ENCLOSURE (2)

BG&E Calculation CA00800, "Total Loop Uncertainty for the Plant Computer's Determination of Main Feedwater Pump Discharge Pressure," Revision 1

Calvert Cliffs Nuclear Power Plant, Inc.
December 3, 2008

CALCULATION COVER SHEET
(Attachment 19)

ESP No.: ES200100656-000	Supp No.: 000	Rev. No.: 0000	Page 1 of 14

INITIATION (Control Doc Type - DCALC)

DCALC No.: CA00800 — Revision No.: 1

Vendor Calculation (Check one): ☒ Yes ☐ No

Responsible Group: I & C Engineering

Responsible Engineer: Dvorak, D. A.

CALCULATION

Engineering Discipline:
☐ Civil ☒ Instr & Controls ☐ Nuc Engrg
☐ Electrical ☐ Mechanical ☐ Diesel Gen Project
☐ Life Cycle Mngmt ☐ Reliability Engrg ☐ Nuc Fuel Mngmt
☐ Other:

Title: TOTAL LOOP UNCERTAINTY CALCULATION FOR THE PLANT COMPUTER'S DETERMINATION OF MAIN FEEDWATER PUMP DISCHARGE PRESSURE

Unit ☒ Unit 1 ☒ Unit 2 ☐ Common

Proprietary or Safeguards Calculation ☐ YES ☒ NO

Comments: None

Vendor Calc No.: CCN-IC-02004 — Revision No.: 0

Vendor Name: Hurst Technologies, Corp.

Safety Class (Check one): ☐ SR ☐ AQ ☒ NSR

There are no assumptions that require Verification during walkdown: AIT # N/A

This calculation **SUPERSEDES**: None

REVIEW AND APPROVAL:

Responsible Engineer: Hurst Technologies, Corp. — Date:

Independent Reviewer: NA — Date:

Approval: NA — Date:

OR (for Vendor Calcs)

Owner Acceptance Reviewer: [signature] — Date: 10/18/02

TOTAL LOOP UNCERTAINTY CALCULATION FOR THE PLANT COMPUTER'S DETERMINATION OF MAIN FEEDWATER PUMP DISCHARGE PRESSURE

For Calvert Cliffs Nuclear Power Plant
Units 1 & 2

Calculation No. CCN-IC-02004 Revision 0

Prepared By Hurst Technologies, Corp.

Project: CCNUFC

Client: Constellation Nuclear
Calvert Cliffs Nuclear Power Plant
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RECORD OF REVISIONS

Rev.	Date	Pages Involved	Description	Originator
0	5/13/94	All	Initial Issue	E. R. Kreahling
1	5/21/02	All	Reformat calculation	W. R. Smith

1.0 PURPOSE

The purpose of this calculation is to determine the total uncertainty of the Main Feedwater Pump Discharge Pressure indication on the plant computer. The calculation will also determine total device uncertainty for the loop transmitters and for the plant computer. Uncertainties are determined only for normal plant operating conditions. This calculation applies to Unit 1 and to Unit 2.

2.0 COMPONENT LISTING

This calculation applies to the following instruments:

Pressure Differential Transmitters

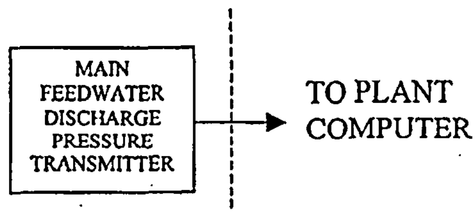
1-PT-4490
1-PT-4495
2-PT-4490
2-PT-4495

Plant Computer Point ID's

P4490 P4495

3.0 FIGURES

3.1 Loop Block Diagram



4.0 METHOD OF ANALYSIS

This calculation is performed in accordance with ES-028, Instrument Loop Uncertainty / Setpoint Methodology. This calculation utilizes the Square Root Sum of the Squares (SRSS) methodology when all variables are random, independent and normally distributed.

This calculation determines device uncertainties for the main feedwater pump discharge pressure transmitters, 1(2)PT-4490 and 1(2)PT-4495, and the device uncertainty of their respective plant computer point ID's. The device uncertainties are used to calculate the associated loop uncertainty with respect to the final output device, which is the plant computer.

5.0 DESIGN INPUTS

5.1 FEEDWATER PUMP DISCHARGE PRESSURE SENSOR CONSIDERATIONS

TAG NUMBER:	1-PT-4490 1-PT-4495 2-PT-4490 2-PT-4495	[7.7]
MANUFACTURER:	ROSEMOUNT	[7.2]
MODEL NUMBER:	3051CG-5A22A1AB4	[7.2]
SPAN:	2000 PSIG	[7.2]

5.1.1 Per References 7.1, the Reference Accuracy for a range code 5 transmitter with a turn down ratio of less than 10:1 is ± 0.075% Span. Therefore, the sensor Reference Accuracy (RAs) is given as:

$RA_S = 0.075\%$ Span

5.1.2 Per the Master Calibration Data Sheets (Reference 7.2), the Sensor Setting Tolerance is ± 0.25 % Span. Therefore:

$STs = \pm 0.25\ \%$ Span

5.1.3 For conservatism, and to provide flexibility in the choice of test equipment, the Sensor Measurement and Test Equipment Effect (MTEs) is set equal to the Setting Tolerance (STs) of the sensor. Therefore,

$MTEs = \pm 0.25\%$ Span

5.1.4 Per Reference 7.1, the Sensor Stability, or Drift term (DRs) is given as ± 0.25% of Upper Range Limit (URL) for 5 years, and the URL for this transmitter is 2000 PSID. Per Reference 7.3, the maximum calibration interval is 30 months, which is bounded by the specification interval. Per Reference 7.2, the sensor calibrated span is 2000 PSI. Therefore, the Sensor Drift (DRs) is given as:

$$DRs = \pm \left[\frac{(0.25)(2000\ PSID)}{2000\ PSID}\right] \%\ Span$$

$$DRs = \pm 0.25\%\ Span$$

5.1.5 Since the transmitters addressed in this calculation are gage pressure transmitters, there is no sensor static pressure effect (SPEs). Therefore:

SPEs = N/A

5.1.6 Per Reference 7.1, the Sensor Power Supply Effects (PSEs) are given as less than ± 0.005% span per 1 Volt change. Per reference 7.3, the power supplies for the sensors are regulated to within ± 5 VDC. Therefore, the sensor Power Supply Effect (PSEs) is given as:

$$PSEs = \pm (0.005\%\ Span / VDC)\ (5\ VDC)$$

$$PSEs = \pm 0.025\%\ Span$$

Per Reference 7.3, uncertainties less than ± 0.05% are considered negligible, therefore:

PSEs = N/A

5.1.7 Per Reference 7.1, the Sensor Temperature Effect (TEs) is given as ±0.0125% Upper Range Limit (URL) plus 0.0625% Span per 50°F change. Per Reference 7.4, the maximum and minimum temperature of the turbine building (12ft elevation) are 123°F and 60°F (design minimum). Therefore, the maximum change in temperature (ΔT) from calibration to operating temperature is 63°F. The calibrated span of these sensors is 2000 PSIG (reference 7.2) and the URL is 2000 PSIG (reference 7.1). Therefore, the Sensor Temperature Effect (TEs) is given as:

$$TEs = \pm\left[\left(\frac{(0.0125\% * 2000)}{2000\,PSI} + 0.0625\%\,Span\right)\left(\frac{63\,\Delta T}{50\,\Delta T}\right)\right]$$

$$TEs = \pm\, 0.09\%\ Span$$

5.2 PROCESS MEASUREMENT EFFECT CONSIDERATIONS

Per Reference 7.8, these transmitters are located 85 inches below the process pipe tap. Per Reference 7.2, a + 3 PSIG offset is calibrated into these transmitters. Per Reference 7.3, the minimum calibration temperature is 68°F. Per Reference 7.3, Process Measurement Effect is a single sided bias (PMEb) calculated using the following equation:

$$PMEb = \left(\frac{h(\rho_N - \rho_C)}{144}\right)\left(\frac{100\%\,Span}{2000}\right)$$

where,

h = height of sensing line
= 85 inches = 7.08 feet

ρ_N = sensing line fill fluid density during normal operation
= 61.87048 lbm/ft^3 @ 123°F, 1100 psia

ρ_C = sensing line fill fluid density during calibration
= 62.53402 lbm/ft^3 @ 68°F, 1100 psia

NOTE: The factor 144 is used to convert from lbf/ft^2 to lbf/in^2. At standard gravity, lbm may be replaced with lbf.

Therefore,

PMEb = -0.0016% Span

Per Reference 7.3, uncertainty terms that are ≤ 0.05% Span have a negligible effect on calculation results, and may therefore be disregarded. Thus:

PMEb = N/A

5.3 PLANT COMPUTER CONSIDERATIONS

DEVICE:	Computer Products, Inc. DAS Multiplexer Plant Computer	[7.5]
POINT ID NUMBER:	P4490 P4495	[7.7]
SPAN:	0 to 1.28 VDC	[7.5]

5.3.1 Per Reference 7.5, the reference accuracy of the computer is given as ± 0.12626 % Span. For conservatism, this calculation will use a value of ± 0.15 % Span for the computer Reference Accuracy term (RA_C). Therefore,

$$RA_C = \pm\ 0.15\ \%\ \text{Span}$$

5.3.2 Per Assumption 6.1, the computer setting tolerance (ST_C) is equal to the value of the computer reference accuracy, RA_C. Therefore,

$$ST_C = \pm\ 0.15\ \%\ \text{Span}$$

5.3.3 For conservatism, and to provide flexibility in the choice of test equipment, the computer Measurement and Test Equipment Effect (MTE_C) is set equal to the Setting Tolerance (ST_C) of the computer. Therefore,

$$MTE_C = \pm\ 0.15\ \%\ \text{Span}$$

5.3.4 Per Reference 7.5, the computer temperature effect is given as ± 0.50 % Range per 100 ° F. Per Reference 7.5, the range of the computer is 0 to 1.28 volts and the span is 0.2 to 1.0 volts. The computer is located adjacent to the control room and is considered to have the same temperature profile as the control room. Per Reference 7.6, the maximum ΔT for the control room envelope is given as 10° F. Thus, the computer Temperature Effects (TE_C) are given as:

$$TE_C = \pm\ [(0.50\%\ \text{Span})(1.28\ \text{volts})/(0.8\ \text{volts})](10°\text{F}/100°\text{F})$$
$$TE_C = \pm\ 0.08\ \%\ \text{Span}$$

5.3.5 Per Reference 7.5, the computer Power Supply Effect (PSE_C) is not applicable. Therefore,

$$PSE_C = \text{N/A}$$

5.3.6 Per Reference 7.5, the computer Drift uncertainty (DR_C) is given as ± 0.05 % Range for a period of 6 months. Expressing the drift term in % Span yields a drift value of ± 0.08 % Span for a period of 6 months (0.05%*(1.28/0.8)). The drift for a period of 30 months is calculated per Reference 7.3. Therefore, the computer Drift uncertainty (DR_C) is given as:

$$DR_C = \pm [(30 \text{ months}/6 \text{ months})*(0.08 \text{ \% Flow Span})^2]^{1/2}$$
$$DR_C = \pm\ 0.18 \text{ \% Span}$$

6.0 ASSUMPTIONS

6.1 Computer Setting Tolerance (ST_C) is assumed to be bounded by the conservative value used for computer reference accuracy (Section 5.3.1).

7.0 REFERENCES

7.1 BGE Vendor Technical Manual VTM # 12904-017, Model 3051C Smart Pressure Transmitter, Revision 4

Rosemount, Inc. Manual 00813-0100-4001, "Model 3051 Smart Pressure Transmitter Family", August 1996 (Excerpts in Attachment A)

7.2 BGE Master Calibration Date Sheets:

COMPONENT	REVISION
1-PT-4490	2
1-PT-4495	2
2-PT-4490	2
2-PT-4495	3

7.3 Calvert Cliffs Engineering Standard ES-028, "Instrument Loop Uncertainty and Setpoint Methodology", Revision 1.

7.4 ES-014, "Summary Of Ambient Environmental Conditions", Revision 1

UFSAR Chapter 9, Table 9-18, Revision 26

7.5 BGE Calculation I-90-174, Revision 0, "Device Uncertainty Calculation; Plant Computer; 4-20 Input Points"

7.6 OI-22F, "Control Room and Cable Spreading Rooms Ventilation", Revision 22.

7.7 Loop Diagrams

BGE Drawing 60920 Sh. 15, Rev. 6
BGE Drawing 60920 Sh. 15A, Rev. 6
BGE Drawing 62622 Sh. 15, Rev. 4
BGE Drawing 62622 Sh. 15A, Rev. 4

7.8 Drawing, 12507A-0001 "Feedwater Pump Discharge", Revision 21
Drawing, 13519A-0001 "Feedwater Pump Discharge", Revision 15
Drawing, 13519A-0002 "Feedwater Pump Discharge", Revision 12

8.0 IDENTIFICATION OF COMPUTER CODES

None

9.0 CALCULATION

9.1 TOTAL DEVICE UNCERTAINTIES

9.1.1 SENSOR TOTAL DEVICE UNCERTAINTY

The normal uncertainties associated with the sensor (normal TDU_S) are calculated as follows:

$$TDU_S = \pm\sqrt{RA_S^2 + ST_S^2 + MTE_S^2 + DR_S^2 + TE_S^2}$$

$$TDU_S = \pm 0.45\% \text{ Span}$$

9.1.2 PLANT COMPUTER TOTAL DEVICE UNCERTAINTY

The normal uncertainties associated with the computer point (normal TDU_C) are as follows:

$$TDU_C = \pm\sqrt{RA_C^2 + ST_C^2 + MTE_C^2 + DR_C^2 + TE_C^2}$$

$$TDU_C = \pm 0.33\% \text{ Span}$$

9.2 TOTAL LOOP UNCERTAINTIES

9.2.1 TOTAL LOOP UNCERTAINTY AT TRANSMITTER OUTPUT

The total loop uncertainty at the transmitter output (TLU_S) is equal to the Total Device Uncertainty of the sensor (TDU_S). Results are presented in units of % Span and PSIG (based on a span of 2000 PSIG).

$$TLU_S = TDU_S = \pm 0.45\% \text{ Span}$$

$$TLU_S \text{ (PSIG)} = \pm 0.45\% \text{ Span} * 2000 \text{ PSIG } 100\% \text{ Span} = \pm 9.00 \text{ PSIG}$$

9.2.2 TOTAL LOOP UNCERTAINTY AT PLANT COMPUTER

The total loop uncertainty at the plant computer (TLU_C) is determined by combining the Total Devices Uncertainties for the sensors and the plant computer as follows. Results are presented in units of % Span and PSIG (based on a span of 2000 PSIG).

$$TLU_C = \pm\sqrt{TDU_S^2 + TDU_C^2} \ \%\text{Span}$$

$$TLU_C = \pm 0.56\% \text{ Span}$$

$$TLU_C \text{ (PSIG)} = \pm 0.56\% \text{ Span} * 2000 \text{ PSIG} / 100\% \text{ Span} = \pm 11.20 \text{ PSIG}$$

10.0 CONCLUSIONS

This calculation has determined the following Total Device Uncertainty values:

10.1 Feedwater Discharge Pressure Transmitters (Span = 2000 PSIG)

$TDU_S = \pm 0.45\%$ Span $= \pm 9.00$ PSIG

10.2 Plant Computer Points for Feedwater Pump Discharge Pressure (Span = 2000 PSIG)

$TDU_C = \pm 0.33\%$ Span $= \pm 6.60$ PSIG

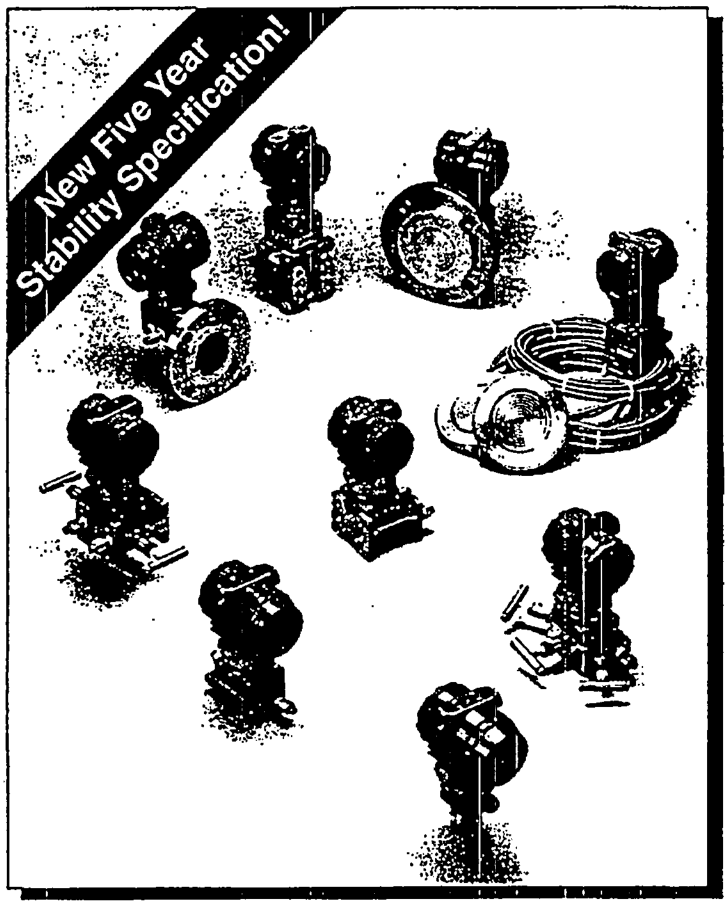
This calculation has determined the following Total Loop Uncertainty value:

10.3 Plant Computer Indication of Feedwater Pump Discharge Pressure (Span = 2000 PSIG)

$TLU_C = \pm 0.56\%$ Span $= \pm 11.20$ PSIG

00813-0100-4001
English
August 1996

Model 3051 Smart Pressure Transmitter Family



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Temperature Limits (continued)

Process *At atmospheric pressures and above.*

TABLE 5. Model 3051 Temperature Limits.

Models 3051CD, 3051CG, 3051CA	
Silicone Fill Sensor(1)	
with Coplanar Flange	–40 to 250 °F (–40 to 121 °C)(2)
with Traditional Flange	–40 to 300 °F (–40 to 149 °C)(2)
with Level Flange	
Horizontal Mount	–40 to 250 °F (–40 to 121 °C)(2)
Vertical Mount	–40 to 300 °F (–40 to 149 °C)(2)
with Model 305 Integral Manifold	–40 to 300 °F (–40 to 149 °C)(2)
Inert Fill Sensor(1)	0 to 185 °F (–18 to 85 °C)(3)(4)
Model 3051H (Process Fill Fluid)	
D.C.® Silicone 200(1)	–40 to 375 °F (–40 to191 °C)
Inert(1)	–50 to 350 °F (–45 to 177 °C)
Neobee M-20(1)	0 to 375 °F (–18 to 191 °C)
Model 3051T (Process Fill Fluid)	
Silicone Fill Sensor(1)	–40 to 250°F (–40 to 121°C)(2)
Inert Fill Sensor(1)	–22 to 250°F (–30 to 121°C)(2)
Model 3051L Low-Side Temperature Limits	
Silicone Fill Sensor(1)	–40 to 250 °F (–40 to 121 °C)(2)
Inert Fill Sensor(1)	0 to 185 °F (–18 to 85 °C)(2)
Model 3051L High-Side Temperature Limits (Process Fill Fluid)	
Syltherm® XLT	–100 to 300 °F (–73 to 149 °C)
D.C. Silicone 704(5)	60 to 600 °F (15 to 315 °C)
D.C. Silicone 200	–40 to 400 °F (–40 to 205 °C)
Inert	–50 to 350 °F (–45 to 177 °C)
Glycerin and Water	0 to 200 °F (–18 to 93 °C)
Neobee M-20®	0 to 400 °F (–18 to 205 °C)
Propylene Glycol and Water	0 to 200 °F (–18 to 93 °C)
Syltherm 800	–50 to 400 °F (–45 to 205 °C)

(1) Process temperatures above 185 °F (85 °C) require derating the ambient limits by a 1.5:1 ratio (0.6:1 ratio for Model 3051H).
(2) 220 °F (104 °C) limit in vacuum service; 130 °F (54 °C) for pressures below 0.5 psia.
(3) 160 °F (71 °C) limit in vacuum service.
(4) Not available for Model 3051CA.
(5) Upper limit is for seal assemblies mounted away from the transmitter with the use of capillaries.

Humidity Limits

0–100% relative humidity.

Turn-on Time

Performance within specifications less than 2.0 seconds after power is applied to transmitter.

Volumetric Displacement

Less than 0.005 in^3 (0.08 cm^3).

Damping

Analog output response to a step input change is user-selectable from 0 to 36 seconds for one time constant. This software damping is in addition to sensor module response time.

Performance Specifications

(Zero-based spans, reference conditions, silicone oil fill, 316 SST isolating diaphragms, 4–20 mA analog output, and digital trim values equal to the span setpoints.)

Models 3051CD/CG – Differential, Gage

Accuracy

±0.075% of span.

±0.100% of span for Model 3051CD Range 1.

Note

For spans less than 10:1 (15:1 for Model 3051CD Range 1) rangedown, accuracy =

$$\pm\left[0.025 + 0.005\left(\frac{\text{URL}}{\text{Span}}\right)\right]\% \text{ of Span}$$

Ambient Temperature Effect per 50 °F (28 °C)

±(0.0125% URL + 0.0625% span) spans from 1:1 to 10:1.

±(0.025% URL + 0.125% span) spans from 10:1 to 100:1.

Range 1: ±(0.1% URL + 0.25% span).

Static Pressure Effect (Model 3051CD only)

Zero Error (can be calibrated out at line pressure)

±0.1% of URL/1,000 psi (6.9 MPa) for line pressures from 0 to 2,000 psi (0 to 13.7 MPa).

±0.2% of URL/1,000 psi (6.9 MPa) for line pressures above 2,000 psi (13.7 MPa).

Range 1: ±0.25% of URL/1,000 psi (6.9 MPa).

Span Error*

±0.2% of reading/1,000 psi (6.9 MPa).

±0.4% of reading/1,000 psi (6.9 MPa) for Range 1.

** Range 4 and 5: See manual for calibration procedure.*

Total Performance** NEW!

±0.25% of span for ±50 °F (28 °C) temperature changes, up to 1,000 psi (6.9 MPa) line pressure, from 1:1 to 5:1 rangedown.

*** Total Performance is based on the combined errors of reference accuracy, ambient temperature effect, and span line pressure effect.*

Stability improved!

±0.25% of URL for 5 years.
Range 1: ±0.2% of URL for 1 year.

Mounting Position Effect

Zero shifts up to 2.5 inH_2O (0.62 kPa), which can be calibrated out. No span effect.

Specifications