COMMONWEALTH EDISON COMPANY
CALCULATION TITLE PAGE

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■ SAFETY RELATED ☐ REGULATORY RELATED ☐ NON-SAFETY RELATED

CALCULATION TITLE:

Main Steam Tunnel Temperature Isolation Setpoint Error Analysis

STATION/UNIT: LaSalle Units 1 & 2 SYSTEM ABBREVIATION: LD

EQUIPMENT NO.: PROJECT NO.: N/A

TE-1(2)E31-N029A, B, C, D
TE-1(2)E31-N030A, B, C, D
TS-1(2)E31-N615A, B, C, D

REV: 0 STATUS: Approved For Use QA SERIAL NO. OR CHRON NO.

PREPARED BY: Thomas J. Van Wyk [signature] DATE: 1/16/96

REVISION SUMMARY:

Initial Issue

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

REVIEWED BY: W D Cumgaertner DATE: 1/16/96

REVIEW METHOD: DETAILED REVIEW COMMENTS (C OR NC): NC

APPROVED BY: [signature] DATE: 1-16-96

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CALCULATION REVISION PAGE

CALCULATION NO. NED-I-EIC-0208 PAGE NO.: 2 of 30

REV: STATUS: QA SERIAL NO. OR CHRON NO.

PREPARED BY:____________________ DATE:__________

REVISION SUMMARY:

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

REVIEWED BY:____________________ DATE:__________

REVIEW METHOD: COMMENTS (C OR NC):______

APPROVED BY:____________________ DATE:__________

REV: STATUS: QA SERIAL NO. OR CHRON NO.

PREPARED BY:____________________ DATE:__________

REVISION SUMMARY:

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

REVIEWED BY:____________________ DATE:__________

REVIEW METHOD: COMMENTS (C OR NC):______

APPROVED BY:____________________ DATE:__________

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1.0 PURPOSE/OBJECTIVE OF CALCULATION

The purpose of this calculation is to determine the calibrated setpoint and allowable value for the Main Steam Tunnel Area Vent High Differential Temperature Isolation instrument channels. This channel provides a Tech Spec setpoint and initiates a Group I isolation of the MSIVs and MSL drain valves on high differential temperature.

The calculation is valid under normal operating and accident environmental conditions and allows for all normal operating and accident errors, thus ensuring Tech Spec compliance for the following instruments:

TE-1E31-N029A,B,C,D	TE-2E31-N029A,B,C,D
TE-1E31-N030A,B,C,D	TE-2E31-N030A,B,C,D
TS-1E31-N615A,B,C,D	TS-2E31-N615A,B,C,D

2.0 METHODOLOGY AND ACCEPTANCE CRITERIA

The methodology used herein is based on ComEd documents, References 3.2 and 3.3.

2.1 The evaluation of errors used to determine the "Total Error" (TE) is consistent with the above methodology with the following exception:

(a) The calibration tolerance is assumed to describe the limits of the as-left component outputs. For a random error, this corresponds to 100% of the population and can be statistically represented by a 3 sigma value. Per References 2 and 3, the "Setting Tolerance" (ST) is defined as a random error which is due to the procedural allowances given to the technician performing the calibration. For this calculation:

ST = calibration tolerance / 3

2.2 As stated in Section 1, the objective of this calculation is to determine the available margin between the analytical limit and the nominal Tech Spec Setpoint. The acceptance criteria for this calculation is that a positive margin is required.

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3.0 REFERENCES

3.1 ANSI/ISA-S67.04-1988, "Setpoints for Nuclear Safety Related Instrumentation."

3.2 TID-E/I&C-20, "Basis for Analysis of Instrument Channel Set-point Error & Loop Accuracy", Rev. 0, dated 4/6/92.

3.3 TID-E/I&C-10, "Analysis of Instrument Channel Setpoint Error and Instrument Loop Accuracy", Rev. 0, dated 4/6/92.

3.4 LaSalle Station Procedures

LIS-MS-105A (Rev. 3), "Unit 1 Main Steam Tunnel Area Vent High Differential Temperature Isolation Instrument Channels A and C Refuel Calibration", dated 3/22/94.
LIS-MS-105B (Rev. 3), "Unit 1 Main Steam Tunnel Area Vent High Differential Temperature Isolation Instrument Channels B and D Refuel Calibration", dated 2/18/94.
LIS-MS-205A (Rev. 3), "Unit 2 Main Steam Tunnel Area Vent High Differential Temperature Isolation Instrument Channels A and C Refuel Calibration", dated 2/14/94.
LIS-MS-205B (Rev. 3), "Unit 2 Main Steam Tunnel Area Vent High Differential Temperature Isolation Instrument Channels B and D Refuel Calibration", dated 3/22/94.

3.5 LaSalle Station UFSAR, Rev 6, Tables 3.11-7, 16, 24, dated April 1990.

3.6 Riley Company, Instruction and Operating Manual, Model 86 Temp-Matic Thermocouple Monitor, Revision 1.

3.7 Commonwealth Edison Company Calculation No. NED-I-EIC-0255, "Measurement & Test Equipment Accuracy Calculation For Use With CECo BWRs", Rev. 0, CHRON # 208597.

3.8 Commonwealth Edison Company Instrument Database, Specific and Supplemental Data Sheet for the following instruments:

TE-1E31-N029A,B,C,D	TE-2E31-N029A,B,C,D
TE-1E31-N030A,B,C,D	TE-2E31-N030A,B,C,D
TS-1E31-N615A,B,C,D	TS-2E31-N615A,B,C,D

3.9 CECo Environmental Qualification Equipment Identification Binder, LaSalle Units 1 & 2, Project No. 6548/49-00, CQD File No. 017141, Rev. 05, Sheet D1 of D4, approval date 9/12/91.

3.10 GE Data Sheet Drawing No. 145C3224, "Temperature Element", Rev. 2, dated 3/22/74.

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3.11 ASTM, American National Standard C96.2-1973, "Standard Temperature - Electromotive Force (EMF) Tables for Thermocouples".

3.12 Sargent & Lundy Report SL-4493, "Final Report on Insulation Resistance and Its Presumed Effects on Circuit Accuracy LaSalle County Station", dated October 12, 1988.

3.13 Sargent & Lundy Calculation CID-MISC-01, "Instrument Loop Evaluation for Parasitic Resistance", Rev. 0, dated 2/3/87.

3.14 Acton Environmental Testing Corporation Test Report No. 16436-82N, "Nuclear Qualification Testing of Temperature Measurement Devices Per IEEE Std. 323-1974 and IEEE Std. 344-1975", Revision 3, dated 1/31/84.

3.15 LaSalle Station Unit 1 Technical Specifications, as amended through Amendment 107, dated October 20, 1995, and LaSalle Station Unit 2 Technical Specifications, as amended through Amendment 93, dated October 20, 1995.

3.16 Transmation IS 1061 Thermocouple Calibrators Specification, Fluke 2160A Digital Thermometers Specification Data Sheets, and Fluke 8500A Digital Multimeter Resistive value Specification.

3.17 ComEd Calculation BSA-L-95-05, rev. 0. (for analytical limit).

3.18 Record of telephone conversation with General Electric (Kaz Utsumi) stating that the Reference Accuracy for the Riley Tempmatic Model 86 in this application is 2% of span. This will be further documented in a letter from GE to follow. (Attachment 1).

4.0 DESIGN INPUTS

4.1 Thermocouple extension wire has the identical conductor types as the thermocouple and the thermocouple head terminals, and therefore there is no emf drop or rise at the point of connection on the thermocouple. Per Reference 3.6, the resistance drop of the extension wire will introduce an error of ±3°F.

4.2 Temperature, radiation and humidity errors, when available from the manufacturer, were evaluated with respect to the normal operating conditions specified in the LaSalle Station EQ zones. The EQ zone requirements for each instrument was obtained from the LaSalle County Station EQ zone maps.(Reference 3.5)

4.3 For a Type E thermocouple, the output span for 0°F to 150°F is 5.067 mV, based on a reference junction temperature of 32°F. Because the installed reference junctions are not maintained at 32°F, the actual thermocouple output will vary by a constant equal to the emf developed between 32°F and the actual temperature of the reference junctions. Because the thermocouple output varies by a constant, the span of 5.067 mV remains the same, and is used in this calculation.

5.0 ASSUMPTIONS

5.1 Published instrument vendor specifications are considered to be 2 sigma values unless specific information is available to indicate otherwise.

5.2 Temperature, humidity and pressure errors have been incorporated when provided by the manufacturer. Otherwise, these errors are assumed to be included within the manufacturer's reference accuracy specification.

5.3 Evaluation of M&TE errors is based on the assumption that the test equipment listed in Section 9.0 is used. Use of test equipment less accurate than that listed will require evaluation of the effect on calculation results.

5.4 Drift error has been assumed to be 0.5% of Setpoint per 18 month, unless specified otherwise by the manufacturer. The calculated drift error will be adjusted for surveillance intervals of greater or lesser length based on calibration frequency.

5.5 In accordance with Reference 3.7, it is assumed that the M&TE listed in Section 9.0 is calibrated to the required manufacturer's recommendations and within the manufacturer's required environmental conditions. As such, It is assumed that the calibration standard accuracy error of M&TE is negligible with respect to the other terms.

5.6 Radiation induced errors associated with normal environments 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 re-calibrated. Therefore, unless specifically published by the equipment vendor, the normal radiation errors can be assumed to be included within the instrument drift related errors.

5.7 A minimum temperature of 60°F was assumed for general access areas in the reactor building.

6.0 INSTRUMENT CHANNEL CONFIGURATION

The MS Tunnel area differential temperature loop consists of two thermocouples each equipped with thermocouple extension wire, feeding a differential temperature switch.

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7.0 PROCESS PARAMETERS

Temperature(Max)	212°F
Pressure(Max)	40 PSIG for first 10 sec.
Radiation	1 x 10E7 Rads
Relative Humidity	Steam

8.0 LOOP ELEMENT DATA

8.1 PYCO Model 102-9039-11-6 Thermocouple (Reference 3.9)

From References 3.10, and 3.11,

Thermocouple Type:	Chromel-Const. (Type E)
Temperature Range:	32° to 600°F
Accuracy:	± 2°F

8.1.1 Environmental Data for Thermocouple Location

Thermocouple Locations (Reference 3.8 and 3.9): Reactor Building, Main Steam Tunnel.

TE-1(2)E31-N029A-D	Local Mount	EQ Zone H5C
TE-1(2)E31-N030A-D	Local Mount	EQ Zone H5C

Normal Operating Conditions for Environmental Zone H5C. (Reference 3.5)

Temperature	60°F-130°F (Assumption 5.7)
Pressure	-0.4" W.G.
Radiation	6 x 10^6 Rads (40-Year Dose)
Relative Humidity	20 - 95%

Accident Conditions for Environmental Zone H5C. (Reference 3.5)

Temperature	60°F-212°F (Assumption 5.7)
Pressure	40 PSIG for first 10 sec.
Radiation	1 x 10^7 Rads (40-Year Dose)
Relative Humidity	Steam

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8.2 Riley Model 86, Temp-Matic Thermocouple Monitor (Reference 3.8)

From Reference 3.6,

Reference Accuracy:	± 2% of span (Ref. 3.18)
Repeatability:	± 0.25% of span
Hysteresis:	± 0.1% of span
Conformity:	± 0.65% span
Temperature Limits:	14° to 140°F
Line Voltage Effect:	± 0.5% of span over range of normal operating voltages
Normal Operating Voltage:	120 VAC ± 10%
Maximum loop Resistance:	500 Ω
Impedance:	250 KΩ

8.2.1 Environmental Data for Temperature Switch Location

Switch Locations (Reference 3.8): Unit 1/2 Control Room

TS-1(2)E31-N615A,C	1(2)H13-P632	EQ Zone C1A
TS-1(2)E31-N615B,D	1(2)H13-P642	EQ Zone C1A

Normal Operating and Accident Conditions for Environmental Zone C1A. (Reference 3.5)

Temperature	72°F-74°F
Pressure	0" to +0.25" W.G.
Radiation	1 x 10^3 Rads (40-Year Dose)
Relative Humidity	35 - 45%

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9.0 CALIBRATION INSTRUMENT DATA

Per the station procedures (Reference 3.4) the following devices may potentially be used as measurement and test equipment when performing calibrations on the devices within the subject instrument loop.

$MTE2_D$ (Reference 3.7 and 3.16)

Fluke Model 8500A Digital Multimeter

Range	100 mVdc
Resolution	0.001 mV
Calibrated Accuracy	±(0.005% reading + 8 counts)
Temperature Coefficient	±(0.0003% rdg + 0.5 count) /°C (From 0° to 18° and 28° to 50°C)

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10.0 CALIBRATION PROCEDURE DATA

The Instrument Calibration Procedures (Reference 3.4), provide the following:

Calibrated Span:	0° to 150°F
Allowable Range: (Setting Tolerance)	2.143 to 2.248 mVdc (-0.053/+0.052 mVdc)
Nominal T. S. Setpoint:	65°F (2.196 mVdc) (Ref. 3.17)
Analytical Limit:	72.5°F (2.450 mVdc) (Ref. 3.17)
Calibration Frequency:	Refuel (24 months)*
Late Factor:	25% (6 months)

*NOTE: Current calibration frequency is 18 months. Calculation will use 24 months to be more conservative and to allow for the proposed 24 month fuel cycle.

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11.0 THERMOCOUPLE ERRORS (MODULE 1)

The thermocouple has an analog input and an analog output. Therefore, it is classified as an analog module.

11.1 Random Error, Normal Operating Conditions ($\sigma 1n$)

11.1.1 Thermocouple Reference Accuracy (RA1)

The thermocouple Reference Accuracy is determined by direct application of the Vendor's Specification listed in Section 8.1.

$$RA1 = \pm 2.0°F$$

The Vendor's specification for accuracy is a 2σ value. (Assumption 5.1)

$$RA1_{(1\sigma)} = \pm[2.0°F/2]$$

$$= \pm 1.0°F$$

11.1.2 Thermocouple Calibration Error (CAL1)

The existing Station Procedures do not calibrate the thermocouples. Therefore:

$$CAL1 = 0$$

11.1.3 Thermocouple Setting Tolerance Error (ST1)

Since the thermocouples are not calibrated, there is no setting tolerance. Therefore:

$$ST1 = 0$$

11.1.4 Random Input Errors ($\sigma in1n$)

The thermocouple is the first module in the loop. Therefore:

$$\sigma in1n = 0$$

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11.1.5 Resistance Drop of the Extension Wire ($\sigma RD1n$)

Since the thermocouple extension wires are made of the same material as the thermocouple itself, there is no emf rise or drop across the thermocouple head terminals. However, there is a resistance drop across the extension wire, which is routed through the reactor building and auxiliary building to the control room. Per Design Input 4.1, the resistance drop of thermocouple extension wire results in an error of ±3.0°F.

$$\sigma RD1n = \pm 3.0°F$$

The resistance drop value is a 2σ value. (Assumption 5.1)

$$\sigma RD1n_{(1\sigma)} = \pm 3.0°F / 2$$

$$= \pm 1.5°F$$

11.1.6 Calculation of Thermocouple Random Error ($\sigma 1n$)

$$\sigma 1n = \pm[(RA1)^2 + (CAL1)^2 + (ST1)^2 + (\sigma in1n)^2 + (\sigma RD1n)^2]^{0.5}$$

$$= \pm[(1.0°F)^2 + (0)^2 + (0)^2 + (0)^2 + (1.5°F)^2]^{0.5}$$

$$= \pm 1.802776°F$$

11.2 Random Error, Accident Conditions ($\sigma 1a$)

For the purpose of this calculation, it is assumed that the random error determined for normal operating conditions (Section 11.1.6) is the same error that would occur during accident conditions since random errors are not dependent on the environmental conditions.

$$\sigma 1a = \sigma 1n = \pm 1.802776°F$$

$$= \pm 1.802776°F\ (5.067\ mV/150°F) = 0.060898\ mV$$

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11.3 Non-Random Errors Normal Operating Conditions ($\Sigma e1n$)

11.3.1 The thermocouples are passive devices which produce a millivolt signal proportional to temperature. As such, they are not affected by the following non-random errors:

Humidity Errors:	eH1n = 0
Radiation Errors:	eR1n = 0
Seismic Errors:	eS1n = 0
Static Pressure Effects:	eSP1n = 0
Ambient Pressure Errors:	eP1n = 0
Power Supply Effects:	eV1n = 0
Drift:	eD1n = 0

11.3.2 Temperature error (eT1n)

The thermocouples are designed to exhibit a precise temperature effect, which is used to develop the signal provided to the loop. Since the thermocouples are designed to function in temperatures well above the system design temperature, there is no temperature error other than the accuracy error. Therefore,

$$eT1n = 0$$

11.3.3 Insulation Resistance Error (eIR1n)

There are no terminal blocks in 100% relative humidity areas. References 3.12 and 3.13 state that insulation resistance error for thermocouples is negligible, therefore,

$$eIR1n = 0$$

11.3.4 Non-Random error for Normal Operating Conditions

$$\Sigma e1n = eH1n + eR1n + eS1n + eSP1n + eP1n + eV1n + eD1n + eT1n + eIR1n$$

$$= 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0$$

$$\Sigma e1n = \pm 0°F$$

11.4 Non-Random Errors Accident Conditions (Σe1a)

11.4.1 Seismic Error (eS1a)

Seismic testing was performed on selected Pyco thermocouple models. Per Reference 3.14, the tested units demonstrated consistent calibration readings both prior to and following seismic tests. Therefore, seismic error is considered negligible.

eS1a = 0

11.4.2 Radiation Error (eR1a)

There are no radiation errors described in the Vendor's specification for the thermocouple. Per Reference 3.14, the radiation dose rate for the exposure of the instrument was 0.80 x 10^6 rads per hour for 276.4 hours, which resulted in a radiation dose of 2.2112 x 10^8 rads. Per Section 8.1.1, for accident conditions, a 40-year dose is 1 x 10^7 rads. The test exposure was greater than the accident dose, therefore, radiation error will be considered to be negligible.

eR1a = 0

11.4.3 The thermocouples are passive devices which produce a millivolt signal proportional to temperature. As such, they are not affected by the following non-random errors:

Humidity Errors:	eH1a = 0
Static Pressure Effects:	eSP1a = 0
Ambient Pressure Errors:	eP1a = 0
Power Supply Effects:	eV1a = 0
Drift:	eD1a = 0

11.4.4 Temperature error (eT1n)

The thermocouples are designed to exhibit a precise temperature effect, which is used to develop the signal provided to the loop. Since the thermocouples are designed to function in temperatures well above the system design temperature, there is no temperature error other than the accuracy error. Therefore,

eT1a = 0

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11.4.5 Non-random error, Accident Operating Conditions

$$\Sigma e1a = eH1a + eR1a + eS1a + eSP1a + eP1a + eV1a + eD1a + eT1a + eIR1a$$

$$= 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0$$

$$\Sigma e1a = \pm 0°F$$

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11.5 TEMPERATURE SWITCH ERRORS (MODULE 2)

The temperature switch has an analog input and a discrete output. Therefore, it is classified as a bistable module.

11.5.1 Random Error ($\sigma 2$)

11.5.1.a Reference Accuracy (RA2)

Section 8.2 provides vendor's terms for reference accuracy, repeatability, hysteresis, and conformity. From Section 10.0, the calibrated span is 150°F. Per Assumption 5.1, the terms are considered to be 2σ values and will be combined using SRSS. Therefore, RA2 is determined as follows:

In general:

$$RA2 = [(\text{Ref. Acc.})^2 + (\text{Repeat.})^2 + (\text{Hyster.})^2 + (\text{Conformity})^2]^{1/2}$$

$$RA2 = [(0.02 \bullet 150°F)^2 + (0.0025 \bullet 150°F)^2 + (0.001 \bullet 150°F)^2 + (0.0065 \bullet 150°F)^2]^{1/2}$$

$$= \pm\ 3.180212°F$$

Per Assumption 5.1, the standard deviation for reference accuracy ($RA2_{(1\sigma)}$) is RA2/2, therefore:

$$RA2_{(1\sigma)} = \pm\ (3.180212°F)/2$$

$$= \pm\ 1.590106°F$$

11.5.1.b Calibration Error (CAL2)

Per Reference 3.4, apply a test voltage to the switch through the resistance decade box while measuring the voltage with a DMM listed in Section 9.0, and recording the temperature at which the switch contact opens.

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The Calibration Error consists of following errors:

- DMM Error ($MTE2_D$) present at the switch input
- Calibration Standard Error (STD)

11.5.1.b.1 Measurement & Test Equipment Error (MTE2)

Determination of DMM error present at the switch input

Fluke Model 8500A, ($MTE2_D$)

Reference accuracy (RAMTE) is equal to the Manufacturer's reference accuracy. For determination of RAMTE, the worst-case reading is that which is the highest value for the calibration limits in the instrument loop (5.067 mVdc). From the data in Sect. 9.0,

$$RAMTE = \pm(0.005\% \text{ reading} + 8 \text{ counts})$$

$$= \pm[(0.00005) \bullet (5.067 \text{ mVdc}) + 8(0.001 \text{ mVdc})]$$

$$= \pm 0.008253 \text{ mVdc}$$

The standard deviation of reference accuracy ($RAMTE_{(1\sigma)}$) is RAMTE/2 (Assumption 5.1). Therefore,

$$RAMTE_{(1\sigma)} = \pm 0.008253 \text{ mVdc} / 2 = \pm 0.004127 \text{ mVdc}$$

The temperature switch is calibrated in the control room which has an ambient temperature range of 73 ± 1°F (Reference 3.5). This temperature range is within the range given by the M&TE vendors where no temperature effect occurs. Therefore, there is no temperature effect for this application.

$$TEMTE_{(1\sigma)} = 0$$

REMTE, the reading error is defined as the least significant digit for a digital readout. Therefore, from Section 9.0,

$$REMTE = \pm 0.001 \text{ mVdc}$$

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From Reference 3.2, the total measurement error for the calibration instruments listed in Section 9.0 is determined using the following equation:

$$MTE2_D = \pm[(RAMTE_{(1\sigma)} + TEMTE_{(1\sigma)})^2 + (REMTE)^2]^{0.5}$$

$$= \pm [(0.004127 \text{ mV} + 0)^2 + (0.001 \text{ mV})^2]^{0.5}$$

$$= \pm 0.004246 \text{ mV}$$

11.5.1.b.2 Calibration Standard Error (STD2)

The error due to calibration accuracy of calibration equipment is assumed to be negligible (Assumption 5.5). Therefore,

$$STD2 = 0$$

11.5.1.b.3 Determination of Calibration Error (CAL2)

$$CAL2 = [\pm(MTE2_D^2 + STD2^2)]^{½}$$

$$= [\pm(0.004246 \text{ mV})^2 + (0)^2]^{0.5}$$

$$CAL2 = \pm 0.004246 \text{ mV}$$

11.5.2 Setting Tolerance (ST2)

Per the allowable range tolerance data in Section 10.0, the setting tolerances for the switches are not equally negative and positive. For conservatism and to ease combining error terms, the greater of the two values for the switch will be considered as the setting tolerance. Therefore,

$$ST2 = \pm 0.053 \text{ mVdc}$$

Per Section 2.1, ST2 is considered a 3σ value, therefore $ST2_{(1\sigma)} = ST2/3$.

$$ST2_{(1\sigma)} = \pm (0.053 \text{ mVdc})/3 = \pm 0.017667 \text{ mVdc}$$

11.5.3 Random Input Error ($\sigma in2n$)

The random error present at the input to the switch is due to the thermocouple and was calculated in Section 11.1.6. The scaling conversion is directly proportional due to the linearity of the devices. The value for $\sigma 1$ determined in Section 11.1.6 is provided in terms of the thermocouple output error. Therefore,

$\sigma 1n = \sigma in2n$

$\sigma in2n = \pm 1.802776°F$

11.5.4 Determination of Total Random Errors ($\sigma 2n$)

11.5.4.a Total Random Error ($\sigma 2n$)

In order to combine the random error terms, both calibration error and setting tolerance must be converted to degrees Fahrenheit. This is done by applying the error to the setpoint to determine a range, and then using the °F vs mVdc ratio from Design Input 4.3 to find the corresponding temperature change.

CAL2 = ± 0.004246mVdc ● (150°F/5.067 mV) = 0.125696°F

ST2 = ± 0.017667 mVdc ● (150°F/5.067 mV) = 0.523002°F

$$\sigma 2n = [(RA2)^2 + (CAL2)^2 + (ST2)^2 + (\sigma in2n)^2]^{1/2}$$

$$= \pm[(1.590106°F)^2 + (0.125696°F)^2 + (0.523002°F)^2 + (1.802776°F)^2]^{1/2}$$

$$= \pm 2.463284°F$$

11.6 Random Error, Accident Conditions ($\sigma 2a$)

The temperature switch is located in a controlled environmental area such that Normal Operating Conditions and Accident Conditions are the same. Therefore, for the purpose of this calculation, since random errors are not dependent on environmental conditions, total random error for normal and accident conditions is assumed to be the same.

11.6.1 Total Random Error For Setpoint Margin Determination ($\sigma 2a$)

$$\sigma 2a = \sigma 2n = \pm 2.463284°F$$

11.7 Non-Random Errors Normal Operating Conditions ($\Sigma e2n$)

11.7.1 Humidity Error (eH2n)

There are no humidity errors described in the Vendor's specification for the temperature switch. These errors are assumed to be included in instrument reference accuracy (Assumption 5.2). Therefore,

eH2n = 0

11.7.2 Temperature Error (eT2n)

The Vendor does not provide a temperature effect specification. However, the operating temperature limits for the switch are from 14°F to 140°F. The normal operating ambient temperature at the switch location is 72°F-74°F (Section 8.2.1) which is bounded by the manufacturers specification. Therefore,

eT2n = 0

11.7.3 Radiation Error (eR2n)

There are no radiation errors described in the Vendor's specification for the temperature switch. These errors are assumed to be included in instrument drift related errors (Assumption 5.6). Therefore,

eR2n = 0

11.7.4 Seismic Error (eS2n)

A seismic event defines a particular type of accident condition. Errors included on the instrument due to seismic vibrations are defined only for accident conditions and therefore, are not applicable during normal plant conditions.

eS2n = 0

11.7.5 Static Pressure Offset (eSP2n)

The temperature switch is an electrical device and as such is not affected by static pressure. Therefore,

eSP2n = 0

11.7.6 Pressure Error (eP2n)

The temperature switch is an electrical device and as such is not affected by ambient pressure. Therefore,

$eP2n = 0$

11.7.7 Process Error (ep2n)

There are no process errors associated with the temperature switch. Therefore,

$ep2n = 0$

11.7.8 Power Supply Effects (eV2n)

Per Section 8.2, the power supply effects are as follows:

$$eV2n = \pm[0.5\%\ span] = \pm[0.005 \bullet 150°F]$$

$$= \pm\ 0.75°F$$

11.7.9 Temperature Switch Drift Error (eD2n)

The vendor does not provide a drift specification for the switch which is an electrical device. Therefore, it is assumed to be 0.5% of setpoint per 18 months (Assumption 5.4). The calibration frequency (SI) is 24 months and the late factor (LF) is 6 months. Therefore,

$$eD2n = \pm(0.5\%(setpoint)/18\ months)(SI)(1 + LF/SI)$$

$$= \pm(0.005 \bullet (65°F)/18\ months)(24\ months)(1 + 6/24)$$

$$= \pm\ 0.541667°F$$

11.7.10 Non-Random Input Error (ein2n)

The non-random input error is due to the thermocouple and was calculated in Section 11.3.4.

$\Sigma e1n = ein2n = 0°F$

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11.7.11 Total Non-Random Error Normal Operating Conditions ($\Sigma e2n$)

$$\Sigma e2n = eH2n + eT2n + eR2n + eS2n + eSP2n + eP2n + ep2n + eV2n + eD2n + ein2n$$

$$\Sigma e2n = 0 + 0 + 0 + 0 + 0 + 0 \pm 0.75°F + 0 \pm 0.541667°F + 0$$

$$= \pm 1.291667°F$$

11.8 Non-Random Error, Accident Conditions ($\Sigma e2a$)

11.8.1 Humidity Error (eH2a)

There are no humidity errors described in the Vendor's specification for the temperature switch. These errors are assumed to be included in instrument reference accuracy (Assumption 5.2). Therefore,

eH2a = 0

11.8.2 Temperature Error (eT2a)

The Vendor does not provide a temperature effect specification. However, the operating temperature limits for the switch are from 14°F to 140°F. The operating ambient temperature at the switch location is 72°F-74°F (Section 8.2.1). Therefore,

eT2a = 0

11.8.3 Radiation Error (eR2a)

There are no radiation errors described in the Vendor's specification for the temperature switch. These errors are assumed to be included in instrument drift related errors (Assumption 5.6). Therefore,

eR2a = 0

11.8.4 Seismic Error (eS2a)

The switch is seismically qualified and the vendor did not include any error due to a seismic event (section 8.2.1). Therefore,

eS2a = 0

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11.8.5 Static Pressure Offset (eSP2a)

The temperature switch is an electrical device and as such is not affected by static pressure. Therefore,

eSP2a = 0

11.8.6 Pressure Error (eP2a)

The temperature switch is an electrical device and as such is not affected by ambient pressure. Therefore,

eP2a = 0

11.8.7 Process Error (ep2a)

There are no process errors associated with the temperature switch. Therefore,

ep2a = 0

11.8.8 Power Supply Effects (eV2a)

Per Section 8.2, the power supply effects are as follows:

$$eV2a = \pm[0.5\% \text{ span}] = \pm[0.005 \bullet 150°F]$$

$$= \pm 0.75°F$$

11.8.9 Drift Error (eD2a)

The drift error is calculated in Section 11.7.10 for normal conditions, and is the same for accident conditions since drift is not dependent on the environment:

$$e2Dn = e2Da = \pm 0.541667°F$$

11.8.10 Non-Random Input Error (ein2a)

The non-random input error is due to the thermocouple and was calculated in Section 11.4.5, and is used as input to the switch:

$$\Sigma e1a = ein2a = 0°F$$

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11.8.11 Total Non-Random Error Accident Operating Conditions ($\Sigma e2a$)

$\Sigma e2a$ = eH2a + eT2a + eR2a + eS2a + eSP2a + eP2a + ep2a + eV2a + eD2a + ein2a

$\Sigma e2a = 0 + 0 + 0 + 0 + 0 + 0 + 0 \pm 0.75°F \pm 0.541667°F \pm 0°F$

$= \pm 1.291667°F$

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12.0 TOTAL ERROR NORMAL OPERATING AND ACCIDENT CONDITIONS (TE)

The total error is determined as follows:

$$TE = 2 \bullet (\sigma 2) + \Sigma e2$$

12.1 Total Error, Normal Operating Conditions (TE2n)

From Section 11.5.4.a, $\sigma 2n = \pm 2.463284°F$

From Section 11.7.12, $\Sigma e2n = \pm 1.291667°F$

$TEn = \pm (2 \bullet 2.463284°F) \pm 1.291667°F$

$= \pm 6.218235°F$

12.2 Total Error, Accident Operating Conditions (TE2a)

From Section 11.6.1, $\sigma 2a = \pm 2.463284°F$

From Section 11.8.12, $\Sigma e2a = \pm 1.291667°F$

$TEa = \pm (2 \bullet 2.463284°F) \pm 1.291667°F$

$= \pm 6.218235°F$

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13.0 DETERMINATION OF THE NOMINAL TRIP SETPOINT

13.1 Analytical Limit (AL)

From Section 10.0,

AL = 72.5°F

13.2 Setpoint Margin (MAR)

For determining new nominal trip setpoints, margin is defined as 0.5% of process measured span.

MAR = 0.5% • 150°F

= 0.75°F

13.3 Determination of Nominal Trip Setpoint

NTSP = AL - (TEa + MAR)

= 72.5°F - (6.218235°F + 0.75°F)

= 65.531765°F

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13.4 Allowable Value

The allowable value for actuation on an increasing parameter is given by:

$$AV = NTSP - TEn$$

For this calculation, the error term for calculation of the allowable value will include only the normal error terms for the temperature switch because the thermocouple is not part of the switch calibration process. Therefore:

$$\sigma 2n = [(RA2)^2 + (CAL2)^2 + (ST2)^2]^{½}$$

$$= \pm[(1.590106°F)^2 + (0.125696°F)^2 + (0.523002°F)^2]^{½}$$

$$= \pm 1.678621°F$$

From Section 11.7.11:

$$\Sigma e2n = \pm 1.291667°F$$

Total error is determined as follows:

$$TE = 2 \bullet (\sigma 2n) + \Sigma e2n$$

$$= 2 \bullet (1.678621°F) + 1.291667°F$$

$$= 4.648909°F$$

$$AV = 65.531765°F + 4.648909°F$$

$$= 70.180674°F$$

$$\approx 70.1°F$$

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14.0 Conclusions

14.1 Nominal Trip Setpoint

This calculation determines a nominal trip setpoint for the Main Steam Tunnel Temperature Isolation Setpoint that ensures a high level of confidence that the Analytical Limit will not be exceeded under normal or accident operating conditions.

Recommended Nominal Trip setpoint ≤ 65.6°F

14.2 Allowable Value

The recommended Allowable Values is ≤ 70.1°F

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Record of Telephone Conversation

Date: January 16, 1996

With: Pete VandeVisse, ComEd NES
Pete Wicyk, ComEd NES
Dean Crumpacker, ComEd NES
Tom VanWyk, LaSalle Site Design Engineering
Jose Casillas, GE SanJose, Nuclear Energy Dept (408-925-6910)
Kaz Utsumi, GE SanJose, Nuclear Energy Dept (408-925-3707)

Subject: Riley model 86 Temp-Matic Thermocouple Monitor Accuracy

Conversation:
The Riley vendor manual for this model switch indicates that it may be used in applications with a maximum signal loop resistance of 500 Ω. The LaSalle application for the Main Steam Tunnel Temperature Isolation Setpoint uses loop resistance of 500-1000Ω. ComEd asked GE whether a loop resistance greater than 500Ω would effect the reference accuracy of the Temp-Matic.

GE responded that loop accuracies up to 1000Ω were acceptable, and that the associated reference accuracy, used in the GE methodology, was 2% of span. This reference accuracy was applicable provided that the loop resistance was calibrated out of the thermocouple channel calibration. NOTE: LaSalle calibration procedures are performed with a decade box substituting for the thermocouple during calibration, which removes the loop resistance from the calibration error.

Jose Casillas agreed to provide a letter to ComEd by 1/17/95 documenting the reference accuracy of the Riley model 86 thermocouple monitor as discussed above.