FirstEnergy

CALCULATION

NOP-CC-3002-01 Rev. 05

CALCULATION NO.	VENDOR CALCULATION NO.
8700-SP-1RC-30	N/A

☒ BV1 ☐ BV2 ☐ BV1/2 ☐ BV3 ☐ BVSWT | ☐ DB | ☐ PY

Title/Subject:

Instrument Uncertainty for Refueling Level Indicator LI-1RC-481C

Category:	☒ Active ☐ Historical ☐ Study — **Vendor Calc Summary:** Yes ☐ No ☒
Classification:	☐ Tier 1 Calculation ☒ Safety-Related/Augmented Quality ☐ Non-safety-Related
Open Assumptions?:	☐ Yes ☒ No If Yes, Enter Tracking Number
System Number:	6
Functional Location :	BV-LI-1RC-481C, BV-LT-1RC-481C
Commitments:	None
Initiating Documents:	CR 2016-1173

(PY) Calculation Type:

(PY) Referenced In USAR Validation Database ☐ Yes ☐ No | (PY) Referenced In Atlas? ☐ Yes ☐ No

Computer Program(s)

Program Name	Version / Revision	Category	Status	Description
Microsoft Office Suite	365	C	Active	Word Processing, Spreadsheet

Revision Record

Rev.	Affected Pages	Originator *(Print, Sign & Date)*	Reviewer/Design Verifier *(Print, Sign & Date)*	Approver *(Print, Sign & Date)*
0		C. F. Ciocca [signature] 3/29/16	D. V. Hwang [signature] 3/29/16	J. P. Blattner [signature] 4/1/16
	Description of Change: Original Calculation			
	Describe where the calculation will be evaluated for 10CFR50.59 and/or 10CFR72.48 applicability. RAD 16-00681			
Rev.	Affected Pages	Originator *(Print, Sign & Date)*	Reviewer/Design Verifier *(Print, Sign & Date)*	Approver *(Print, Sign & Date)*
	Description of Change:			
	Describe where the calculation will be evaluated for 10CFR50.59 and/or 10CFR72.48 applicability. Attached RAD/Screen 15-03244.			
Rev.	Affected Pages	Originator *(Print, Sign & Date)*	Reviewer/Design Verifier *(Print, Sign & Date)*	Approver *(Print, Sign & Date)*
	Description of Change:			
	Describe where the calculation will be evaluated for 10CFR50.59 and/or 10CFR72.48 applicability.			

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OBJECTIVE OR PURPOSE:

During refueling operations temporary instrumentation is installed consisting of an indicator, LI-1RC-481C, a Dixson model BB101, connected to a Rosemount 1154DP5RA transmitter which in turn utilizes comparators LC-1RW-494 for a high refueling water level alarm, LC-1FW-494A for a low refueling water level alarm, and LC-1FW-494B for an alarm on entering Reduced inventory. The objective and purpose of this calculation is to define the channel statistical allowance for the indicator upon meeting the Emergency Action Level (EAL) indication CA7 for loss of residual heat removal capability as identified in CR 2016-01173 (DIN 2). The uncertainty calculated here is for LI-1RC-481C, the indication loop only, the comparator accuracy is not analyzed in this calculation, as it is not utilized by the EAL, reference DIN 16.

SCOPE OF CALCULATION:

The scope of this calculation provides the uncertainty for the EAL indication and the associated instrument loop of LI-1RC-481C when utilized for temporary RCS level indication. Temporary RCS level instrumentation was installed previously to meet requirements of Generic Letter 88-17 (DIN 1) with the instrumentation last modification being ECP 02-0239 (DIN 4). The loss of residual heat removal capability is governed by procedure 1OM-53C.4.1.10.1 (DIN 15).

SUMMARY OF RESULTS/CONCLUSIONS:

The instrumentation loop uncertainty of ± 1.98 inches for an ambient temperature swing of 20°F supports an EAL indication of 16 inches or higher. For an ambient temperature swing of 50°F the instrument loop uncertainty of ± 3.62 inches, which would require an EAL indication change, to a recommended value higher than 18 inches.

LIMITATIONS OR RESTRICTIONS ON CALCULATION APPLICABILITY:

This calculation is applicable only to LI-1RC-481C indication when calibrated and configured for use as a temporary RCS level indication during plant outages. This calculation does not address the instrument loop uncertainty for comparators LC-1FW-494, LC-1FW-494A, and LC-1FW-494B, recorder TR-1RC-408 Pen 2, or computer point L1442A.

IMPACT ON OUTPUT DOCUMENTS:

EAL indication for CA7, DIN # 16, EPP Plan Section 4 - Emergency Conditions, is supported based on the instrument uncertainties identified within this calculation for a 20°F ambient temperature change from transmitter ambient calibrated conditions. A larger ambient temperature change of 50°F from calibration conditions will require a higher indication for the EAL.

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DOCUMENT INDEX

DIN No.	Document Number/Title	Revision, Edition, Date	Reference	Input	Output
1	Generic Letter 88-17, "Loss Of Decay Heat Removal (Generic Letter NO. 88-17) 10 CFR 50.54(f)"	October 17, 1988	☒	☐	☐
2	CR 2016-01173, "Discrepancies Identified In EAL Instrumentation Review"	January 1, 2016	☒	☐	☐
3	1CMP-6RC-REFL LVL-1C-3I, "Temporary RCS Level Indication for Refueling - C Loop"	Issue 4 Revision 26	☐	☒	☐
4	ECP 02-0239, "RCS Temporary Level Improvement"	March 2003	☒	☐	☐
5	071-40208C, "Datasheet BB101P, Dixson Bargraph"	Revision 0204	☐	☒	☐
6	07.031-0053, "Model 1154 Alphaline Pressure Transmitter"	Revision N	☐	☒	☐
7	07.023-0024, "Install, Oper, And Main Instr For SA101-13B101/BB202 Level Indicators"	Revision E	☐	☒	☐
8	M and TE Specifications, "Hewlett Packard Model 974A"	Revision FOO, May 29, 2007	☐	☒	☐
9	1OM-6.4.AQ, "Draining the RCS to Reduced Inventory / Midloop Condition"	Revision 13	☒	☐	☐
10	1OM-6.4.N, "Draining the RCS for Refueling"	Revision 25	☒	☐	☐
11	1OM-20.4.N, "Draining the Refueling Cavity and RHR System for Maintenance"	Revision 3	☒	☐	☐
12	1OM-11.3.D.2, "Filling Reactor Refueling Cavity Checklist"	Issue 4, Revision 1	☒	☐	☐
13	1OM-20.4.E, "Draining the Refueling Cavity"	Revision 38	☒	☐	☐
14	1OM-6.5.A.84, "Figure 6-84 – RCS Level Scale"	Issue 4, Revision 1	☐	☒	☐
15	1OM-53C.4.1.10.1, "Loss of Residual Heat Removal Capability"	Revision 15	☒	☐	☐
16	EPP-PLAN-SECTION-4, "EPP Plan Section 4 - Emergency Conditions"	Revision 30	☐	☐	☒
17	ISA-RP67.04.02, "Methodologies For The Determination Of Setpoints For Nuclear Safety-Related Instrumentation"	December 12, 2010	☒	☐	☐
18	ES-E-009, "Engineering Standards Manual, Unit 1 / 2, Instrument Setpoint Calculations"	Revision 0	☒	☐	☐
19	8700-RE-0025AK, "Outline - Vertical Board Section "C""	Revision 18	☒	☐	☐
20			☐	☐	☐

CALCULATION COMPUTATION (BODY OF CALCULATION):

ANALYSIS METHODOLOGY

The loop uncertainty allowance is determined by calculating the channel uncertainty for the applicable terms. From (DINs 17, & 18)

$$CSA = \pm \{(A^2 + B^2 + C^2)^{1/2} + L - M\}$$

where; A, B, C are random uncertainties
L is a bias uncertainty in the positive direction
M is a bias uncertainty in the negative direction

The following is a determination of the applicable terms for the instrument loop accuracy calculations. Each applicable term is identified with a calculation, or discussion as to the value of the term and the inclusion as a random, dependent, independent, or bias term to the overall CSA calculation.

The following equation is typical of the equation used in the following analysis and is used to define the CSA for the indicator used in the Emergency Action Limit (EAL).

$$CSA = \pm [(SCA + SMTE)^2 + (SPSE)^2 + (STE)^2 + (SD + SMTE)^2 + (SRA)^2 + (ICA + IMTE)^2 + (ITE)^2 + (IRA)^2]^{1/2}$$

ASSUMPTIONS / DESIGN INPUTS

D.I.-1 Instrument Drift Assumption - The manufacturer of the Rosemount transmitter provides for a drift allowance of ± 0.2% of upper range limit for a 30 month time period in DIN 6. As the transmitter is in service for refueling where the time period is typically in weeks, less than two months, a conservative allowance for 15 months of ± 0.1% upper range limit will be utilized. This allowance exceeds all previous plant refueling outages and is sufficient for the purpose of this calculation.

D.I.-2 Operating Environment and Temperature Effects - The Rosemount transmitter temperature effects are based on a 100°F change from the calibration temperature per DIN 6. During refueling outages, the containment temperature is within a 20°F increase from the calibration temperature.

D.I.-3 Operating Environment and Temperature Effects - An evaluation of a 50°F increase is sufficient to address containment temperature increases due to boiling off RCS inventory. A 50°F allowance is to address temperature increases during the timeframe and amount of volume of inventory loss to provide reliable indications of the RCS level prior to exceeding a 50°F increase in ambient containment temperature, or an expected containment temperature of 125°F given nominal calibration temperatures of 75°F.

D.I.-4 Steam Pressure/Temperature - An allowance for steam pressure or temperature effects as specified in DIN 6 is not applicable in the containment during refueling outage conditions.

D.I.-5 Chemical Spray - An allowance for chemical spray exposure as specified in DIN 6 is not applicable in the containment during refueling outage conditions.

D.I.-6 Post DBE Operation - An allowance for post DBE operation as specified in DIN 6 is not applicable in the containment during refueling outage conditions.

D.I.-7 Overpressure Effect - An allowance for overpressure effects as specified in DIN 6 is not applicable in the containment during refueling outage at ambient atmospheric conditions.

D.I.-8 Load Effects - Load variations for the transmitter are not applicable as stated in DIN 6.

D.I.-9 Radiation Effects - Radiation qualification for the transmitter is reported to a 55 megarad exposure in DIN 6, which is deemed not applicable during a refueling as plant actively monitors containment radiation for personnel exposures and any unexpected spills or leaks during refueling work.

D.I.-10 Seismic Effect - A seismic uncertainty as specified in DIN 6 is not be considered since this device is not credited during plant operations, i.e. utilized in modes 5 and 6 only.

ACCEPTANCE CRITERIA

There is no safety analysis limit associated with the indication of the RCS level. The indication of reactor level is an Emergency Action Limit in EPP-PLAN-Section-4, as CA7, DIN 16. It is recommended that the action limit is chosen such that there is sufficient instrument span between the end of the instrument range and the chosen limit to accommodate instrument loop uncertainties provided in this calculation for the expected plant conditions, either 20 or 50°F containment temperature changes from calibration temperature.

COMPUTATION

The following is a determination of the applicable terms for the instrument loop accuracy calculations. Each applicable term is identified with a calculation, or discussion as to the value of the term and the inclusion as a random, dependent, independent, or bias term to the overall CSA calculation.

The following equation is used to define the CSA for the indication uncertainty of the 1RC-481C instrument loop.

$$CSA = \pm\,[(SCA + SMTE)^2 + (SPSE)^2 + (STE)^2 + (SD + SMTE)^2 + (SRA)^2 + (ICA + IMTE)^2 + (ITE)^2 + (IRA)^2]^{1/2}$$

Primary Element Accuracy (PEA) (DINs 3 & 14)

This term is random, independent of other terms, and combined independently in the SRSS. There is no primary element associated with this device. Therefore, this term is not used.

PEA = ± 0.0% span

Process Measurement Allowance (PMA) (DINs 9, 10, 11, 12, & 13)

This is a random independent term combined independently in the SRSS of the terms. The RCS level is relative stagnant during refueling activities, drain down and filling activities are inherently slow events, i.e. the RCPs are not in service, therefore this application is not influenced by process measurement effects.

For the purpose of this analysis, the containment temperature change from calibration is utilized as the basis for the effective temperature shift in instrumentation uncertainties. Calibration temperatures are typically evaluated at 68°F, however containment temperatures during outages are higher and 75° is the normal assumed calibration temperature. The uncertainties calculated for the instrumentation are adjusted by the amount of change in temperature, not the actual temperatures. The process temperatures, the RCS level being measured, may have an impact on the overall measurements.

For discussion, it is assumed that the calibration temperature is 75°F, and consistent with the instrument evaluations, temperature changes are evaluated at 20°F and 50°F about the calibration temperature. The containment temperature changes could be 55°F or 25°F. A temperature of 55°F would represent a higher density water leg, generating an indication higher than actual level or in a non-conservative direction. This impact should be considered as a bias and added to the SRSS of the random errors, however a process temperature of 55°F cannot be representative of boiling of the RCS in reducing inventory and is therefore considered not applicable to this analysis. The lower temperature of 25°F is below freezing and again determined to be not realistic as the transmitter head would be frozen and not representative of the RCS level. For the higher temperatures, 95°F for a 20°F temperature change, represents a reduced shift in density resulting in an indication lower than actual reaching the EAL limit earlier than required. This effect is considered to be conservative, and is expected for

RCS boiling considerations. The direction of actual temperatures being higher than the calibration temperature is conservatively not credited in this analysis. Consistently, a 50°F increase to 125°F again would indicate lower than actual with the same conclusions that this conservatism is not credited in this analysis. Therefore the PMA term is not used in this analysis.

PMA = ± 0.0% span

SENSOR INFORMATION

FLOC Number	BV-LT-1RC-481C	DIN 3
Manufacturer	Rosemount	DIN 3
Model #	1154DP5RA	DIN 3
Calibrated Span	130 – 330 inches	DIN 3
Range	0 – 750 inches	DIN 6
Location	Elevation 721' 6" Containment, Crane Wall, RCP-C	DIN 3

Sensor Reference Accuracy (SRA) (DIN 6)

This effect is random and independent of other terms, and typically is included in the SRSS independent of the other terms. The manufacturer specifies ± 0.25% of the calibrated span including the combined effects of linearity, hysteresis and repeatability.

SRA = ± 0.25% span

Sensor Calibration Accuracy (SCA) (DIN 3)

This is a random dependent uncertainty, which is combined in the SRSS equation with the M&TE term. The calibration accuracy is specified in the calibration procedure as ± 0.010 Vdc on a 4 volt span of 1 – 5 Vdc.

SCA = ± 0.25% span

Sensor Measurement & Test Equipment (SMTE) (DINs 3 & 8)

This is a random uncertainty, which is typically combined in the SRSS equation as a dependent term with the sensor calibration accuracy, and again with the drift term. The SMTE consists of two terms for measuring the voltage, the DVM and the precision resistor with the accuracy of the test pressure gauge for the input. Each uncertainty is calculated independently and combined using the SRSS technique to determine an overall value of SMTE.

The $SMTE_{guage}$ is based on the requirements of DIN 3 to be within ± 0.165 inches:

$SMTE_{guage}$ = ± (0.165 inches) / (200 inch span)

$SMTE_{guage}$ = ± 0.083% span

Voltage measurements of the transmitter output are taken with the HP 974A DVM which is determined by a percentage of the reading, top of the 5 Vdc scale, and number of counts in accordance with DIN 8:

$SMTE_{dvm} = \pm ((5\ V_{scale}) * 0.0005 + (0.002\ counts)) / (4\ Vdc\ span)$

$SMTE_{dvm} = \pm\ 0.113\%$ span

Voltage measurements utilize a precision resistor with an accuracy stipulated in DIN 3 as 0.01% percent. This is combined with the DVM accuracy to get an overall allowance for the DVM measurements.

$SMTE_{resistor} = \pm\ 0.01\%$

$SMTE_{DVM} = \pm\ (SMTE_{resistor}^2 + SMTE_{dvm}^2)^{1/2}$

$SMTE_{DVM} = \pm\ (0.010\%^2 + 0.113\%^2)^{1/2}$

$SMTE_{DVM} = \pm\ 0.113\%$ span

The total sensor M&TE is calculated by combining the accuracy and readability terms using the SRSS method as follows:

$SMTE = \pm\ (SMTE_{guage}^2 + SMTE_{DVM}^2)^{1/2}$

$SMTE = \pm\ (0.083\%^2 + 0.113\%^2)^{1/2}$

$SMTE = \pm\ 0.14\%$ span

Sensor Drift (SD) (DIN 6 & D.I.-1)

This is a random dependent uncertainty, which is typically combined in the SRSS equation with the M&TE term. Based on Design Input D.I. - 1, a drift allowance of ± 0.1% of the operating range upper limit has been determined to be applicable for this analysis for a 15 month conservative drift value.

$SD = \pm\ (0.001 * (750\ inches)) / (200\ inch\ span)$

$SD = \pm\ 0.375\%$ span

Sensor Temperature Effect (STE) (DIN 6, D.I.-2, & D. I.-3)

This effect is random and independent of other terms, and is included in the SRSS independent of the other terms. The temperature effect, the change in temperature from calibration conditions, is calculated for both a 20°F and a 50°F temperature change. The effect defined in DIN 6 represents a 100°F change, therefore each of the two temperatures of interest, 20 and 50°F will be determined by the percentage of the 100°F value for each temperature. From DIN 6 the equation for determining the temperature effect is:

± (0.75% upper range limit + 0.5% span) per 100°F ambient temperature change

Therefore, calculating the effect for 20°F and 50°F:

$STE_{20°F} = \pm\ (((750\ inches * 0.75\%P) + (200\ inches * 0.5\%)) / (100°F / 5)) / (200\ inch\ span)$

$STE_{20°F} = \pm\ 0.663\%$ span

$STE_{50°F}$ = ± (((750 inches * 0.75%P) + (200 inches * 0.5%)) / (100°F / 2)) / (200 inch span)

$STE_{50°F}$ = ± 1.656% span

Sensor Pressure Effect (SPE) (DIN 6)

This effect is random and independent of other terms, and typically is included in the SRSS independent of the other terms. This term is applicable to d/p transmitters and is based on the process pressure per 1000 psi. During refueling the pressure of the RCS is essentially atmospheric and essentially static with no RCPs in service, therefore there is no allowance necessary as draining and filling operations has no significant increase in the process pressure beyond ambient conditions when specified in terms of 1000 psi operating pressures.

SPE = ± 0.0 % span

Sensor Power Supply Effects (SPSE) (DIN 6)

This effect is random and independent of other terms, and typically is included in the SRSS independent of the other terms. Based on the manufacturer's information the effect is less than 0.005% of output span/volt. Since the output is 5 Vdc on the 1 – 5 Vdc span of 4 Vdc, the larger value of 5 Vdc is used to calculate the effect.

SPSE = ± (5 Vdc * 0.005%) / 4

SPSE = ± 0.006% span

Seismic Effect (SE) (DIN 6 & D.I.-10)

This effect is random and independent of other terms, and is normally included in the SRSS independent of the other terms. Based on the discussion contained in D. I.-10, the effect in zero and not used in the calculation.

SE = ± 0.0% span

Radiation Effect (EA) (DIN 6 & D.I.-9)

This Environmental Allowance (EA) effect is due to accident conditions, the containment rad monitors are continuously monitored during refueling operations and the error associated with the transmitter, reported in 55 megarad range is not applicable and not used in the calculations.

EA = + 0.0% span

Load Effects (EA) (DIN 6 & D.I.-8)

Per the manufacturer's specifications in DIN 6 , there are no load effects to consider, therefore this term is determined to be zero and not used in the calculation.

LE = ± 0.0% span

Overpressure Effects (OP) (DIN 6 & D.I.-7)

The overpressure effects defined in DIN 6 are applicable to the process over pressurization of the instrument. Since the instrument is calculation during refueling and removed prior to operation, this transmitter is never exposed to, or have the capability of being over pressurized. Therefore this term is determined to be zero and not used in the calculation.

OP = ± 0.0% span

Post DBE Operation (DBE) (DIN 6 & D.I.-6)

The Design Basis Event effects for the transmitter are determined to be zero and not used in the calculation based on the use as a refueling only instrument, therefore this effect is not used in the calculation.

DBE = + 0.0% span

Chemical Spray Effects (CE) (DIN 6 & D.I.-5)

The instrument loop is not utilized during plant operations, and is used only during refueling operations, for the purpose of this calculation and based on D.I-5 the chemical spray allowance is determined to be zero and not used in the calculation.

CE = + 0.0% span

Steam Temperature and Pressure (STP) (DIN 6 & D.I.-4)

Use of the instrument loop is during refueling activities, therefore the ability for the reactor to produce steam is limited to boiling of uncontained RCS inventory, and therefore the pressure is below that worth considering any effects for, as increased pressure would require the entire containment to be pressurized. This will not occur to any significant value that would impact the accuracy of the transmitter. As for temperature effects, those are considered in the temperature effects defined above for the 20 and 50°F considerations, where 50°F temperature rise may be postulated by the boiling of the RCS inventory. This term is not included in this calculation.

INDICATOR INFORMATION

FLOC Number	BV-LI-1RC-481C	DIN 3
Manufacturer	Dixson	DIN 3
Model #	BB101	DIN 3
Calibrated Span	14 – 214 inches	DIN 3
Location	Unit 1 Main Control Room Vertical Board Section C	DIN 19

Indicator Calibration Tolerance (ICA) (DIN 3)

This is a random dependent uncertainty, which is combined in the SRSS equation with the M&TE term. The calibration accuracy is specified in the calibration procedure as ± 0.2 inches on a 200 inch span.

ICA = ± (0.2 inches) / (200 inches)

ICA = ± 0.1% span

Indicator Reference Accuracy (IRA) (DINs 5 & 7)

The indicator is a Dixson BB101 model digital indicator. The manufacturer's specifications include effects for linearity, zero stability, gain stability, resolution, and accuracy. Each reference accuracy individual term is defined or developed below and consolidated by a square root sum of the squares approach for one IRA term. The highest reading, 5 Vdc is used for the 5 Vdc scale, as the largest effects are determined at the highest Vdc.

$IRA_{linearity} = \pm ((0.02\% * \text{Full Scale})^2 + (1\ \text{count})^2)^{1/2}$

$IRA_{linearity} = \pm ((0.02\% * 5\ \text{Vdc})^2 + (0.001)^2)^{1/2} / 4\ \text{Vdc span}$

$IRA_{linearity} = \pm 0.035\%$ span

$IRA_{accuracy} = \pm ((0.05\% * \text{Full Scale})^2 + (1\ \text{count})^2)^{1/2}$

$IRA_{accuracy} = \pm ((0.05\% * 5\ \text{Vdc})^2 + (0.001)^2)^{1/2} / 4\ \text{Vdc span}$

$IRA_{accuracy} = \pm\ 0.067\%\ \text{span}$

$IRA_{Impedance} = \pm\ (0.05\% * 5\ \text{Vdc}) / 4\ \text{Vdc span}$

$IRA_{Impedance} = \pm\ 0.063\%\ \text{span}$

$IRA_{resolution} = \pm\ 0.01\% * 5\ \text{Vdc} / 4\ \text{Vdc span}$

$IRA_{resolution} = \pm\ 0.013\%\ \text{span}$

Individual IRA terms are consolidated by SRSS into one term.

$IRA = \pm\ (IRA_{linearity}{}^2 + IRA_{accuracy}{}^2 + IRA_{Impedance}{}^2 + IRA_{resolution}{}^2)^{1/2}$

$IRA = \pm\ (0.035\%^2 + 0.067\%^2 + 0.063\%^2 + 0.013\%^2)^{1/2}$

$IRA = \pm\ 0.099\%\ \text{span}$

Indicator Temperature Effects (ITE) (DIN 7, D.I.-2)

Temperature effects on the digital indicator are addressed through two terms, zero stability and gain stability addressed in degrees C. Since the temperature rise is being evaluated at 20°F for the containment, this is used as the nominal rise for the control room given a controlled environment where the indicator is located, therefore an allowance for a 20°F change will be included here. The vendor equation is substituted with 11°C for the 20°F change. Since the indicator is located in the control room, there is no additional errors associated for the case where the transmitter is exposed to a 50°F change.

For the zero stability effect:

$ITE_{20zero} = \pm\ (0.0001 * 11°C) / 4Vdc\ \text{span}$

$ITE_{20zero} = \pm\ 0.028\%\ \text{span}$

For the gain stability effect:

$ITE_{20gain} = \pm\ (0.0002 * 11°C) / 4Vdc\ \text{span}$

$ITE_{20gain} = \pm\ 0.055\%\ \text{span}$

The resulting ITE terms are calculated for each temperature case.

$ITE_{20} = \pm\ (ITE_{20zero}{}^2 + ITE_{20gain}{}^2)^{1/2}$

$ITE_{20} = \pm\ (0.028\%^2 + 0.055\%^2)^{1/2}$

$ITE_{20} = \pm\ 0.061\%\ \text{span}$

Indicator Maintenance and Test Equipment (IMTE) (DIN 3 & 7)

Calibration of the indicator is performed by knowing the input voltage, measured via DVM and precision resistor, and reading the digital output. Three terms are combined via SRSS, the DVM, precision resistor, and the resolution, also included in the reference accuracy, in determining the calibration accuracy of the meter.

$IMTE = \pm (IMTE_{resistor}^2 + IMTE_{DVM}^2 + IMTE_{resolution}^2)^{1/2}$

Where: $IMTE_{resistor} = SMTE_{resistor}$,

$IMTE_{DVM} = SMTE_{DVM}$

IMTEresolution = IRAresolution

$IMTE = \pm (0.010\%^2 + 0.113\%^2 + 0.013\%^2)^{1/2}$

IMTE = ± 0.114% span

Indicator Drift (ID) (DIN 7)

Indicator drift is not defined in the vendor information, DIN 7. The vendor documentation does reference a zero and gain stability allowances. These have previously been incorporated into the temperature accuracy and are applicable to each of the two temperatures for evaluation, both 20 and 50°F. For the purpose of this calculation the indicator drift is determined to be zero and not repeated here as it is already included in the temperature effect terms. As the digital indicator is programmable, there is no additional associated specific drift allowance to be included here.

ID = ± 0.0% span

Channel Statistical Accuracy

This analysis will address uncertainties associated with the indication uncertainty for the 1RC- 481C instrument loop at 20°F and 50°F temperature swings from the calibration temperature.

1. Calculating the CSA for the 20°F ambient containment temperature change.

$CSA = \pm [(SCA + SMTE)^2 + (SPSE)^2 + (STE)^2 + (SD + SMTE)^2 + (SRA)^2 + (ICA + IMTE)^2 + (ITE)^2 + (IRA)^2]^{1/2}$

Substituting the values for the terms in percent span:

$CSA = \pm [(0.25 + 0.14)^2 + (0.006)^2 + (0.663)^2 + (0.375 + 0.14)^2 + (0.25)^2 + (0.1 + 0.114)^2 + (0.061)^2 + (0.099)^2]^{1/2}$

CSA = ± 0.989% span, or ± 1.98 inches

2. Calculating the CSA for the 50°F ambient containment temperature change.

$CSA = \pm [(SCA + SMTE)^2 + (SPSE)^2 + (STE)^2 + (SD + SMTE)^2 + (SRA)^2 + (ICA + IMTE)^2 + (ITE)^2 + (IRA)^2]^{1/2}$

Substituting the values for the terms in percent span:

$CSA = \pm [(0.25 + 0.14)^2 + (0.006)^2 + (1.656)^2 + (0.375 + 0.14)^2 + (0.25)^2 + (0.1 + 0.114)^2 + (0.061)^2 + (0.099)^2]^{1/2}$

CSA = ± 1.81% span, or ± 3.62 inches

MARGINS

For calculation of instrumentation setpoints, surveillance limits, and the resulting Margin the following equation applies:

Instrumentation Setpoint = Analytical Limit (AL) ± (CSA + Margin)

For indication uncertainties, there is no defined safety analysis limit as the definition for instrumentation setpoints is explicit to automatic actuation, i.e. comparator or automatic actions. The Emergency Action Limit for the current procedure is specified as indicated 16 inches or 2 inches above the bottom of the instrument span. This effectively would represent a margin of 0.02 inches if one were to calculate the indication as a setpoint automatic for automatic actions. Given the calculation for a 50°F temperature rise, the uncertainty is larger than the 2 inches to the bottom of the span. For an EAL to be acceptable given a 50°F temperature change, a setpoint above 18 inches is recommended.

CONCLUSION

The existing EAL indication action level is at 2 inches above the bottom of the instrument span which can be read on the digital indicator, BV-LI-1RC-481C, however the digital bar graph represents only the first LED. It should be noted that during calibration, the first point for calibration is the first LED or 2 inch input.

RESULTS / IMPACTS

Given that EAL is representative of the first LED at 2 inches, and the uncertainty for the indication for the digital readout is at 1.98 inches, it is recommended that consideration be given to increasing the indication action limit for the 20°F evaluated temperature rise.

Should the more conservative 50°F temperature rise be considered for the EAL, then the setpoint must be increased to a recommended value above 18 inches.