ATTACHMENT 4

LaSalle County Station Calculation L-003230, Revision 1b, "CW Inlet Temperature Uncertainty Analysis"

6-20-12

CC-AA-309-1001 ~~Att. 1~~
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ATTACHMENT 1
Design Analysis Cover Sheet
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Design Analysis **Last Page No.** [6] ~~4~~ 5

Analysis No.: [1] L-003230 **Revision:** [2] 001B Major ☐ Minor ☒

Title: [3] CW Inlet Temperature Uncertainty Analysis

EC/ECR No.: [4] 389270 **Revision:** [5] 000

		Component(s): [14]	
Station(s): [7]	LaSalle		
Unit No.: [8]	1,2	1TE-CW010 (TE)	2TE-CW010 (TE)
Discipline: [9]	INDC ~~DEE~~ 6-20-12	1TE-CW011 (TE)	2TE-CW011 (TE)
Descrip. Code/Keyword: [10]	I04	1TT-CW010 (TT)	2TE-CW010 (TT)
Safety/QA Class: [11]	NSR	1TT-CW011 (TT)	2TE-CW011 (TT)
System Code: [12]	CW	U1 Computer Point F285	U2Computer Point F285
Structure: [13]	N/A	U1 Computer Point F286	U2Computer Point F286

CONTROLLED DOCUMENT REFERENCES [15]

Document No.:	**From/To**	**Document No.:**	**From/To**
N/A			

Is this Design Analysis Safeguards Information? [16] **Yes** ☐ **No** ☒ If yes, see SY-AA-101-106

Does this Design Analysis contain Unverified Assumptions? [17] **Yes** ☐ **No** ☒ If yes, ATI/AR#:

This Design Analysis SUPERCEDES: [18] **N/A** **in its entirety.**

Description of Revision (list changed pages when all pages of original analysis were not changed): [19]

The purpose of this calculation is to evaluate the loop uncertainty for the CW Inlet Temperature Indication Loops. The purpose of this minor revision is to evaluate the loop uncertainty for the CW Inlet Temperature Indication Loops for a temperature of 107°F which corresponds to a pending amendment to Technical Specification 3.7.3 per EC 389270.

This minor revision corrects a typographical error in Section 7 which has no effect on this calculation

The following sections are affected (listing affected pages is not appropriate as there are other minor revisions.): Section 4.0 (revised 4.1.2), Section 6 (revised 6.2.1.2.1, 6.2.1.2.4, 6.2.1.6 Section 7 (7.1.3)

This minor revision has no impact on the current total uncertainty.

Preparer: [20] Joe Prostko (Print Name) Joe Prostko (Sign Name) 6-19-12 (Date)

Method of Review: [21] **Detailed Review** ☒ **Alternate Calculations (attached)** ☐ **Testing** ☐

Reviewer: [22] T. J. VAN WYK (Print Name) TJ VanWyk (Sign Name) 6/19/12 (Date)

Review Notes: [23] Independent review ☒ Peer review ☐

(For External Analyses Only)

External Approver: [24] ______ (Print Name) ______ (Sign Name) ______ (Date)

Exelon Reviewer: [25] ______ (Print Name) ______ (Sign Name) ______ (Date)

Independent 3rd Party Review Reqd? [26] **Yes** ☐ **No** ☒

Exelon Approver: [27] Elizabeth Zacharias (Print Name) Elizabeth Zacharias (Sign Name) 6/20/12 (Date)

4 Design Inputs

Revise section 4.1.2 to read as follows:

4.1.2 The resistance value equivalent to the temperature value of interest (107° F) for the RTDs was obtained from the Minco calibration reports for the RTDs installed at LaSalle (Ref.5.4.10). The highest of the four resistances values was 116.190Ω. This value will be used to determine the M&TE error for the indicating loop (applied to Module 2). The change in resistance per 1° F change in temperature (0.214Ω/° F) was also obtained using the actual resistance values in the calibration reports for 107° F and 108° F. A temperature point of interest lower than 107° F would result in a lower resistance value used to calculate the M&TE error, Therefore the value at 107°F bounds all lesser resistance values.

6 Calculations

Revise section 6.2.1.2.1 to read as follows:

6.2.1.2.1 Measurement & Test Equipment Error **MTE2**

HP 34401A
Reference Accuracy is the manufacturer's accuracy (± 0.01% reading + 0.001% of range for the 1kΩ) as a 2σ value (Section 5.4.6). The highest reading of interest is 107°F. The Minco calibration reports for the RTDs show that the highest resistance value for this temperature is 116.190Ω. (Section 4.1.2)

$\mathrm{RAMTE}_{2\sigma} = \pm 0.01\% \times 116.190\Omega + (0.00001 \times 1000\Omega)$

$= \pm 0.0116\Omega + 0.01\Omega = 0.0216\Omega$

$= \pm 0.0216\Omega \times 1°\mathrm{F}/0.214\Omega = 0.101°\mathrm{F}$

$\mathbf{RAMTE2} = \pm \mathbf{0.051°F}$

The manufacturer also specifies a Temperature coefficient for this range (1kΩ) for 0°C to 18°C and 28°C to 55°C as 0.0006% of reading + 0.0001% of range per °C. The normal turbine building ambient temperature in the zone where the transmitter is installed varies from 83°F to 102°F(Ref. 5.5.2). For additional conservatism, this range is expanded to 75°F to 102°F (or 23.9°C to 38.9°C). The lower temperature (23.9°C) is within the range where the coefficient is not applicable, so the applicable ΔT is: (38.9°C - 28°C) or 10.9°C

$\mathrm{TEMTE2}_{2\sigma} = \pm (0.0006\% \times 116.190\Omega) + (0.000001 \times 1000\Omega)$

$= \pm\, 0.00070\Omega\ + 0.001\Omega = \pm\, 0.00170\Omega$

$= \pm\, 0.00170\Omega \times 1°\text{F}/0.214\Omega = 0.00794°\text{F}$

RAMTE2 **= ± 0.00397°F**

The temperature error is a degradation of the specified accuracy and is not considered an additional random error. Therefore, the total M&TE error for the HP 34401A is:

MTE2 $= \pm\, [(0.051°\text{F})^2 + (0.00397°\text{F})^2]^{1/2}$

MTE2 **= ± 0.0512°F**

Fluke 45 (medium speed)

Reference Accuracy is the manufacturer's accuracy [± (0.05% reading + 2 LSD + 0.02Ω)] as a 2σ value (Section 5.4.6) [The LSD for the Fluke 45 is 0.01Ω.] The highest reading of interest is 107°F. The Minco calibration reports for the RTDs show that the highest resistance value for this temperature is 116.190Ω. (Section 4.1.2)

$RA_{2\sigma}$ $= \pm(0.05\% \times 116.190\Omega) + [(2 \times 0.01\Omega) + 0.02\Omega]$

$= \pm\, 0.0581\Omega + 0.04\Omega = 0.0981\Omega$

$= \pm\, 0.0981\Omega \times 1°\text{F}/0.214\Omega = 0.458°\text{F}$

MTE2 **= ± 0.229°F**

The Fluke 45 (med. speed) M&TE error is bounding and will be used to evaluate total loop uncertainty.

Revise section 6.2.1.2.4 to read as follows:

6.2.1.2.4 Calibration Error **CAL2**

The total calibration error for the M&TE is:

$$\begin{aligned} CAL2 &= \pm [(MTE2)^2 + (STD2)^2 + (ST2)^2]^{1/2} \\ &= \pm [(0.229°F)^2 + (0)^2 + (0.18)^2]^{1/2} \end{aligned}$$

$$\mathbf{CAL2 = \pm 0.291°F}$$

Revise section 6.2.1.6 to read as follows:

6.2.1.6 Total Random Error **σ2**

$$\begin{aligned} \sigma 2 &= \pm [(RA2)^2 + (CAL2\,)^2 + (\sigma T2)^2 + (\sigma 2in)^2 + (\sigma 2PS)^2]^{1/2} \\ \sigma 2 &= \pm [(0.285°F)^2 + (0.291°F)^2 + (0.045°F)^2 + (0.150°F)^2 + \\ &\quad (0°F)^2]^{1/2} \end{aligned}$$

$$\boldsymbol{\sigma}\mathbf{2 = \pm 0.436°F}$$

7 Summary and Conclusion (Total Error)

Revise section 7.1.3 to read as follows:

To obtain a more accurate value of the UHS temperature using these instruments, the average of the available values can be taken. This assumes that the four readings are sensing the same input temperature and that there is little effect between the input and the measurement point.

$$T_{CWAverage} = \frac{T_{1TE-CW010} + T_{1TE-CW011} + T_{2TE-CW010} + T_{2TE-CW011}}{4}$$

The accuracy of this process is considered the same as the accuracy of summing networks addressed in References 5.1.1 and 5.1.2, or by the multiple test criterion of Reference 5.1.4 Section 3.2.

In all of these cases the final random uncertainty (σ) is the square root sum of the squares of the individual channel random uncertainties considering the multiplier for each of the uncertainties is one divided by the number of channels that are being averaged. The non-random uncertainty (e) will remain the same as for a single loop (Ref. 5.1.4 , Section 3.2).

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$$\sigma_{Average} = \sqrt{\left(\frac{\sigma_1}{n}\right)^2 + \left(\frac{\sigma_2}{n}\right)^2 + \left(\frac{\sigma_3}{n}\right)^2 + \bullet \;\bullet\; \bullet\; \bullet + \left(\frac{\sigma_n}{n}\right)^2}$$

If all of the instrument loops are identical then this equation will reduce to:

$$\sigma_{Average} = \frac{\sigma_i}{\sqrt{n}} + e$$

Thus for the CW temperatures, the accuracy of the average of the readings for **two loops** will be:

$$\sigma_{Average} = \frac{0.717}{\sqrt{2}} + e = 0.508 + 0.018 = 0.53\,^{\circ}\mathrm{F}$$

Conculsions

The increase in CW Inlet Temperature Indication from 101.5° F to 107° F results in an increase in the resistance values used in this analysis from 115.013Ω to 116.190Ω. This increase in resistance, results in a 0.001° F increase in the Total Calibration Error (CAL2). This Total Calibration Error is used to calculate the Total Random Error **σ2.** This minor revision 001B shows that Total Calibration Error increase does not change the Total Random Error **σ2**. Therefore based on the Total Random Error **σ2** not changing, the total uncertainty remains the same.

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Revision 4

ATTACHMENT 2
Design Analysis Minor Revision Cover Sheet

Design Analysis (Minor Revision) | **Last Page No.** [6] 12

Analysis No.: [1] L-003230 **Revision:** [2] 001A
Title: [3] CW Inlet Temperature Uncertainty Analysis

EC/ECR No.: [4] 368598 **Revision:** [5] 0

Station(s): [7] LaSalle
Unit No.: [8] 1/2
Safety/QA Class: [9] Non – Safety Related
System Code(s): [10] CW

Is this Design Analysis Safeguards Information? [11] **Yes** ☐ **No** ☒ If yes, see SY-AA-101-106
Does this Design Analysis contain Unverified Assumptions? [12] **Yes** ☐ **No** ☒ If yes, ATI/AR#:
This Design Analysis SUPERCEDES: [13] **N/A** **in its entirety.**

Description of Changes (list affected pages): [14]
This calculation is being revised to clarify the temperature value of interest discussed in step 4.1.2 of the calculation and correct typo's on steps 6.3.1.4 and 6.3.1.5. The affected pages include pages 4 and 12.

Disposition of Changes: [15]

This calculation was originally performed using a temperature value of interest of 101.5°F, which corresponded to a pending amendment to Technical Specification 3.7.3. (RS-07-112). The final approved amendment limited the maximum CW temperature to only 101.25°F opposed to the original value of 101.5°F.

A statement has been added to the calculation stating the temperature value of interest is bounded by 101.5°F. Engineering has reviewed the calculation and determined that using a value of 101.5°F is conservative.

The typographical errors that were identified had no affect on the results of this calculation.

Preparer: [16] Cindy Snyder (Print Name) Cindy Snyder (Sign Name) 1/4/08 (Date)

Method of Review: [17] **Detailed Review** ☒ **Alternate Calculations** ☐ **Testing** ☐
Reviewer: [18] T.J. VanWyk (Print Name) (Sign Name) 1/4/08 (Date)
Review Notes: [19] Independent review ☒ Peer review ☐

(For External Analyses Only)
External Approver: [20] N/A (Print Name) (Sign Name) (Date)
Exelon Reviewer [21] N/A (Print Name) (Sign Name) (Date)

Exelon Approver: [22] E. ZACHARIAS (Print Name) Elizabeth Zacharias (Sign Name) 01/04/08 (Date)

3.1 Evaluation of M&TE errors for the digital multimeter is based on the assumption that the test equipment listed in Section 4.5 is used.

3.2 It is assumed that the calibration standard of the equipment utilized is more accurate than the M&TE equipment by a ratio of at least 4:1 such that the calibration standard errors can be considered negligible with respect to the M&TE specification per Section2.6. This is considered a reasonable assumption since M&TE equipment is certified to its required accuracy under laboratory conditions.

4 DESIGN INPUTS

4.1 The new instrument loops will consist of the following components: high accuracy RTD temperature elements, temperature transmitters, precision input resistors at the field input to the I/O card, and the D/A conversion in the PPC I/O equipment. The loop components evaluated in this document have the following specifications:

4.1.1 New Minco RTDs in the existing thermowells (replacing the existing thermocouples). The new RTDs have the following performance specifications (Ref. 5.4.1):

Repeatability: ±0.2°F

[The RTDs are designed to EN60751 Class A specifications with high precision and repeatability requirements. Thus, this specification could be considered to be at a 3σ confidence level. However, for conservatism, this specification will be used as a 2σ value.]

Drift: ±0.1°F/year (Ref. 5.4.3)

[The study in Reference 5.5.3 shows that RTDs are inherently stable, and after the first few months following installation RTDs attain a stable condition from which it may not drift sufficiently to exceed accuracy limits. RTD cross-calibration is performed to identify if an element has experienced significant drift. Although the RTDs are not separately calibrated, for conservatism the vendor's drift value will be expanded using the loop calibration interval of 4 years (+ 1 year late factor).]

4.1.2 The resistance value equivalent to a bounding temperature value of interest (101.5°F) for the RTDs was obtained from the Minco calibration reports for the RTDs installed at LaSalle (Ref. 5.4.10). The highest of the four resistance values was 115.013Ω. This value will be used to determine the M&TE error for the indicating loop (applied to Module 2). The change in resistance per 1°F change in temperature (0.214Ω/°F) was also obtained using the actual resistance values in the calibration reports for 101.5°F and 102.5°F. (A temperature value of 101.5°F conservatively bounds Technical Specification surveillance value of 101.25°F.)

4.1.3 New ifm® efector600 TR2432 temperature transmitter modules. These new modules have the following performance specification (Ref.5.4.4, 5.4.5):

Accuracy (includes drift):	±0.54°F / 2 years
"Temperature Drift":	±0.1% of measured range/ 10°C

[Note: Ref. 5.4.5 indicates that the accuracy specification includes drift error and is warranted to hold the accuracy and drift within the specified value for 2 years. It further states that testing is performed on 100% of the devices after production to verify conformance with these specifications. Therefore, these values are 3σ confidence level. It also states that the accuracy specification includes the resolution error and electronic component drift, and that there are no other environmental influences that will affect the accuracy specification.]

6.3 PPC I/O MODULE ERRORS (MODULE 3)

6.3.1 Random Error **σ3**

6.3.1.1 Reference Accuracy **RA3**

Reference Accuracy is ± 0.025% calibrated range (Ref. 5.4.9). The calibrated range is 30°F to 120°F (120°F – 30°F = 90°F).

$RA3_{2\sigma}$ = ±0.00025 x 90°F = 0.0225°F

RA3 = ±0.0113°F

6.3.1.2 Calibration Error **CAL3**

The I/O module is not separately calibrated; indication is verified during loop calibration.

CAL3 = ±0°F

6.3.1.3 Drift Error **D3**

The vendor does not specify a drift error specification for the I/O module.

D3 = ± 0°F

6.3.1.4 Random Input Error **σ3in**

σ3in = σ2 = **± 0.436°F**

6.3.1.5 Total Random Error **σ3**

$$\sigma3 = \pm[(RA3)^2 + (CAL3)^2 + (\sigma D3)^2 + (\sigma 3in)^2]^{1/2}$$

$$\sigma3 = \pm[(0.0113°F)^2 + (0.0°F)^2 + (0°F)^2 + (0.436°F)^2]^{1/2}$$

σ3 = ± 0.436°F

6.3.2 Non-Random Error **Σe3**

6.3.2.1 Humidity Error **e3H**

No humidity effect errors are provided by the manufacturer'; specified RH for PPC equipment is 20 to 80% RH. The I/O module is located in EQ Zone C1A, (Section 4.6), where expected RH levels are 20 to 50%. Humidity errors are negligible. (Reference 5.1.2, Appendix I)

e3H = 0

6.3.2.2 Radiation Error **e3R**

No radiation errors are provided in the manufacturer's specifications. Per Section 2.8, it is reasonable to consider the normal radiation effect as negligible. Therefore,

e3R = 0

6.3.2.3 Seismic Error **e2S**

No seismic effect errors are provided in the manufacturer's specifications. A seismic event defines a particular accident condition. Therefore, there is no seismic error for normal operating conditions

e3S = 0

ATTACHMENT 1
Design Analysis Major Revision Cover Sheet

Design Analysis (Major Revision) **Last Page No.:** [6] 14, Att. J Page J1

Analysis No.: [1] L-003230 **Revision:** [2] 001

Title: [3] CW Inlet Temperature Uncertainty Analysis

EC/ECR No.: [4] 366827 **Revision:** [5] 0

Station(s): [7] LaSalle

Unit No.: [8] 1, 2

Discipline: [9] 8/1/07 ~~I&C~~ DEE, INDC

Descrip. Code/Keyword: [10] 104

Safety/QA Class: [11] NS

System Code: [12] CW

Structure: [13] N/A

Component(s): [14]

1TE-CW010 (TE)	2TE-CW010 (TE)
1TE-CW011 (TE)	2TE-CW011 (TE)
1TT-CW010 (TT)	2TT-CW010 (TT)
1TT-CW011 (TT)	2TT-CW011 (TT)
U1 Computer Point F285	U2 Computer Point F285
U1 Computer Point F286	U2 Computer Point F286

CONTROLLED DOCUMENT REFERENCES [15]

Document No.:	From/To	Document No.:	From/To

Is this Design Analysis Safeguards Information? [16] Yes ☐ No ☒ If yes, see SY-AA-101-106

Does this Design Analysis contain Unverified Assumptions? [17] Yes ☐ No ☒ If yes, ATI/AR#:

This Design Analysis SUPERCEDES: [18] **in its entirety.**

Description of Revision (list affected pages for partials): [19] Revised Total Uncertainty section to evaluate total uncertainty using 2σ Single Sided random error term. Added reference to ISA-RP67.04.02-2000. Corrected typo in Section 6.2.1.3.

Preparer: [20] T. J. Van Wyk (Print Name) Thomas J. Van Wyk (Sign Name) 8/1/07 (Date)

Method of Review: [21] **Detailed Review** ☒ **Alternate Calculations (attached)** ☐ **Testing** ☐

Reviewer: [22] Vikram R. Shah (Print Name) (Sign Name) 8/1/07 (Date)

Review Notes: [23] Independent review ☒ Peer review ☐

(For External Analyses Only)

External Approver: [24] (Print Name) (Sign Name) (Date)

Exelon Reviewer: [25] (Print Name) (Sign Name) (Date)

Independent 3rd Party Review Reqd? [26] Yes ☐ No ☒

Exelon Approver: [27] John Rommel (Print Name) (Sign Name) 8/1/07 (Date)

CC-AA-309-1001
Revision 1

ATTACHMENT 1
Design Analysis Cover Sheet

Page 1.1 | Rev 1

Last Page No. 14

Analysis No. L-003230 **Revision** 000
EC/ECR No. 361689 **Revision** 000
Title: CW Inlet Temperature Uncertainty Analysis

Station(s) LaSalle
Unit No.: 1, 2
Discipline ~~I&C~~ INDC, DEE 9/2/06
Description Code/ Keyword I04
Safety Class NSR
System Code CW
Structure N/A

Component(s)	
1TE-CW010 (TE)	2TE-CW010 (TE)
1TE-CW011 (TE)	2TE-CW011 (TE)
1TT-CW010 (TT)	2TT-CW010 (TT)
1TT-CW011 (TT)	2TT-CW011 (TT)
U1 Computer Point F285	U2 Computer Point F285
U1 Computer Point F286	U2 Computer Point F286

9/2/06

CONTROLLED DOCUMENT REFERENCES

Document No.	**From/To**	**Document No.**	**From/To**

Is this Design Analysis Safeguards? Yes ☐ No ☒
Does this Design Analysis Contain Unverified Assumptions? Yes ☐ No ☒ ATI/AR#
Is a Supplemental Review Required? Yes ☐ No ☒ If yes, complete Attachment 3

Preparer T. J. Van Wyk (Print Name) — (Sign Name) — 8/2/06 (Date)

Reviewer V. R. Shah (Print Name) — (Sign Name) — 8/2/06 (Date)

Method of Review ☒ Detailed Review ☐ Alternate Calculations ☐ Testing

Review Notes:

Approver L. L. Lehman (Print Name) — (Sign Name) — 8-2-06 (Date)

(For External Analyses Only)
Exelon Reviewer N/A (Print Name) — (Sign Name) — (Date)

Approver N/A (Print Name) — (Sign Name) — (Date)

Description of Revision (list affected pages for partials):

THIS DESIGN ANALYSIS SUPERCEDES:

CALCULATION TABLE OF CONTENTS

CALCULATION NO. L-003230 Revision 001 PAGE NO. 2

1 PURPOSE / OBJECTIVE

1.1 The purpose of this calculation is to evaluate the loop uncertainty for the CW Inlet Temperature Indication Loops. These are revised instrument loops that were implemented by EC359060 for Unit 1 and EC359114 for Unit 2.

1.2 These instrument loops provide Ultimate Heat Sink (UHS) temperature indication via the Plant Process Computer (PPC). These new loop configurations replaced the existing thermocouples 1(2)CW010/011 (the sensing elements for computer points F285/F286) with new RTD temperature sensing elements and new temperature compensators (transmitters), and relocated the computer inputs to the appropriate Input/Output (I/O) analog input cards.

2 METHODOLOGY AND ACCEPTANCE CRITERIA

2.1 The methodology used for this calculation is based on NES-EIC-20.04 "Analysis of Instrument Channel Setpoint Error and Instrument Loop Accuracy", Rev. 4 (Reference 5.1.2). Additionally, for calculating the average uncertainty using up to four indicating loops, the multiple test criterion of ASME PTC 19.1 (Ref. 5.1.4), Section 3.2 was used.

2.2 The instrumentation evaluated in this calculation provides indication (via the Plant Process Computer) for Ultimate Heat Sink Temperature. This is a non-safety indication loop, but the indication is used to verify the Technical Specification SR 3.7.3.1 is met. In accordance with Reference 5.1.2, Appendix D, a Level 3 evaluation is appropriate for this analysis.

2.2.1 However, in response to questions during the NRC review of the License Amendment Request to increase the UHS temperature surveillance requirement value, this analysis will evaluate all uncertainty terms and determine the total uncertainty value using methodology consistent with safety-related indicating loops (Reference 5.1.2, Appendix D, Level 2).

2.2.2 For additional conservatism, this calculation will determine the total uncertainty using methodology consistent with safety-related actuation loops (Reference 5.1.2, Appendix D, Level 1), but applying the random error as a 2σ single sided uncertainty value. (Reference 5.1.5, Section 8, p.53)

2.3 Temperature, humidity and pressure errors, when available from the manufacturer, are to be evaluated with respect to the conditions specified in the station EQ Zones. If not provided, an evaluation must be made to ensure that the environmental conditions are bounded by the manufacturer's specified operational limits. If the environmental conditions are bounded, these error effects are considered to be included in the manufacturer's reference accuracy.

2.4 Published instrument vendor specifications are considered to be based on sufficiently large samples so that the probability and confidence level meets the 2σ criteria, unless stated otherwise by the vendor (Reference 5.1.2, Appendix A, Section 8.0).

2.5 For normal error analysis, normal vibrations and seismic effects are considered negligible or capable of being calibrated out in accordance with Appendix I of Reference 5.1.2.

2.6 The calibration standard error is considered negligible; the calibration standard error (STD) is more accurate than the M&TE by a ratio of at least 4:1 (Reference 5.1.2, Appendix A, Section 5.1.4).

2.7 The insulation resistance error is considered negligible unless the instrumentation is expected to operate in an abnormal or harsh environment (Reference 5.1.2, Appendix A, Section 7.0).

2.8 Reference 5.1.2, Appendix I states that the effects of normal radiation are small and accounted for in the periodic calibration process. Outside of containment during normal operation, the uncertainty introduced by radiation effects on components is considered to be negligible.

3 ASSUMPTIONS AND LIMITATIONS

3.1 Evaluation of M&TE errors for the digital multimeter is based on the assumption that the test equipment listed in Section 4.5 is used.

3.2 It is assumed that the calibration standard of the equipment utilized is more accurate than the M&TE equipment by a ratio of at least 4:1 such that the calibration standard errors can be considered negligible with respect to the M&TE specification per Section2.6. This is considered a reasonable assumption since M&TE equipment is certified to its required accuracy under laboratory conditions.

4 DESIGN INPUTS

4.1 The new instrument loops will consist of the following components: high accuracy RTD temperature elements, temperature transmitters, precision input resistors at the field input to the I/O card, and the D/A conversion in the PPC I/O equipment. The loop components evaluated in this document have the following specifications:

4.1.1 New Minco RTDs in the existing thermowells (replacing the existing thermocouples). The new RTDs have the following performance specifications (Ref. 5.4.1):

Repeatability: ±0.2°F

[The RTDs are designed to EN60751 Class A specifications with high precision and repeatability requirements. Thus, this specification could be considered to be at a 3σ confidence level. However, for conservatism, this specification will be used as a 2σ value.]

Drift: ±0.1°F/year (Ref. 5.4.3)

[The study in Reference 5.5.3 shows that RTDs are inherently stable, and after the first few months following installation RTDs attain a stable condition from which it may not drift sufficiently to exceed accuracy limits. RTD cross-calibration is performed to identify if an element has experienced significant drift. Although the RTDs are not separately calibrated, for conservatism the vendor's drift value will be expanded using the loop calibration interval of 4 years (+ 1 year late factor).]

4.1.2 The resistance value equivalent to the temperature value of interest (101.5°F) for the RTDs was obtained from the Minco calibration reports for the RTDs installed at LaSalle (Ref. 5.4.10). The highest of the four resistance values was 115.013Ω. This value will be used to determine the M&TE error for the indicating loop (applied to Module 2). The change in resistance per 1°F change in temperature (0.214Ω/°F) was also obtained using the actual resistance values in the calibration reports for 101.5°F and 102.5°F.

4.1.3 New ifm® efector600 TR2432 temperature transmitter modules. These new modules have the following performance specification (Ref.5.4.4, 5.4.5):

Accuracy (includes drift):	±0.54°F / 2 years
"Temperature Drift":	±0.1% of measured range/ 10°C

[Note: Ref. 5.4.5 indicates that the accuracy specification includes drift error and is warranted to hold the accuracy and drift within the specified value for 2 years. It further states that testing is performed on 100% of the devices after production to verify conformance with these specifications. Therefore, these values are 3σ confidence level. It also states that the accuracy specification includes the resolution error and electronic component drift, and that there are no other environmental influences that will affect the accuracy specification.]

4.1.4 PPC I/O input card. The I/O input cards have the following performance specification (Ref.5.4.9): [2σ]

Accuracy: ±0.025% of full scale (30°F to 120°F)

4.2 RTD extension wire has the identical conductor types as the RTD, and therefore there is no emf drop or change in conductor size at the point of connection on the RTD (Ref. 5.4.2).

4.3 The Instrument Loop power supply is a SOLA® SDN 2.5-24-100P (Ref. 5.4.8), which has the following performance specifications: [2σ]

Output tolerance:	± 2% overall (combined Line, load, time, and temperature related changes)
Temperature range:	-10°C to 60°C
Humidity:	< 90% RH, non-condensing

4.4 The precision signal resistor at the input terminals of the I/O card (Module 3) is a high-precision resistor with a tolerance of ± 0.02% (Reference 5.3.2) [2σ]

4.5 The loop is calibrated using a variable resistance input (to simulate the RTD input), measured with either a Fluke 45 DMM or an HP 34401A, and reading the indicated temperature at the PPC. The calibration procedures (Ref. 5.2.1 and 5.2.2) each specify that one loop will be calibrated using either the Fluke 45 OR the HP 34401A. The other loop must be calibrated using the other DMM.

4.5.1 Reference Accuracy for the Fluke 45 (medium speed) on the 300Ω range is:

(± 0.05% reading + 2 LSD + 0.02Ω) (Ref. 5.4.6) [2σ]

4.5.2 Reference Accuracy for the HP 34401A on the 1kΩ range is:

± (0.01% reading + 0.001% range) (Ref. 5.4.7) [2σ]

Temperature coefficient for the HP 34401A on the 1kΩ range is (for 0°C to 18°C and 28°C to 55°C):

± (0.0006% of reading + 0.0001% of range /°C) (Ref. 5.4.7) [2σ]

4.6 LOCAL SERVICE ENVIRONMENTS (Ref. 5.5.2)

Table 4.6

	RTDs	Ifm efector600 TR2432	Plant Process Computer
EQ Zone	H7		C1A
Location	Turbine Bldg		Control Room (Computer Room)
Temperature	83°F to 102°F		50 to 104°F (Normal: 65 to 85°F)
Pressure	0 "wc		0.125 to +3.0 "wc
Humidity	39 to 47% RH		2.6 to 90% RH [see note below]

[Note: Per reference 5.5.2. the normal expected humidity in this zone is 20 to 50% RH]

4.7 Calibration Tolerance

The calibration tolerance for these indication loops is ± 0.54°F. Per Ref. 5.1.2, this is a 3σ value.

5 REFERENCES

5.1 METHODOLOGY

5.1.1 ANSI/ISA-S67.04-Part 1-1994, "Setpoints for Nuclear Safety Related Instrumentation"

5.1.2 NES-EIC-20.04, "Analysis of Instrument Channel Setpoint Error and Instrument Loop Accuracy," Revision 4

5.1.3 ANSI/ISA TR67.04.09, "Graded Approaches to Setpoint Determination," dated 10/15/05

5.1.4 ASME PTC 19.1, Part 1, "Measurement Uncertainty," 1985

5.1.5 ISA-RP67.04.02-2000, "Methodologies for the Determination of Setpoints for Nuclear Safety-Related Instrumentation."

5.2 PROCEDURES

5.2.1 LIP-CW-501 [New loop-specific calibration procedure in development; tracked by EC359060]

5.2.2 LIP-CW-601 [New loop-specific calibration procedure in development; tracked by EC359114]

5.3 LASALLE STATION DRAWINGS

5.3.1 1E-2-4022ZC "Schematic Diagram, Circulating Water System CW Pt. 3," as revised by EC359114.
1E-1-4022ZC "Schematic Diagram, Circulating Water System CW Pt. 3," Revision D.

5.3.2 1 E-2-4707AA, "Wiring Diag Analog Input Cab 2C91-P607 AITs 1,2,3,4 Left Side," as revised by EC359114,
1 E-1-4707AA, "Wiring Diag Analog Input Cab 1C91-P607 AITs 1,2,3,4 Left Side," Revision R.

5.4 VENDOR PRODUCT INFORMATION

5.4.1 Minco® Quotation 160056-2, January 26, 2006

5.4.2 Minco® Drawing S100995, dated 4/27/99

5.4.3 E-mail from Keith Johnson or Minco® to Vikram Shah of LaSalle dated 7/25/06

5.4.4 ifm efector600® TR2432 Operating Instructions, 701724/01, dated 02/04

5.4.5 Letter from Ameera Shah of ifm efector to Vikram Shah of LaSalle dated 7/26/06

5.4.6 Fluke® 45 Dual Display Multimeter Users Manual, Revision 4, dated 07/97

5.4.7 HP 34401A Multimeter User's Guide, Edition 4, printed February 1996

5.4.8 SOLA® SDN Power Supplies Specifications for SDN 2.5-24-100P

5.4.9 RTP® 8436 Series Analog Input Cards Technical Manual, 981-0021-211A, Rev. A, dated 04-96

5.4.10 Minco Report of Calibration for Platinum RTD, Model S100995PD, Serial No. P/N366

5.5 OTHER REFERENCES

5.5.1 LaSalle Technical Specifications, Sections 3.7.3, B 3.7.3, Amendments 178/164

5.5.2 LaSalle UFSAR, Rev. 16, Tables 3.11-18 and 3.11-24

5.5.3 EPRI TR-103099, "Effects of Resistance Temperature Detector Aging on Cross-Calibration Techniques," Final Report dated June 1994

6 CALCULATIONS

6.1 RTD ERRORS (MODULE 1)

6.1.1 Random Errors **$\sigma 1$**

6.1.1.1 RTD Reference Accuracy **RA1**

The RTD Reference Accuracy is ±0.2°F (Section 4.1.1). This is a 2σ value.

$RA1_{2\sigma} = \pm 0.2°F / 2$

$\mathbf{RA1} = \pm \mathbf{0.1°F}$

6.1.1.2 RTD Calibration Error **CAL1**

The RTDs are not separately calibrated. Therefore, there is no calibration tolerance for this module. (The loop calibration tolerance is applied to Module 2, which is the module that is adjusted during loop calibration.)

$\mathbf{CAL1} = \mathbf{0}$

6.1.1.3 RTD Setting Tolerance ST1

The RTDs are not separately calibrated. Therefore, there is no setting tolerance for this module. (The loop calibration tolerance is applied to Module 2, which is the module that is adjusted during loop calibration.)

$\mathbf{ST1} = \mathbf{0}$

6.1.1.4 Random Input Errors $\sigma 1in$

The RTDs are the first modules in the loop. Therefore,

$\mathbf{\sigma 1in} = \mathbf{0}$

6.1.1.5 Drift Error D1

The RTD Drift value (IDE) specified by the vendor is ± 0.1°F/year. [2σ] The RTDs are not separately calibrated: RTD cross-calibration is performed to identify if an RTD has experienced significant drift. For conservatism the vendor's drift value will be expanded using the loop calibration interval (Section 4.1.1). The interval for these indicating loops is 4 years. The 25% late factor is 1year. (VDP is the vendor drift period, or 1 year in this case.)

$$\begin{aligned} D1_{2\sigma} &= [IDE] \times [(SI + LF)/VDP)]^{1/2} \\ &= [0.1°F] \times [(4 \text{ years} + 1\text{year})/1\text{year}]^{1/2} \\ &= 0.1°F \times 2.236 \\ &= 0.224°F \end{aligned}$$

$\mathbf{D1} = \mathbf{0.112°F}$

6.1.1.6 RTD Random Error **$\sigma 1$**

$$\begin{aligned} \sigma 1 &= \pm [(RA1n)^2 + (CAL1)^2 + (ST1)^2 + (\sigma 1in)^2 + (D1)^2]^{1/2} \\ &= \pm [(0.1°F)^2 + (0)^2 + (0)^2 + (0)^2 + (0.112)^2]^{1/2} \\ &= \pm 0.150\ °F \end{aligned}$$

$\mathbf{\sigma 1} = \pm \mathbf{0.150\ °F}$

6.1.2 Non-Random Errors Σ**e1**

RTDs are passive devices that produce a resistance signal proportional to temperature. As such, they are not affected by the following non-random effects.

Humidity Effects:	eH1 = 0
Static Pressure Effects:	eSP1 = 0
Ambient Pressure Effects:	eP1 = 0
Power Supply Effects:	eV1 = 0
Seismic Effects:	eS1 = 0
Radiation Effects:	eR1 = 0
Process Effects:	ePr1 = 0

6.1.2.1 Insulation Resistance Errors **eIR1**

Insulation Resistance error is to be evaluated where actuation functions are expected to operate in an abnormal or harsh environment (Section 2.7). There are no terminal blocks in 100% relative humidity areas, therefore,

eIR1 = 0

6.1.2.2 Resistance Drop of the Extension Wire **eRD1**

Since the RTD extension wires are made of the same material as the RTD itself, there is no emf rise or drop across the RTD head terminals (Section 4.2)

eRD1 = 0

6.1.2.3 Temperature Errors **eT1**

RTDs are designed to exhibit a precise temperature effect that is used to develop the input signal to the loop. Since the RTDs are designed to function at temperatures well above the system design temperature, there is no temperature error other than the reference accuracy error. Therefore,

eT1 = 0

6.1.2.4 Non-Random Input Errors **e1in**

The RTD is the first module in the loop. Therefore,

e1in = 0

6.1.2.5 Non-Random Error Σ**e1**

Σe1 = eH1 + eSP1 + eP1 + eV1 + eS1 + eR1 + eT1 + eIR1 + ePr1 + eIR1 + eRD1 + e1in
= 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 = 0°F

Σe1 = 0°F

6.2 TEMPERATURE TRANSMITTER ERRORS (MODULE 2)

6.2.1 Random Error σ**2**

6.2.1.1 Reference Accuracy **RA2**

Reference Accuracy is ± 0.54°F (Section 4.1.3). This is a 3σ value.

RA2 = ± 0.54°F / 3 = ± 0.18°F

Per Reference 5.4.5, this accuracy includes drift and is warranted for 2 years. The calibration interval is 4 years. The 25% late factor is 1year. (VDP is the vendor drift period, or 2 years in this case.) The formula for applying the surveillance interval to Drift will be applied to the entire RA2 error term.

RA2 = $\pm [\text{IDE}] \times [(\text{SI} + \text{LF})/\text{VDP})]^{1/2}$
= $\pm [0.18°\text{F}] \times [(4\text{years} + 1\text{ year})/2\text{ years})]^{1/2}$
= $\pm [0.18°\text{F}] \times [1.581139]$

RA2 = ± 0.285°F

6.2.1.2 Calibration Error **CAL2**

The loop is calibrated using a variable resistance input, measured with a Fluke 189 DMM, and reading the indicated temperature at the PPC.

6.2.1.2.1 Measurement & Test Equipment Error **MTE2**

HP 34401A
Reference Accuracy is the manufacturer's accuracy (± 0.01% reading + 0.001% of range for the 1kΩ) as a 2σ value (Section 5.4.6). The highest reading of interest is 101.5°F. The Minco calibration reports for the RTDs show that the highest resistance value for this temperature is 115.013Ω. (Section 4.1.2)

$\text{RAMTE}_{2\sigma}$ = $\pm 0.01\% \times 115.013\Omega + (0.00001 \times 1000\Omega)$
= $\pm 0.0115\Omega + 0.01\Omega = 0.0215\Omega$
= $\pm 0.0215\Omega \times 1°\text{F}/0.214\Omega = 0.100°\text{F}$

RAMTE2 = ± 0.050°F

The manufacturer also specifies a Temperature coefficient for this range (1kΩ) for 0°C to 18°C and 28°C to 55°C as 0.0006% of reading + 0.0001% of range per °C. The normal turbine building ambient temperature in the zone where the transmitter is installed varies from 83°F to 102°F(Ref. 5.5.2). For additional conservatism, this range is expanded to 75°F to 102°F (or 23.9°C to 38.9°C). The lower temperature (23.9°C) is within the range where the coefficient is not applicable, so the applicable ΔT is: (38.9°C - 28°C) or 10.9°C

$\text{TEMTE2}_{2\sigma}$ = $\pm(0.0006\% \times 115.013\Omega) + (0.000001 \times 1000\Omega)$
= $\pm 0.00069\Omega + 0.001\Omega = \pm 0.00169\Omega$
= $\pm 0.00169\Omega \times 1°\text{F}/0.214\Omega = 0.00789°\text{F}$

RAMTE2 = ± 0.00395°F

The temperature error is a degradation of the specified accuracy and is not considered an additional random error. Therefore, the total M&TE error for the HP 34401A is:

MTE2 = $\pm [(0.050°\text{F})^2 + (0.00395°\text{F})^2]^{1/2}$

MTE2 = ± 0.0502°F

Fluke 45 (medium speed)
Reference Accuracy is the manufacturer's accuracy [± (0.05% reading + 2 LSD + 0.02Ω)] as a 2σ value (Section 5.4.6). [The LSD for the Fluke 45 is 0.01Ω.] The highest reading of interest is 101.5°F. The Minco calibration reports for the RTDs show that the highest resistance value for this temperature is 115.013Ω. (Section 4.1.2)

$\text{RA}_{2\sigma}$ = $\pm(0.05\% \times 115.013\Omega) + [(2 \times 0.01\Omega) + 0.02\Omega]$

$= \pm 0.0575\Omega + 0.04\Omega = 0.0975\Omega$
$= \pm 0.0975\Omega \times 1°F/0.214\Omega = 0.456°F$

MTE2 $= \pm 0.228°F$

The Fluke 45 (med. speed) M&TE error is bounding and will be used to evaluate total loop uncertainty.

6.2.1.2.2 Calibration Standard Error **STD2**

The calibration standard error is evaluated as negligible (Section 3.2).

STD2 = 0

6.2.1.2.3 Loop Calibration Tolerance **ST2**

The calibration tolerance for this indicating loop is ± 0.54°F (Section 4.7). [3σ]

ST2 = $\pm 0.54°F / 3$

ST2 = $\pm 0.18°F$

6.2.1.2.4 Calibration Error **CAL2**

The total calibration error for the M&TE is:

CAL2 $= \pm [(MTE2)^2 + (STD2)^2 + (ST2)^2]^{1/2}$
$= \pm [(0.228°F)^2 + (0)^2 + (0.18)^2]^{1/2}$

CAL2 = $\pm 0.29°F$

6.2.1.3 Ambient Temperature Error **σT2**

The vendor states the "temperature drift" error for the temperature transmitter as 0.1% of measuring range / 10°C (Ref. 4.1.3) [3σ]. This is applied in this calculation as an ambient temperature error. Measuring range: 30 to 120°F = 90°F.

The normal turbine building ambient temperature in the zone where the transmitter is installed varies from 83°F to 102°F(Ref. 5.5.2). For additional conservatism, this range is expanded to 75°F to 102°F (27°F difference).

$\sigma T2_{3\sigma} = \pm (0.1\% * \text{Span})$
$= \pm [(0.001 * 90°F)/10°C \times (27°F \times 5°F/9°C)$
$= \pm 0.135\ °F / 3$

σT2 = $\pm 0.045°F$

6.2.1.4 Random Input Error **σ2in**

σ2in = σ1 = **± 0.150°F**

6.2.1.5 Power Supply Effects **σ2PS**

The transmitter specifications are valid for voltages between 20 and 30 vDC. The 24-volt power supply variability is less than ± 2% all errors combined (4.3). This is equal to 23.5vDC to 24.5vDC. Therefore,

σ2PS = **± 0 °F**

6.2.1.6 Total Random Error **σ2**

$$\sigma2 = \pm [(RA2)^2 + (CAL2)^2 + (\sigma T2)^2 + (\sigma 2in)^2 + (\sigma 2PS)^2]^{1/2}$$

$$\sigma2 = \pm [(0.285°F)^2 + (0.290°F)^2 + (0.045°F)^2 + (0.150°F)^2 + (0°F)^2]^{1/2}$$

$$\boldsymbol{\sigma 2 = \pm 0.436°F}$$

6.2.2 Non-Random Error **Σe2**

6.2.2.1 Humidity Error **e2H**

No humidity effect errors are provided in the manufacturer's specifications, and the humidity conditions at the instrument location are within the operating limits of the module. Humidity errors are negligible during normal conditions. (Reference 5.1.2, Appendix I)

e2H = 0

6.2.2.2 Radiation Error **e2R**

No radiation errors are provided in the manufacturer's specifications. Per Section 2.8, it is reasonable to consider the normal radiation effect as negligible. Therefore,

e2R = 0

6.2.2.3 Seismic Error **e2S**

No seismic effect errors are provided in the manufacturer's specifications. A seismic event defines a particular type of accident condition. Therefore, there is no seismic error for normal operating conditions

e2S = 0

6.2.2.4 Static Pressure Offset Error **e2SP**

The transmitter is an electrical device and therefore not affected by static pressure.

e2SP = 0

6.2.2.5 Ambient Pressure Error **e2P**

The transmitter is an electrical device and therefore not affected by ambient pressure.

e2P = 0

6.2.2.6 Process Error **e2Pr**

The transmitter receives an analog input from an RTD. Any errors associated with the conversion of temperature to resistance have been accounted for as RTD errors. Therefore,

e2Pr = 0

6.2.2.7 Non-Random Input Error **e2in**

e2in = Σe1 = 0

6.2.2.8 Total Non-Random Error **Σe2**

$$\Sigma e2 = e2H + e2R + e2S + e2SP + e2P + e2Pr + e2in$$

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

$$\boldsymbol{\Sigma e2 = 0}$$

6.3 PPC I/O MODULE ERRORS (MODULE 3)

6.3.1 Random Error $\sigma 3$

6.3.1.1 Reference Accuracy **RA3**

Reference Accuracy is ± 0.025% calibrated range (Ref. 5.4.9). The calibrated range is 30°F to 120°F (120°F – 30°F = 90°F).

$$RA3_{2\sigma} = \pm 0.00025 \times 90°F = 0.0225°F$$

$$\mathbf{RA3 = \pm 0.0113°F}$$

6.3.1.2 Calibration Error **CAL3**

The I/O module is not separately calibrated; indication is verified during loop calibration.

$$\mathbf{CAL3 = \pm 0°F}$$

6.3.1.3 Drift Error **D3**

The vendor does not specify a drift error specification for the I/O module.

$$\mathbf{D3 = \pm 0°F}$$

6.3.1.4 Random Input Error σ**3in**

$$\boldsymbol{\sigma 3in} = \sigma 2 = \mathbf{\pm 0.437°F}$$

6.3.1.5 Total Random Error σ**3**

$$\sigma 3 = \pm [(RA3)^2 + (CAL3)^2 + (\sigma D3)^2 + (\sigma 3in)^2 + (\sigma 3r)^2]^{1/2}$$
$$\sigma 3 = \pm [(0.0113°F)^2 + (0.0°F)^2 + (0°F)^2 + (0.436°F)^2]^{1/2}$$

$$\boldsymbol{\sigma 3} = \mathbf{\pm 0.436°F}$$

6.3.2 Non-Random Error Σ**e3**

6.3.2.1 Humidity Error **e3H**

No humidity effect errors are provided by the manufacturer'; specified RH for PPC equipment is 20 to 80% RH. The I/O module is located in EQ Zone C1A, (Section 4.6), where expected RH levels are 20 to 50%. Humidity errors are negligible. (Reference 5.1.2, Appendix I)

e3H = 0

6.3.2.2 Radiation Error **e3R**

No radiation errors are provided in the manufacturer's specifications. Per Section 2.8, it is reasonable to consider the normal radiation effect as negligible. Therefore,

e3R = 0

6.3.2.3 Seismic Error **e2S**

No seismic effect errors are provided in the manufacturer's specifications. A seismic event defines a particular accident condition. Therefore, there is no seismic error for normal operating conditions

e3S = 0

6.3.2.4 Static Pressure Offset Error **e3SP**

The I/O module is an electrical device and therefore not affected by static pressure.

e3SP = 0

6.3.2.5 Ambient Pressure Error **e3P**

The I/O module is an electrical device and therefore not affected by ambient pressure.

e3P = 0

6.3.2.6 Process Error **e3Pr**

The I/O module receives an analog current input from the transmitter. Any errors associated with the conversions of temperature to resistance, and resistance to current have been accounted for as errors associated with modules 1 and 2. Therefore,

e3Pr = 0

6.3.2.7 Input Signal Resistor Error **e3SR**

e3SR = ± (0.02% * Span) (Section 4.4)
= ± 0.0002 * 90°F
= ± 0.018 °F

e3SR = ± 0.018°F

6.3.2.8 Non-Random Input Error **e3in**

e3in = Σe2 = 0

6.3.2.9 Total Non-Random Error **Σe3**

Σe3 = e3H + e3R + e3S + e3SP + e3P + e3Pr + e3SR + e3in
= 0 + 0 + 0 + 0 + 0 + 0 + 0.018 + 0

Σe3 = 0.018

7 SUMMARY AND CONCLUSION (TOTAL ERROR)

7.1.1 As discussed in Methodology Section 2.2.1, Level 2 methodology is applied for determining Total Error for this indication loop:

TE = σ3 + Σe3
= ± (0.436°F)+ 0.018°F
= ± 0.454°F

TE = ± 0.454°F

Using the Level 2 methodology (1σ random error), total uncertainty for one CW Inlet Temperature Indication loop is ± 0.454°F

7.1.2 As discussed in Methodology Section 2.2.2, the methodology applied for determining Total Error for this indication loop calculates the random error at a 2σ level for a single sided variable:

TE = 1.645*σ3 + Σe3 [2σ Single Sided]
= + (1.645*(0.436°F))+ 0.018°F
= + 0.717°F + 0.018°F
= + 0.735°F

TE = + 0.74°F

Therefore, using methodology similar to Level 1 (2σ Single Sided random uncertainty), the total uncertainty for one CW Inlet Temperature Indication loop is + 0.74°F

7.1.3 To obtain a more accurate value of the UHS temperature using these instruments, the average of the available values can be taken. This assumes that the four readings are sensing the same input temperature and that there is little effect between the input and the measurement point.

$$T_{CWAverage} = \frac{T_{1TE-CW010} + T_{1TE-CW011} + T_{2TE-CW010} + T_{2TE-CW011}}{4}$$

The accuracy of this process is considered the same as the accuracy of summing networks addressed in References 5.1.1 and 5.1.2, or by the multiple test criterion of Reference 5.1.4 Section 3.2.

In all of these cases the final random uncertainty (σ) is the square root sum of the squares of the individual channel random uncertainties considering the multiplier for each of the uncertainties is one divided by the number of channels that are being averaged. The non-random uncertainty (e) will remain the same as for a single loop (Ref. 5.1.4, Section 3.2).

$$\sigma_{Average} = \sqrt{\left(\frac{\sigma_1}{n}\right)^2 + \left(\frac{\sigma_2}{n}\right)^2 + \left(\frac{\sigma_3}{n}\right)^2 + \bullet \;\bullet \;\bullet \;\bullet + \left(\frac{\sigma_n}{n}\right)^2}$$

If all of the instrument loops are identical then this equation will reduce to:

$$\sigma_{Average} = \frac{\sigma_i}{\sqrt{n}} + e$$

Thus for the CW temperatures, the accuracy of the average of the readings for **two loops** will be:

$$\sigma_{Average} = \frac{0.717}{\sqrt{2}} + e = 0.308 + 0.018 = 0.53\ ^{\circ}\mathrm{F}$$

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Attachment A
Page A1 (final)
of A1

QUOTATION

To: Vikram Shah
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Marseilles IL 61341-9757
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Fax:

Fax Order to 763-571-0942 or
E-Mail Order to custserv@minco.com

Quote No: 160056-2
Page: 1
Date: January 26, 2006
RFQ: RTD Assemblies

CC: Thermo/Cense, Inc.
942 Turret Court
Mundelein, IL 60060
Phone: 847-949-8070,8071
Fax: 847-949-8074

Please Reference Above Quote Number When Placing Your Order.

Item	Description	Quantity	Unit Price U.S. $
1	Minco Part # ASSEMBLY Assembly Consisting Of: CGASSY CH359P2T6 FG113-1 FG750F8M12 XS853PD157X4 X = Class A sensor. Single Element RTD assembly	1 - 9	162.60
2	Minco Part # XRT07 Test charge for a chart of temperature readings at .1F intervals from -272F to 932F	1 - 9	425.00

Notes:

1. These assemblies will replace the existing head that is on the thermowell. This is due to not knowing how long the replacement probe would need to be. The drawing does not provide all of this information to determine the proper length. Lead time for these parts is also relatively short as compared to a special probe.
2. 1. Probe length is 15.6". This is the necessary length of the probe to fit in the thermowell and fit into the connection head.
   2. The probe diameter is .25", but will fit in the thermowell without any reduction in performance.
   3. Drift specifications on the S852 sensor is listed as +/- .2 F per year, repeatability is also +/- .2 F. This specification assumes cycling throughout the full temperature range of the sensor, from -50C to 260C. A smaller temperuture cycle will change the amount of drift.

WHEN ORDERING SPECIFY CASE LENGTH, NUMBER OF LEADS, AND LEAD LENGTH.

REVISIONS					
REV	DESCRIPTION	DATE	ECO	DR	APPD

S100995PD48Z36 ← EXAMPLE OF MODEL NUMBER

S100995	SPECIFICATIONS DRAWING NUMBER.
PD	SENSING ELEMENT: PD = 100 OHM ±.06%, .00385 PLATINUM.
48	CASE LENGTH A IN .1" INCREMENTS (48 = 4.8"). MINIMUM A = 28 (2.8") [71]; MAXIMUM A = 480 (48.0") [1219].
Z	NUMBER OF LEADS: Y = 2 LEADS; Z = 3 LEADS; X = 4 LEADS.
36	LEAD LENGTH B IN INCHES.

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Attachment B
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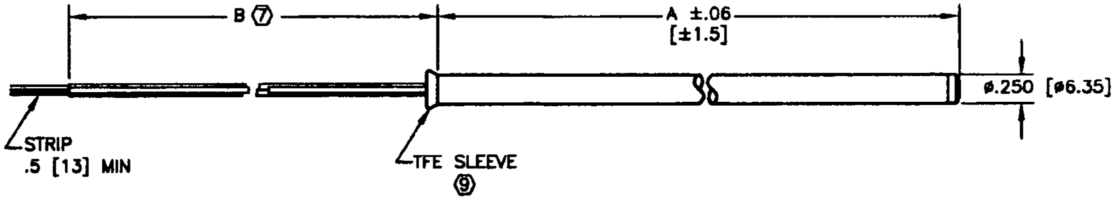
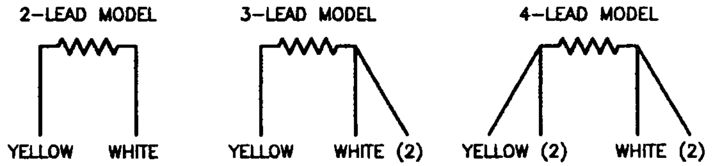
QF Page B1



SCHEMATIC DIAGRAMS



1. ELEMENT: PLATINUM.
2. RESISTANCE: 100.00 OHMS ±.06% (100.06/99.94) AT 0°C (32°F), EXCLUDING LEADWIRE RESISTANCE; R/T TABLES #5-100 (°C) AND #6-100 (°F).
3. RESISTANCE-TEMPERATURE COEFFICIENT: .00385 OHM/OHM/°C NOMINAL FROM 0°C TO 100°C.
4. TEMPERATURE RANGE: -50°C TO 260°C (-58°F TO 500°F).
5. INSULATION RESISTANCE: 1000 MEGOHMS MINIMUM AT 500 VOLTS DC, LEADS TO CASE.
6. LEADS: AWG #22, STRANDED, TFE INSULATED.

⑦ TOLERANCE ON LEAD LENGTH:
71" [1803] AND UNDER: +2/-0" [+51/-0];
72" TO 119" [1829 TO 3023]: +4/-0" [+102/-0];
120" [3048] AND OVER: +6/-0" [+152/-0].

8. CASE: STAINLESS STEEL, COPPER ALLOY TIP.

⑨ CASE MAY BE CUT TO SHORTER LENGTH. USE CARE NOT TO DAMAGE LEADWIRE INSULATION. LOCATE THE SLIP-FIT TFE SLEEVE IN END OF CUT-OFF CASE TO PROTECT LEADWIRE INSULATION AT POINT OF EMERGENCE. MINIMUM A FOR CUT-OFF CASE IS 28 (2.8") [71].

10. THE RESISTANCE THERMOMETER WILL MEET THE RESISTANCE-TEMPERATURE RELATIONSHIP AND TOLERANCES SPECIFIED IN IEC 751, CLASS A.

UNLESS OTHERWISE SPECIFIED
DIMENSIONS AND TOLERANCES IN INCHES
DIMENSIONS IN [ ] ARE IN MILLIMETERS

ONE PLACE (.0)	±.020	[±0,51]
TWO PLACE (.00)	±.010	[±0,25]
THREE PLACE (.000)	±.005	[±0,13]
ANGLES:		

MATERIAL:

FINISH:

	INITIALS	DATE
DR	WAB	04-13-99
CHK	PHP	04-27-99
APP		
ENGR	DLW	04-27-99
QA		
PRD		
NEXT ASSY		INIT. JOB 5–
USED ON		

ITEM	REQD	PART/STOCK NO	MATERIAL DESCRIPTION

TITLE:
RESISTANCE THERMOMETER
PROBE TYPE, TIP-SENSITIVE
S100995 SERIES

CGP Transferred 04/27/99 WAB

SCALE: NONE
STOCK NO
DWG SIZE B

MINCO PRODUCTS, INC.
MINNEAPOLIS, MN, USA
COMPANY CONFIDENTIAL
PROPRIETARY INFORMATION OF MINCO PRODUCTS, INC.
DO NOT DUPLICATE

CAGE IDENT. 09359
THIRD ANGLE PROJECTION

S100995
REV –
SHEET 1 OF 1

Print Date: 07/28/2006 10:12

L-003230 Rev. 001
Attachment C
Page C1 (final)
of C1

From: Keith Jensen [Keith.Jensen@minco.com]
Sent: Wednesday, July 26, 2006 9:22 AM
To: Shah, Vikram R.
Subject: Fwd: Exelon Corporation

100995.pdf

```
>>> Keith Jensen 7/25/2006 3:50 PM >>>
Vikram Shah  815-415-3828
Exelon Corporation
Marsailles IL
vikram.shah@exelon.com

XS853PD157X4     RFQ 160056-2

The S100995 probe meets the EN60751 Class A +/- 0.06% @ 0C sensor
accuracy requirements

Minco estimates the drift per year over the range of 30F to 120F would
be expected to be around  0.1F or less (PHP)

The drawing is attached

Keith Jensen  763-586-2908
Applications Engineer
MINCO PRODUCTS INC.
Minneapolis MN
keith.jensen@minco.com
```

L-003230 Rev. 001
Attachment D
Page D1 of D2

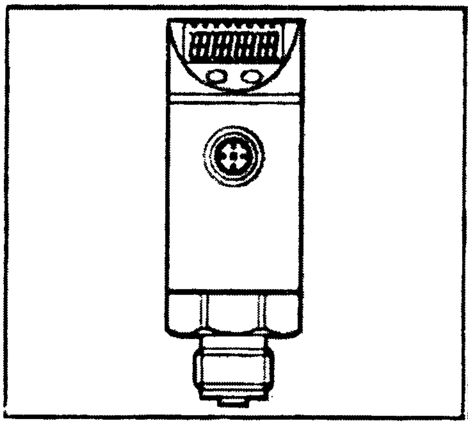
CE

ifm electronic

Bedienungsanleitung
Operating instructions
Notice utilisateurs

efector600

Auswerteelektronik für Temperatursensoren
Control monitor for temperature sensors
Amplificateur pour sondes de température
TR2432



DEUTSCH
ENGLISH
FRANÇAIS

Sachnr. 701724/01 02/04

L-003230 Rev. 00
Attachment D
Page D2 (final)

Technical data

Operating voltage [V]	20 ... 30 DC [1]
Current rating [mA]	250
	Short-circuit prot., reverse polarity prot. / overload prot., watchdog
Voltage drop [V]	< 2
Current consumption [mA]	< 55[2]
Constant current sensor [mA]	0.2 (Pt 1000 element)
Constant current sensor [mA]	2.0 (Pt 100 element)
Power-on delay time [s]	1.5
Response time switching output [ms]	130
Analogue output (measuring range scaleable)	4 ... 20 mA / 0 ... 10 V
Max. load current output [Ω]	(UB - 10) x 50; 700 at UB = 24 V
Min. load with voltage output [Ω]	2000
Response time analogue output [ms]	384
Accuracy	
Switching output [°C/°F]	± 0.3 / ± 0.54
Analog output [°C/°F]	± 0.3 / ± 0.54 ✓
Display [°C/°F]	± (0.3 / ± 0.54 + ½ Digit)
Resolution	
Switching output [°C/°F]	0.1 / 0.1
Analogue output [°C/°F]	0.1 / 0.1 ✓
Display [°C/°F]	0.1 / 0.1
Temperature drift [% of value of measuring range/10 K]	± 0.1 ✓
Housing material	stainless steel (304S15); EPDM/X (Santoprene); PC (Macrolon); Pocan; FPM (Viton)
Operating temperature [°C]	-25 ... +70
Storage temperature [°C]	-40 ... +85
Protection	IP 67, III
Insulation resistance [MΩ]	> 100 (500 V DC)
Shock resistance [g]	50 (DIN / IEC 68-2-27, 11ms)
Vibration resistance [g]	20 (DIN / IEC 68-2-6, 10 - 2000 Hz)
EMC	
EN 61000-4-2 ESD:	4 / 8 KV
EN 61000-4-3 HF radiated:	10 V/m
EN 61000-4-4 Burst:	2 KV
EN 61000-4-6 HF conducted:	10 V

---

[1] to EN50178, SELV, PELV;
referring to UL: see page 21 (Electrical connection).

[2] 41 mA when the display is switched off;
the values apply to the operating voltage = 24 V and unloaded outputs.

ifm efector inc.
782 Springdale Drive, Exton, PA 19341 • 800-441-8246 • Fax: 800-329-0436 • www.ifmefector.com

July 26, 2006

Mr. Vikram Shah
Exelon Corporation
2601 N 21st Rd.
Marseilles, Illinois 61341

Dear Vikram:

This letter is in response to your concern about the specifications of the **ifm efector** TR2432 temperature sensor. The following points should clarify the questions that you had:

- After production, 100% of the sensors are verified and tested to the specifications listed on our datasheet.
- The analog accuracy specification of (+/- 0.54°F) already includes the analog resolution value of (0.1°F), and is inclusive of any electronic component drift.
- The temperature drift specification is the electronic drift that occurs for every 10°C change in temperature that occurs in the application. This drift is in addition to the accuracy specification.
- There are no other environmental influences that will affect the accuracy specification.
- These sensors have a warranty period of 2 years.

Please contact me if you have any further questions, or if you require any additional information.

Best regards,

Ameera Shah

Ameera Shah
Product Support Engineer
Fluid Sensors Team

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Attachment F
Page F1 (final)

Attachment F: Fluke 45 Accuracy Specifications

OHMS

Range	Resolution			Accuracy	Typical Full Full Scale Voltage	Max Current Through the Unknown
	Slow	Medium	Fast			
300Ω	—	10 mΩ	100 MΩ	0.05% + 2 + 0.02Ω	0.25	1 mA
3 kΩ	—	100 MΩ	1Ω	0.05% + 2	0.24	120 μA
30 kΩ	—	1Ω	10Ω	0.05% + 2	0.29	14 μA
300 kΩ	—	10Ω	100Ω	0.05% + 2	0.29	1.5 μA
3 MΩ	—	100Ω	1 kΩ	0.06% + 2	0.3	150 μA
30 MΩ	—	1 kΩ	10 kΩ	0.25% + 3	2.25	320 μA
300 MΩ*	—	100 kΩ	1 MΩ	2%	2.9	320 μA
100Ω	1 mΩ	—	—	0.05% + 8 + 0.02Ω	0.09	1 mA
1000Ω	10 mΩ	—	—	0.05% + 8 + 0.02Ω	0.10	120 μA
10 kΩ	100 mΩ	—	—	0.05% + 8	0.11	14 μA
100 kΩ	1Ω	—	—	0.05% + 8	0.11	1.5 μA
1000 kΩ	10Ω	—	—	0.06% + 8	0.12	150 μA
10 MΩ	100Ω	—	—	0.25% + 6	1.5	150 μA
100 MΩ*	100 kΩ	—	—	2 % + 2	2.75	320 μA

*Because of the method used to measure resistance, the 100 MΩ (slow) and 300 MΩ (medium and fast) ranges cannot measure below 3.2 MΩ and 20 MΩ, respectively. "UL" (underload) is shown on the display for resistances below these nominal points, and the computer interface outputs "+1E-9".

Open Circuit Voltage

3.2 volts maximum on the 100Ω, 300Ω, 30 MΩ, 100 MΩ, and 300 MΩ ranges, 1.5 volts maximum on all other ranges.

Input Protection

500V dc or rms ac on all ranges

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Attachment G
Page G1 (final)

SDN™ Specifications (Single Phase)

Description	Catalog Number				
	SDN 2.5-24-100P	SDN 4-24-100LP	SDN 5-24-100P	SDN 10-24-100P	SDN 20-24-100P
Input					
Nominal Voltage	115/230 VAC auto select				
-AC Range	85-132/176-264 VAC				
-DC Range[6]	90-375 VDC	210-375 VDC			N/A
-Frequency	47 - 63 Hz				
Nominal Current[1]	1.3 A / 0.7 A	2.1 A / 1.0 A	2.2 A / 1.0 A	5 A / 2 A typ.	9 A/ 3.9 A
-Inrush current max.	typ. < 25 A	typ. < 20 A		typ. < 40 A	
Efficiency (Losses[2]**)**	> 87.5% typ (8.8 W)	> 88% typ (13.1 W)	> 88% typ (16.4 W)	> 88% typ (32.7 W)	> 90% typ (48 W)
Power Factor Correction	Units Fulfill EN61000-3-2				
Output					
Nominal Voltage	24 VDC (22.5 - 28.5 VDC adj.)	24 VDC (22.5 - 25.5 VDC adj.)	24 VDC (22.5 - 28.5 VDC adj.)		
-Tolerance	< ±2% overall (combination Line, load, time and temperature related changes)				
-Ripple[3]	< 50 mVpp				
Nominal Current	2.5 A (60 W)	3.8 A (92 W)	5 A (120 W)	10 A (240 W)	20 A (480 W)
-Peak Current[4]	1.6x Nominal Current < 2 sec.	4.2 A max at 23.8V	6 A 2x Nominal Current < 2 sec.	12 A 2x Nominal Current < 2 sec.	25 A 2x Nominal Current < 2 sec.
-Current Limit	Fold Forward (Current rises, voltage drops to maintain constant power during overload up to max peak current)				
Holdup Time[5]	> 50 ms	> 100 ms	> 100 ms		> 20 ms
Parallel Operation	Single or Parallel use is selectable via Front Panel Switch (SDN4 should not be used in parallel as Class 2 rating would be violated.)				
General					
EMC: **-Emissions**	EN61000-6-3, -4; Class B EN55011, EN55022 Radiated and Conducted including Annex A.				
-Immunity	EN61000-6-1, -2; EN61000-4-2 Level 4, EN61000-4-3 Level 3; EN61000-4-6 Level 3; EN61000-4-4 Level 4 input and Level 3 output, EN61000-4-5 Isolation Class 4, EN61000-4-11; Transient resistance according to VDE 0160/W2 over entire load range.				
Approvals	EN60950; EN50178; EN60204, UL508 Listed, cULus; UL60950, cRUus, CE (LVD 73/23 & 93/68/EEC) EN61000-3-2, IEC60079-15 (Class 1, Zone 2, Hazardous Location, Groups A, B, C, D w/ T3A temp class up to 60°C Ambient.) SEMI F47 Sag Immunity. SDN2.5 & SDN4 - UL60950 testing to include approval as Class 2 power supply.				
Temperature	Storage: -25°C...+85°C Operation. -10°-60°C full power with operation to 70°C possible with a linear derating to half power from 60°C to 70°C (Convection cooling, no forced air required). Operation up to 50% load permissable with sideways or front side up mounting orientation. The relative humidity is < 90% RH, noncondensing; IEC 68-2-2, 68-2-3. For operation below -10°C, contact Technical Services.				
MTBF:	> 820,000 hours	> 640,000 hours		> 600,000 hours	> 510,000 hours
- Standard	Bellcore Issue 6 Method 1 Case 3 @ 40C				MIL217F @ 30C
Warranty	5 years				
General Protection/Safety	Protected against continuous short-circuit, overload, open-circuit. Protection class 1 (IEC536), degree of protection IP20 (IEC 529) Safe low voltage: SELV (acc.EN60950)				
Status Indicators	Green LED and DC OK signal (N.O. Solid State Contact rated 200 mA / 60 VDC)				
Installation					
Fusing **-Input**	Internally fused. External 10 A slow acting fusing for the input is recommended to protect input wiring.				
-Output	Outputs are capable of providing high currents for short periods of time for inductive load startup or switching. Fusing may be required for wire/loads if 2x Nominal O/P current rating cannot be tolerated. Continuous current overload allows for reliable fuse tripping.				
Mounting	Simple snap-on system for DIN Rail TS35/7.5 or TS35/15 or chassis-mounted (optional screw mounting set SDN-PMBRK2 required).				
Connections	Input: IP20-rated screw terminals, connector size range: 16-10 AWG (1.5-6 mm2) for solid conductors, 16-12 AWG (0.5-4 mm2) for flexible conductors. Output: Two connectors per output, connector size range: 16-10 AWG (1.5 - 6 mm2) for solid conductors				
Case	Fully enclosed metal housing with fine ventilation grid to keep out small parts.				
-Free Space	25 mm above and below, 25 mm left and right, 10 mm in front		25 mm above and below, 25 mm left and right, 15 mm in front	70 mm above and below, 25 mm left and right, 15 mm in front	
H x W x D (inches/mm)	4.88 in. x 1.97 in. x 4.55 in. (124 mm x 50 mm x 116 mm)	4.88 in. x 2.56 in. x 4.55 in. (124 mm x 65 mm x 116 mm)		4.88 in. x 3.26 in. x 4.55 in. (124 mm x 83 mm x 116 mm)	4.88 in. x 6.88 in. x 4.55 in. (124 mm x 175 mm x 116 mm)
Weight (lbs/g)	1 lb (460g)	1.5 lbs (620g)		2.2 lbs (1100g)	3 lbs (1520g)

[1] Input current ratings are conservatively specified with low input, worst case efficiency and power factor.

[2] Losses are heat dissipation in watts at full load, nominal input line.

[3] Ripple/noise is stated as typical values when measured with a 20 MHz, bandwidth scope and 50 Ohm resistor.

[4] All peak current is calculated at 24 Volt levels.

[5] Full load, 100 VAC Input @ T_{amb} = +25°C

[6] Not UL listed for DC Input.

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Attachment H
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of H1

8436/32 8-Channel Isolated Low-Level Analog Input Card

The RTP8436/32 8-Channel Isolated Analog Input Card provides high accuracy low-level (±160 mV) analog measurements. Sampling transformers provide channel-to-channel isolation. Very high noise immunity is characteristic of the transformer multiplexer, achieving 160 dB of common mode rejection. Immunity to noise is further enhanced with a two-pole low pass filter, set to provide 70 dB of normal mode rejection at 60 Hz.

Analog to digital conversion is performed by a 16-bit switched capacitor successive approximation A/D converter. A precision voltage source provides a self-test function for the card's amplifiers and A/D converter. No field adjustments are necessary after the initial factory setup.

Specifications

Input Signal Range:	± 160 mV
Multiplexer Type:	8-channel solid state multiplexer with individual transformers for complete channel-to-channel isolation
Sample Rate:	50 samples per second per channel
Accuracy:	0.025% of Full Scale
Temperature Ranges:	–25° to +85°C (–13° to +185°F), storage 0° to +55°C (+32° to +131°F), standard operating –20° to +60°C (–4° to +140°F), extended operating **Note:** Input measurements may not meet the accuracy specification at the upper or lower ends of the extended operating range.
Isolation:	600 VAC RMS or 400 VDC 1500 VAC @ 60 Hz for 60 seconds withstand
Common Mode Voltage:	600 VAC RMS or 400 VDC continuous
Common Mode Rejection:	–160 dB at 60 Hz (100Ω unbalanced)
Common Mode Crosstalk:	–150 dB at 60 Hz
Normal Mode Rejection:	2-pole low-pass filter, –70 dB at 60 Hz
Input Impedance:	5 MΩ in parallel with 10 pF at 50 samples/second per channel
Input Bias Current:	8 nA maximum at 50 samples/second per channel
Input Source Impedance:	100Ω maximum to meet accuracy specification

* * * Report of Calibration * * *
for
Platinum Resistance Thermometer
Model S100995PD
Serial No. P/N366

RTC-CW011

T(°F)	R(ohms)	T(°F)	R(ohms)	T(°F)	R(ohms)	T(°F)	R(ohms)
100.0	114.692	105.0	115.762	110.0	116.832	115.0	117.901
100.1	114.713	105.1	115.784	110.1	116.854	115.1	117.922
100.2	114.735	105.2	115.805	110.2	116.875	115.2	117.944
100.3	114.756	105.3	115.827	110.3	116.896	115.3	117.965
100.4	114.777	105.4	115.848	110.4	116.918	115.4	117.986
100.5	114.799	105.5	115.869	110.5	116.939	115.5	118.008
100.6	114.820	105.6	115.891	110.6	116.961	115.6	118.029
100.7	114.842	105.7	115.912	110.7	116.982	115.7	118.051
100.8	114.863	105.8	115.934	110.8	117.003	115.8	118.072
100.9	114.884	105.9	115.955	110.9	117.025	115.9	118.093
101.0	114.906	106.0	115.976	111.0	117.046	116.0	118.115
101.1	114.927	106.1	115.998	111.1	117.067	116.1	118.136
101.2	114.949	106.2	116.019	111.2	117.089	116.2	118.157
101.3	114.970	106.3	116.041	111.3	117.110	116.3	118.179
101.4	114.992	106.4	116.062	111.4	117.132	116.4	118.200
101.5	115.013	106.5	116.083	111.5	117.153	116.5	118.221
101.6	115.034	106.6	116.105	111.6	117.174	116.6	118.243
101.7	115.056	106.7	116.126	111.7	117.196	116.7	118.264
101.8	115.077	106.8	116.148	111.8	117.217	116.8	118.286
101.9	115.099	106.9	116.169	111.9	117.238	116.9	118.307
102.0	115.120	107.0	116.190	112.0	117.260	117.0	118.328
102.1	115.142	107.1	116.212	112.1	117.281	117.1	118.350
102.2	115.163	107.2	116.233	112.2	117.303	117.2	118.371
102.3	115.184	107.3	116.255	112.3	117.324	117.3	118.392
102.4	115.206	107.4	116.276	112.4	117.345	117.4	118.414
102.5	115.227	107.5	116.297	112.5	117.367	117.5	118.435
102.6	115.249	107.6	116.319	112.6	117.388	117.6	118.456
102.7	115.270	107.7	116.340	112.7	117.410	117.7	118.478
102.8	115.291	107.8	116.362	112.8	117.431	117.8	118.499
102.9	115.313	107.9	116.383	112.9	117.452	117.9	118.520
103.0	115.334	108.0	116.404	113.0	117.474	118.0	118.542
103.1	115.356	108.1	116.426	113.1	117.495	118.1	118.563
103.2	115.377	108.2	116.447	113.2	117.516	118.2	118.585
103.3	115.399	108.3	116.469	113.3	117.538	118.3	118.606
103.4	115.420	108.4	116.490	113.4	117.559	118.4	118.627
103.5	115.441	108.5	116.511	113.5	117.580	118.5	118.649
103.6	115.463	108.6	116.533	113.6	117.602	118.6	118.670
103.7	115.484	108.7	116.554	113.7	117.623	118.7	118.691
103.8	115.506	108.8	116.576	113.8	117.645	118.8	118.713
103.9	115.527	108.9	116.597	113.9	117.666	118.9	118.734
104.0	115.548	109.0	116.618	114.0	117.687	119.0	118.755
104.1	115.570	109.1	116.640	114.1	117.709	119.1	118.777
104.2	115.591	109.2	116.661	114.2	117.730	119.2	118.798
104.3	115.613	109.3	116.683	114.3	117.751	119.3	118.819
104.4	115.634	109.4	116.704	114.4	117.773	119.4	118.841
104.5	115.655	109.5	116.725	114.5	117.794	119.5	118.862
104.6	115.677	109.6	116.747	114.6	117.816	119.6	118.883
104.7	115.698	109.7	116.768	114.7	117.837	119.7	118.905
104.8	115.720	109.8	116.789	114.8	117.858	119.8	118.926
104.9	115.741	109.9	116.811	114.9	117.880	119.9	118.947
105.0	115.762	110.0	116.832	115.0	117.901	120.0	118.969

L-003230 Rev. 001
Attachment J
Page J1 (final)
of J1
[illegible]

DC Characteristics

Accuracy Specifications ± (% of reading + % of range) [1]

Function	Range [3]	Test Current or Burden Voltage	24 Hour [2] 23°C ± 1°C	90 Day 23°C ± 5°C	1 Year 23°C ± 5°C	Temperature Coefficient /°C 0°C – 18°C 28°C – 55°C
DC Voltage	100.0000 mV		0.0030 + 0.0030	0.0040 + 0.0035	0.0050 + 0.0035	0.0005 + 0.0005
	1.000000 V		0.0020 + 0.0006	0.0030 + 0.0007	0.0040 + 0.0007	0.0005 + 0.0001
	10.00000 V		0.0015 + 0.0004	0.0020 + 0.0005	0.0035 + 0.0005	0.0005 + 0.0001
	100.0000 V		0.0020 + 0.0006	0.0035 + 0.0006	0.0045 + 0.0006	0.0005 + 0.0001
	1000.000 V		0.0020 + 0.0006	0.0035 + 0.0010	0.0045 + 0.0010	0.0005 + 0.0001
Resistance [4]	100.0000 Ω	1 mA	0.0030 + 0.0030	0.008 + 0.004	0.010 + 0.004	0.0006 + 0.0005
	1.000000 kΩ	1 mA	0.0020 + 0.0005	0.008 + 0.001	0.010 + 0.001	0.0006 + 0.0001
	10.00000 kΩ	100 µA	0.0020 + 0.0005	0.008 + 0.001	0.010 + 0.001	0.0006 + 0.0001
	100.0000 kΩ	10 µA	0.0020 + 0.0005	0.008 + 0.001	0.010 + 0.001	0.0006 + 0.0001
	1.000000 MΩ	5 µA	0.002 + 0.001	0.008 + 0.001	0.010 + 0.001	0.0010 + 0.0002
	10.00000 MΩ	500 nA	0.015 + 0.001	0.020 + 0.001	0.040 + 0.001	0.0030 + 0.0004
	100.0000 MΩ	500 nA // 10 MΩ	0.300 + 0.010	0.800 + 0.010	0.800 + 0.010	0.1500 + 0.0002
DC Current	10.00000 mA	< 0.1 V	0.005 + 0.010	0.030 + 0.020	0.050 + 0.020	0.002 + 0.0020
	100.0000 mA	< 0.6 V	0.01 + 0.004	0.030 + 0.005	0.050 + 0.005	0.002 + 0.0005
	1.000000 A	< 1 V	0.05 + 0.006	0.080 + 0.010	0.100 + 0.010	0.005 + 0.0010
	3.000000 A	< 2 V	0.10 + 0.020	0.120 + 0.020	0.120 + 0.020	0.005 + 0.0020
Continuity	1000.0 Ω	1 mA	0.002 + 0.010	0.008 + 0.020	0.010 + 0.020	0.001 + 0.002
Diode Test	1.0000 V	1 mA	0.002 + 0.010	0.008 + 0.020	0.010 + 0.020	0.001 + 0.002
DC:DC Ratio	100 mV to 1000 V		(Input Accuracy) + (Reference Accuracy) *Input Accuracy* = accuracy specification for the HI-LO input signal. *Reference Accuracy* = accuracy specification for the HI-LO reference input signal.			

Transfer Accuracy (typical)

$$\frac{(\text{ 24 hour \% of range error })}{2}$$

Conditions:

- Within 10 minutes and ± 0.5°C.
- Within ±10% of initial value.
- Following a 2-hour warm-up.
- Fixed range between 10% and 100% of full scale.
- Using 6½ digit slow resolution (100 PLC).
- Measurements are made using accepted metrology practices.