Attachment 3

Engineering Calculation Supporting The Uncertainty Analysis

DOMINION NUCLEAR CONNECTICUT, INC.
MILLSTONE POWER STATION UNIT 2

Note: This form is only applicable to **Revision 6** of this procedure.
Complete the fields with text or an **X** as required.

Calculation Number:	Revision:	Addendum:	Sub type:	Decommissioning Record?
98-ENG-02405D2	2	N/A	ENG	☐Yes ☒No

Vendor (If not Dominion):	Calculation Preparation Risk: ☒Low ☐Medium ☐High
Vendor Proprietary: ☐Yes ☐No	Pre-Job Brief Completed: ☐Yes ☒No ☐NA

Calculation Quality Class: ☐Safety Related ☐NSQ ☒Non-Safety Related

Subject (Calculation Title):

Millstone Unit 2 Service Water Inlet Temperature - Indicator Accuracy TI-6928, TI-6929, & TI-6930

Addendum Title:

N/A

Station(s) and Unit(s):	Affected System(s), Structure(s), or Component(s):
NA ☐1 ☐2 ☐3 SU ☐1 ☐2 KW ☐ MP ☐1 ☒2 ☐3 ☐CO (Note: If both SU and NA then only check CO)	SWS (2326A)

Purpose (Executive Summary):

The purpose of this Calculation is to determine the uncertainty (i.e., the Channel Statistical Allowance – CSA) values associated with Service Water Vital Cooler Inlet Temperature Indicators TI-6928, TI-6929, and TI-6930. The indication uncertainty (CSA) values determined in this calculation are for MILD / NON-HARSH conditions. Revision 2 of this calculation incorporates the relevant information from Calculation 98-ENG-02405D2, Revision 1, Addendums A and B and the results of IEE 10000008752, V00.

Originator (Qual. Required): Printed Name (1) (3)		Signature: (1) (3)	Date: (1) (3)
Nancy M. Nowlan		[signature]	8/6/12
Reviewer (Qual. Required): Printed Name (1) Gus Filippides	Type of Review: (2) Independent	Signature: [signature]	Date: 8/6/12
Approver: Printed Name Keith Deslandes		Signature: [signature]	Date: 8/6/12

Note: Physical or electronic signatures are acceptable.

Note: At the discretion of the originator, a facsimile of this cover sheet that does not contain the "CM-AA-CLC-301"or "Attachment 1" headers may be used. Facsimiles must contain all of the elements of the cover sheet in the current revision of CM-AA-CLC-301. (1) Add lines for additional originators or reviewers as necessary. (2) Note if reviews are "Independent," "Peer," "Subject Matter Expert," "Supervisor," or "Owner's." (3) Enter N/A for Owner's Review of Vendor Calculation.

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Attachments

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Attachment 2 - Pages from VTM-25203-002-002, Rev. 1, AI 2000 Rev. 4.3 Temperature Transmitter

Attachment 3 - Pages from Microtronics Model 5630031 Digital Indicator Manual

Attachment 4 - Pages from IC 2429B Safety Related Instrument Calibrations – Shutdown, Rev. 011-05

Attachment 5 - Calibration/replacement cycle information for RTDs TE-6928, TE-6929, and TE-6930 and the calibration frequency for Temperature Indicators TI-6928, TI-6929, and TI-6930

Attachment 6 - Process Conditions under which the Service Water Inlet Source Temperature is Homogeneous

Attachment 7 - Pages from VTM-25203-479-001, Rev. 2, Minco Temperature Sensors and Instruments and from IEE Number 10000008752, Version V00

Attachment 8 - ETE-MP-2012-1135, Rev. 0, Justification for the Table Accuracy Value Used in the MINCo RTD SCA Term in Calculation No. 98-ENG-02405D2

1. *Record of Revision and Addenda*

Rev. 0 Original issue

Rev. 1 Revision 1 adds the indicator uncertainties with improved calibration acceptance criteria, increased calibration frequency, and replacement of RTDs every ten years. Revision 1 also corrects various typos.

Add. A Addendum A updates the uncertainty calculation to reflect a change in calibration frequency of the rack electronics and the RTD sensors. To minimize equipment uncertainty, the rack electronics shall be calibrated annually. Also, the RTD sensors shall be calibrated every five years in lieu of the currently assumed value of 10 years.

Add. B Addendum B provides a basis for the combined uncertainty should the three indicators be averaged together under conditions where the temperature of the service water source for the three temperature measurements can be considered homogeneous.

Rev. 2 Revision 2 incorporates the relevant information from Calculation 98-ENG-02405D2, Revision 1, Addendums A and B. This revision incorporates the results of IEE No. 10000008752, V00 which allows for the changing out of the Minco RTDs with Burns Engineering RTDs. Additional information has been added to the calculation to explain the methodology used for reducing the indication uncertainty by using the average of two or three indicated temperature values. Finally, Revision 2 of this calculation is based on CM-AA-CLC-301, Revision 6 which has added additional sections and administrative requirements for this calculation revision. This is a major revision to this calculation and therefore no Revision Bars will be used to show the changes.

This calculation is a Design Input for Millstone Unit 2 LBDCR No. 11-MPS2-014. The 50.59/72.48 Applicability Review, Design Effects Table (DET), and the Document Impact Summary (DIS) will be completed in accordance with the LBDCR change process used to implement LBDCR No. 11-MPS2-014.

2. *Cumulative Effects Review*

The relevant information from Calculation 98-ENG-02405D2, Revision 1, Addendums A and B has been incorporated into this revision. This revision incorporates the results of IEE No. 10000008752, V00 which allows for the changing out of the Minco RTDs with Burns Engineering RTDs. In addition, this revision will bring this calculation up to current conditions and standards in accordance with CM-AA-CLC-301, Revision 6, Millstone Specification SP-ST-EE-286, Revision 6, and Dominion Standard STD-EEN-0304, Revision 6.

3. References

3.1 Millstone Specification SP-ST-EE-286, Revision 6, Guidelines for Calculating Instrument Uncertainties.

3.2 NUSCO Drawing No. 25203-28500, Sh. 741, Rev. 01; Millstone Unit 2 TE-6928, TE-6931 Service Water Temperature Loop Diagram.

3.3 NUSCO Drawing No. 25203-28500, Sh. 742, Rev. 01; Millstone Unit 2 TE-6929, TE-6930, TE-6932, TE-6933 Service Water Temperature Loop Diagram.

3.4 IC 2429B Safety Related Instrument Calibrations - Shutdown, Rev. 011-5. See Attachment 4.

3.5 VTM-25203-002-002, Revision 1, AI-2000 Revision 4.3 Smart Temperature Transmitter Operating Information. See Attachment 2.

3.6 IEE Number 10000008752, Version V00, MINCO S7927 RTD, Burns Model WSP/Millstone/Unit 2. See Attachment 1.

3.7 Microtronics Model 5630031 Current Loop Powerless Digital Indicator Manual. See Attachment 3.

3.8 CM-AA-CLC-301, Revision 6, Engineering Calculations.

3.9 Dominion Standard STD-EEN-0304, Revision 6, Calculating Instrumentation Uncertainties by the Square Root of the Sum of the Squares Method.

3.10 PDCR 2-13-91, Service Water Temperature Indicator Replacement TI-6928, TI-6929, TI-6930, TI-6931, TI-6932, & TI-6933.

3.11 NUREG/CR-3659, "A Mathematical Model for Assessing the Uncertainties of Instrumentation Measurements for Power and Flow of PWR Reactors".

3.12 Engineering Technical Evaluation ETE-CEE-2012-0012, Revision 0, Transmittal of Calculation 98-ENG-02405D2, Revision 2.

3.13 VTM-25203-479-001, Rev. 2, Minco Temperature Sensors and Instruments.

3.14 Engineering Technical Evaluation ETE-MP-2012-1135, "Justification for the Table Accuracy Value Used in the MINCo RTD SCA Term in Calculation No. 98-ENG-02405D2."

4. Computer Codes Used

No Computer Codes were used to perform this calculation.

5. *Identification of Computer Inputs and Outputs*

No Computer Inputs and Outputs were used to develop this calculation.

6. *Purpose*

The purpose of this Calculation is to determine the uncertainty (i.e., the Channel Statistical Allowance - CSA) values associated with Unit 2 Service Water Vital Cooler Inlet Temperature Indicators TI-6928, TI-6929, and TI-6930. The indication uncertainty (CSA) values determined in this calculation are for MILD / NON-HARSH conditions. Revision 2 of this calculation incorporates the relevant information from Calculation 98-ENG-02405D2, Revision 1, Addendums A and B. This revision incorporates the results of IEE No. 10000008752, V00 which allows for the changing out of the Minco RTDs with Burns Engineering RTDs. Additional information has been added to the calculation to explain the methodology used for reducing the indication uncertainty by using the average of two or three indicated temperature values. Finally, Revision 2 of this calculation is based on CM-AA-CLC-301, Revision 6 which has added additional sections and administrative requirements for this calculation revision. This is a major revision to this calculation and therefore no Revision Bars will be used to show the changes.

7. *Instrument Loop Block Diagram*

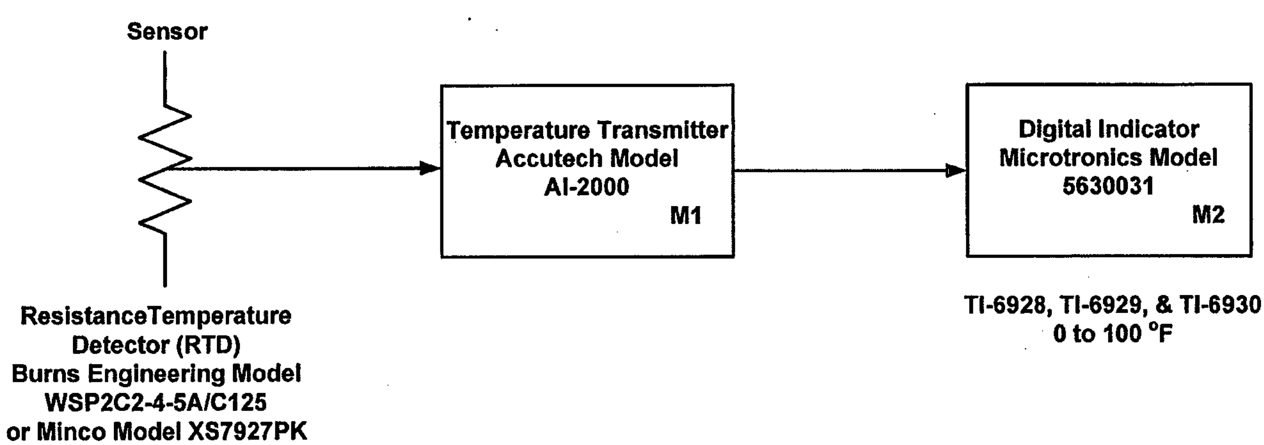

Figure 7.1 – Unit 2 Service Water Inlet Temperature Indicators TI-6928, TI-6929, and TI-6930

Figure 7.1 illustrates the instrument configuration that develops Unit 2 Service Water Vital Cooler Inlet Temperature Indication. Figure 7.1 is representative of all three instrument loops.

8. Design Inputs

The design inputs for this Calculation are manufacturer's published data sheets, previously approved calculations, station-controlled drawings and other controlled documents as listed in Section 3.0, References.

9. Assumptions

9.1 This calculation is for non-harsh conditions, therefore cable error, radiation effects, and other harsh environmental conditions are not considered.

9.2 As described in Attachment 6, the individual measured temperatures as indicated on TI-6928, TI-6929, and TI-6930 can deviate from normal due to temporary thermal transients caused by main condenser waterbox backflushes and by thermal mussel cooks performed in the individual bays. The temporary transients affect the individual temperature readings immediately at the beginning of the flush or cook, then the offset exponentially decays back to normal reading within one hour. These temperature transients can be considered to be a Process Measurement Accuracy (PMA) error term if temperature measurements are made and recorded during these transient conditions. However, procedure controls are in place to avoid taking average temperature measurements during transient conditions and for one hour thereafter (Reference 3.12). Therefore, the PMA error term is assumed to be zero for purposes of this calculation.

9.3 No systematic errors (treated as bias) have been identified for these temperature loops.

9.4 Sensor M&TE errors are included in the vendor stated calibration accuracy for the RTDs.

9.5 The RTDs addressed in this calculation are calibrated every five years (See Attachment 5).

9.6 Temperature Indicators TI-6928, TI-6929, and TI-6930 and their associated temperature transmitters are calibrated on a yearly basis (See Attachment 5).

9.7 The installed RTDs for TE-6928, TE-6929, and/or TE-6930 can be either Minco Model S7927 200 Ω Platinum RTDs or Burns Engineering Model WSP2C2-4-5A 200 Ω Platinum RTDs. Both types of these RTDs are either calibrated on-site or by the manufacturer. This calculation will use the error components from the Burns Engineering Model WSP2C2-4-5A specifications/calibration data or from the Minco Model S7927 specifications/calibration data.

9.8 RTDs TE-6928, TE-6929, and TE-6930 were recalibrated in the August to October time frame of 2009. TE-6928 was recalibrated by AWO no. 53M20707631, TE-6929 was recalibrated by AWO no. 53M20707633, and TE-6930 was recalibrated by AWO no. 53M20707632.

10. Methodology

This calculation uses the methodology presented in Dominion Standard STD-EEN-0304, Revision 6, "Calculating Instrumentation Uncertainties by the Square Root of the Sum of the Squares Method" (Reference 3.9) and the guidelines from Millstone Specification SP-ST-EE-286, Revision 6, "Guidelines for Calculating Instrument Uncertainties" (Reference 3.1) to determine the uncertainties associated with Service Water Vital Cooler Inlet Temperature Indicators TI-6928, TI-6929, and TI-6930. Both the Millstone Specification and the Dominion Standard treat the development of the error terms in a similar manner. This calculation will be performed using the Module Calibration method as described in Reference 3.9. Any other differences with respect to the error terms defined in each reference document will be explained as they are encountered in Section 11.0.

Dependent channel error components (interactive) are combined arithmetically into independent channel groups. These groups and other independent channel error components are combined statistically using (SRSS) to give a resultant channel error or Channel Statistical Allowance (CSA).

The CSA determined in this calculation is a variation of generic equations presented in STD-EEN-0304, Revision 6, Section 6.1 (Reference 3.9). For normal conditions:

$$\mathbf{CSA = SE \pm [EA^2 + PMA^2 + PEA^2 + (SCA + SMTE)^2 + SD^2 + SPE^2 + STE^2 + SPSE^2 + (M1 + M1MTE)^2 + (M2 + M2TE)^2 + ... + (Mn + MnMTE)^2 + RD^2 + RTE^2 + RRA^2]^{1/2}}$$

Equation 1

The error terms in the equation above have their usual meaning and are described in Section 11.0.

11. Calculations

The following CSA calculation applies for Millstone Unit 2 Service Water Vital Cooler Inlet Temperature Indicators TI-6928, TI-6929, and TI-6930. These instrument loops have the following identical components:

1) RTD - Burns Engineering or Minco 200 Ω Platinum (or equivalent) RTD (References 3.6 & 3.13)
2) Temperature Transmitter - Accutech Model AI-2000 (Reference 3.5)
3) Digital Temperature Indicator - Microtronics Model 5630031 (References 3.7 & 3.10)

SE = Systematic Errors

Systematic Errors have a unidirectional impact on a channel and are treated as a bias. There are no systematic errors associated with these temperature loops.

SE = ± 0.000 % of span (Assumption 9.3)

EA = Environmental Allowance

This EA term accounts for Radiation Allowance (RA), LOCA/HELB Effects (DLH), LOCA/HELB Effects (PLH), Insulation Resistance Effects (IRE), and Seismic Effects (SE) as noted in Reference 3.1. This calculation is for non-harsh environmental conditions, therefore EA is zero.

EA = ± 0.000 % of span (Assumption 9.1 & Reference 3.1)

PMA = Process Measurement Accuracy

The Process Measurement Accuracy error is assumed to be zero for this calculation. See Assumption 9.2 for additional information.

PMA = ± 0.000 % of span (Assumption 9.2)

PEA = Primary Element Accuracy

There are no primary elements in these loops. There is a thermowell used for the RTDs, but no physical conversion process takes place due to the use of the thermowell except for adding a time constant to the process measurement. This CSA uncertainty calculation is for static conditions.

PEA = ± 0.000 % of span (Reference 3.6)

SCA = Sensor Calibration Accuracy (Minco Model XS7927PK or Burns Engineering, Model WSP2C2-4-5A)

The calibrated range for RTDs TE-6928, TE-6929, and TE-6930 is 0 °F to 100 °F. Sensor Accuracy refers to how closely the RTD resistance matches that of tabulated R versus T curve calculated value at the given temperature as provided by the manufacturer.

The Burns Engineering information included in IEE No. 10000008752, V00 specifies two different error components that are associated with the accuracy of the RTD (Reference 3.6 and Attachment 1). The three error terms given below will be treated as random, independent variables that will statistically combined to determine the overall Sensor Calibration Accuracy for the Burns Engineering RTD. Calibrated Burns RTDs are provided with a documented ± 25 mK or ± 0.025 °C uncertainty.

1. Vendor Calibration Accuracy = ± 0.025 °C = ± (0.025 °C * 9 °F / 5 °C) = ± 0.045 °F = ± 0.045 %

2. Repeatability = ± 0.100 °F over range 32 °F to 900 °F = 0.100 °F = 0.100 %

$SCA_{BURNS} = \pm \sqrt{(0.045^2 + 0.100^2)} = \pm 0.110$ %

$SCA_{BURNS} = \pm$ 0.110 % of span (Reference 3.4, Assumption 9.7, and Attachment 1)

The Minco RTD information included in Reference 3.13 and Attachment 7 specifies two different error components that are associated with the accuracy of the RTD (Reference 3.13 and Attachment 7). The five error terms given below will be treated as random, independent variables that will statistically combined to determine the overall Sensor Calibration Accuracy for the Minco RTD. Refer to ETE-MP-2012-1135 for the basis for the Table Accuracy statement.

1. Table Accuracy = ± 0.025 °C = ± (0.025 °C * 9 °F / 5 °C) = ± 0.045 °F = ± 0.045 % of span

2. Repeatability = ± 0.010 °C at 0.0 °C = (0.010 °C * 9 °F / 5 °C) = ± 0.018 °F = ± 0.018 % of span

$SCA_{Minco} = \pm \sqrt{(0.045^2 + 0.018^2)} = \pm 0.048$ %

$SCA_{Minco} = \pm$ 0.048 % of span (Reference 3.13, Assumption 9.7, and Attachment 7)

SMTE = Sensor Measuring & Test Equipment (for Burns Engineering RTD or Minco RTD)

The SMTE is included in the SCA term.

SMTE = ± 0.000 % of span (Assumption 9.4)

SD = Sensor Drift (for Burns Engineering RTD or Minco RTD)

The RTD stability term is associated with Sensor Drift. Stability is the ability of an RTD to maintain its accuracy over a period of time. According to Attachment 5, the RTDs are calibrated every 5 years. Using a 5 year period and treating each period as statistically independent, we have the following Sensor Drift error.

Burns Engineering does not provide a specific stability error term for the Model Number WSP2C2-4-5A RTD. However, Reference 3.6 provides a value of 0.01 °C for temperature elements subjected to temperatures < 25 °C.

$SD_{BURNS} = \pm \sqrt{(5 * (0.01\,°C * 9°F / 5\,°C)^2)} = \pm 0.040\,°F = \pm 0.040\,\%$ for a 0 to 100 °F instrument span

$SD_{BURNS} = \pm$ 0.040 % of span (Reference 3.6, Assumptions 9.5 & 9.7, and Attachment 5)

As shown in Attachment 7 and in Reference 3.13, Minco provides a stability term of ± 0.05 °C per year.

$SD_{MINCO} = \pm \sqrt{(5 * (0.05\,°C * 9°F / 5\,°C)^2)} = \pm 0.201\,°F = \pm 0.201\,\%$ for a 0 °F to 100 °F instrument span

$SD_{MINCO} = \pm$ 0.201 % of span (Reference 3.13, Assumptions 9.5 & 9.7, and Attachment 7)

SPE = Sensor Pressure Effects (for Burns Engineering RTD or Minco RTD)

There are no pressure effects associated with RTDs installed in a thermowell and that are subjected to mild conditions. This term is not applicable for these instrument loops.

SPE = ± 0.000 % of span (Attachment 1 and Assumptions 9.1 & 9.7)

STE = Sensor Temperature Effects (for Burns Engineering RTD or Minco RTD)

There are no sensor temperature effects associated with RTD's for mild conditions. According to Reference 3.6, the RTD end seal and lead wires for the Burns Engineering RTDs are rated for a temperature span of - 50 °F to 400 °F. According to the Minco Product Information provided in Attachment 7, the Minco RTD connectors are rated for an ambient temperature range of - 40 °F to 212 °F. This term is not applicable for these instrument loops.

STE = ± 0.000 % of span (Reference 3.6, Attachment 7, and Assumptions 9.1 & 9.7)

SPSE = Sensor Power Supply Effect (For Accutech Model AI-2000 Temperature Transmitter)

According to Reference 3.5, the sensor power supply effect is < ± 0.005 % of span per volt. According to Reference 3.5, the nominal input voltage is 24 VDC with a range of 12 VDC to 42 VDC. For a typical load of 250 Ω, the nominal supply voltage is stated as 18 VDC. The power supply voltage is not checked during the performance of Reference 3.4. For conservatism, a ± 12 VDC offset value will be assumed from the nominal 24 VDC input voltage. Therefore SPSE is:

SPSE = ± 12 * 0.005 % of span = ± 0.060 % of span

SPSE = ± 0.060 % of span (References 3.4 and 3.5)

M1 = Temperature Transmitter Calibration Accuracy

According to Reference 3.4, these instrument loops are string calibrated such that a resistance simulator (i.e., decade box) is connected to the input of the Temperature Transmitter and the output is read on the Digital Indicator (See Attachment 4). Therefore, the calibration accuracy of the Temperature Transmitter is embedded in the accuracy associated with the Digital Indicator (M2).

M1 = ± 0.000 % of span (Reference 3.4 and Attachment 4)

M1MTE = Temperature Transmitter Measuring & Test Equipment

According to Reference 3.4, these instrument loops are string calibrated such that a resistance simulator (i.e., decade box) is connected to the input of the Temperature Transmitter and the output is read on the Digital Indicator (See Attachment 4). Therefore, the accuracy of the Temperature Transmitter Measuring & Test Equipment is embedded in the accuracy associated with the Digital Indicator (M2).

M1MTE = ± 0.000 % of span (Reference 3.4 and Attachment 4)

M2 = Digital Indicator Calibration Accuracy

According to Reference 3.4, these instrument loops are string calibrated such that a resistance simulator (i.e., decade box) is connected to the input of the Temperature Transmitter and the output is read on the Digital Indicator (See Attachment 4). According to Reference 3.4, the string calibration accuracy for the Digital Indicator (M2) is ± 0.300 °F. Therefore, M2 = ± (0.300 °F / 100.0 °F) * 100 % = ± 0.300 % of span.

M2 = ± 0.300 % of span (Reference 3.4 and Attachment 4)

M2MTE = Digital Indicator Measuring & Test Equipment

According to Reference 3.4 and Attachment 4, these instrument loops are string calibrated such that a resistance simulator (i.e., decade box) is connected to the input of the Temperature Transmitter and the output is read on the Digital Indicator (See Attachment 4). According to Reference 3.4, the string calibration for the Digital Indicator uses an RTD simulator with an accuracy of ± 0.01 % in the range of 150 Ω to 250 Ω, where 250 Ω bounds the instrument range for the three Indicators. Based on Reference 3.4, using TI-6928, the minimum instrument span is 43.226 Ω. Therefore, M2MTE = ± (0.01 % * 250 Ω) / 43.226 Ω = ± 0.058 %.

M2MTE = ± 0.058 % of span (Reference 3.4 and Attachment 4)

RD = Rack Drift

According to Reference 3.5 and Attachment 2, the Long Term Stability for the Temperature Transmitter (M1) is less than 0.05 % of reading ± 2.1 uA per year. There is no drift or stability term provided for the Digital Indicator (M2) in Reference 3.7. These instrument loops are calibrated once per year (Assumption 9.6 and Attachment 5). The Long Term Stability term used for the Temperature Transmitter for one year will be used to bound the drift seen for the whole instrument loop (i.e., the Temperature Transmitter and the Digital Indicator) on a yearly basis.

Therefore, RD = ± 0.05 % + ((0.021 mA / 16 mA) * 100 % = ± 0.181 %

RD = ± 0.181 % of span (References 3.5 & 3.7, Assumption 9.6, and Attachment 5)

RTE = Rack Temperature Effects

The Rack Temperature Effects are included in the M2 and the Rack Drift Terms.

RTE = ± 0.000 % of span (References 3.5 and 3.7)

RRA = Rack Readability Allowance / OIA = Overall Indicator Accuracy

Reference 3.7 provides the accuracy specification for the Digital Indicator (M2). The accuracy of ± 0.05 % + 1 count is embedded in the M2 term. Based on Reference 3.7, the resolution for the Digital Indicator is ± 0.05 %. The resolution error will be used as the RRA/OIA error for this instrument loop.

RRA/OIA = ± 0.050 % of span (Reference 3.7)

CSA = Channel Statistical Allowance with the Minco Model XS7927PK RTDs Installed

For the Millstone Unit 2 Service Water Inlet Temperature Loops, the error term values given above are substituted into Equation 1 to yield the Channel Statistical Allowance or the overall uncertainty associated with Temperature Indicators TI-6928, TI-6929, and TI-6930 for MILD / NON-HARSH conditions. The uncertainty values reported below are based on the Minco Model XS7927PK RTDs being installed in these temperature loops.

The CSA or the overall uncertainty for an individual temperature indication using Minco RTDs is based on Equation 1 and is given below.

$$\mathbf{CSA = SE \pm [EA^2 + PMA^2 + PEA^2 + (SCA + SMTE)^2 + SD^2 + SPE^2 + STE^2 + SPSE^2 + (M1 + M1MTE)^2 + (M2 + M2TE)^2 + ... + (Mn + MnMTE)^2 + RD^2 + RTE^2 + RRA^2]^{1/2}}$$

Where:

SE =	0.000 % of span
EA =	0.000 % of span
PMA =	0.000 % of span
PEA =	0.000 % of span
SCA_{MINCO} =	0.048 % of span
SMTE =	0.000 % of span
SD_{MINCO} =	0.201 % of span
SPE =	0.000 % of span
STE =	0.000 % of span
SPSE =	0.060 % of span
M1 =	0.000 % of span
M1MTE =	0.000 % of span
M2 =	0.300 % of span
M2MTE =	0.058 % of span
RD =	0.181 % of span
RTE =	0.000 % of span
RRA/OIA =	0.050 % of span

$$CSA = 0.0 \pm [0.0^2 + 0.0^2 + 0.0^2 + (0.048 + 0.0)^2 + 0.201^2 + 0.0^2 + 0.0^2 + 0.060^2 + (0.0 + 0.0)^2 + (0.300 + 0.058)^2 + 0.181^2 + 0.0^2 + 0.050^2]^{1/2}$$

CSA = $\underline{+}$ 0.458 % of span

The Channel Statistical Allowance or the overall uncertainty for a single Digital Temperature Indicator using the Minco RTDs is:

CSA = ± 0.458 % of span = ± 0.458 °F based on a process range of 0 °F to 100 °F

Millstone Unit 2 Service Water Temperature Indication using Minco Model XS7927PK RTDs (Average of 2 or 3 Operable RTDs)

NUREG/CR-3659 (Reference 3.11) states that the uncertainty of a variable can be reduced by a factor of $1/\sqrt{\eta}$ when taking the average of readings from η independent sensors. There are three Service Water Inlet Temperature Indicators, one for each of the three Unit 2 AC switchgear room coolers. Each temperature indicator monitors the inlet service water temperature to one of the three AC switchgear room coolers. One Service Water Pump that takes suction from the Intake Structure provides the service water input to two of the three AC switchgear room coolers and the other running Service Water Pump provides the service water input to the third AC switchgear room cooler. For normal plant conditions, with no maintenance or backflushes going on in the condenser water boxes, the Service Water Inlet Temperature RTDs are monitoring the bulk homogeneous water temperature from the Intake Structure.

In summary, the uncertainty of the Average Service Water Temperature Indication as read from two of the three Digital Indicators or from all three Digital Indicators is calculated as:

Average Service Water Inlet Temperature Uncertainty (2 indicators) = $CSA_{single\ indicator} / \sqrt{2}$

Equation 2

Average Service Water Inlet Temperature Uncertainty (3 indicators) = $CSA_{single\ indicator} / \sqrt{3}$

Equation 3

The Channel Statistical Allowance or the overall uncertainty associated with the averaging of two of the three Service Water Inlet Temperature Indicators and with Minco RTDs installed is:

Average Service Water Inlet Temperature Uncertainty = $\pm$ 0.458 % of span / $\sqrt{2}$ = $\pm$ 0.324 % of span

Average Service Water Inlet Temperature Uncertainty (2 of 3) = $\pm$ 0.324 % of span = $\pm$ 0.324 °F

The Channel Statistical Allowance or the overall uncertainty associated with the averaging of all three Service Water Inlet Temperature Indicators and with Minco RTDs installed is:

Average Service Water Inlet Temperature Uncertainty = $\pm$ 0.458 % of span / $\sqrt{3}$ = $\pm$ 0.264 % of span

Average Service Water Inlet Temperature Uncertainty (3 of 3) = $\pm$ 0.264 % of span = $\pm$ 0.264 °F

CSA = Channel Statistical Allowance with the Burns Engineering Model WSP2C2-4-5A RTDs Installed

For the Millstone Unit 2 Service Water Inlet Temperature Loops, the error term values given above are substituted into Equation 1 to yield the Channel Statistical Allowance or the overall uncertainty associated with Temperature Indicators TI-6928, TI-6929, and TI-6930 for MILD / NON-HARSH conditions. The uncertainty values reported below are based on the Burns Engineering Model WSP2C2-4-5A RTDs being installed in these temperature loops.

The CSA or the overall uncertainty for an individual temperature indication using Burns Engineering RTDs is based on Equation 1 and is given below.

$$\mathbf{CSA = SE \pm [EA^2 + PMA^2 + PEA^2 + (SCA + SMTE)^2 + SD^2 + SPE^2 + STE^2 + SPSE^2 + (M1 + M1MTE)^2 + (M2 + M2TE)^2 + ... + (Mn + MnMTE)^2 + RD^2 + RTE^2 + RRA^2]^{1/2}}$$

Where:

SE =	0.000 % of span
EA =	0.000 % of span
PMA =	0.000 % of span
PEA =	0.000 % of span
SCA_{BURNS} =	0.110 % of span
SMTE =	0.000 % of span
SD_{BURNS} =	0.040 % of span
SPE =	0.000 % of span
STE =	0.000 % of span
SPSE =	0.060 % of span
M1 =	0.000 % of span
M1MTE =	0.000 % of span
M2 =	0.300 % of span
M2MTE =	0.058 % of span
RD =	0.181 % of span
RTE =	0.000 % of span
RRA/OIA =	0.050 % of span

$$CSA = 0.0 \pm [0.0^2 + 0.0^2 + 0.0^2 + (0.110 + 0.0)^2 + 0.040^2 + 0.0^2 + 0.0^2 + 0.060^2 + (0.0 + 0.0)^2 + (0.300 + 0.058)^2 + 0.181^2 + 0.0^2 + 0.050^2]^{1/2}$$

CSA = $\underline{+}$ 0.425 % of span

The Channel Statistical Allowance or the overall uncertainty for a single Digital Temperature Indicator using the Burns Engineering RTDs is:

CSA = ± 0.425 % of span = ± 0.425 °F based on a process range of 0 °F to 100 °F

Millstone Unit 2 Service Water Temperature Indication using Burns Engineering Model WSP2C2-4-5A RTDs (Average of 2 or 3 Operable RTDs)

NUREG/CR-3659 (Reference 3.11) states that the uncertainty of a variable can be reduced by a factor of $1/\sqrt{\eta}$ when taking the average of readings from η independent sensors. There are three Service Water Inlet Temperature Indicators, one for each of the three Unit 2 AC switchgear room coolers. Each temperature indicator monitors the inlet service water temperature to one of the three AC switchgear room coolers. One Service Water Pump that takes suction from the Intake Structure provides the service water input to two of the three AC switchgear room coolers and the other running Service Water Pump provides the service water input to the third AC switchgear room cooler. For normal plant conditions, with no maintenance or backflushes going on in the condenser water boxes, the Service Water Inlet Temperature RTDs are monitoring the bulk homogeneous water temperature from the Intake Structure.

In summary, the uncertainty of the Average Service Water Temperature Indication as read from two of the three Digital Indicators or from all three Digital Indicators is calculated as:

Average Service Water Inlet Temperature Uncertainty (2 indicators) = $CSA_{single\ indicator} / \sqrt{2}$

Equation 2

Average Service Water Inlet Temperature Uncertainty (3 indicators) = $CSA_{single\ indicator} / \sqrt{3}$

Equation 3

The Channel Statistical Allowance or the overall uncertainty associated with the averaging of two of the three Service Water Inlet Temperature Indicators and with Burns Engineering RTDs installed is:

Average Service Water Inlet Temperature Uncertainty = $\pm$ 0.425 % of span / $\sqrt{2}$ = $\pm$ 0.301 % of span

Average Service Water Inlet Temperature Uncertainty (2 of 3) = $\pm$ 0.301 % of span = $\pm$ 0.301 °F

The Channel Statistical Allowance or the overall uncertainty associated with the averaging of all three Service Water Inlet Temperature Indicators and with Burns Engineering RTDs installed is:

Average Service Water Inlet Temperature Uncertainty = $\pm$ 0.425 % of span / $\sqrt{3}$ = $\pm$ 0.245 % of span

Average Service Water Inlet Temperature Uncertainty (3 of 3) = $\pm$ 0.245 % of span = $\pm$ 0.245 °F

12. Results and/or Conclusions

Channel Statistical Allowance (CSA) Values for Minco Model XS7927PK RTDs

The Channel Statistical Allowance or the overall uncertainty for a single Digital Temperature Indicator using Minco Model XS7927PK RTDs is:

CSA = ± 0.458 % of span = ± 0.458 °F based on a process range of 0 °F to 100 °F

The bounding Channel Statistical Allowance or the bounding overall uncertainty associated with the averaging of two of the three Service Water Inlet Temperature Indicators is:

Average Service Water Inlet Temperature Uncertainty (2 of 3) = ± 0.324 % of span = ± 0.324 °F

The bounding Channel Statistical Allowance or the bounding overall uncertainty associated with the averaging of all three Service Water Inlet Temperature Indicators is:

Average Service Water Inlet Temperature Uncertainty (3 of 3) = ± 0.264 % of span = ± 0.264 °F

Channel Statistical Allowance (CSA) Values for Burns Engineering Model WSP2C2-4-5A RTDs

The Channel Statistical Allowance or the overall uncertainty for a single Digital Temperature Indicator using Burns Engineering Model WSP2C2-4-5A RTDs is:

CSA = ± 0.425 % of span = ± 0.425 °F based on a process range of 0 °F to 100 °F

The bounding Channel Statistical Allowance or the bounding overall uncertainty associated with the averaging of two of the three Service Water Inlet Temperature Indicators is:

Average Service Water Inlet Temperature Uncertainty (2 of 3) = ± 0.301 % of span = ± 0.301 °F

The bounding Channel Statistical Allowance or the bounding overall uncertainty associated with the averaging of all three Service Water Inlet Temperature Indicators is:

Average Service Water Inlet Temperature Uncertainty (3 of 3) = ± 0.245 % of span = ± 0.245 °F

13. Precautions and Limitations

As described in Attachment 6, the individual measured temperatures as indicated on TI-6928, TI-6929, and TI-6930 can deviate from normal due to temporary thermal transients caused by main condenser waterbox backflushes and by thermal mussel cooks performed in the individual bays. The temporary transients affect the individual temperature readings immediately at the beginning of the flush or cook, then the offset exponentially decays back to normal reading within one hour. These temperature transients can be considered to be a Process Measurement Accuracy (PMA) error term if temperature measurements are made and recorded during these transient conditions. Procedure controls need to be in place to avoid taking temperature measurements during transient conditions and for one hour thereafter with respect to the temperature averaging techniques described in Section 11 of this calculation (Reference 3.12). These procedure controls will allow the PMA error term to be zero for purposes of this calculation.

NOTE: If "Yes" is not answered, an explanation may be provided below. Reference may be made to explanations contained in the calculation or addendum.

Questions:	Yes	N/A
1. Have the sources of design inputs been correctly selected and referenced in the calculation?	[X]	[ ]
2. Are the sources of design inputs up-to-date and retrievable/attached to the calculation?	[X]	[ ]
3. Where appropriate, have the other disciplines reviewed or provided the design inputs for which they are responsible?	[X]	[ ]
4. Have design inputs been confirmed by analysis, test, measurement, field walkdown, or other pertinent means as appropriate for the configuration analyzed?	[X]	[ ]
5. Have the bases for assumptions been adequately and clearly presented and are they bounded by the Station Design Basis?	[X]	[ ]
6. Were appropriate calculation/analytic methods used and are outputs reasonable when compared to inputs?	[X]	[ ]
7. Are computations technically accurate?	[X]	[ ]
8. Has the calculation made appropriate allowances for instrument errors and calibration equipment errors?	[X]	[ ]
9. Have those computer codes used in the analysis been referenced in the calculation?	[ ]	[X]
10. Have all exceptions to station design basis criteria and regulatory requirements been identified and justified in accordance with NQA-1-1994?	[ ]	[X]
11. Has the design authority/original preparer for this calculation been informed of its revision or addendum, if required?	[ ]	[X]

Comments: (Attach additional pages if needed)

3. Michael F. Marino (MPS Engineering) was contacted to provide design input for this calculation revision.

9. No computer codes were used to generate this calculation revision.

10. No exceptions to the station design basis were taken in order to develop this calculation revision.

11. The signatories on this calculation are the design authority for this calculation revision.

Signature: (Preparer) [signature] NANCY M. NOWLAN Date: 8/6/12

Signature: (Reviewer) G. Filippides [signature] Date: 8/6/12

Note: Physical or electronic signatures are acceptable.