev. 3, "Containment Bldg. Nuclear Boiler Piping"
- 4.4.11 M01-1107-05, Rev. D, "General Arrangement Aux. Fuel Bldg. & Containment Mezz. Floor Plan EL. 755'-0" & 762'-0" "
- 4.4.12 M01-1117-05, Rev. E, "List of Equipment on General Arrangement"
- 4.4.13 865E997AC, Rev. 2, "Reactor Level & Pressure Local Panel A"
- 4.4.14 112D2212AC, Rev. 2, "Reactor Level & Pressure Local Panel B"

4.5 Passport (D030), For Information Only
- 4.5.1 EIN 1B21N095A & B Rosemount Transmitters, Model 1153DB4PC
- 4.5.2 EIN 1B21N695A & B Analog Trip Module, Model 147D8505G005
- 4.5.3 EIN 1B21N693A & B Analog Trip Module, Model 147D8505G005
- 4.5.4 EIN PG1509, dated 10/15/00

4.6 Calculations
- 4.6.1 Calculation IP-C-0089, Rev. 0, "M&TE Uncertainty Calculation".

4.7 Equipment Qualification
- 4.7.1 SQ-CL001, Rev. 29, Rosemount 1153 Series B and 1154 transmitters.
- 4.7.2 SQ-CL603, Rev. 15, Qualification for MCR Panels.

4.8 IP-3040, Letter from L.H. Larson, to J.H. Greene, dated January 23, 1987, "Clinton Power Station, Unit 1 Setpoint Methodology Program"; CPS File Number N55-87 (1-23)6 #45123.

4.9 Design Specifications/Data Sheets
- 4.9.1 LT054, Rev. D, "Level Transmitters", Instrument Data Sheet for 1B21N095A,B
- 4.9.2 DSDS 22A4622AV, Rev 12, "Nuclear Boiler System Design Spec Data Sheet"
- 4.9.3 Performance Specification 22A7866, Revision 4, "Analog Trip Unit".
- 4.9.4 Design Specification 22A4622, Rev. 7, "Nuclear Boiler System"
- 4.9.5 PL442X491 Rev.23 "Card Ident List P661"
- 4.9.6 PL442X492 Rev.23 "Card Ident List P662"

4.10 Construction Work Requests and Plant Survey Data
- 4.10.1 CWR 12339, Survey Data, dated 1/14/85
- 4.10.2 Homer Chastain plant survey data for RF-4, Document Number Y-103230, File Code U070-93(12-14)-6

4.11 Reports/Correspondence Related to RPV Level
- 4.11.1 Reactor Pressure Vessel Water Level Measurement System Evaluation Report, prepared by GE for CPS, dated November 1984
- 4.11.2 Not Used
- 4.11.3 Y-103435, RPV Level Head Corrections Using Survey Elevations from RF-4, 2/15/94
- 4.11.4 EDE-42-1289, Rev. 2, Clinton Reactor Vessel Water Level Transmitter Calibration, July 1990
- 4.11.5 JAM-00185-NSED, Document Number Y-94738, File Code B94-90(08-20)-6, "GE SIL 470 Supp 1 and CR 1-88-09-058 RPV Level Head Corrections", Memo from J. A. Miller, Manager-NSED to J. G. Cook, Plant Manager, dated 8/20/90

4.12 Calibration Procedures
- 4.12.1 CPS 9433.09, Rev. 34a, "ECCS Reactor Vessel Water Level B21-N095A(B) CHANNEL CALIBRATION".
- 4.12.2 CPS 9433.09D001, Rev. 35, "ECCS Reactor Vessel Water Level B21-N095A CHANNEL CALIBRATION DATA SHEET".
- 4.12.3 CPS 9433.09D002, Rev. 35, "ECCS Reactor Vessel Water Level B21-N095B CHANNEL CALIBRATION DATA SHEET".
- 4.12.4 CPS 9030.01, Rev. 30, "Analog Trip Module (ATM) Functional and Calibration Check Instructions".
- 4.12.5 CPS 9030.01C007, Rev. 24, "RCIC Reactor Water Level B21-N693A(B) Checklist"
- 4.12.6 CPS 9030.01C009, Rev. 24, "ADS Reactor Water Level B21-N695A(B) Checklist"

5.0 OUTPUTS

5.1 CPS 9433.09, Rev. 34, Change b, "ECCS Reactor Vessel Water Level B21-N095A(B) CHANNEL CALIBRATION".

5.2 CPS 9433.09D001, Rev. 35, "ECCS Reactor Vessel Water Level B21-N095A CHANNEL CALIBRATION DATA SHEET".

5.3 CPS 9433.09D002, Rev. 35, "ECCS Reactor Vessel Water Level B21-N095B CHANNEL CALIBRATION DATA SHEET".

5.4 CPS 9030.01, Rev. 31, "Analog Trip Module (ATM) Functional and Calibration Check Instructions".

5.5 CPS 9030.01C007, Rev. 24, "RCIC Reactor Water Level B21-N693A(B) Checklist"

5.6 CPS 9030.01C009, Rev. 24, "ADS Reactor Water Level B21-N695A(B) Checklist"

5.7 CPS Operational Requirements Manual (ORM) Rev. 33

5.7.1 Attachment 2-9 Table 5, "Emergency Core Cooling System (ECCS) Instrumentation Trip Setpoints"

5.7.1.1 Item 4d, "Reactor Vessel Water Level-Low, Level 3 (Confirmatory)"

5.7.1.2 Item 5d, "Reactor Vessel Water Level-Low, Level 3 (Confirmatory)"

5.7.2 Attachment 2-11 Table 6, "Reactor Core Isolation Cooling (RCIC) System Instrumentation Trip Setpoints" Item b, "Reactor Vessel Water Level-High, Level 8"

5.8 CPS 3305.01, Rev. 9, "Reactor Protective System"

5.9 CPS Technical Specification, Amendment 140

5.9.1 Section 3.3.5.2, "Reactor Core Isolation Cooing (RCIC) System Instrumentation"

5.9.1.1 Table 3.3.5.2-1, Item 2, "Reactor Vessel Water Level-High, Level 8"

5.9.2 Section 3.3.5.1, "Emergency Core Cooling System (ECCS) Instrumentation",

5.9.2.1 Table 3.3.5.1-1, Item 4.d, "Reactor Vessel Water Level-Low, Level 3 (Confirmatory)"

5.9.2.2 Table 3.3.5.1-1, Item 5.d, "Reactor Vessel Water Level-Low, Level 3 (Confirmatory)"

7.4.2.7 Humidity Effect (HE_{ATM}) – The vendor does not provide any specification for this effect (Input 4.9.3). Therefore, per Assumption 2.2, the Humidity Effect is considered to be included in the Vendor Accuracy.

$$\mathbf{HE_{ATM} = 0}$$

7.4.2.8 Power Supply Effect (PSE_{ATM}) - The vendor does not provide any specification for this effect (Input 4.9.3). Therefore, per Assumption 2.2, the Power Supply Effect is considered to be included in the Vendor Accuracy.

$$\mathbf{PSE_{ATM} = 0}$$

7.4.2.9 RFI/EMI Effect (REE_{ATM}) – Per Assumption 2.9, the effects of RFI/EMI are considered negligible.

$$\mathbf{REE_{ATM} = 0}$$

7.4.2.10 Bias (B_{ATM}) – From Appendix C of Reference 6.1, Bias is defined as a systematic or fixed instrument uncertainty that is predictable for a given set of conditions because of the existence of a known direction (positive or negative). No such error was identified for the ATMs used for measurement of RPV level. Therefore:

$$\mathbf{B_{ATM} = 0}$$

7.4.2.11 From Section 7.3.1, A_{ATM} is calculated by:

$$A_i = \pm N \sqrt{\left(\frac{VA_i}{n}\right)^2 + \left(\frac{ATE_i}{n}\right)^2 + \left(\frac{OPE_i}{n}\right)^2 + \left(\frac{SPE_i}{n}\right)^2 + \left(\frac{SE_i}{n}\right)^2 \ldots + \left(\frac{RE_i}{n}\right)^2 + \left(\frac{HE_i}{n}\right)^2 + \left(\frac{PSE_i}{n}\right)^2 + \left(\frac{REE_i}{n}\right)^2} \pm B$$

(2σ)

Substituting into the A_i equation where:

VA_{ATM}	$= \pm 0.2500\%$ Span (2σ)	Section 7.4.2.1
ATE_{ATM}	$= 0$	Section 7.4.2.2
OPE_{ATM}	$= 0$	Section 7.4.2.3
SPE_{ATM}	$= 0$	Section 7.4.2.4
SE_{ATM}	$= 0$	Section 7.4.2.5
RE_{ATM}	$= 0$	Section 7.4.2.6
HE_{ATM}	$= 0$	Section 7.4.2.7
PSE_{ATM}	$= 0$	Section 7.4.2.8
REE_{ATM}	$= 0$	Section 7.4.2.9
B_{ATM}	$= 0$	Section 7.4.2.10

$$A_{ATM} = \pm 2\sqrt{\left(\frac{0.25\%\ Span}{2}\right)^2 + (0)^2 + (0)^2 + (0)^2 + (0)^2 + (0)^2 + (0)^2 + (0)^2 + (0)^2} + 0$$

A_{ATM} $= \pm 0.2500\%$ Span (2σ)

7.4.3 Loop Accuracy

From Section 7.2 there are 2 trip units associated with each loop providing the Level 3 and Level 8 trip functions.

From Section 7.3.1:

$$A_L = \pm\sqrt{A_1^2 + A_2^2 + A_3^2 + \ldots} \pm B \qquad (2\sigma)$$

7.4.3.1 Level 3 trip ($A_{L\text{-Level 3}}$)

Substituting into the equation for A_L where:

$A_{LT\text{-Level 3}}$	$= \pm 2.0317$ % Span	(2σ)	Section 7.4.1.11.4
A_{ATM}	$= \pm 0.2500$% Span	(2σ)	Section 7.4.2.11
$B_{LT\text{-Level 3}}$	$= 0$		Section 7.4.1.10
B_{ATM}	$= 0$		Section 7.4.2.10

$$A_{L-Level3} = \pm\sqrt{A_{LT-Level3}^{\ 2} + A_{ATM}^{\ 2}} \pm B_{LT-Level3} \pm B_{ATM}$$
$$A_{L-Level3} = \pm\sqrt{2.0317\%\ Span^2 + 0.25\%\ Span^2} \pm 0 \pm 0$$

$A_{L\text{-Level 3}}$ **= ±2.0470% Span** **(2σ)**

7.4.3.2 Level 8 trip ($A_{L\text{-Level 8}}$)

Substituting into the equation for A_L where:

$A_{LT\text{-Level8}}$	$= \pm 2.5973$ % Span	(2σ)	Section 7.4.1.11.4
A_{ATM}	$= \pm 0.2500$% Span	(2σ)	Section 7.4.2.11
$B_{LT\text{-Level 8}}$	$= 0$		Section 7.4.1.10
B_{ATM}	$= 0$		Section 7.4.2.11

$$A_{L-Level8} = \pm\sqrt{A_{LT-Level8}^{\ 2} + A_{ATM}^{\ 2}} \pm B_{LT-Level8} \pm B_{ATM}$$
$$A_{L-Level8} = \pm\sqrt{2.5973\%\ Span^2 + 0.25\%\ Span^2} \pm 0 \pm 0$$

$A_{L\text{-Level 8}}$ **= ±2.6093% Span** **(2σ)**

7.5 Loop Calibration Error (C_L)

Loop Calibration Error is determined by the SRSSs of As-Left Tolerance (ALT_i), Calibration Tool Error (C_i), and Calibration Standards Error ($C_{i\ STD}$) for the individual devices in the loop. The equation below is used to calculate this effect.

From Section 7.3.2:

$$C_L = \pm N\sqrt{\sum\left(\frac{ALT_i}{n}\right)^2 + \sum\left(\frac{C_i}{n}\right)^2 + \sum\left(\frac{C_iSTD}{n}\right)^2} \qquad (2\sigma)$$

7.5.1 As-Left Tolerance (ALT_L)

From Section 7.3.7:

$$ALT_L = \pm(N)\sqrt{\left(\frac{ALT_1}{n}\right)^2 + \left(\frac{ALT_2}{n}\right)^2 + \ldots + \left(\frac{ALT_n}{n}\right)^2} \quad (2\sigma)$$

Where:

$$ALT_i = \pm VA_i \quad (2\sigma)$$

Determining the ALT for the transmitter (ALT_{LT}):

VA_{LT} = ± 0.2500% Span (Section 7.4.1.1)

Therefore;

ALT_{LT} = ±0.2500% Span (2σ)

Determining the ALT for the Analog Trip Unit (ALT_{ATM}):

VA_{ATM} = ± 0.2500% Span (Section 7.4.2.1)

Therefore;

ALT_{ATM} = ±0.2500% Span (2σ)

Per Section 7.2, a single transmitter and 2 identical trip units generate the Level 3 and Level 8 trips. Therefore a single loop As-Left Tolerance (ALT_L) is representative of both trip functions.

Substituting ALT_{LT} and ALT_{ATM} into the equation for ALT_L;

$$ALT_L = \pm(N)\sqrt{\left(\frac{ALT_{LT}}{n}\right)^2 + \left(\frac{ALT_{ATM}}{n}\right)^2}$$

$$ALT_L = \pm(2)\sqrt{\left(\frac{0.25\%\ Span}{2}\right)^2 + \left(\frac{0.25\%\ Span}{2}\right)^2}$$

ALT_L = ± 0.3536% Span (2σ)

Converting ALT_L to "inwc" for comparison to tolerance in calibration procedures;

Per Assumption 2.13, Cold Calibrated Span = 41.70 inwc.

ALT_L = ±0.3536% Span
ALT_L = ±0.3536% Span * 41.7 inwc / 100%Span
ALT_L = ±0.1475 inwc (2σ)

Per Inputs 4.12.2 and 4.12.3, As-Left Tolerance for Loop Calibration of Trip #1 is –64.66 inwc to –64.37 inwc. The As-Left Tolerance for Loop calibration of Trip #2 is –35.00 inwc to –34.71 inwc. In both cases the difference between upper and lower tolerance limits is 0.29 inwc and in both cases the As-Left Tolerance specified by the calibration procedures is non-symmetrical.

Per Section 4.4.2 of Reference 6.1, "ALT_L selected for use in the calibration procedure should be used to calculate C_L and AFT_L." Per direction from CPS, single sided uncertainties such as this one shall be taken as the span of a tolerance evenly distributed around the nominal setpoint. Therefore:

ALT_L = ±0.145 inwc (2σ)

Rounded down to the precision specified in the calibration procedure:

ALT_L = ±0.14 inwc (2σ)

Converting ALT_L to process span (inches);
ALT_L = ±0.14 inwc
ALT_L = ±0.14 inwc / (60 inches / 41.7 inwc)
ALT_L = ±0.20 inches (2σ)

Converting ALT_L to "% Span" for use in calculation;

Per Assumption 2.13, Cold Calibrated Span = 41.70 inwc.

ALT_L = ±0.14 inwc
ALT_L = ±0.14 inwc / (41.7 inwc / 100%Span)
ALT_L = ±0.3357%CC Span (2σ)

As discussed in Section 3.0, cold calibrated span is equivalent to process span when the plant is at NOP/NOT. Since the loop is required to function only when the plant is at NOP/NOT. Therefore:

%CC Span = % Process Span = % Span

ALT_L = ±0.3357% Span **(2σ)**

7.5.2 Calibration Tool Error (C_i)

7.5.2.1 Transmitter Calibration Tool Error (C_{LT})

Reference 6.1 provides the method for determining the Measurement and Test Equipment (C_i) uncertainty. As discussed in Section 3.0, as a first approach, use the least accurate M&TE from input 4.6.1 that can support the existing setpoint and Allowable Value.

Input 4.12.1 addresses the functional testing of the master and slave trip units (Section 8.1), loop calibration (Section 8.2), transmitter calibration (Sections 8.3 and 8.6) and calibration of the master and slave trip units (Sections 8.4 and 8.5). Section 7.0 of Input 4.12.1 requires the use of a test gauge, Digital Voltmeter (DVM), and 250 ohm (Ω) precision resistor in addition to the DAC during performance of the procedure. Specifically:

- Functional testing of the trip units is accomplished using only the DAC.
- Loop calibration requires usage of the test gauge only.
- Transmitter calibration employs the test gauge, precision resistor and DVM.
- Calibration of the Master and Slave trip units is performed using only the DAC.

Per Section 7.0 of Input 4.12.1;

- the DVM shall be capable of measuring 0-5 Vdc ±0.002 Vdc,
- the test gauge shall have a range of 0-75 inwc with an accuracy of ±0.079 inwc, and
- the 250 Ω precision resistor is required to be within ± 0.02 Ω.

To enhance accuracy during calibration, this uncertainty calculation utilizes the Fluke 45 multimeter accuracy specification. Per page 10 of Attachment 3 of Input 4.6.1, Fluke 45 multimeter has an uncertainty of ±0.097% Span for the 1-5 VDC range. Similarly, a

Heise Model HQS-2 Digital Pressure Module with a range of 0 – 100 inwc and an accuracy of ±0.0250% span will be used in calculating the uncertainty.

<u>The M&TE error for the voltmeter (C_{VM}) is therefore:</u>

C_{VM} = ±0.097% Span (3σ)

C_{VM} = ±0.004 Vdc (max temp band of 22°C) Input 4.6.1

<u>The M&TE error for the precision resistor (C_{PR}) is therefore:</u>

$C_{PR} = \pm 0.02\Omega/250\Omega * 100$

C_{PR} = ±0.008% Span (3σ)

<u>The M&TE error for the Heise HQS-2 digital indicator (C_{PG}) is therefore:</u>

The errors for this gauge are derived from Attachment 3, as follows:

Vendor Accuracy (VA) = ± 0.025% full scale

Per Attachment 3, the HQS-2 indicator is temperature compensated over a range of 20°F to 120°F, therefore:

ATE = 0

Per Attachment 3, the HQS-2 indicator is calibrated to within ± 0.03 inwc over a 0-100 inwc range.

ALT = ± 0.03 inwc * (100% full scale/100 inwc)

ALT = ± 0.0300% full scale

Per Input 4.6.1, Paragraph 3.5, the digital indicator IRE is conservatively taken as the least significant digit of the digital display and is considered insignificant.

IRE = 0

$$C_{PG} = \pm [VA^2 + ATE^2 + IRE^2 + ALT^2]^{1/2}$$

Where, from above:

VA = ± 0.0250% Span

ATE = 0

IRE = 0

ALT = ± 0.0300% Span

Substituting:

$C_{PG} = \pm [0.0250^2 + 0 + 0 + 0.0300^2]^{½}$
$= \pm 0.0391\%$ FS

Converting to inwc:

$C_{PG} = \pm 0.0391\%$ FS * (100 inwc/100%FS)
$C_{PG} = \pm 0.0391$ inwc (3σ)

Converting to the 41.70 inwc span of the transmitter:

$C_{PG} = \pm 0.0391\%$ Span (100 inwc/41.70 inwc)
$C_{PG} = \pm 0.0938\%$ Span (3σ)

$$C_{LT} = \pm\sqrt{C_{PG}^2 + C_{VM}^2 + C_{PR}^2}$$

Substituting:

$$C_{LT} = \pm\sqrt{0.0938\%\ Span^2 + 0.097\%\ Span^2 + 0.008\%\ Span^2}$$

$C_{LT} = \pm$ 0.1351% Span **(3σ)**

7.5.2.2 ATM Calibration Tool Error (C_{ATM})

The ATM's are calibrated using a DAC. The DAC accuracy has been evaluated in Input 4.6.1. Per Input 4.6.1, the DAC accuracy for the ATM is ± 0.151% span. Therefore:

$C_{ATM} = \pm$ 0.151% span **(3σ)**

7.5.3 Calibration Standard Error (C_{STD}):

Per Assumption 2.8, Calibration Standard Error is considered negligible for the purposes of this analysis.

$C_{STD} = 0$

7.5.4 Loop Calibration Error (C_L):

Per Section 7.2, a single transmitter and 2 identical trip units generate the Level 3 and Level 8 trips. Therefore a single loop Calibration Error (C_L) is representative of both trip functions.

Per Section 8.2 of Input 4.12.1, the loop calibration is performed using a pressure gauge only. Substituting into the equation from C_L:

From above:

ALT_L	= ±0.3357% Span	(2σ)	Section 7.5.1
C_{PG}	= ±0.0938% Span	(3σ)	Section 7.5.2.1
C_iSTD	= 0		Section 7.5.3

Substituting terms:

$$C_L = \pm 2\sqrt{\left(\frac{0.3357\ \%\ Span}{2}\right)^2 + \left(\frac{0.0938\ \%\ Span}{3}\right)^2 + 0^2}$$

C_L = ± 0.3415% Span (2σ)

7.6 Loop Drift

7.6.1 Transmitter Drift (D_{LT}):

Per Input 4.2.1, Drift is ± 0.2% of URL for 30 months. Drift will be determined based on a nominal 30 month calibration interval (Assumption 2.6), in accordance with Technical Specifications allowance for extended surveillance for up to 1.25% of the required interval, or 30 months (24*1.25=30).

- Per Assumption 2.13, Cold Calibrated Span = 41.70 inwc
- From Input 4.2.1, Upper Range Limit = 150 inwc

Therefore:

D_{LT} = ± 0.20% URL
D_{LT} = ± 0.20% * (150 inwc / 41.70 inwc)
D_{LT} = ± 0.7194%CC Span (2σ)

7.6.2 Analog Trip Unit Drift (D_{ATM}):

Per Input 4.9.3, Drift is ±0.25% of Span for a period of 30 days. Per the calibration procedure (Input 4.12.4), the calibration frequency is 92 days. Technical Specifications allow for the surveillance to be delayed for up to 1.25% of the required interval, or 115 days (92*1.25=115). Therefore, per Eqn. 2 of Ref. 6.1:

$D_{ATM} = \pm\, 0.25\%\ \text{Span} * (115\ \text{days}/30\ \text{days})^{1/2}$

$D_{ATM} = \pm\, \mathbf{0.4895\%\ Span}$ (2σ)

7.6.3 Loop Drift:
From Section 7.3.3, Loop Drift is calculated:

$$D_L = \pm N \sqrt{\left(\frac{D_1}{n}\right)^2 + \left(\frac{D_2}{n}\right)^2 + \ldots + \left(\frac{D_n}{n}\right)^2} \quad (2\sigma)$$

Per Section 7.2, a single transmitter and identical trip units generate the Level 3 and Level 8 trips. Therefore a single loop Drift (D_L) is representative of both trip functions.

As discussed in Section 3.0, cold calibrated span is equivalent to process span when the plant is at NOP/NOT. Since the loop is required to function only when the plant is at NOP/NOT. Therefore:

%CC Span = % Process Span = % Span

Substituting from above;

$$D_L = \pm N \sqrt{\left(\frac{D_{LT}}{n}\right)^2 + \left(\frac{D_{ATU}}{n}\right)^2}$$

$$D_L = \pm 2 \sqrt{\left(\frac{0.7194\ \%\ Span}{2}\right)^2 + \left(\frac{0.4895\ \%\ Span}{2}\right)^2}$$

$\mathbf{D_L = \pm\, 0.8701\%\ Span}$ (2σ)

7.7 Process Measurement Accuracy (PMA):

The parameter measured is the reactor water level. Per Input 4.8, the PMA determined for the RPV Level 3 & 8 Trips is 0.68 inches and is attributable to the change in density of the water in portions of the reference and variable legs both inside and outside the drywell.

Process Span = 60 inches Input 4.9.1
Converting to % Span:

PMA = ± 0.68 inches
= ± 0.68 inches / 60 inches* 100% Span
= **± 1.1333% Span** **(2σ)**

7.8 Primary Element Accuracy (PEA):

The parameter measured is the reactor water level. Per Input 4.8, the PEA for RPV Level 3 and Level 8 (NR) functions is 0.5 inches and is attributable to uncertainty associated with the elevation measurement of the level transmitter reference leg condensation pot. Clinton Power Station commissioned a professional survey to determine condensate pot elevations. The results of this survey (Input 4.10.2) document the elevation of various points related to the top of the shield wall. Given the instruments used to take measurements and the qualification of the individuals performing and overseeing the work the 0.5 inches allowed for PEA in Input 4.8 is considered conservative.

Process Span = 60 inches Input 4.9.1

Converting to % Span:

PEA = ± 0.5 inches
= ± 0.5 inches / 60 inches* 100% Span
= **± 0.8333% Span** **(2σ)**

8.0 RESULTS

8.1 Calculation of the Trip Setpoint:

From Section 7.3.4;

For process variables that increase to trip.

$$NTSP_{INC} = AL - \left(\frac{1.645}{2}\right)\sqrt{A_L^{\,2} + C_L^{\,2} + D_L^{\,2} + PMA^2 + PEA^2} - B$$

For process variables that decrease to trip.

$$NTSP_{DEC} = AL + \left(\frac{1.645}{2}\right)\sqrt{A_L^{\,2} + C_L^{\,2} + D_L^{\,2} + PMA^2 + PEA^2} + B$$

8.1.1 Calculation of the Level 3 NTSP ($NTSP_{Level\ 3}$)

From Input 4.9.2, the Analytical Limit (AL) for Reactor Vessel Water Level – Low, Level 3 is 7.6 inches.

Substituting into the equation for $NTSP_{(DEC)}$ where:

$AL_{Level\ 3}$	= 7.6 inches		Input 4.9.2
Process Span	= 60 inches		Input 4.9.1
PMA	= ± 0.6800 inches		Section 7.7
PEA	= ± 0.5000 inches		Section 7.8
$A_{L\text{-}Level\ 3}$	= ± 2.0470% Span	(2σ)	Section 7.4.3.1
	= ± 2.0470% Span * 60 inches		
	= ± 1.2282 inches		
C_L	= ± 0.3415% Span	(2σ)	Section 7.5.4
	= ± 0.3415% Span * 60 inches		
	= ± 0.2049 inches		
D_L	= ± 0.8701% Span	(2σ)	Section 7.6.3
	= ± 0.8701% Span * 60 inches		
	= ± 0.5221 inches		
B	= 0		

$$NTSP_{Level3} = AL_{Level3} + \left(\frac{1.645}{N}\right)\sqrt{A_{L-Level3}^{\ 2} + C_{L-Level3}^{\ 2} + D_{L-Level3}^{\ 2} + PMA^2 + PEA^2} \pm B$$

$$NTSP_{Level3} = 7.6\ in. + \left(\frac{1.645}{2}\right)\sqrt{\begin{matrix}1.2282\ in.^2 + 0.2049\ in.^2 + 0.5221\ in.^2 \ldots \\ + 0.6800\ in.^2 + 0.5000\ in.^2\end{matrix}} \pm 0$$

$$NTSP_{Level3} = 8.9097\ in.$$

This calculation determines the NTSP to be 8.9 inches (Rounded). The current setpoint in the CPS Operational Requirements Manual (Outputs 5.7.1.1 and 5.7.1.2), is ≥ 8.9 inches, which is equal to the setpoint calculated above. The methodolgy of Reference 6.1 established symmetrical As-Found and As-Left tolerances about the NTSP and Reset, thus the recommendation is to utilize an NTSP of 8.9 inches and delete the "≥" sign. Therefore:

$NTSP_{Level\ 3}$ = 8.9 inches

8.1.2 Calculation of the Level 8 NTSP ($NTSP_{Level\ 8}$)

From Input 4.9.2, the Analytical Limit (AL) for Reactor Vessel Water Level – High, Level 8 is 53.8 inches. However per Input 4.8, the AL is listed as 53.7 inches. The most conservative value of 53.7 inches will be used.

Substituting into the equation for $NTSP_{(INC)}$ where:

$AL_{Level\ 8}$	= 53.7 inches		Input 4.9.2
Process Span	= 60 inches		Input 4.9.1
PMA	= ± 0.6800 inches		Section 7.7
PEA	= ± 0.5000 inches		Section 7.8
$A_{L-Level\ 8}$	= ± 2.6093% Span	(2σ)	Section 7.4.3.2
	= ± 2.6093% Span * 60 inches		
	= ± 1.5656 inches		
C_L	= ± 0.3415% Span	(2σ)	Section 7.5.4
	= ± 0.3415% Span * 60 inches		
	= ± 0.2049 inches		
D_L	= ± 0.8701% Span	(2σ)	Section 7.6.3
	= ± 0.8701% Span * 60 inches		
	= ± 0.5221 inches		
B	= 0		

$$NTSP_{Level\,8} = AL_{Level\,8} - \left(\frac{1.645}{N}\right)\sqrt{A_{L-Level\,8}^{\;2} + C_L^{\;2} + D_L^{\;2} + PMA^2 + PEA^2} \pm B$$

$$NTSP_{Level\,8} = 53.7\ in. - \left(\frac{1.645}{2}\right)\sqrt{\begin{matrix}1.5656\ in.^2 + 0.2049\ in.^2 + 0.5221\ in.^2 \ldots \\ + 0.6800\ in.^2 + 0.5000\ in.^2\end{matrix}} \pm 0$$

$$NTSP_{Level\,8} = 52.1661\ in.$$

Section 8.1.2 of this calculation determined NTSP to be 52.1661 inches. The current setpoint in the CPS Operational Requirements Manual (Output 5.7.2) is ≤ 52.0 inches, which is more conservative than the setpoint calculated above. The methodolgy of Reference 6.1 established symmetrical As-Found and As-Left tolerances about the NTSP and Reset, thus the recommendation is to utilize an NTSP of ≤ 52.0 inches and delete the "≤" sign. Therefore:

$NTSP_{Level\,8}$ = 52.0 inches

8.2 Calculation of As-Found Values

From Section 7.3.6:

The loop As-Found Tolerance (AFT) will be calculated as follows:

$$AFT_L = \pm(N)\sqrt{\left(\frac{C_L}{n}\right)^2 + \left(\frac{D_L}{n}\right)^2} \qquad (2\sigma)$$

Where:

D_L = Loop devices' drift value, as defined in Section 7.3.1
C_L = Loop devices' calibration effect, as defined in Section 7.3.1

$$AFT_i = \pm(N)\sqrt{\left(\frac{ALT_i}{n}\right)^2 + \left(\frac{D_i}{n}\right)^2 + \left(\frac{C_i}{n}\right)^2} \qquad (2\sigma)$$

Where:

ALT_i = device's As-Left Tolerance
D_i = device's drift value
C_i = errors of M&TE used to calibrate the device

8.2.1 Calculating Level Transmitter As-Found Tolerance (AFT_{LT}):

Substituting into the equation for AFT_i where:

ALT_{LT}	= ±0.2500% span	(2σ)	Section 7.5.1
D_{LT}	= ±0.7194% span	(2σ)	Section 7.6.1
C_{LT}	= ±0.1351 % span	(3σ)	Section 7.5.2.1

Substituting:

$$AFT_{LT} = \pm N\sqrt{\left(\frac{ALT_{LT}}{n}\right)^2 + \left(\frac{D_{LT}}{n}\right)^2 + \left(\frac{C_{LT}}{n}\right)^2}$$

$$AFT_{LTi} = \pm 2\sqrt{\left(\frac{0.25\%\ Span}{2}\right)^2 + \left(\frac{0.7194\ \%\ Span}{2}\right)^2 + \left(\frac{0.1351\ \%\ Span}{3}\right)^2}$$

AFT_{LT} = ± 0.7669 % Span **(2σ)**

8.2.2 ATM As-Found Tolerance (AFT_{ATM}):

Substituting into the equation for AFT_i where:

ALT_{ATM}	= ±0.2500% span	(2σ)	Section 7.5.1
D_{ATM}	= ±0.4895% span	(2σ)	Section 7.6.2
C_{ATM}	= ±0.1510 % span	(3σ)	Section 7.5.2.2

$$AFT_{ATM} = \pm N\sqrt{\left(\frac{ALT_{ATM}}{n}\right)^2 + \left(\frac{D_{ATM}}{n}\right)^2 + \left(\frac{C_{ATM}}{n}\right)^2}$$

$$AFT_{ATM} = \pm 2\sqrt{\left(\frac{0.25\%\ Span}{2}\right)^2 + \left(\frac{0.4895\ \%\ Span}{2}\right)^2 + \left(\frac{0.1510\ \%\ Span}{3}\right)^2}$$

AFT_{ATM} = ±0.5588% Span **(2σ)**

8.2.3 Loop As-Found Tolerance (AFT_L):

Per Section 7.2, a single transmitter and trip unit with 2 outputs generate the Level 3 and Level 8 trips. Therefore a single loop As-Found Tolerance (ALT_L) is representative of both trip functions.

Substituting into the equation for AFT_L where:

C_L	= ± 0.3415% Span	(2σ)	Section 7.5.4
D_L	= ± 0.8701% Span	(2σ)	Section 7.6.3

$$AFT_L = \pm N\sqrt{\left(\frac{C_L}{n}\right)^2 + \left(\frac{D_L}{n}\right)^2}$$

$$AFT_L = \pm 2\sqrt{\left(\frac{0.3415\%\ Span}{2}\right)^2 + \left(\frac{0.8701\%\ Span}{2}\right)^2}$$

AFT_L = ±0.9347% Span (2σ)

Per Assumption 2.13, Cold Calibrated Span = 41.70 inwc.

AFT_L = ± 0.9347% Span * 41.7 inwc
AFT_L = ± 0.3898 inwc (2σ)

Rounded down to the precision used in the calibration procedures (Inputs 4.12.2 and 4.12.3):

AFT_L = ± 0.38 inwc (2σ)

Converting AFT_L to "inches" for use in Sections 8.3 and 8.4:

From Input 4.9.1, Process Span = 60 inches.
Per Assumption 2.13, Cold Calibrated Span = 41.70 inwc.

Therefore:

AFT_L = ± 0.38 inwc * (60 inches / 41.7 inwc)
AFT_L = ± 0.5468 inches

Rounding up (for conservatism) to the precision of AV in Section 8.3:

$$\mathbf{AFT_L = \pm 0.6\ inches} \qquad (2\sigma)$$

8.3 Calculation of the Allowable Value (AV)

The Allowable Value may be calculated for an increasing trip as follows:

$$\mathbf{AV_{(INC)} = NTSP + AFT_L}$$

The Allowable Value may be calculated for a decreasing trip as follows:

$$\mathbf{AV_{(DEC)} = NTSP - AFT_L}$$

8.3.1 Calculation of the Reactor Water Level – Low, Level 3 Allowable Value ($AV_{Level\ 3}$)

Substituting into the equation for a decreasing setpoint where:

$NTSP_{Level\ 3}$	= 8.9 inches	Section 8.1.1
AFT_L	= 0.6 inches	Section 8.2.3

$AV_{(DEC)} = NTSP - AFT_L$
$AV_{(DEC)} = 8.9\ inches - 0.6\ inches$

$\mathbf{AV_{Level\ 3} \geq 8.3\ inches}$

8.3.2 Calculation of the Reactor Water Level – High, Level 8 Allowable Value ($AV_{Level\ 8}$)

Substituting into the equation for a decreasing setpoint where:

$NTSP_{Level\ 8}$	= 52.0 inches	Section 8.1.2
AFT_L	= 0.6 inches	Section 8.2.3

$AV_{(DEC)} = NTSP + AFT_L$
$AV_{(DEC)} = 52.0\ inches + 0.6\ inches$

$\mathbf{AV_{Level\ 8} \leq 52.6\ inches}$

8.4 Calculation of Reset Value

The trip reset value is selected to prevent overlap with the acceptable NTSP tolerance band, and also to prevent interference with normal plant operations. The maximum reset value is calculated as follows for the decreasing trip function, using the largest loop tolerance:

$$\textbf{Reset} = \textbf{NTSP} + \textbf{AFT}_\textbf{L}$$

The minimum reset value is calculated as follows for the increasing trip function, using the largest loop tolerance:

$$\textbf{Reset} = \textbf{NTSP} - \textbf{AFT}_\textbf{L}$$

From Inputs 4.12.2, 4.12.3 and 4.12.6, the existing differential between trip and reset is 1.8 inches. This is a difference of 3% of span, which equals the standard differential used for ATMs at CPS. A larger reset differential is more conservative (i.e., moves the process further away from the Analytic Limit before allowing a reset condition). The 1.8 inch existing reset differntial will be conservatively added to the NTSP in lieu of the smaller 0.6 inch AFT_L.

The maximum reset value is calculated as follows for the increasing and decreasing trip functions, using the largest loop tolerance:

$$\text{Reset}_{(\text{Dec})} = \text{NTSP} + 1.8 \text{ inches}$$

$$\text{Reset}_{(\text{Inc})} = \text{NTSP} - 1.8 \text{ inches}$$

8.4.1 Reset for Reactor Vessel water Level – Low, Level 3 ($\text{Reset}_{\text{Level 3}}$):

$$\text{Reset}_{\text{Level 3}} = \text{NTSP} + 1.8 \text{ inches} = 8.9 \text{ inches} + 1.8 \text{ inches}$$

$$\textbf{Reset}_{\textbf{Level 3}} = \textbf{10.7 inches}$$

8.4.2 Reset for Reactor Vessel water Level – High, Level 8 ($\text{Reset}_{\text{Level 8}}$):

$$\text{Reset}_{\text{Level 8}} = \text{NTSP}_{\text{Level 8}} - 1.8 \text{ inches} = 52.0 \text{ inches} - 1.8 \text{ inches}$$

$$\textbf{Reset}_{\textbf{Level 8}} = \textbf{50.2 inches}$$

9.0 CONCLUSIONS

9.1 RPV Level – Low, Level 3

Section 8.1.1 of this calculation determined NTSP to be 8.9 inches demonstrating the design NTSP value of 8.9 inches given in Table 1 of Input 4.9.2 is conservative. The ≥ symbol will be dropped from the ORM (Outputs 5.7.1.1 and 5.7.1.2) as this calculation establishes a symmetrical As-Found tolerance.

$NTSP_{Level\,3}$ = 8.9 inches

This design calculation provides the basis for establishing the Tech. Spec. Allowable Value at ≥ 8.6 inches, demonstrating the "Tech Spec Limit" value of 8.3 inches given in Table 1 of Input 4.9.2 is conservative. The calculated value is selected to prevent overlap between the AFT_L and AV.

$AV_{Level\,3} \geq$ 8.3 inches

The scaling for the RPV Low Level 3 Trip function is addressed in Attachment 1 to this calculation. A "Results Summary" is included in Attachment 2 to this calculation.

The relationship between the Allowable Value, NTSP and Reset setting values for the Loop and ATM is not directly proportional. This is due to the existence of a 20 BTU sub-cooled region in the reactor vessel. The Loop and ATM input values calculated in Attachment 1 shall be used when calibrating those devices. Interpolation between input and output spans would result in incorrect AV, NTSP and Reset setting values.

Upper Range Limit	60.0 inches
Reset	10.7 inches
+AFT	9.5 inches
+ALT	9.1 inches
Nominal Trip Setpoint	8.9 inches
-ALT	8.7 inches
-AFT	8.3 inches
Allowable Value	≥8.3 inches
Analytical Limit	7.6 inches
Lower Range Limit	0.0 inches

9.2 RPV Level – High, Level 8

Section 8.1.2 of this calculation determined NTSP to be 52.1661 inches demonstrating the design NTSP value of 52.0 inches given in Table 1 of Input 4.9.2 is conservative. The ≤ symbol will be dropped from the ORM (Output 5.7.2) as this calculation establishes a symmetrical As-Found tolerance.

$\mathbf{NTSP_{Level\ 8} = 52.0\ inches}$

This design calculation provides the basis for establishing the Tech. Spec. Allowable Value at ≤ 52.6 inches, equaling the "Tech Spec Limit" value given in Table 1 of Input 4.9.2

$\mathbf{AV_{Level\ 8} \leq 52.6\ inches}$

The scaling for the RPV High Level 8 Trip function is addressed in Attachment 1 to this calculation. A "Results Summary" is included in Attachment 2 to this calculation.

The relationship between the Allowable Value, NTSP and Reset setting values for the Loop and ATM is not directly proportional. This is due to the existence of a 20 BTU sub-cooled region in the reactor vessel. The Loop and ATM input values calculated in Attachment 1 shall be used when calibrating those devices. Interpolation between input and output spans would result in incorrect AV, NTSP and Reset setting values.

Upper Range Limit	60.0 inches
Analytical Limit	53.7 inches
Allowable Value	≤52.6 inches
+AFT	52.6 inches
+ALT	52.2 inches
Nominal Trip Setpoint	52.0 inches
-ALT	51.8 inches
-AFT	51.4 inches
Reset	50.2 inches
Lower Range Limit	0.0 inches

SCALING OF RPV LEVEL 3 AND LEVEL 8 (NR) INSTRUMENT LOOPS (1B21N095A & B)

1.0 LEVEL TRANSMITTER SCALING

1.1 TRANMITTER SPECIFIC INFORMATION

EIN: 1B21N095A & B

Manufacturer: Rosemount Inc.
Model No.: 1153DB4PC
Input: 0 to + 60 inwc
Output: 1-5 Vdc

Process Range

Min (p)	Max (P)	Units
p = 0	P = +60	inches

Transmitter Output Range

Min(o)	Max(O)	Units
o=1	O=5	Vdc

1.2 THEORY

As described in Input 4.11.4, the collapsed water level in the vessel annulus is determined by measuring the differential pressure between the two reactor vessel nozzles. The general equation provided to determine this differential pressure is Equation 3-1 of Input 4.11.4 and is:

$$\Delta P = \upsilon_{68}[h_w/\upsilon_w + h_s/\upsilon_s + \Delta h_d/\upsilon_d + \Delta h_{rb}/\upsilon_{rb}]$$

Per Section 3.0 of Input 4.11.4, the equation (EQN 3-2) for determination of differential pressure (ΔP) narrow range instruments is:

$$\Delta P = \nu_{68} [h_w (1/\nu_w - 1/\nu_s) + H/\nu_s + \Delta h_d/\nu_d + \Delta h_{rb}/\nu_{rb}]$$

Where:

h_w = height of vessel water column above the variable leg nozzle (VLN.ELEV).

- $h_w$min = LI0.ELEV.COLD - VLN.ELEV + LIMIN
- $h_w$max = $h_w$min + LISPAN
- LISPAN = LIMAX - LIMIN

H = elevation differential between the condensing chamber (CCELEV.COLD) and the variable leg nozzle (VLN.ELEV).
= $h_w + h_s$

Δh_d = drywell sensing line drop differential
= $h_d$var - $h_d$ref

Δh_{rb} = reactor building sensing line drop differential
= VLP.ELEV – RLP.ELEV

υ_{68} = specific volume of water at standard temperature, 68°F and 1 atmosphere pressure (ST&P); 0.01604537 ft^3/lbm

υ_w = specific volume of vessel water at vessel temperature and pressure

υ_s = specific volume of vessel steam at vessel pressure and temperature

υ_d = specific volume of instrument line water at drywell temperature and vessel pressure

υ_{rb} = specific volume of instrument (reference/variable) line water (compressed) at reactor building temperature and vessel pressure

1.3 PHYSICAL INFORMATION

The physical arrangement of instrument installations vary slightly. The physical installation information for each of the 4 instrument installations is provided in Tables 1A through 1D below.

Table 1A

Instrument	1B21-N095A		
Condensing Chamber	1B21-D004A		
TERM	**ELEV (ft) Note 1**	**Conversion**	**ELEV (inches above vessel zero)**
CCELEV.COLD (Note 2)	793.31'	(793.31'-744.0')*12"/'-(1.315"/2)	591.06"
VLN.ELEV (N13/20°)	786.42'	(786.42'-744.0')*12"/'	509.04"
RLP.ELEV (1MD-128)	790'-9 9/16" 790.80'	(790.80'-744')*12"/'	561.56"
VLP.ELEV (1MD-159)	784'-2" 784.17'	(784.17'-744.0')*12"/'	482.00"
SUB.ELEV (Note 3)	-	-	508.20"
TCH.ELEV (Note 4)	N/A	N/A	N/A
LI0.ELEV.COLD (Note 5)	-	-	520.62"
Vessel Zero (Note 6)	744.0'	(744.0'-744.0')*12"/'	0.0"

Table 1B

Instrument	1B21-N095B		
Condensing Chamber	1B21-D004B		
TERM	**ELEV (ft) Note 1**	**Conversion**	**ELEV (inches above vessel zero)**
CCELEV.COLD (Note 2)	793.35'	(793.35'-744.0')*12"/'-(1.315"/2)	591.54"
VLN.ELEV (N13/200°)	786.38'	(786.38'-744.0')*12"/'	508.56"
RLP.ELEV (1MD-129)	790'-9" 790.75'	(790.75'-744')*12"/'	561.00"
VLP.ELEV (1MD-132)	782-8 ¼" 782.69'	(782.69'-744.0')*12"/'	464.25"
SUB.ELEV (Note 3)	-	-	508.20"
TCH.ELEV (Note 4)	-	-	576.00"
LI0.ELEV.COLD (Note 5)	-	-	520.62"
Vessel Zero (Note 6)	744.0'	(744.0'-744.0')*12"/'	0.0"

Table 1A and 1B Notes:

1. Drywell wall penetration elevations (RLP.ELEV and VLP.ELEV) are from Input 4.10.1. The condensing chamber (CC.ELEV) and vessel nozzle (VLN.ELEV) elevations were obtained from the Homer Chastain survey data and the associated CWRs (Input 4.10.2) rather than CWRs, as the Homer Chastain survey data is considered more recent and more reliable.
2. Per Inputs 4.4.9 & 4.4.10, the piping connecting the condensate pot to the reactor vessel is Schedule 160, 1" Stainless Steel, SMLS pipe. According to Reference 6.7, the outside diameter of 1"-Sch. 160 pipe is nominally 1.315". The centerline elevation of the condensing chambers were determined from the elevation of the top of the "Instrument ref. Leg Pipe", referred to as "ELEV. E" in Attachment 3 of Input 4.10.2, less 0.6575 inches (OD / 2 = 1.315 / 2 = 0.6575 inches).
3. Per Input 4.11.4.
4. Per Input 4.11.4, only those transmitters attached to condensing chamber 1B21-D004B experience an elevated temperature at elevations above 576".
5. Instrument Zero (520.62") is from Input 4.11.4.
6. Vessel Zero (744.0') is from Input 4.11.4.

CCELEV.COLD	=	centerline elevation of the condensing chamber inlet while cold
LIMIN	=	minimum indication for a given level instrument
LIMAX	=	maximum indication for a given level instrument
LISPAN	=	the difference between LIMAX and LIMIN (LIMAX – LIMIN)
LI0. ELEV	=	water level instrument zero, except fuel zone. Instrument zero is 15 inches above the bottom of the dryer skirt. The TAF/FZ is the top of active fuel for the fuel zone level instruments.
RLP.ELEV	=	reference leg penetration (drywell penetration) elevation
SUB.ELEV	=	elevation under which it is assumed that reactor coolant is sub-cooled. This elevation is the elevation of the narrow range variable leg nozzle.

TCH.ELEV	=	elevation in the drywell above which the drywell temperature is higher
Vessel Invert	=	elevation of the interior vessel floor at the Reactor Pressure Vessel "RPV" bottom head.
Vessel Zero	=	a reference point inside the RPV bottom head. The vessel zero is 0.71 inches above the vessel invert.
VLN.ELEV	=	variable leg nozzle (RPV penetration) elevation while cold
VLP.ELEV	=	variable leg penetration (RPV penetration) elevation

1.4 CALCULATION

Since the elevation of condensate chambers and drywell wall penetrations are different for each of the channels, the results of the head correction and scaling calculations will differ slightly. The following calculation (Channel A) demonstrates the techniques used. The results for Channels A & B are presented in Table 2 at the end of this section.

From Section 1.2 above:

$$\Delta P = \nu_{68} [h_w (1/\nu_w - 1/\nu_s) + H/\nu_s + \Delta h_d/\nu_d + \Delta h_{rb}/\nu_{rb}]$$

This calculation will determine the differential pressure (ΔP) with the water level in the reactor at the minimum (LIMIN) and maximum (LIMAX) limits of the instruments range. Rewriting the equation above:

$$\Delta P_{min} = \nu_{68} [h_w min (1/\nu_w - 1/\nu_s) + H/\nu_s + \Delta h_d/\nu_d + \Delta h_{rb}/\nu_{rb}]$$

$$\Delta P_{max} = \nu_{68} [h_w max (1/\nu_w - 1/\nu_s) + H/\nu_s + \Delta h_d/\nu_d + \Delta h_{rb}/\nu_{rb}]$$

Deriving each term:

From Section 1.2 above:

$h_w min$ = LI0.ELEV.COLD - VLN.ELEV + LIMIN
$h_w max$ = $h_w min$ + LISPAN
LISPAN = LIMAX - LIMIN

From Table 1A above:

LI0.ELEV = 520.62 inches

VLN.ELEV = 509.04 inches

From Input 4.9.1:
LIMIN = 0 inches
LIMAX = 60 inches

Substituting:
$h_w$min = 520.62 inches – 509.04 inches + 0 inches
= 11.58 inches

$h_w$max = 11.58 inches + (60 inches – 0 inches)
= 71.58 inches

From Input 4.11.4:
H = [1+c] * [CCELEV.COLD – VLN.ELEV] – IDCCSIP/2

The centerline elevation of the condensing chambers was determined from the elevation of the top of the pipe connecting the RPV and the condensate pot, referred to as "ELEV. E" in Attachment 3 of Input 4.10.2, less 0.6575 inches per Calculation Table 1 Note 2. Therefore, "CCELEV.COLD – ID/2" is replaced by CCELEV.COLD from Table 1A.

Per Input 4.11.4, the thermal expansion correction factor for the reactor vessel at 1025 psig and 549.3°F is 3.727E-03 in/in (c = 0.003727 in/in).

Rewriting the equation:

H = [1+c] * [CCELEV.COLD – VLN.ELEV]
= [1+0.003727] * [591.06in – 509.04 inches]
= 82.33 inches

From Input 4.11.4:
$h_d$var = [1+c] * VLN.ELEV – VLP.ELEV
= [1+0.003727] * 509.04 inches – 482.00 inches
= 28.93719 inches

$h_d$ref = [1+c] * CCELEV.COLD – IDCCSIP/2 – RLP. ELEV

The centerline elevation of the condensing chambers was determined from the elevation of the top of the pipe connecting the RPV and the condensate pot, referred to as "ELEV. E" in Attachment 3 of Input 4.10.2, less 0.6575 inches per

Calculation Table 1 note 2. Therefore, "CCELEV.COLD – ID/2" is replaced by CCELEV.COLD from Table 1A.

Rewriting the equation:

$h_d$refl = [1+c] * CCELEV.COLD – RLP. ELEV
= [1+0.003727] * 591.06 inches– 561.56 inches
= 31.70 inches

Δh_d = $h_d$var - $h_d$refl
= 28.93719 inches - 31.7 inches
= - 2.77 inches

Deviation from example calculation for 1B21N095A

Per Input 4.11.4, the transmitter sensing line attached to condensing chamber 1B21-D004B experiences an elevated temperature of 190°F above elevation 576.00 in. The remaining portion of the sensing line within the drywell experiences a temperature of 135°F. This condition requires a deviation in the calculation of Δh_d for 1B21N095B.

From Ref. 6.6:
$\nu_{vd1} = 0.01621815\ ft^3/lb$
$\nu_{vd2} = 0.01651595\ ft^3/lb$

As shown above, Δh_d is the difference between $h_d$var – $h_d$refl. $h_d$var is unaffected because it is located entirely below the drywell 576.00 in level. The lower 15.00 in portion (576.00 – RLP or 576.00 in – 561.00 in) experiences 135°F (Δh_drefl). The upper 15.54 in portion (CCELEV.COLD – 576.00 in or 591.54 in – 576.00) experiences 190°F (Δh_dref2).

The vessel growth correction factor (0.003727) is applied to Δh_dref2 only, as the section between 576 in and the condensate chamber is free to move. Whereas the section between the 576 in and the Reference Leg Penetration is constant. Δh_drefl =15.00 in and Δh_dref2 = 17.75 in.

Because the calibration data is calculated based upon 68°F water, the formula given in Input 4.11.4 multiplies Δh_d times the ratio of the specific volume of water at 68 degrees to the specific volume of water at 135 degrees. It is therefore necessary to normalize the $h_d$ref2 term to it's equivalent head at 135°. This is accomplished by multiplying $h_d$ref2 times the ratio of the specific volumes of water at 135° to 190°

(both at 1025 psig). Once normalized in this fashion, Δh_d is calculated as follows and used as shown in the remainder of the example calculation:

$$\Delta h_d = h_d var - h_d ref1 - h_d ref2$$

Where

$h_d var$ = (1 + c) * VLN.ELEV – VLP.ELEV
= (1 + 0.003727) * 508.56 in – 464.25 in
= 46.21 in

$h_d ref1$ = TCH.ELEV – RLP.ELEV
= 576.00 in – 561.00 in
= 15.00 in

$h_d ref2$ = (1 + c) * CCELEV.COLD – TCH.ELEV
= (1 + 0.003727) * 591.54 in – 576.00 in
= 17.75 in

Δh_d = $h_d var - (h_d ref1 + h_d ref2 * \upsilon_{135}/\upsilon_{190})$
= 46.21 in – (15.00 in + 17.75 in * $\upsilon_{135}/\upsilon_{190}$)
= 46.21 in – [15.00 in + 17.75 in ...
* (0.016218150/0.01651595)]
= 13.78 in

<u>Resuming example calculation for 1B21N095A</u>

From Input 4.11.4:

Δh_{rb} = VLP.ELEV – RLP.ELEV
= 482.00 inches – 561.56 inches
= -79.56 inches

From Section 1.2:

$\nu_{68} = 0.01604537$ ft³/lbm

Per Input 4.11.4, vessel conditions are 1025 psig, 549.3°F, saturated above nozzle N13, and sub-cooled 20 BTU/lbm below N13. However, the range of 1B21-N095A does not extend below the elevation of N-13. Therefore this information is not relevant to this calculation. From steam tables (Ref. 6.6) for saturated steam and water:

ν_w = 0.02173445 ft^3/lbm
ν_s = 0.42697 ft^3/lbm

Per Input 4.11.4, the temperatures in the drywell and containment are 135°F and 80°F, respectively. From steam tables (Ref. 6.6) for superheated steam and compressed water:

ν_d = Specific Volume of water at 1039.7 psia and 135°F
ν_d = 0.01621815 ft^3/lbm

ν_{rb} = Specific Volume of water at 1039.7 psia and 80°F
ν_{rb} = 0.01602092 ft^3/lbm

Solving for ΔP_{min} and ΔP_{max}:

ΔP_{min} = ν_{68} [$h_w$min ($1/\nu_w$ - $1/\nu_s$) + H/ν_s + $\Delta h_d/\nu_d$ + $\Delta h_{rb}/\nu_{rb}$]
= 0.01604537 ft^3/lbm * [11.58 inches* (1/0.02173445 ft^3/lbm – 1/0.42697 ft^3/lbm) + (82.33 inches/ 0.42697 ft^3/lbm) + (-2.77 inches/ 0.01621815 ft^3/lbm) + (-79.56 inches/ 0.01602092 ft^3/lbm)]
= -71.21 inwc

ΔP_{max} = ν_{68} [$h_w$max ($1/\nu_w$ - $1/\nu_s$) + H/ν_s + $\Delta h_d/\nu_d$ + $\Delta h_{rb}/\nu_{rb}$]
= 0.01604537 ft^3/lbm * [71.58 inches* (1/0.02173445 ft^3/lbm – 1/0.42697 ft^3/lbm) + (82.33 inches/ 0.42697 ft^3/lbm) + (-2.77 inches/ 0.01621815 ft^3/lbm) + (-79.56 inches/ 0.01602092 ft^3/lbm)]
= -29.17 inwc

As noted in Section 7.4.1, the transmitter is a Rosemount 1153DB4PC, which per Input 4.2.1 has a static pressure correction of +0.75% of input per 1000 psi. Thus, the correction factor (CF) is determined as,

CF = (1025 psig/1000 psi) x 0.0075 = 0.00769

Applying the correction factor to ΔP_{min} and ΔP_{max}:

Span Corrected Lower Range Limit = ΔP_{min} / (1+CF)
= -71.21 inwc / (1+0.00769)
= -70.67 inwc

Span Corrected Upper Range Limit = ΔP_{max} / (1+CF)
= -29.17 inwc / (1+0.00769)
= -28.95 inwc

CC Span = | (Span Corrected Upper Range Limit – Span Corrected Lower Range Limit) |

Substituting from above:

CC Span = |(-28.95 inwc – (-70.67 inwc))|
CC Span = 41.72 inwc

The calculated results of Cold Calibrated Span verifies Assumption 2.13 as conservative. Assuming a CC Span (41.7 inwc) that is smaller than the actual CC Span (41.72) results in a slightly larger turn-down ratio and therefore slightly larger transmitter uncertainty.

Table 2

Instrument	1B21-N095A	1B21-N095B
Operating Press	1025 psig	
CCELEV.COLD	591.06 inches	591.54 inches
VLN.ELEV	509.04 inches	508.56 inches
RLP.ELEV	561.56 inches	561.00 inches
VLP.ELEV	482.00 inches	464.25 inches
SUB.ELEV	508.20 inches	508.20 inches
TCH.ELEV	N/A	576.00 inches
LI0.ELEV.COLD	520.62 inches	
Vessel Zero	744.0 feet	
LIMAX	60 inches	
LIMIN	0 inches	
LISPAN	60 inches	
C	0.003727 in/in	
$h_w$min	11.58 inches	12.06 inches
$h_w$max	71.58 inches	72.06 inches
H	82.33 inches	83.29 inches
$h_d$var	28.94 inches	46.21 inches
$h_d$ref1	31.7 inches	15.00 inches
$h_d$ref2	N/A	17.75 inches
Δh_d	-2.77 inches	13.78 inches
Δh_{rb}	-79.56 inches	-96.75 inches
v_{68}	0.01604537 ft^3/lbm	
v_w	0.02173445 ft^3/lbm	
v_s	0.42697000 ft^3/lbm	
v_{d1}	0.01621815 ft^3/lbm	
v_{d2}	N/A	0.01651595 ft^3/lbm
v_{rb}	0.01602092 ft^3/lbm	
ΔPmin	-71.21 inwc	-71.69 inwc
ΔPmax	-29.17 inwc	-29.65 inwc
CF	0.00769	
Span Corrected Calibrated Range Lower Limit	-70.67 inwc	-71.14 inwc
Span Corrected Calibrated Range Upper Limit	-28.95 inwc	-29.42 inwc
Cold Calibrated Span	41.72 inwc	41.72 inwc

Determining the cardinal point values for cold calibration of the level transmitters.

Per Inputs 4.12.2 and 4.12.3, cardinal points are at 0%, 25%, 50%, 75%, and 100% span.

Per Attachment 1 Section 1.1, Transmitter Output Range:
0% = 1.0 Vdc
100% = 5.0 Vdc

From Attachment 1 Section 1.4, Transmitter Span Corrected Range Limits:
0% = -70.67 inwc
100% = -28.95 inwc

Interpolating for calibration cardinal points (inwc):
Cardinal Point = % span * (-28.95 inwc - (-70.67 inwc)) + (-70.68 inwc)

0% = 0% * (-28.95 inwc - (-70.67 inwc)) + (-70.67 inwc)
= -70.67 inwc

25% = 25% * (-28.95 inwc - (-70.67 inwc)) + (-70.67 inwc)
= -60.24 inwc

50% = 50% * (-28.95 inwc - (-70.67 inwc)) + (-70.67 inwc)
= -49.81 inwc

75% = 75% * (-28.95 inwc - (-70.67 inwc)) + (-70.67 inwc)
= -39.38 inwc

100% = 100% * (-28.95 inwc - (-70.67 inwc)) + (-70.67 inwc)
= -28.95 inwc

The calibration cardinal points for all level transmitters are presented Table 3.

TABLE 3

Instrument	1B21-N095A	1B21-N095B
% Span	Calibration Pressure	
0%	-70.67 inwc	-71.14 inwc
25%	-60.24 inwc	-60.71 inwc
50%	-49.81 inwc	-50.28 inwc
75%	-39.38 inwc	-39.85 inwc
100%	-28.95 inwc	-29.42 inwc

Interpolating for calibration cardinal points (Vdc):
Cardinal Point = % span * (5.0 Vdc – 1.0 Vdc) + 1.0 Vdc

0% = 0% * (5.0 Vdc – 1.0 Vdc) + 1.0 Vdc
= 1.0 Vdc

25% = 25% * (5.0 Vdc – 1.0 Vdc) + 1.0 Vdc
= 2.0 Vdc

50% = 50% * (5.0 Vdc – 1.0 Vdc) + 1.0 Vdc
= 3.0 Vdc

75% = 75% * (5.0 Vdc – 1.0 Vdc) + 1.0 Vdc
= 4.0 Vdc

100% = 100% * (5.0 Vdc – 1.0 Vdc) + 1.0 Vdc
= 5.0 Vdc

2.0 ANALOG TRIP MODULE SCALING

2.1 ANALOG TRIP MODULE SPECIFIC INFORMATION

EIN: 1B21N695A & B (RPV Level – Low, Level 3)
1B21N693A & B (RPV Level - High, Level 8)

Manufacturer: GE.
Model No.: 147D8505G005
Input: 1.000 - 5.000 Vdc
Output: discrete trip signal

Input Range

Min (p)	Max (P)	Units
p = 1	P = 5	Vdc

2.2 LOOP SCALING INFORMATION

The cold calibration values for setpoints, Allowable Values and Resets derived in Section 8 of the uncertainty calculation are determined by substituting the calculated value for "$h_w$min" then recalculating "ΔPmin" and "Span Corrected Calibrated Range Lower Limit" as illustrated in Attachment 1,Section 1.4.

Where:

$AV_{Level\ 3}$ = AV is calculated value from Section 8.3.1

$AV_{Level\ 8}$ = AV is calculated value from Section 8.3.2

$NTSP_{Level\ 3}$ = NTSP is calculated value from Section 8.1.1

$NTSP_{Level\ 8}$ = NTSP is calculated value from Section 8.1.2

$Reset_{Level\ 3}$ = Reset is calculated value from Section 8.4

$Reset_{Level\ 8}$ = Reset is calculated value from Section 8.4

h_wAVLevel 3 = height of vessel water column above the variable leg nozzle (VLN.ELEV) at Level 3 Allowable Value

h_wAVLevel 8 = height of vessel water column above the variable leg nozzle (VLN.ELEV) at Level 8 Allowable Value

h_wLevel 3 = height of vessel water column above the variable leg nozzle (VLN.ELEV) at Level 3

h_wLevel 8 = height of vessel water column above the variable leg nozzle (VLN.ELEV) at Level 8

h_wLevel 3 Reset = height of vessel water column above the variable leg nozzle (VLN.ELEV) at Level 3 Reset

h_wLevel 8 Reset = height of vessel water column above the variable leg nozzle (VLN.ELEV) at Level 8 Reset

$\Delta P\text{-}AV_{Level3}$ = differential pressure on transmitter with RPV water level at Level 3 Allowable value

$\Delta P\text{-}AV_{Level8}$ = differential pressure on transmitter with RPV water level at Level 8 Allowable value

ΔP_{Level3} = differential pressure on transmitter with RPV water level at Level 3

ΔP_{Level8} = differential pressure on transmitter with RPV water level at Level 8

$\Delta P_{Level3Reset}$ = differential pressure on transmitter with RPV water level at Level 3 Reset

$\Delta P_{Level8Reset}$ = differential pressure on transmitter with RPV water level at Level 8 Reset

Span Corrected Level 3 Setpoint = differential pressure at $NTSP_{Level\ 3}$ corrected for span.

Span Corrected Level 8 Setpoint = differential pressure at $NTSP_{Level\ 8}$ corrected for span.

Span Corrected Level 3 AV = differential pressure at $AV_{Level\ 3}$ corrected for span.

Span Corrected Level 8 AV = differential pressure at $AV_{Level\ 8}$ corrected for span.

Span Corrected Level 3 Reset = differential pressure at $Reset_{Level\ 3}$ corrected for span.

Span Corrected Level 8 Reset = differential pressure at $Reset_{Level\ 8}$ corrected for span.

Calculating RPV Level – Low, Low, Level 3 Trip Unit Scaling:

Per Section 8.3.1:
$AV_{Level\,3}$ = 8.3 in

Per Section 8.1.1:
$NTSP_{Level\,3}$ = 8.9 in

Per Section 8.4.1:
$Reset_{Level\,3}$ = 10.7 in

From Attachment 1, Section 1.4:
$h_w min$ = LI0.ELEV.COLD - VLN.ELEV + LIMIN

Substituting "$NTSP_{Level\,3}$" for "LIMIN":
$h_w Level\ 3$ = LI0.ELEV.COLD - VLN.ELEV + $NTSP_{Level\,3}$
= 520.62 inches – 509.04 inches + 8.90 inches
= 20.48 inches

Substituting "$Reset_{Level\,3}$" for "LIMIN":
$h_w Level\ 3\ Reset$ = LI0.ELEV.COLD - VLN.ELEV + $Reset_{Level\,3}$
= 520.62 inches – 509.04 inches + 10.7 inches
= 22.28 inches

Substituting "$AV_{Level\,3}$" for "LIMIN":
$h_w AVLevel\ 3$ = LI0.ELEV.COLD - VLN.ELEV + $AV_{Level\,3}$
= 520.62 inches – 509.04 inches + 8.3 inches
= 19.88 inches

From Attachment 1, Section 1.4:

$$\Delta P_{min} = \nu_{68}\,[h_w min\,(1/\nu_w - 1/\nu_s) + H/\nu_s + \Delta h_d/\nu_d + \Delta h_{rb}/\nu_{rb}]$$

Substituting "$h_w Level\ 3\ NTSP$" for "$h_w min$":

$$\Delta P_{Level3} = \nu_{68}\,[h_w Level\ 3\,(1/\nu_w - 1/\nu_s) + H/\nu_s + \Delta h_d/\nu_d + \Delta h_{rb}/\nu_{rb}]$$

$$= 0.01604537\ ft^3/lbm * [20.48\ inches * (1/0.02173445\ ft^3/lbm - 1/0.42697\ ft^3/lbm) + (82.33\ inches\ /\ 0.42697\ ft^3/lbm) + (-2.77\ inches\ /\ 0.01621815\ ft^3/lbm) + (-79.56\ inches\ /\ 0.01602092\ ft^3/lbm)]$$

$$= -64.98\ inwc$$

Substituting "h_wLevel 3 Reset" for "$h_w$min":

$\Delta P_{Level3Reset}$ = v_{68} [h_wLevel 3 Reset ($1/v_w - 1/v_s$) + H/v_s + $\Delta h_d/v_d + \Delta h_{rb}/v_{rb}$]
= 0.016046 ft^3/lbm * [22.28 inches * (1/0.02173445 ft^3/lbm – 1/0.42697 ft^3/lbm) + (82.33 inches / 0.42697 ft^3/lbm) + (-2.77 inches / 0.01621815 ft^3/lbm) + (-79.56 inches / 0.01602092 ft^3/lbm)]
= -63.72 inwc

Substituting "h_wAVLevel 3 " for "$h_w$min":

$\Delta P\text{-}AV_{Level3}$ = v_{68} [h_wAVLevel 3 ($1/v_w - 1/v_s$) + H/v_s + $\Delta h_d/v_d + \Delta h_{rb}/v_{rb}$]
= 0.016046 ft^3/lbm * [19.88 inches * (1/0.02173445 ft^3/lbm – 1/0.42697 ft^3/lbm) + (82.33 inches / 0.42697 ft^3/lbm) + (-2.77 inches / 0.01621815 ft^3/lbm) + (-79.56 inches / 0.01602092 ft^3/lbm)]
= -65.40 inwc

Applying the correction factor to ΔP_{Level3}:

Span Corrected Level 3 Setpoint = ΔP_{Level3} / (1+CF)
= -64.98 inwc / (1+0.00769)
= -64.48 inwc

Span Corrected Level 3 Reset = $\Delta P_{Level3Reset}$ / (1+CF)
= -63.72 inwc / (1+0.00769)
= -63.23 inwc

Span Corrected Level 3 AV = $\Delta P_{AVLevel3}$ / (1+CF)
= -65.40 inwc / (1+0.00769)
= -64.90 inwc

Calculating RPV Level – High, Level 8 Trip Unit Scaling:

Per Section 8.3.2
$AV_{Level\ 8}$ = 52.6 inches

Per Section 8.1.2:
$NTSP_{Level\ 8}$ = 52.0 inches

Per Section 8.4.2:
$Reset_{Level\ 8}$ = 50.2 inches

From Attachment 1, Section 1.4:

$h_w min$ = LI0.ELEV.COLD - VLN.ELEV + LIMIN

Substituting "$NTSP_{Level\ 8}$" for "LIMIN":

$h_w Level\ 8$ = LI0.ELEV.COLD - VLN.ELEV + $NTSP_{Level\ 8}$
= 520.62 inches – 509.04 inches + 52.0 inches
= 63.58 inches

Substituting "$Reset_{Level\ 3}$" for "LIMIN":

$h_w Level\ 8\ Reset$ = LI0.ELEV.COLD - VLN.ELEV + $Reset_{Level\ 8}$
= 520.62 inches – 509.04 inches + 50.2 inches
= 61.78 inches

Substituting "$AV_{Level\ 8}$" for "LIMIN":

$h_w AVLevel8$ = LI0.ELEV.COLD - VLN.ELEV + $AV_{Level\ 8}$
= 520.62 inches – 509.04 inches + 52.6 inches
= 64.18 inches

From Attachment 1, Section 1.4:

$$\Delta P_{min} = \nu_{68}\,[h_w min\,(1/\nu_w - 1/\nu_s) + H/\nu_s + \Delta h_d/\nu_d + \Delta h_{rb}/\nu_{rb}]$$

Substituting "$h_w Level\ 8$ " for "$h_w min$":

$$\Delta P_{Level8} = \nu_{68}\,[h_w Level\ 8\,(1/\nu_w - 1/\nu_s) + H/\nu_s + \Delta h_d/\nu_d + \Delta h_{rb}/\nu_{rb}]$$

= 0.01604537 ft^3/lbm * [63.58 inches * (1/0.02173445 ft^3/lbm – 1/0.42697 ft^3/lbm) + (82.33 inches / 0.42697 ft^3/lbm) + (-2.77 inches / 0.01621815 ft^3/lbm) + (-79.56 inches / 0.01602092 ft^3/lbm)]

= -34.78 inwc

Substituting "$h_w Level\ 8\ Reset$" for "$h_w min$":

$$\Delta P_{Level8Reset} = \nu_{68}\,[h_w Level\ 8\ Reset\,(1/\nu_w - 1/\nu_s) + H/\nu_s + \Delta h_d/\nu_d + \Delta h_{rb}/\nu_{rb}]$$

= 0.01604537 ft^3/lbm * [61.78 inches * (1/0.02173445 ft^3/lbm – 1/0.42697 ft^3/lbm) + (82.33 inches / 0.42697 ft^3/lbm) + (-2.77 inches / 0.01621815 ft^3/lbm) + (-79.56 inches / 0.01602092 ft^3/lbm)]

= -36.04 inwc

Substituting "h_wAVLevel 8 " for "$h_w$min":

ΔP-AV$_{Level8}$ = ν_{68} [h_wAVLevel 8 $(1/\nu_w - 1/\nu_s) + H/\nu_s + \Delta h_d/\nu_d + \Delta h_{rb}/\nu_{rb}$]

= 0.01604537 ft^3/lbm * [64.18 inches * (1/0.02173445 ft^3/lbm – 1/0.42697 ft^3/lbm) + (82.33 inches / 0.42697 ft^3/lbm) + (-2.77 inches / 0.01621815 ft^3/lbm) + (-79.56 inches / 0.01602092 ft^3/lbm)]

= -34.36 inwc

Applying the correction factor to ΔP_{Level8}:

Span Corrected Level 8 Setpoint = ΔP_{Level8} / (1+CF)
= -34.78 inwc / (1+0.00769)
= -34.51 inwc

Span Corrected Level 8 Reset = $\Delta P_{Level8Reset}$ / (1+CF)
= -36.04 inwc / (1+0.00769)
= -35.76 inwc

Span Corrected Level 8 AV = $\Delta P_{AVLevel8}$ / (1+CF)
= -34.36 inwc / (1+0.00769)
= -34.10 inwc

Table 4 provides the calculated Span Corrected values.

Table 4

Instrument	1B21-N695A & 1B21-N693A	1B21-N695B & 1B21-N693B
$AV_{Level\ 3}$	8.3 inches	
$NTSP_{Level\ 3}$	8.9 inches	
$Reset_{Level\ 3}$	10.7 inches	
$Reset_{Level\ 8}$	50.2 inches	
$NTSP_{Level\ 8}$	52.0 inches	
$AV_{Level\ 8}$	52.6 inches	
hwAVLevel 3	19.88 inches	20.36 inches
h_wLevel 3	20.48 inches	20.96 inches
h_wLevel 3 Reset	22.28 inches	22.76 inches
h_wLevel 8 Reset	61.78 inches	62.26 inches
h_wLevel 8	63.58 inches	64.06 inches
hwAVLevel 3	64.18 inches	64.66 inches
$\Delta P\text{-}AV_{Level3}$	-65.40 inwc	-65.87 inwc
ΔP_{Level3}	-64.98 inwc	-65.45 inwc
$\Delta P_{Level3Reset}$	-63.72 inwc	-64.19 inwc
$\Delta P_{Level8Reset}$	-36.04 inwc	-36.51 inwc
ΔP_{Level8}	-34.78 inwc	-35.25 inwc
$\Delta P\text{-}AV_{Level8}$	-34.36 inwc	-34.83 inwc
Span Corrected Level 3 AV	-64.90 inwc	-65.37 inwc
Span Corrected Level 3 Setpoint	-64.48 inwc	-64.95 inwc
Span Corrected Level 3 Reset	-63.23 inwc	-63.70 inwc
Span Corrected Level 8 Reset	-35.76 inwc	-36.23 inwc
Span Corrected Level 8 Setpoint	-34.51 inwc	-34.98 inwc
Span Corrected Level 8 AV	-34.10 inwc	-34.57 inwc

1B21N095A,B CALIBRATION INFORMATION

- Per Inputs 4.12.2 and 4.12.3, transmitter calibration input is measured in "inwc" and output is monitored in "Vdc".
- Per Section 1.1 of Attachment 1, output span of the level transmitter is 4 Vdc (5 Vdc – 1 Vdc)
- Per Section 7.5.1 of the uncertainty calculation $ALT_{LT} = \pm 0.2500\%$ Span. Therefore;
  $ALT_{LT} = \pm 0.25\%$ Span * 4 Vdc
  $ALT_{LT} = \pm 0.010$Vdc (rounded down to 3 decimal places to agree with the calibration procedures)
- Per Section 8.3.1 of the uncertainty calculation $AFT_{LT} = \pm 0.7669\%$ Span.
  $AFT_{LT} = \pm 0.7669\%$ Span * 4 Vdc
  $AFT_{LT} = \pm 0.030$ Vdc (rounded down to 3 decimal places to agree with the calibration procedures)

Cal. Pt.	Input Pressure (inwc)		Output (volts DC)	
	1B21-N095A	1B21-N095B	AFT	ALT
			(±0.030 Vdc)	(±0.010 Vdc)
0%	-70.67	-71.14	1.000 (0.970 to 1.030)	1.000 (0.990 to 1.010)
25%	-60.24	-60.71	2.000 (1.970 to 2.030)	2.000 (1.990 to 2.010)
50%	-49.81	-50.28	3.000 (2.970 to 3.030)	3.000 (2.990 to 3.010)
75%	-39.38	-39.85	4.000 (3.970 to 4.030)	4.000 (3.990 to 4.010)
100%	-28.95	-29.42	5.000 (4.970 to 5.030)	5.000 (4.990 to 5.010)

1B21-N695A,B & 1B21N693A,B ATM CALIBRATION INFORMATION

- Per Inputs 4.12.2 and 4.12.3, ATM calibration input is measured in "IN Water" and output is monitored by trip and reset action of the ATM.
- Per Input 4.9.1, Process Span = 60 inches
- Per Section 7.5.1 of the uncertainty calculation $ALT_{ATM} = \pm 0.2500\%$ Span.

  $ALT_{ATM} = \pm 0.25\%$ Span * 60 inches
  $ALT_{ATM} = \pm 0.1$ inches (rounded to 1 decimal places to agree with the calibration procedures)

- Per Section 8.3.2 of the uncertainty calculation $AFT_{ATM} = \pm 0.5588\%$ Span.

  $AFT_{ATM} = \pm 0.5588\%$ Span * 60 inches
  $AFT_{ATM} = \pm 0.3$ inches (rounded to 1 decimal places to agree with the calibration procedures)

1B21N695A ATM Calibration

Cal. Pt.	Input	Output	
	Inches	AFT	ALT
		(±0.3 inches)	(±0.1 inches)
AV	≥ 8.3	≥ 8.3 inches	≥ 8.3 inches
Setpoint	8.9	8.9 inches (8.6 to 9.2)	8.9 inches (8.8 to 9.0)
Reset	10.7	10.7 inches (10.4 to 11.0)	10.7 inches (10.6 to 10.8)

1B21N695B ATM Calibration

Cal. Pt.	Input	Output	
	Inches	AFT	ALT
		(±0.3 inches)	(±0.1 inches)
AV	≥ 8.3	≥ 8.3 inches	≥ 8.3 inches
Setpoint	8.9	8.9 inches (8.6 to 9.2)	8.9 inches (8.8 to 9.0)
Reset	10.7	10.7 inches (10.4 to 11.0)	10.7 inches (10.6 to 10.8)

1B21N693A ATM Calibration

Cal. Pt.	Input	Output	
	Inches	AFT	ALT
		(±0.3 inches)	(±0.1 inches)
AV	≤ 52.6	≤ 52.6 inches	≤ 52.6 inches
Setpoint	52.0	52.0 inches (51.7 to 52.3)	52.0 inches (51.9 to 52.1)
Reset	50.2	50.2 inches (49.9 to 50.5)	50.2 inches (50.1 to 50.3)

1B21N693B ATM Calibration

Cal. Pt.	Input	Output	
	Inches	AFT	ALT
		(±0.3 inches)	(±0.1 inches)
AV	≤ 52.6	≤ 52.6 inches	≤ 52.6 inches
Setpoint	52.0	52.0 inches (51.7 to 52.3)	52.0 inches (51.9 to 52.1)
Reset	50.2	50.2 inches (49.9 to 50.5)	50.2 inches (50.1 to 50.3)

1B21-N095A,B, 1B21-N695A,B & 1B21N693A,B
LOOP CALIBRATION INFORMATION

- Per Inputs 4.12.2 and 4.12.3, ATM calibration input is measured in "inwc" and output is monitored by trip and reset action of the ATM.
- Per Assumption 2.13 Cold Calibrated Span = 41.70 inwc.
- Per Section 7.5.1 of the uncertainty calculation $ALT_L = \pm 0.14$ inwc.
- Per Section 8.3.3 of the uncertainty calculation $AFT_L = \pm 0.38$ inwc.

1B21N095A and 1B21N695A Loop Calibration

Cal. Pt.	Input	Output	
	inwc	AFT	ALT
		(± 0.38 inwc)	(± 0.14 inwc)
AV	≥ -64.90	≥ -64.90 inwc	≥ -64.90 inwc
Setpoint	-64.48	-64.48 inwc (-64.10 to -64.86)	-64.48 inwc (-64.34 to -64.62)
Reset	-63.23	-63.23 inwc (-62.85 to -63.61)	-63.23 inwc (-63.09 to -63.37)

1B21N095B and 1B21N695B Loop Calibration

Cal. Pt.	Input	Output	
	inwc	AFT	ALT
		(± 0.38 inwc)	(± 0.14 inwc)
AV	≥ -65.37	≥ -65.37 inwc	≥ -65.37 inwc
Setpoint	-64.95	-64.95 inwc (-64.57 to -65.33)	-64.95 inwc (-64.81 to -65.09)
Reset	-63.70	-63.70 inwc (-63.32 to -64.08)	-63.70 inwc (-63.56 to -63.84)

1B21N095A and 1B21N693A Loop Calibration

Cal. Pt.	Input	Output	
	inwc	AFT	ALT
		(± 0.38 inwc)	(± 0.14 inwc)
AV	≤ -34.10	≤ -34.10 inwc	≤ -34.10 inwc
Setpoint	-34.51	-34.51 inwc (-34.13 to -34.89)	-34.51 inwc (-34.37 to -34.65)
Reset	-35.76	-35.76 inwc (-35.38 to -36.14)	-35.76 inwc (-35.62 to -35.9)

1B21N095B and 1B21N693B Loop Calibration

Cal. Pt.	Input	Output	
	inwc	AFT	ALT
		(± 0.38 inwc)	(± 0.14 inwc)
AV	≤ -34.57	≤ -34.57 inwc	≤ -34.57 inwc
Setpoint	-34.98	-34.98 inwc (-34.60 to -35.36)	-34.98 inwc (-34.84 to -35.12)
Reset	-36.23	-36.23 inwc (-35.85 to -36.61)	-36.23 inwc (-36.09 to -36.37)

RESULTS SUMMARY

The following tables list the applicable results of this calculation.

Primary Sensor Scaling/Calibration					
Primary Sensor	Calibration Span				
	0%	25%	50%	75%	100%
1B21N095A	-70.67 inwc	-60.24 inwc	-49.81 inwc	-39.38 inwc	-28.95 inwc
1B21N095B	-71.14 inwc	-60.71 inwc	-50.28 inwc	-39.85 inwc	-29.42 inwc

Individual Component Setting Tolerances		
Component EIN	As-Found	As-Left
1B21N095A,B	± 0.030 Vdc	± 0.010 Vdc
1B21N695A,B 1B21N693A,B	± 0.3 inches	± 0.1 inches

Loop Calibration - Trip Setpoint, Reset and Setting Tolerances				
Component EIN	Setpoint	Reset	As-Found	As-Left
1B21N695A	-64.48 inwc	-63.23 inwc	± 0.38 inwc	± 0.14 inwc
1B21N695B	-64.95 inwc	-63.70 inwc		
1B21N693A	-34.51 inwc	-35.76 inwc		
1B21N693B	-34.98 inwc	-36.23 inwc		

Loop Calibration - Allowable Value	
Component EIN	Allowable Value
1B21N695A	≥ -64.90 inwc
1B21N695B	≥ -65.37 inwc
1B21N693A	≤ -34.10 inwc
1B21N693B	≤ -34.57 inwc

M&TE Used In Calculation (if specified in calculation)			
Manufacturer	Model Number	Range	Total Accuracy (Eng. Units)
Heise	HQS-2 or equivalent	0 – 100 inwc	±0.0391 inwc Temp band of (20°F to 120°F)
Fluke	45 (Slow) (or equivalent)	1-5 Volts (span)	±0.004 Vdc
Precision Resistor	NA	250 Ω	0.02 Ω

FSAR/Technical Specification Setpoints		
Component EIN	Allowable Value / Design Setpoint	FSAR/Technical Specification Section
1B21N695A,B	≥8.3 inches 8.9 inches	Tech. Spec. Tables: 3.3.5.1-1 Items 4.d, 5.d ORM Tables: Table 5, Items 4.d, 5.d
1B21N693A,B	≤52.6 inches 52.0 inches	Tech. Spec. Table 3.3.5.2-1 Item 2 ORM Table 6, Item b

EIN: PG1509

NOUN NAME: Digital Pressure Module
MANUFACTURER: Heise
MODEL NO.: HQS-2
SERIAL NO.: 16364
RANGE: 0 to 100 inwc

ACCURACY: ± *0.03 INWC*

ENVIRONMENTAL LIMITATIONS: Operating ambient temperature is limited to 20°F to 120°F without corrections. Contact the Cal Lab for corrections if ambient temperature is outside the above specified range.

NOTE: This pressure module must be used in a Heise Digital Indicator assembly, model number ST-2H, or equivalent. The assembly supplies operating power and a digital readout for the pressure module. The Digital Indicator Assembly has voltage and current functions which are not certified for use for quantitative data.

Approved by: [signature] 10/15/00

11/03/99 10:21 ☎1 800 287 4000 THERMO CENSE ⊘004/005

LIST PRICES APPLYING TO BULLETIN ST2H-1 | **HEISE®** | **DIGITAL PRESSURE INDICATORS**

Effective June 15, 1999

ST2H/PS-1A/99
Page 3 of 4

HQS-2: QUICK SELECT PRESSURE MODULES

Gauge and Absolute (All ranges include 316SS isolation, except where indicated by "*")

psi	Inches Water	Inches Mercury	mm Mercury	kPa	Bar KgCm²	mBar cmH₂O	mmH₂O	Accuracy† ±0.025%	Accuracy† ±0.05%	Accuracy† ±0.1%
5* 10 15 30 50 60 100 150 200 250 300	100* 150* 250 300 500 1000	10* 20 30 50 100 200 300 500	250* 500 750 1000 1500 3000 5000	25* 40* 60 100 160 250 400 600 1000 mPa 1 1.6	1 1.6 2.5 4 6 10 16	250* 300* 400* 500* 600 1000 1600 2000 2500 4000 5000 6000 10,000	3000* 5000* 10,000	Gauge Pressure 650.00 [2] Absolute Pressure 725.00 [2]	600.00 [1] 675.00 [1]	550.00 [1] 625.00 [1]
500 600 1000 1500 2000 2500 3000 5000 6000 7500		1000		2.5 4.0 6.0 10 16 25 40 60	25 40 60 100 160 250 400 500			Gauge Pressure 750.00 [2] Absolute Pressure 825.00 [2]	700.00 [1] 775.00 [1]	650.00 [1] 725.00 [1]
10,000								–	–	790.00
psi	**Inches Water**	**Inches Mercury**	**mm Mercury**	**kPa**	**Bar kg/cm²**	**mBar cmH₂O**	**mmH₂O**	**Accuracy† ±0.025%**	**Accuracy† ±0.05%**	**Accuracy† ±0.1%**
Vacuum										
5* 10 15		10* 20 30	250* 500 750	25* 40* 60 100	0.25* 0.4* 0.6 1.0	250* 400* 600 1000	3000* 5000*	725.00 [2]	675.00 [1]	625.00 [1]
Compound										
±5 ±10 ±15 −15/30 −15/60	±100* ±250 ±400	±10 ±20 ±30 −30/60 −30/100	±300 ±500 ±750 −750/1500 −750/3000	±25* ±40* ±60 ±100 −100/200 −100/400	±0.25* ±0.40* ±0.60 ±1.0 −1/2 −1/4	±250* ±400* ±600 ±1000 −1000/2000 −1000/4000	±3000* ±6000 ±10,000	725.00 [2]	675.00 [1]	625.00 [1]

*Non-isolated; for clean dry gas only.

†Maximum includes nonlinearity, nonrepeatability and hysteresis.

HQS-2 OPTIONS

Enhanced Calibration (no additional temperature error throughout operating range of 20-120°F) 100.00
Non-Standard Ranges 115.00
G ¼ British Standard Fitting 30.00
Flush Port (isolated sensors only) 95.00
Welded VCR Connection (with standard finish on gland) 85.00
Oxygen Cleaning (isolated sensors only) 115.00

Reference: Bulletin ST2H-1

RPV LEVEL SCALING – EXCEL SPREADSHEET

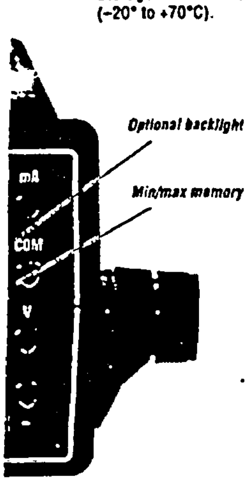
HEISE MODEL ST-2H INDICATOR SPECIFICATIONS

Standard Display: Alphanumeric LCD, 0.37-inch height, 2 lines, 16 characters/line.
Optional Display: Backlit LCD alphanumeric with 2 lines and 16 characters/line.
Display Resolution: ±0.002% of span with damping 1 part in 50,000 (max).
Display Update Rate: 100 ms.
Engineering Units: psi, in.H_2O, in.Hg, ftSW, bar, mbar, kPa, MPa, mmHg, cmH_2O, mmH_2O and kgcm^2 and any single user-programmable engineering unit.
Damping: Programmable averaging from zero through 16 consecutive readings.

TEMPERATURE SPECIFICATIONS

Standard Operating Range: 32° to 120°F (0 to 49°C).

Compensated Range: 20° to 120°F (–7° to +49°C).
Reference Temperature: 70 ±3°F.
Standard Temperature Effect: ±0.004% of span per degree Fahrenheit over the compensated range.
Optional: Quick-Select modules are available calibrated to maintain rated accuracy over the 20° to 120°F (–7° to +49°C) compensated temperature range.
Storage Limits: –4°F to +158°F (–20° to +70°C).



ELECTRICAL SPECIFICATIONS

Electrical Sourcing Specification:
24 Vdc at 25mA.
Electrical Measurement Specification:

Input (volts)	Accuracy
0/10 Vdc	±0.025% F.S.
0/30 Vdc	±0.10% F.S.
Input (mA)	**Accuracy**
0/20 mA	±0.03% F.S.
0/50 mA	±0.05% F.S.

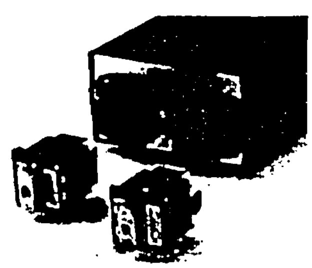
Auto-ranging 10/30 Vdc & 20/50mA
Temperature Effects Electrical Measurement: ±0.001% of span per °F over the compensated range.

INTERFACE AND DATA LOGGING

RS232 Serial Interface: with 9-pin D type at 300, 1200, 2400, 9600 baud.
Field Calibration: Calibration module and proper pressure and electrical standards are required.
Optional Data Logging capacity:
Standard measurements: 714 records.
Date/time stamped measurements: 384 records.
Optional Certification Generation Firmware: Stores 10 complete sets of calibration data including 10 "as found" and 10 "as left" data sets.

MECHANICAL SPECIFICATIONS

Weight: ST-2H Base unit: 3.0 lb (1.4 kg).
Housing: Molded, high-impact ABS case.
Electrical Connections: Standard banana jacks.
Optional Battery Power Supply:
5 "AA" nicads with built-in charger.
External Power Supply: AC adaptor 9 Vdc, 500mA.
Portable Operation: 20 hours with optional backlight off, 2 hours with backlight on.
Warm-up: 5 minutes for rated accuracy (maximum), 30 minutes for complete stability.



HQS Modular Sensor System

ACCESSORIES

AC Adaptors: provide 9 Vdc output.

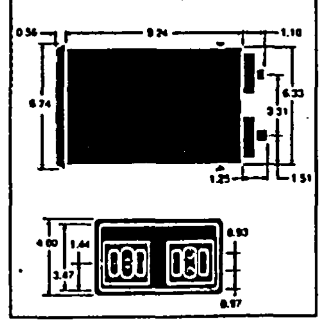
Part Number	Adapts from
831X016-01	110 Vac, 60Hz
831X016-02	100 Vac, 50 Hz
831X016-03	230 Vac, 50 Hz

Calibration Quick-Select Module:
For calibration of base unit electronics.
Part Number: CQS.
System Protection Module: Protects base unit when only one measurement module is required.
Part Number: HQS-XS.
Cable Assembly: Connects base unit to 9-pin female serial port on computer.
Part Number: 838X011-01.
Adapter 9-pin to 25-pin: Serial port connector on computer.
Part Number: 838X012-01.
Hoses: provide ¼-20 UNF internal fittings. For use with pumps and general process connections.
3 ft hose, *Part Number:* 840X007-01.
5 ft hose, *Part Number:* 840X007-02.
¼ NPT external fitting adaptor to convert hose connector from ¼-20 to NPT.
Part Number: 840X006-01.

FOR MORE INFORMATION

Request the following documents:
Temperature Module: HQS-1
Pressure Modules: PTE-1
Pumps: HACC-P
Voltage Adapter: HACC-SM
How to Order: See Price Sheet ST-2H-1 for ordering information.
Contact us at: 203-426-3115.

ST-2H Dimesion Drawings



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Jay 1/26/02

DEPT/DIV C/NSED	CALCULATION NO. IP-C-0059 ATTACHMENT 4	REVISION 0 VOLUME A	SHEET 1 of 4

RPV LEVEL SCALING – EXCEL SPREADSHEET

	A	B	C	D	E	F
1	Instrument	1B21-N095A				
2	Cond Chamber	1B21-D004A				
3	Operating Presure	psia			1025	
4						
5		feet	inches	cubic feet / lbm	inwc	vdc
6	CCELEV.COLD	793.31	591.06			
7	VLN.ELEV	786.42	509.04			
8	RLP.ELEV	790.80	561.56			
9	VLP.ELEV	784.17	482.00			
10	SUB.ELEV		508.20			
11	TCH.ELEV		-8928.00			
12	LI0.ELEV.COLD		520.62			
13	Vessel Zero	744.00				
14						
15	LIMAX		60.00			
16	AV Level 8		52.60			
17	NTSP level 8		52.00			
18	Reset Level 8		50.20			
19	Reset Level 3		10.70			
20	NTSP level 3		8.90			
21	AV Level 3		8.30			
22	LIMIN		0.00			
23	LISPAN		60.00			
24						
25	c		0.003727			
26						
27	hwmin		11.58			
28	hwAV level 3		19.88			
29	hwlevel 3		20.48			
30	hwlevel 3 reset		22.28			
31	hw level 8 reset		61.78			
32	hwlevel 8		63.58			
33	hwAVlevel 8		64.18			
34	hwmax		71.58			

RPV LEVEL SCALING – EXCEL SPREADSHEET

	A	B	C	D	E	F
1	Instrument	1B21-N095A				
2	Cond Chamber	1B21-D004A				
3	Operating Presure	psia			1025	
4						
5		feet	inches	cubic feet / lbm	inwc	vdc
35						
36	H		82.33			
37						
38	hdvar		28.94			
39	hdref1		31.70			
40	hdref2					
41	delta-hd		-2.77			
42						
43	delta-hrb		-79.56			
44						
45	v68			0.01604537		
46	vw			0.02173445		
47	vs			0.42697000		
48	vd1 (135F)			0.01621815		
49	vd2 (190F)					
50	vrb			0.01602092		
51						
52	delta-Pmin				-71.21	
53	delta-P AV level 3				-65.40	
54	delta-P level 3				-64.98	
55	delta-P level 3 reset				-63.72	
56	delta-P level 8 reset				-36.04	
57	delta-P level 8				-34.78	
58	delta-P AV Level 8				-34.36	
59	delta-Pmax				-29.17	
60						
61	CF				0.00769	
62						
63			Vdc	mA	inwc	in
64	Span Corrected calibrated Range Lower Limit		1.000	4.00	-70.67	0.00
65	Span Corrected AV level 3		1.553	6.213	-64.90	8.300
66	Span Corrected Level 3 Setpoint		1.593	6.373	-64.48	8.900
67	Span Corrected Level 3 reset		1.713	6.853	-63.23	10.700
68	Span Corrected Level 8 reset		4.347	17.387	-35.76	50.200
69	Span Corrected Level 8 Setpoint		4.467	17.867	-34.51	52.000
70	Span Corrected AV Level 8		4.507	18.027	-34.10	52.600
71	Span Corrected calibrated Range Upper Limit		5.000	20.00	-28.95	60.00
72						
73	CC Span					41.72
74						
75					inwc	Vdc
76	LT 0%				-70.67	1.000
77	LT 25%				-60.24	2.000
78	LT 50%				-49.81	3.000
79	LT 75%				-39.38	4.000
80	LT 100%				-28.95	5.000

DEPT/DIV C/NSED	CALCULATION NO. IP-C-0059 ATTACHMENT 4	REVISION 0 VOLUME A	SHEET 3 of 4

RPV LEVEL SCALING – EXCEL SPREADSHEET

	A	G	H	I	J	K
1	Instrument	1B21-N095B				
2	Cond Chamber	1B21-D004B				
3	Operating Presure				1025	
4						
5		feet	inches	cubic feet / lbm	inwc	Vdc
6	CCELEV.COLD	793.35	591.54			
7	VLN.ELEV	786.38	508.56			
8	RLP.ELEV	790.75	561.00			
9	VLP.ELEV	782.69	464.25			
10	SUB.ELEV		508.20			
11	TCH.ELEV		576.00			
12	LI0.ELEV.COLD		520.62			
13	Vessel Zero	744.00				
14						
15	LIMAX		60.00			
16	AV Level 8		52.60			
17	NTSP level 8		52.00			
18	Reset Level 8		50.20			
19	Reset Level 3		10.70			
20	NTSP level 3		8.90			
21	AV Level 3		8.30			
22	LIMIN		0.00			
23	LISPAN		60.00			
24						
25	c		0.003727			
26						
27	hwmin		12.06			
28	hwAV level 3		20.36			
29	hwlevel 3		20.96			
30	hwlevel 3 reset		22.76			
31	hw level 8 reset		62.26			
32	hwlevel 8		64.06			
33	hwAVlevel 8		64.66			
34	hwmax		72.06			

DEPT/DIV C/NSED	CALCULATION NO. IP-C-0059 ATTACHMENT 4	REVISION 0 VOLUME A	SHEET 4 of 4

RPV LEVEL SCALING – EXCEL SPREADSHEET

	A	G	H	I	J	K
1	Instrument	1B21-N095B				
2	Cond Chamber	1B21-D004B				
3	Operating Presure				1025	
4						
5		feet	inches	cubic feet / lbm	inwc	Vdc
35						
36	H		83.29			
37						
38	hdvar		46.21			
39	hdref1		15.00			
40	hdref2		17.75			
41	delta-hd		13.78			
42						
43	delta-hrb		-96.75			
44						
45	v68			0.01604537		
46	vw			0.02173445		
47	vs			0.42697000		
48	vd1 (135F)			0.01621815		
49	vd2 (190F)			0.01651595		
50	vrb			0.01602092		
51						
52	delta-Pmin				-71.69	
53	delta-P AV level 3				-65.87	
54	delta-P level 3				-65.45	
55	delta-P level 3 reset				-64.19	
56	delta-P level 8 reset				-36.51	
57	delta-P level 8				-35.25	
58	delta-P AV Level 8				-34.83	
59	delta-Pmax				-29.65	
60						
61	CF				0.00769	
62						
63			Vdc	mA	inwc	in
64	Span Corrected calibrated Range Lower Limit		1.000	4.00	-71.14	0.00
65	Span Corrected AV level 3		1.553	6.213	-65.37	8.300
66	Span Corrected Level 3 Setpoint		1.593	6.373	-64.95	8.900
67	Span Corrected Level 3 reset		1.713	6.853	-63.70	10.700
68	Span Corrected Level 8 reset		4.347	17.387	-36.23	50.200
69	Span Corrected Level 8 Setpoint		4.467	17.867	-34.98	52.000
70	Span Corrected AV Level 8		4.507	18.027	-34.57	52.600
71	Span Corrected calibrated Range Upper Limit		5.000	20.00	-29.42	60.00
72						
73	CC Span					41.72
74						
75					inwc	Vdc
76	LT 0%				-71.14	1.000
77	LT 25%				-60.71	2.000
78	LT 50%				-50.28	3.000
79	LT 75%				-39.85	4.000
80	LT 100%				-29.42	5.000