# CALCULATION COVER SHEET

ComEd

ZION NUCLEAR STATION

Zion Calculation No.: 22S-B-004E-192

DESCRIPTION CODE: I04

SYSTEM CODE: RC

TITLE: Wide Range RCS Cold Leg Temperature Indication Uncertainty

## REFERENCE NUMBERS

| Type | Number | Type | Number |
|---|---|---|---|
| PROJ | 4950 | | |

**COMPONENT EPN:**

| EPN Number | Compt Type | Component |
|---|---|---|
| Contained Within see Section #5.2.1 | | |

**DOCUMENT NUMBERS:**

| Doc Type | Document Number |
|---|---|
| DWGC | See Sections 5.2.2 - 5.2.5 |
| VTIP | See Sections 5.7.2, 5.7.3 |
| PROC | See Sections 5.6.1 - 5.6.7 |
| DATA | See Section 5.2.1 |
| CALCENG | 22S-B-016E-001 |
| CORR | MSE-REME-0308 Rev. 1 |

**REMARKS:** Initial Issue

| REV. NO. | REVISION | APPROVED | DATE |
|---|---|---|---|
| 0 | Original Issue | D. P. Galanis | 10-18-95 |
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# COMMONWEALTH EDISON COMPANY
## CALCULATION TITLE PAGE

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☒ SAFETY RELATED ☐ REGULATORY RELATED ☐ NON- SAFETY RELATED

CALCULATION TITLE:

Wide Range RCS Cold Leg Temperature Indication Uncertainty

STATION/UNIT: ZION / 1&2 SYSTEM ABBREVIATION: RC

EQUIPMENT NO. Enclosed Within - See Section 5.2.1 PROJECT NO. 4950

REV: 0 STATUS: Approved QA SERIAL NO. OR CHRON NO. N/A DATE: N/A

PREPARED BY: Chuck Hallett *C W Hallett* DATE: *10/18/96*

REVISION SUMMARY: Rev. 0 - INITIAL ISSUE

ELECTRONIC CALCULATION DATA FILES REVISED: None

(Name ext/size/date/hour:min/verification method/remarks)

DO ANY ASSUMPTIONS IN THIS CALCULATION REQUIRE LATER VERIFICATION YES ☐ NO ☒

REVIEWED BY: Steve McCarthy *S. S. McCarthy* DATE: *10/18/96*

REVIEW METHOD: *Detailed Review* COMMENTS (C, NC OR CI): *NC*

APPROVED BY: Dean Galanis *DGE 10/18/96 D. G. Galanis* DATE: *10-18-96*

# COMMONWEALTH EDISON COMPANY
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## 1. PURPOSE / OBJECTIVE

The purpose of this calculation is to determine the indication uncertainty of the Wide Range RCS Cold Leg Temperature Indication, under normal operating conditions. The minimum acceptable Low Temperature Overpressurization Protection (LTOP) enable temperature will also be determined.

## 2. METHODOLOGY / ACCEPTANCE CRITERIA

2.1 Methodology

2.1.1 The methodology used for this calculation is presented in TID-E/I&C-10, "Analysis of Instrument Channel Setpoint Error and Instrument Loop Accuracy" Rev. 0 [5.4.1] and TID-E/I&C-20, "Basis For Analysis of Instrument Channel Setpoint Error and Instrument Loop Accuracy", Rev. 0 [5.4.2].

2.1.2 The format for this calculation differs from that of TID-E/I&C-10, Rev 0, Exhibit B in order to comply with the format set forth in NEP-12-02, Rev 3.

2.1.3 Some instrument channels at nuclear power generating facilities perform functions that are critical for assuring the reactivity process is terminated, the reactor is safely shutdown, and the essential safety feature systems are initiated in a timely manner to mitigate the consequences of design basis accidents or transient events. For these channels, a very high confidence level in the estimation of total instrument channel error is appropriate for assuring that the instrument channel setpoint is established in a manner that allows the channel to perform its protective action during those events before critical safety limits are reached.

Other instrument channels perform functions that provide reactor operators with information that allow them to assess the readiness of safety systems by monitoring various system parameters and allowing operators to verify whether the reading indicates that the system meets certain acceptance criteria depicted in the plant technical specifications. These functions require only a moderate confidence level in the estimation of total instrument channel error.

Accordingly, a graded approach methodology, has been established, following industry recommended practice [5.4.4, 5.4.6], where instrument channels are first classified into one of four levels (Level 1, Level 2, Level 3, and Level 4) according to the highest function served by the instrument channel. Then the errors in the channel modules are identified, documented, and propagated. Finally, the total error for the channel is determined by combining the errors using one of four methods, appropriate to channel level classification. Additionally, where applicable, the setpoint and/or allowable value and allowance for spurious trips (AST), are determined in the manner appropriate for the instrument channel classification

The methodology used in evaluating the accuracy of the loop process measurements and setpoints differ from TID-E/I&C-10 Rev 0 in the following areas:

- Magnitude of confidence interval estimates
- Method of combining non-random error terms
- Application of Drift Error

These differences are in accordance with a Level 3 graded approach methodology. Level 3 is used for calculating setpoints or loop accuracies, where the instrument functions are utilized for "EOP-non-operator actions and RG 1.97 Type B, C, D, and E parameters and Technical Specification Compliance Channels."

2.1.3.1 Magnitude of confidence interval estimates:

Total error is defined in Exhibit A of Reference 5.4.2 as: $Te = t\sigma \pm \Sigma e$

Where: t = confidence interval

$\sigma$ = the total random error that affects the loop output

$\Sigma e$ = the sum of the positive or negative non-random errors that affect the loop output, whichever is applicable

For this calculation a value of 1 will be used for t.

2.1.3.2 Method of combining Non-Random Symmetrical Error Terms

Non-random symmetrical error terms will be combined utilizing the square-root-sum-of-the-squares (SRSS) method rather than the algebraic method.

2.1.3.3 Application of Drift Error

The definition of the drift error term is changed to refer to the time dependent error associated with the performance of entire instrument channels, rather than the performance of individual components within an instrument channel. The drift term (D) is applied only in the calculation of total random error for the last module of the instrument channel. The minimum instrument channel drift error term will be the greater of known drift values or ±1% of span per year ($2\sigma$).

2.2 Acceptance Criteria

Not applicable to instrument uncertainty calculations

## 3. ASSUMPTIONS AND LIMITATIONS

3.1 In accordance with Reference 5.4.2, unless specific information is available to indicate otherwise, published instrument vendor accuracy specifications are assumed to be random, normally distributed, $2\sigma$ uncertainties; equivalent to a 95.5% probability the device error will be bound by the vendors accuracy term.

3.2 Temperature, humidity, normal radiation, seismic, pressure, static pressure and over-pressure effects 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, errors can be assumed to be included within the instrument reference accuracy.

3.3 Power supply variations (eV) are assumed to be negligible due to the regulated and highly reliable sources of power supplied to the safety-related instrument busses.

3.4 Current leakage errors (eIRn) will be considered negligible due to the high insulation resistance values of instrument cable in normal (non-harsh) environments. In accordance with the purpose of this calculation, harsh operating environments will not be considered.

3.5 M&TE error is based upon use of the Fluke 8842A. The applicable calibration procedures References 5.6.3 through 5.6.6 require use of a Fluke 8842A Digital Multimeter for DC voltage measurements.

3.6 The temperature effects on Measuring & Test Equipment due to differences between calibration facilities and field temperatures are minor relative to the calibration accuracy and is therefore statistically insignificant. The temperature effect on M&TE (TEMTE) will equal zero.

3.7 Readability Errors will be considered to be random normally distributed 2$\sigma$ uncertainties based upon Reference 5.4.5 which states "Based on common industry practice, the readability error is often defined as one-half of the smallest scale increment…In most cases, when the readability error is used as one-half the smallest scale increment, this can also be considered to be inclusive of any parallax error."

## 4. DESIGN INPUT

4.1 Per Reference 5.4.7 Section 6.1.4.4., temperature streaming errors for the cold leg temperature sensor are ±0°F.

4.2 MODULE IDENTIFICATION

For brevity, instrument numbers within the calculation body refer to Loop 1(2)T-413B. The following table identifies all loops and instruments to which this calculation applies.

| LOOP | MODULE 1 | MODULE 2 | MODULE 3 |
|---|---|---|---|
| 1(2)T-413B | 1(2)TE-413B | 1(2)TQY-413B / 1(2)TM-413D | 1(2)TR-413 |
| 1(2)T-423B | 1(2)TE-423B | 1(2)TQY-423B / 1(2)TM-423D | 1(2)TR-423 |
| 1(2)T-433B | 1(2)TE-433B | 1(2)TQY-433B / 1(2)TM-433D | 1(2)TR-433 |
| 1(2)T-443B | 1(2)TE-443B | 1(2)TQY-443B / 1(2)TM-443D | 1(2)TR-443 |

**Table 1**

4.3 LOOP ELEMENT DATA

| | Module #1<br>Wide Range RCS Tc RTD<br>[5.2.1] | Module #3<br>Recorder - Green Pen<br>[5.2.1] |
|---|---|---|
| Manufacturer | Conax Corp | Hagan |
| Model number | 741-10000 | Optimac-101 (174501) |
| Calibrated Span | Input 0 to 700°F<br>Output 93.035 to 237.039Ω | Input 1 to 5 Vdc<br>Output - 0 to 700°F |
| Reference Accuracy | ±0.56°F @ 32°F [5.5.2]<br>±0.94°F @ 212°F<br>±1.95°F @ 300°F<br>±2.20°F @ 350°F<br>±2.42°F @ 400°F<br>±2.98°F @ 500°F<br>±3.11°F @ 525°F<br>±3.49°F @ 600°F<br>±3.62°F @ 625°F<br>±4.29°F @ 750°F | ±0.5% Span [5.7.3] |
| Stability (Drift) | Not Applicable [2.1.3.3] | Not Applicable [2.1.3.3] |
| Humidity Limits | 20 to 90% Relative Humidity [5.5.2] | Not Specified |
| Temp. Effect | N/A to temperature sensors | Not Specified |
| Radiation Effect | Not Specified | Not Specified |
| Seismic Effect | Not Specified | Not Specified |
| Static Pressure | N/A to electrical devices | N/A to electrical devices |
| Pressure Effect | N/A to electrical devices | N/A to electrical devices |
| Over Pressure Effect | N/A to electrical devices | N/A to electrical devices |
| Power Supply Effect | N/A to passive device | Not Specified |
| Minor Divisions | N/A | 10°F [5.5.3] |

| | Module #2<br>Eagle 21<br>[5.1.1] |
|---|---|
| Manufacturer | Westinghouse |
| Model number | ERI-03/EAO-01 |
| Calibrated Span | Input 93.035 to 237.039Ω (0 to 700°F)<br>Output 4 to 20 mAdc |
| Total Normal Random Error $\sigma_n$ | ±0.312% span (±2.184°F) |
| Total Normal Positive Non-Random Error $\Sigma e_n^+$ | +0.026% span (+0.182°F) |
| Total Normal Negative Non-Random Error $\Sigma e_n^-$ | –0.026% span (–0.182°F) |

**Table 2**

## 4.4 LOCAL SERVICE ENVIRONMENT

| | MODULE #1 [5.3.1] | MODULES #2, & 3 [5.3.1] |
|---|---|---|
| EQ Zone | C1 | A1 |
| Location | Containment | Auxiliary Building 642' |
| | NORMAL CONDITIONS | |
| Temperature Range | 65°F to 120°F | 74°F to 76°F |
| Pressure | 14.7 psia -0.1 +0.3 | Atmospheric |
| Humidity | 10 to 50% RH | 35 to 45% RH |
| Radiation | 2 x $10^8$ RAD Maximum integrated exposure [40 years + DBE] | 1 x $10^4$ RAD Total maximum integrated dose. |

**Table 3**

## 4.5 CALIBRATION PROCEDURE DATA

| | Module #1 Wide Range RCS Tc RTD | Module #3 Recorder - Green Pen [5.6.3 thru 5.6.6] |
|---|---|---|
| Calibrated Input Range | 0 to 700°F | Auto Calibration - MMI Digital Input to Loop Processor |
| Input Span | 700°F | N/A - Digital |
| Output Range | 93.035 to 237.039Ω | 0 to 700°F |
| Output Span | 144.004Ω | 700° |
| Setting Tolerance | Not Applicable - RTDs are not calibrated | ±7.27°F includes EAO & Recorder |

**Table 4**

## 4.6 MEASURING & TEST EQUIPMENT

### 4.6.1 Fluke 8842A Digital Voltmeter

References 5.6.3 through 5.6.6 specify the Fluke 8842A DVM as the only permissible voltmeter to be used when performing surveillance testing of the Eagle 21 Process Protection Upgrade System.

The Fluke 8842A digital voltmeter has the following uncertainty terms for measuring D.C. voltages when calibrated within 1 year and operated in a 23±5°C environment: [5.7.1]

2 VOLT RANGE

| | | |
|---|---|---|
| MFGR Accuracy: | slow) | 0.003% RDG + 2 counts |
| | medium) | 0.003% RDG + 4 counts |
| | fast) | 0.003% RDG + 2 counts |
| Resolution: | slow) | 10 μV |
| | medium) | 10 μV |
| | fast) | 100 μV |

200 MILLIVOLT RANGE

| | | |
|---|---|---|
| MFGR Accuracy: | slow) | 0.007% RDG + 3 counts |
| | medium) | 0.007% RDG + 5 counts |
| | fast) | 0.007% RDG + 2 counts |
| Resolution: | slow) | 1 μV |
| | medium) | 1 μV |
| | fast) | 10 μV |

4.7 MINIMUM LTOP ENABLE TEMPERATURE

Per Reference 5.1.2, the minimum LTOP/COMS enable temperature under ASME Code Case N-514 is 300.660°F

## 5. REFERENCES

5.1 CALCULATIONS

5.1.1 22S-B-016E-001 Rev. 0, "Eagle 21 Wide Range RTD Loop Accuracies"

5.1.2 MSE-REME-0308 Rev. 1 Westinghouse Electric Company "Zion Units 1 & 2 Enable Temperature Calculations (Including ASME Code Case N-514)"

5.2 DRAWINGS

5.2.1 ComEd Instrument Database (IDATA), Specific Data Sheet, and Supplemental Data Sheet for the following instruments:

| | | | |
|---|---|---|---|
| 1(2)TE-413B | 1(2)TQY-413B | 1(2)TM-413D | 1(2)TR-413 |
| 1(2)TE-423B | 1(2)TQY-423B | 1(2)TM-423D | 1(2)TR-423 |
| 1(2)TE-433B | 1(2)TQY-433B | 1(2)TM-433D | 1(2)TR-433 |
| 1(2)TE-443B | 1(2)TQY-443B | 1(2)TM-443D | 1(2)TR-443 |

5.2.2 22E-1-4945M, Rev. X, Loop Schematic Diagram Reactor Coolant System Part 11

5.2.3 22E-1-4945N, Rev. S, Loop Schematic Diagram Reactor Coolant System Part 12

5.2.4 22E-2-4945M, Rev. R, Loop Schematic Diagram Reactor Coolant System Part 11

5.2.5 22E-2-4945N, Rev. L, Loop Schematic Diagram Reactor Coolant System Part 12

5.3 ENVIRONMENTAL PARAMETERS

5.3.1 Zion Station Environmental Qualification Report; Appendix B - Plant Environmental Conditions Table, Revision 9

5.4 METHODOLOGY

5.4.1 TID-E/I&C-10, "Analysis of Instrument Channel Setpoint Error & Instrument Loop Accuracy", Rev. 0

5.4.2 TID-E/I&C-20, "Basis for Analysis of Instrument Channel Setpoint Error & Loop Accuracy", Rev. 0

5.4.3 WCAP-12582 "Westinghouse Setpoint Methodology for Protections Systems, Zion Units 1 and 2, EAGLE 21 Version", dated August 1991 (Westinghouse Proprietary Version)

5.4.4 International Society for Measurement and Control Recommended Practice ISA-RP67.04 Part II "Methodologies for the Determination of Setpoints for Nuclear Safety-Related Instrumentation"

5.4.5 International Society for Measurement and Control Draft Technical Report ISA-dTR67.04.01 "Indication Uncertainties and Their Relationship With Indicated Values" Draft 2, 1995

5.4.6 International Society for Measurement and Control Draft Technical Report ISA-dTR67.04.09 "Graded Approaches to Setpoint Determination" Draft 1, 1994

5.4.7 WCAP-12523 "Bases Document for Westinghouse Setpoint Methodology for Protection Systems - Commonwealth Edison Company Zion/Byron/Braidwood Units," dated October 1990

5.5 MISCELLANEOUS

5.5.1 Computer Data base GSIN - Instrumentation System Version 0.4

5.5.2 Zion Station Equipment Qualification Binder EQ-ZN-036 "Conax Resistance Temperature Detector"

5.5.3 Zion Station Main Control Room Unit 1 Photo Mosaic 8/31/93

5.6 PROCEDURES

5.6.1 GOP-1, Rev 11 "Plant Heatup"

5.6.2 NEP 12.02, Rev. 3 "Preparation, Review, and Approval of Calculations"

5.6.3 IMAS-1T-413B-443B Rev. 2 "Wide Range Coolant Temperature Cold Leg Eagle Automatic Calibration (Rack 8)"

5.6.4 IMAS-2T-413B-443B Rev. 2 "Wide Range Coolant Temperature Cold Leg Eagle Automatic Calibration (Rack 8)"

5.6.5 IMMS-1T-413B-443B Rev. 1 "Wide Range Coolant Temperature Cold Leg Eagle Manual Calibration (Rack 8)"

5.6.6 IMMS-2T-413B-443B Rev. 1 "Wide Range Coolant Temperature Cold Leg Eagle Manual Calibration (Rack 8)"

5.6.7 TSS-15.6.72, Rev. 18, "RTD Cross Calibration"

5.7 VENDOR

5.7.1 Fluke 8842A Digital Multimeter Instruction Manual, Rev. 2 6/86

5.7.2 VETI W120-852 "Eagle 21 Process Protection Upgrade System - Volume 1 Description" Westinghouse Energy Systems Process Control Division

5.7.3 VETI W120-772 "Control and Protection Instrumentation System Volumes I and II" Westinghouse Instruction Bulletin IB-133-01 "Optimac Electronic Recorder" January 1970

5.7.4 CWE-91-271 "Eagle 21 Rack Inaccuracies" Dated November 7, 1991

## 6. CALCULATIONS

### 6.1 CALCULATION OF MODULE ERRORS

### 6.1.1 MODULE 1 ERRORS

#### 6.1.1.1 Determination of Wide Range RCS RTD Random Errors $\sigma_1$

6.1.1.1.1 RA (Reference Accuracy)

The RTD error used in this calculation will be ±2.2°F, which is the most conservative value bounded by 350°F (LTOP protection disabled @ 320°F). [5.6.1]

$$RA = \frac{Accuracy}{2}$$
$$= \frac{\pm 2.2^\circ F}{2}$$
$$= \frac{\pm 1.1^\circ F}{700^\circ F\ span} \bullet 100\%\ span$$
$$= \pm 0.157\%\ span$$

6.1.1.1.2 CAL (Calibration Equipment Errors)

A cross channel calibration check is performed in Reference 5.6.7 where the Wide Range RTDs are compared with the Narrow Range Protection Channel RTDs with an acceptable tolerance of ±15°F. The Wide Range RCS Tcold RTDs are not adjustable therefore Measuring and Test Equipment uncertainties cannot influence the accuracy of the Wide Range RTDs;

CAL= 0

6.1.1.1.3 Calibration Setting Tolerance Uncertainty ST

The Wide Range RCS Tcold RTDs are primary measurement elements and not adjustable, therefore;

ST = 0

6.1.1.1.4 Drift D

Per Methodology Section 2.1.3.3, drift is applied to the final module in the instrument loop. Therefore;

D = 0

6.1.1.1.5 Determination of Random Errors σ1

$$\sigma_1 = \pm\ [\ RA^2 + CAL^2 + ST^2 + D^2\ ]^{1/2}$$
$$= \pm\ [\ (0.157\%)^2 + (0)^2 + (0)^2 + (0)^2\ ]^{1/2}$$

$= \pm 0.157\%$ span

6.1.1.2 Determination of Wide Range RCS RTD Non-random Errors $\Sigma e_1^+$ and $\Sigma e_1^-$

No module non-random errors are identified by the vendor, therefore

$\Sigma e_1^+ = 0\%$ span

$\Sigma e_1^- = 0\%$ span

6.1.2 MODULE 2 ERRORS

6.1.2.1 Determination of Wide Range RTD Eagle 21 Random Errors $\sigma_2$

From Reference 5.1.1, the Level 3 Graded Approach Eagle 21 components total normal environment random error is equal to ±0.312% span

Combining the RTD random error $\sigma_1$ with the Eagle 21 random error:

$$\sigma_2 = \pm\left[\sigma_1^2 + (\text{Eagle 21 Random Error})^2\right]^{1/2}$$
$$= \pm\left[(0.157\%\ \text{span})^2 + (0.312\%\ \text{span})^2\right]^{1/2}$$
$$= \pm 0.349\%\ \text{span}$$

6.1.2.2 Determination of Wide Range Eagle 21 RTD Non-random Errors $\Sigma e_2^+$ and $\Sigma e_2^-$

From Reference 5.1.1, the Level 3 Graded Approach Eagle 21 components total normal environment non-random errors are equal to ±0.026% span

$$\Sigma e_2^+ = +\left[(\Sigma en_1^+)^2 + (\Sigma^2_{Eagle 21})^2\right]^{1/2}$$
$$= +\left[0^2 + 0.026\%\ \text{span}^2\right]^{1/2}$$
$$= +0.026\%\ \text{span}$$

$$\Sigma en_2^- = -\left[(\Sigma en_1^-)^2 + (\Sigma^2_{Eagle 21})^2\right]^{1/2}$$
$$= -\left[0^2 + 0.026\%\ \text{span}^2\right]^{1/2}$$
$$= -0.026\%\ \text{span}$$

6.1.3 MODULE 3 ERRORS

6.1.3.1 Determination of Wide Range RCS Temperature Recorder Random Errors $\sigma_3$

6.1.3.1.1 RA (Reference Accuracy)

Accuracy = ±0.5% span

$$RA = \frac{Accuracy}{2}$$

$$= \frac{\pm 0.5\%\ \text{span}}{2}$$

$$= \pm 0.25\%\ \text{span}$$

6.1.3.1.2 CAL (Calibration Equipment Errors)

6.1.3.1.2.1 $MTE_1$ - Wide Range RCS Temperature Recorder

The Wide Range RCS Temperature Recorder is considered as M&TE to capture the readability error of the recorder.* All other terms are not applicable and considered as zero.

6.1.3.1.2.1.1 Calibration Accuracy $CAMTE_1$

The Wide Range RCS Temperature Recorder is string calibrated with the Eagle 21 analog output modules. Therefore the CAMTE error has been previously considered.

CAMTE = 0

6.1.3.1.2.1.2 Temperature error of M&TE $TEMTE_1$

Temperature errors are included in the Reference Accuracy of the Wide Range RCS Temperature Recorder

$TEMTE_1 = 0$

6.1.3.1.2.1.3 Other M&TE Errors OTHERMTE

No further M&TE errors are identified

$OTHERMTE_1 = 0$

6.1.3.1.2.1.4 Reading error of M&TE REMTE

Per Reference 5.4.1, reading error is ± 1/4 of the smallest graduation interval on an indicator.

The smallest graduation interval on the Wide Range RCS Temperature Recorders is 10°F.

$$REMTE_1 = \pm \frac{\frac{10°F}{4}}{(700 - 0°F)} \bullet 100\%\ \text{span}$$
$$= \pm 0.357\%\ \text{span}$$

6.1.3.1.2.1.5 $MTE_1$ - Wide Range RCS Temperature Recorder

$$MTE_1 = \pm\left[\left(\left(\frac{CAMTE_1}{2} + \frac{TEMTE_1}{2} + \frac{OTHERMTE_1}{2}\right)^2 + REMTE_1^2\right)\right]^{1/2}$$
$$= \pm\left[\left((0 + 0 + 0)^2 + (0.357\%\ \text{span})^2\right)\right]^{1/2}$$
$$= \pm 0.357\%\ \text{span}$$

6.1.3.1.2.2 Calibration Error CAL

$$CAL = \pm\left[(MTE_1)^2\right]^{1/2}$$
$$= \pm\left[(0.357\%\ \text{span})^2\right]^{1/2}$$
$$= \pm 0.357\%\ \text{span}$$

6.1.3.1.3 Setting Tolerance ST

Calibration procedures require the analog outputs As Left values to be within ± 7.27°F.

$$\text{Setting Tolerance}_{3\sigma} = \pm \frac{7.27°F}{(700°F - 0°F)} \bullet 100\%\ \text{span}$$
$$= \pm 1.039\%\ \text{span}$$

Calculate the setting tolerance uncertainty for one standard deviation;

$$ST = \frac{ST_{3\sigma}}{3} = \frac{\pm 1.039\%\ \text{span}}{3}$$
$$= \pm 0.346\%\ \text{span}$$

6.1.3.1.4 $\sigma_3$ input (Random Error at Module Input)

$\sigma_3$ input = $\sigma_2$ = ± 0.349% span

6.1.3.1.5 Drift D

Per the methodology [2.1.3.3], the 2σ overall channel drift uncertainty equals ±1% of span per 12 months. Per Reference 5.5.1, the calibration period of this channel is 18 months (550 days).

$$Drift_{2\sigma} = \pm\left[(1\%\ span)^2 \bullet \left(\frac{18\ months}{12\ months}\right)^2\right]^{1/2}$$

$$= \pm 1.5\%\ span$$

$$D = \frac{Drift_{2\sigma}}{2}$$ [2.1.3.3]

$$= \frac{1.5\%\ span}{2}$$

$$= \pm 0.75\ span$$

6.1.3.1.6 Readability Error READ

Readability is one-half of one minor division = ±10°F/2 = ±5°F

$$READ = \frac{\dfrac{\pm Readability_{2\sigma}}{2}}{\dfrac{700^\circ F}{100\%\ span}} = \frac{\dfrac{\pm 5^\circ F}{2}}{\dfrac{700^\circ F}{100\%\ span}}$$

$$= \pm 0.357\%\ span$$

6.1.3.1.7 Determination of Random Errors $\sigma_3$

$$\sigma_3 = \pm [\ RA^2 + CAL^2 + ST^2 + \sigma_3 input^2 + D^2 + READ^2\ ]^{1/2}$$

$$= \pm [\ (0.25\%\ span)^2 + (0.357\ \%\ span)^2 + (0.346\ \%\ span)^2 \ldots$$

$$+ (0.349\%\ span)^2 + (0.75\%\ span)^2 + (0.357\%\ span)^2\ ]^{1/2}$$

$$= \pm\ 1.059\%\ span$$

6.1.3.2 Determination of Wide Range RCS Temperature Recorder Non-random Errors $\Sigma e_3^+$ and $\Sigma e_3^-$

No Wide Range RCS Temperature Recorder non-random errors are identified by the vendor, therefore; [5.7.3]

$$\Sigma e_3^+ = +\left[(\Sigma e_2^+)^2 + (0)^2\right]^{1/2}$$

$$= +\left[0.026^2 + 0^2\right]^{1/2}$$

$$= +0.026\%\ span$$

$$\Sigma e_3^- = -\left[(\Sigma e_2^-)^2 + (0)^2\right]^{1/2}$$

$$= -\left[0.026^2 + 0^2\right]^{1/2}$$

$$= -0.026\%\ span$$

6.2 TOTAL INSTRUMENT CHANNEL ERROR

6.2.1 Positive Normal Total Instrument Channel Error (Ten$^+$)

$$Ten^+ = \left(1 \bullet \sigma_3 + \Sigma en_3^+\right) \bullet 700°F$$
$$= (1 \bullet +1.059\%\ span + 0.026\%\ span) \bullet 700°F$$
$$= +7.595°F$$

6.2.2 Negative Normal Total Instrument Channel Error (Ten$^-$)

$$Ten^- = -\left|\left(1 \bullet \sigma_3 + \Sigma en_3^+\right) \bullet 700°F\right|$$
$$= -\left|(1 \bullet +1.059\%\ span + 0.026\%\ span) \bullet 700°F\right|$$
$$= -7.595°F$$

6.3 MINIMUM LTOP/COMS ENABLE TEMPERATURE

Enable Temperature$_{min}$ = Enable Temperature + Ten$^+$
= 300.660°F + 7.595°F
= 308.255°F

## 7. SUMMARY AND CONCLUSIONS

Wide Range RCS $T_{COLD}$ Temperature Recorders have a total loop uncertainty of ±7.595°F. The application of this uncertainty is limited to instrument functions utilized for EOP non-operator actions and Reg Guide 1.97 Type B, C, D and E parameters and Technical Specification Compliance Channels under normal environmental operating conditions.

The minimum acceptable temperature for enabling LTOP/COMS is 308.255°F.

FINAL PAGE

**Attachment F**

**Zion Calculation No. 22S-B-004E-166, Revision 0**