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April 26, 1983

PROPRIETARY
Attachment

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Ms. E. G. Adensam, Chief
Licensing Branch No. 4

Re: McGuire Nuclear Station
Docket No. 50-369

Dear Mr. Denton:

Please refer to our letter of March 14, 1983 concerning a proposed change to McGuire Unit 1 Technical Specifications to reduce the measurement uncertainty for Reactor Coolant System flow rate. It was requested that information which is proprietary to Westinghouse Electric Corporation be withheld from public disclosure. In support of that request, enclosed is one copy of Application for Withholding CAW-83-25 (Non-Proprietary) and the supporting affidavit. Also enclosed are two copies of the attachment to our March 14, 1983 letter -- one copy is proprietary and one copy is non-proprietary.

Very truly yours,

Hal B. Tucker

Hal B. Tucker

REH:jfw

cc: Mr. James P. O'Reilly, Regional Administrator
U. S. Nuclear Regulatory Commission
Region II
101 Marietta Street, NW, Suite 2900
Atlanta, Georgia 30303

Mr. W. T. Orders
NRC Resident Inspector
McGuire Nuclear Station

Add: Y. Hsii
T. Dunning } Prop + Non Prop

B021
Change: LPDR
NRC PDR
NTIS
NSIC } Non Prop. Version

8305050283 830426
PDR ADOCK 05000369
P PDR

Non-Proprietary Version of the
Attachment to the March 14, 1983
letter from H. B. Tucker to Harold R. Denton

1. *Question*

Table 2 of your submittal (letter H.B. Tucker to H.R. Denton, dated November 23, 1982) lists the uncertainty value for the feedwater Venturi flow coefficient (K) as 0.25%, which was obtained from Alden Research Laboratory Standard accuracy. (a) What is the range of flow Reynolds number tested in the laboratory calibration? (b) Is the Reynolds number of the McGuire feedwater flow within the range of laboratory calibration? (c) Does the 0.25% uncertainty also include the Venturi installation allowance? (d) What is the drift affect of the Venturi fouling? Provide a detailed component breakdown and justification of each component uncertainty associated with the overall uncertainty of the Venturi flow coefficient.

Response

(a) The range of flow pipe Reynolds numbers tested in the Alden Research Laboratory calibration was 800,000-3,350,000.

(b) The McGuire feedwater flow pipe Reynolds number is 14,400,000. However, ASME and other references indicate that the Venturi flow coefficient is constant and independent of Reynolds number above 300,000.

(c) No, the 0.25% flow coefficient (K) does not include an installation allowance. The entire flow element was calibrated as a unit including 6.5 diameters of straight pipe upstream from the Venturi entrance. This length of straight pipe is greater than that recommended by ASME for a Venturi flowmeter.

(d) Conceivably fouling could occur such that crud accumulation could affect the static pressure distribution at the Venturi throat pressure taps in a manner that would result in a higher flow for a specified ΔP, however, the reduction in throat area resulting in a lower flow at the specified ΔP is a stronger effect. If fouling occurs and is undetected it would result in an error in a nonconservative direction in precision calorimetric RCS flow measurement. Fouling has a bias effect not a drift effect since it shifts the flow measurement and does not increase the random error. If Venturi fouling is detected, the Venturi will be cleaned prior to the precision heat balance measurement. Fouling has never been a problem in the Duke Power system (Fossil or Nuclear); the use of All-Volatile Chemistry precludes the build-up of crud, which is associated with Trisodiumphosphate water chemistry.

Detailed component breakdown of the Venturi flow coefficient uncertainty is provided in Attachment 1.

2. *Question*

Table 2 lists the feedwater temperature and secondary side pressure measurement uncertainties of ±0.5°F and ±5 psi, respectively. Provide a detailed breakdown of components and uncertainty value of each component (with justification) associated with feedwater temperature and pressure measurements such as RTD calibration, transmitter calibration, drift, and precision register, convertor and computer accuracy, etc.

Response

The component used to measure feedwater temperature during the precision heat balance is a calibrated continuous lead type J thermocouple with an icebath reference junction. The feedwater thermocouple EMF is measured by a L and N-914 Numatron 0-40 mv range. A breakdown of the components follows:

Thermocouple Calibration	± .25°F
Readout Calibration	± .03°F

Standards Lab Calibration Uncertainty-(USL);

$$USL = \sqrt{\Sigma e^2} - \sqrt{(0.25)^2 + (.03)^2} = \pm 0.25°F$$

Additional conservatism is added to this measurement uncertainty.

$$2 \times USL = 2 \times 0.25°F = \underline{\underline{0.5°F}}$$

The component used to measure feedwater pressure during the precision heat balance is a 0-2000 psig bourdon tube gauge with an accuracy of ±0.25% of span.

$$\pm 0.25\% \times 2000 \text{ psig} = \underline{\underline{\pm 5 \text{ psig}}}$$

Neither feedwater temperature nor pressure is measured by the computer during the precision heat balance, both are measured using test instruments.

3. *Question*

Table 2 also lists the RTD calibration and DVM accuracy errors for the cold leg and hot leg temperature measurements. What are the uncertainties for the transmitter calibration, drift, resister and computer?

Response

Hot and cold leg temperature measurements are obtained during the precision heat balance RCS flow measurement by a Digital Ohmmeter, (Fluke-8375A Digital Ohmeter ±0.002% + 1 digit). Using a Digital Ohmmeter attached directly to the RTD leads eliminates the drift due to the process racks, since all process instrumentation is removed from the instrument train.

4. *Question*

Provide justification for assigning ±1.2°F (Table 2) for the hot leg temperature streaming error.

Response

A process measurement error has been incorporated into the reactor coolant system calorimetric flow measurement uncertainty to account for the steady-state temperature gradient in the hot leg, caused by incomplete mixing of the coolant flowing out of different regions of the core at different temperatures. Measurements obtained at a Westinghouse three loop plant established hot leg temperature gradients of [$]^{+a,c}$ in one loop and [$]^{+a,c}$ in another loop while at full power. To offset the effect of this temperature gradient, the hot leg temperature on subsequent plants (including McGuire 1) is measured on a bypass loop connected to the hot leg at three locations around the pipe circumference as shown on Figure 1. Each connection is provided with a probe, or scoop, which samples the coolant over a distance of 7 inches into the 29 inch inside diameter of the pipe With this arrangement, the potential for a difference between actual average hot leg temperature and measured temperature is minimized.

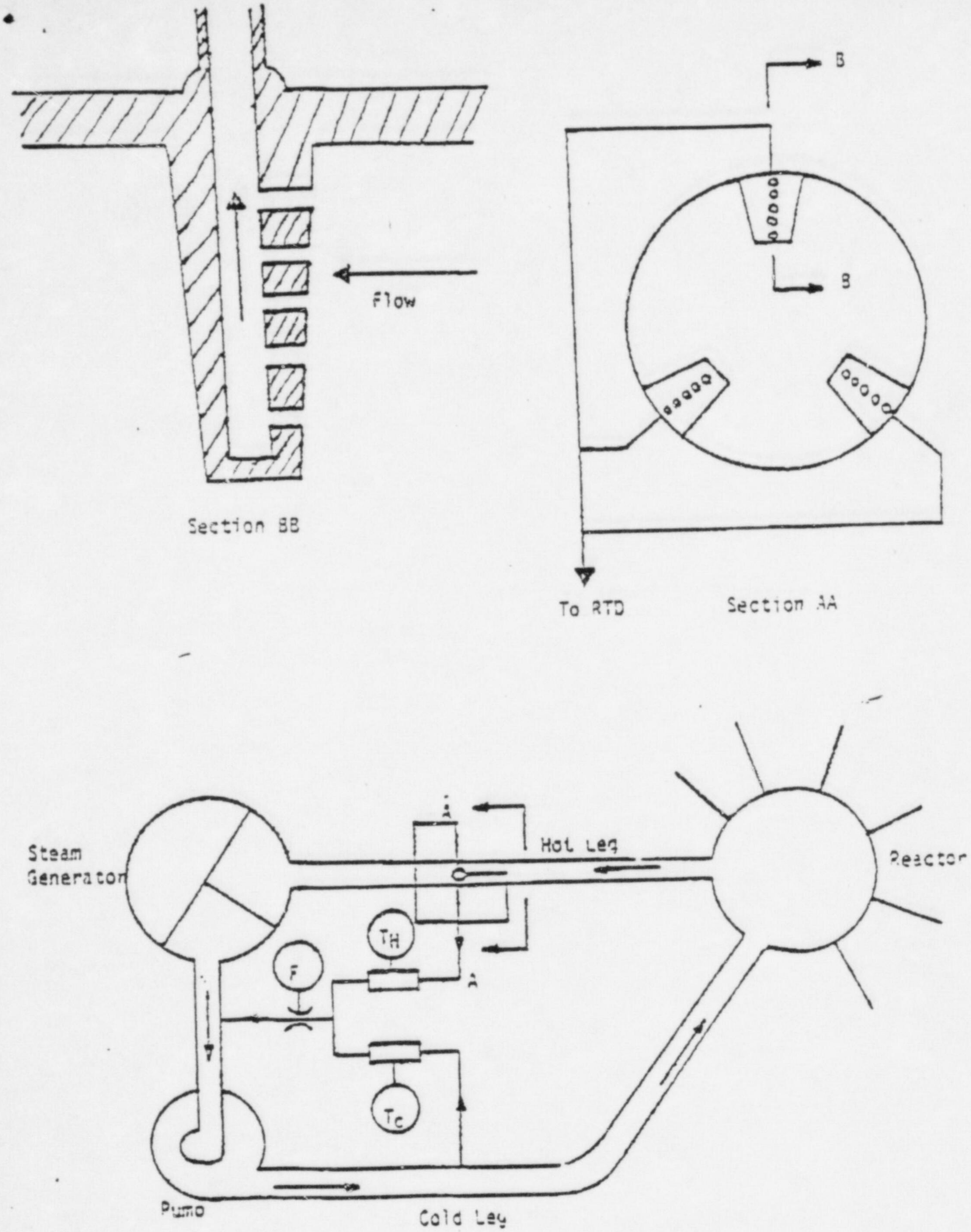

Figure 1 RTD Bypass Loop Scoop Arrangement for Measurement of Hot Leg Temperature

Two factors are considered in the analyses of the measurement error: the temperature distributions that could be present at the scoops, and the deviation from balanced sample flows into the three scoops. With perfectly balanced sample flows, an evaluation of several possible hot leg temperature distributions has shown that the scoops will limit the measurement error to less than [ ]$^{+a,c}$ of the temperature gradient (i.e., [ ]$^{+a,c}$ for a maximum gradient of [ ]$^{+a,c}$. With a conservative sample flow imbalance (50% flow in 1 scoop, 25% flow in 2 scoops) the evaluation has shown that the scoops will limit the measurement error to less than [ ]$^{+a,c}$ of the temperature gradient.

Calculations of the scoop branch line flow imbalances for several plants has shown that the estimated flows in most cases will range between perfectly balanced and a distribution of 40%-30%-30% resulting in smaller errors. In most plants with calculated flow imbalances, the upper scoop is expected to have the highest flow. When the results of the three loop plant test are considered (top of hot leg was hotter than the bottom), the measured hot leg temperature is more likely to be hotter than the average hot leg temperature, leading to a conservatively low calorimetric flow measurement. Since there are uncertainties in the temperature streaming distributions and magnitudes, the allowance for the temperature streaming measurement uncertainty has been set conservatively at [ ]$^{+a,c}$ regardless of the scoop flow distribution.

For McGuire Unit 1 the analysis of the scoop branch lines has shown that the flows should be reasonably balanced. Therefore, the [ ]$^{+a,c}$ allowance for temperature streaming is additionally conservative.

5. *Question*

Tables 3 and 4 list the uncertainty of each parameter for the OAC and DVM elbow tap RCS flow measurements in terms of percentage of RCS flow uncertainty. (a) Provide the uncertainty value (with justification) in terms of the percentage of measurement span of each component and the effect factor of each component to the RCS flow. (b) Provide justification for assigning 0 value on the sensor calibration uncertainty, sensor pressure and temperature effect, and rack temperature effect.

Response

(a) Process Measurement Accuracy (PMA) - A [ ]$^{+a,c}$ uncertainty for the RCS temperature has been assessed for the Automatic Rod Control. The Automatic Rod Controller is placed in manual during the precision heat balance when the elbow tap instrumentation is normalized and held within a very tight tolerance to keep RCS temperature steady. When the unit is returned to process control, the cold leg temperature may fluctuate by [ ]$^{+a,c}$. This affects the density of the water in the elbow meter, thus the flow measurement by the elbow tap instrumentation. The simplified equation for the elbow flow meter is:

$$We = K\sqrt{\Delta P/\rho}$$

The term $\sqrt{1/\rho}$ was evaluated for the ranges of T = 550 ± [ ]$^{+a,c}$, P = 2200 and P = 2200 ± [ ]$^{+a,c}$, T = 550°F. The temperature and pressure fluctuation in this range have a [ ]$^{+a,c}$ and [ ]$^{+a,c}$ effect on flow. The overall effect of the process control is:

$$\left[\qquad \right]^{+a,c}$$

Process Measurement Accuracy, PMA, has been assessed to be [ ]$^{+a,c}$

[ ]$^{+a,c}$

Process Measurement Accuracy (PMA)
Primary Element Accuracy (PEA)
Sensor Drift (SD)
Rack Calibration Accuracy (RCA)
Rack Drift (RD)
Isolator Drift (ID)
Analog to Digital Conversion (A/O)
Readout (RO)

These component uncertainties are standard Westinghouse numbers for the process instrumentation. These have previously been reviewed and approved by the NRC. Refer to: NUREG-0717 Supplement No. 4, Safety Evaluation Report related to the operation of Virgil C. Summer Nuclear Station, Unit No. 1 Docket 50-395, August, 1982.

(b) Sensor Calibration Accuracy (SCA) - The precision heat balance and flow normalization will be used to determine the elbow flowmeter coefficient. The standard transmitter calibration will initially set the transmitter output within an acceptable tolerance for the precision heat balance. The precision heat balance will then normalize the transmitter output which will be used for surveillance during the fuel cycle.

Sensor pressure and temperature effects account for any shifts that may occur due to changes in static pressure on the ΔP cell and ambient temperature respectively. The precision heat balance will be performed while the elbow tap flow transmitter is at its normal operating temperature and pressure. Sensor Temperature Effects (STE) or Sensor Pressure Effects (SPE) do not need to be assessed since the transmitter normalization is performed at normal operating conditions.

The process control racks at McGuire are located in the control room environment which has a FSAR Design Criteria temperature limit of 75±5°F. Therefore, no widely varying temperature effects exist to affect the process racks.

Effect Factors will be quantified in the response to Question 6.

6. *Question*

Quantify the value of the effect factor of the RCS flow uncertainty with respect to each parameter uncertainty listed in Table 2 as well as Tables 3 and 4 required in the question 5.

Response

The effect factors listed in Table 2 were determined by incrementing each parameter required in the analysis within the computer program which is used to arrive at the RCS flow value. This method of computer iteration returns a more conservative value than the Westinghouse ITDP analysis since it arrives at an integrated value for flow changes.

The effect factors in Tables 3 and 4 are derived from converting %ΔP span to % flow for the elbow flowmeter transmitters. Refer to Attachment 2.

7. *Question*

The root sum square (RSS) technique of combining the uncertainties requires that each uncertainty contribution be independent. If they are not independent, their combined effect should be assessed through deterministic method. There are some uncertainty contributions in Table 2 which are not independent. For example, the Venturi thermal expansion factor (Fa)-feedwater density (ρ_f) and enthalpy (h_f) are all dependent upon the feedwater temperature: the feedwater density and steam enthalpy (h_s) are both dependent on steam generator pressure. There may be other non-independent parameters. Justify your use of the RSS technique to combine the uncertainties of these parameters.

Response

Technically, the feedwater temperature and pressure uncertainties are common to several of the error components. However, they are treated as independent quantitites because of the conservatism assumed in the components. The arithmetic summation of their uncertainties has no significant effect on the final result. Treating the error components of the Secondary Side Loop Power Uncertainty as dependent and summing all of the error components, Usec = $[\quad]^{+a,c}$. Combining this with the Total Primary Δh Uncertainty, UΔh prim = $[\quad]^{+a,c}$ the Primary Side Loop Flow Uncertainty equals:

$$U \text{ primary loop flow} = \sqrt{(Usec)^2 + (U\,\Delta h \text{ prim})^2} = [\qquad]^{+a,c}$$

$$U \text{ total primary flow} = \sqrt{\frac{(Usec)^2 + (U\Delta h \text{ prim})^2}{4}} = [\qquad]^{+a,c}$$

There are no other dependent parameters in the analysis.

8. *Question*

For each component associated with the measured parameter, what is the nature of error, i.e., random or biased? What is the error distribution function, i.e., normal or uniform?

Response

Random error is associated with the measured parameters.
The error distribution function is normal.

9. *Question*

Does the total RCS uncertainty value derived in Table 5 represent a 95% probability at 95% confidence value? If so, can the implicit assumption that each uncertainty value be at its 2σ (standard deviation) limit be justified?

Response

The value derived in Table 5 represents a normal, two-sided 95+% probability distribution. All instrument and measurement uncertainties are consistent with or conservative with respect to the Westinghouse ITDP analysis. The probability justification is contained in Attachment 3.

ATTACHMENT 1

Component Breakdown of the Venturi Flow Coefficient

SUBSTANTIATION OF THE ACCURACY OF THE CALIBRATION
AT ALDEN RESEARCH LABORATORIES
USING 100,000-POUND WEIGHING TANK - FOR 14", 16" AND 18" TUBES

ITEM NO.	ITEM	BASIC DATA	ACCURACY % ON "C"		LEGIBILITY % ON "C"	
			%	$(\%)^2$	%	$(\%)^2$
1	Weighing Tank	Error on 80,000-lb is 15 lb, scale is marked in 10-lb. increments	0.0190	0.0004		
		Error on interpolation at 80,000 lb. (± 2 lb)			0.0025	0.0000063
2	Time	Electric Timer	0.0080	0.000064		
		Assuming 50 sec. run with millisecond read as digit.			0.0020	0.0000040
3	Manometer Scale and Reading	Scale graduated in 0.01 ft. assuming 0.01 ft. reading reading error (including error on scale) and minimum 30 manometer readings the following typical errors should be considered:				
		At 0.5 ft. differential	0.1177	0.0138533	0.1177	0.0138533
		" 1.0 ft. "	0.05885	0.0034633	0.05885	0.0034633
		" 2.0 ft. "	0.02942	0.0008655	0.02942	0.0008655
		" 4.0 ft. "	0.01471	0.0002164	0.01471	0.0002164

SUBSTANTIATION OF THE ACCURACY OF THE CALIBRATION
AT ALDEN RESEARCH LABORATORIES
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ITEM NO	ITEM	BASIC DATA	ACCURACY % ON "C"		LEGIBILITY % ON "C"	
			%	$(\%)^2$	%	$(\%)^2$
4/A	Fluctuation Effect on Manometer	Assuming 30 manometer readings and max. peak to peak amplitude of:				
		1% of differential	0.0300	0.0009	0.0300	0.0009
		2% " "	0.0590	0.0035	0.0590	0.0035
		4% " "	0.1180	0.0139	0.1180	0.0139
		With 99% confidence limit.				
4/B	Fluctuation Effect On Manometer	Assuming fifteen manometer readings and max. peak to peak amplitude of:				
		1% of differential	0.0498	0.00248	0.0498	0.00248
		2% " "	0.09954	0.00991	0.9954	0.00991
		4% " "	0.19908	0.03963	0.19908	0.03963
		With 99% confidence limit.				

SUBSTANTIATION OF THE ACCURACY OF THE CALIBRATION AT ALDEN RESEARCH LABORATORIES USING 100,000-POUND WEIGHING TANK - FOR 14", 16" and 18" TUBES

ITEM NO.	ITEM	BASIC DATA	ACCURACY % ON "C" %	ACCURACY % ON "C" $(\%)^2$	LEGIBILITY % ON "C" %	LEGIBILITY % ON "C" $(\%)^2$
5	Chuting	At every run full tank shall be collected	0.03	0.0009	-	-
6	Specific Wgt. Of Water and Mercury	Three parts per 10,000	0.015	0.0023	-	-
7	Thermometer	Accuracy is 0.1F Graduation 0.5F	0.029	0.0000084	0.0024	0.0000057
8	Effect of Piping	70 ft. Useful length is available which represents -				

D	Lgth in Dia.	Piping, Dia. Upstream	Accuracy %	Accuracy $(\%)^2$	Legibility %	Legibility $(\%)^2$
12.125	59 - 6*dia.	63	0	0	0	0
12.50	67 - 6* "	61	0	0	0	0
15.016	56 - 6* "	50	0	0	0	0
16.126	52 - 6* "	46	0	0	0	0

* 6 Dia. laying length of tube and downstream piping

SUBSTANTIATION OF THE ACCURACY OF THE CALIBRATION
AT ALDEN RESEARCH LABORATORIES
USING 100,000-POUND WEIGHING TANK - FOR 14", 16" AND 18" TUBES

ITEM NO.	ITEM	BASIC DATA	ACCURACY % ON "C" %	ACCURACY % ON "C" $(\%)^2$	LEGIBILITY % ON "C" %	LEGIBILITY % ON "C" $(\%)^2$
		SUMMARY FOR WORST CONDITION				
1	Tank		0.0190	0.0004	0.0025	0.0000063
2	Time		0.0080	0.000064	0.0020	0.00004
3	Manometer Scale Read.		0.1177	0.0138533	0.1177	0.0138533
4/A 4/B	Fluctuation of Manom.		0.1991	0.03963	0.1991	0.03963
5	Chuting		0.0300	0.0009	-	-
6	Specific Wgt. of W. and Hg.		0.0150	0.00023	-	-
7	Thermometer		0.0029	0.0000084	0.0024	0.0000057
8	Piping		0	0	0	0
		TOTAL	0.3910	0.055086	0.3237	0.53499
		RSS	-	0.2347	-	0.2313

% Accuracy		% Precision
0.3910	= 4 × σ	= 0.3237
0.0978	= 1 × σ	= 0.0809
0.1955	= 2 × σ	= 0.1619
0.2932	= 3 × σ	= 0.2427

SUBSTANTIATION OF THE ACCURACY OF THE CALIBRATION
AT ALDEN RESEARCH LABORATORIES
USING 100,000-POUND WEIGHING TANK - FOR 14", 16" AND 18" TUBES

ITEM NO.	ITEM	BASIC DATA	ACCURACY % ON "C"		LEGIBILITY % ON "C"	
			%	(%)²	%	(%)²
		SUMMARY FOR BEST CONDITION				
1	Tank		0.0190	0.0004	0.0025	0.0000063
2	Time		0.0080	0.000064	0.0020	0.000004
3	Manometer Scale Read.		0.01471	0.0002164	0.01471	0.0002164
4/A 4/B	Fluctuation of Manom.		0.0300	0.0009	0.0300	0.0009
5	Chuting		0.0300	0.0009	-	-
6	Specific Wgt. of W. and H_g		0.015	0.00023	-	-
7	Thermometer		0.0029	0.0000084	0.0024	0.0000057
8	Piping		0	0	0	0
		TOTAL	0.1196	0.002719	0.0516	0.001132
		RSS	-	0.0521	-	0.0337

% Accuracy		% Precision
0.1196	= 4 × σ =	0.0516
0.0299	= 1 × σ =	0.0129
0.0598	= 2 × σ =	0.0258
0.0897	= 3 × σ =	0.0387

2.00 Substantiation of the accuracy

On this subject are calculations CALC-322/B - pages 1 through 5.

2.01. Pages 1 through 3 are listing the sources of "inaccuracy" and "imprecision" indicating % and $(\%)^2$ values to facilitate further calculations and to give insight of how the accuracy statement is influenced by different calibration components.

2.02 Pages 4 and 5 are summaries indicating worst and best conditions as picked from extremes listed on pages 1 through 3.

2.03 The error effect of fluctuating differential was considered in the following manner:

Half of the max. amplitude (peak to peak) is equal to plus or minus <u>largest error</u> <u>on differential</u>.

Half of this largest differential error equals to the plus or minus largest coefficient error (due to square root relation.)

This plus or minus largest coefficient error equals to 4 x Sigma (σ).

99% confidence limit:

$$\pm \frac{2.585\,\sigma}{\sqrt{N}}$$

N = number of differential readings

Sample calculation for 4% peak to peak amplitude:

$$\text{Max. error on diff.} = \frac{4}{2} = \pm 2\%$$

$$\text{" " "C"} = \frac{2}{2} = \pm 1\%$$

$$\sigma = \frac{1}{4} = \pm 0.25\%$$

99% confidence limit.

$$\pm \frac{2.58 \times 0.25}{\sqrt{30}} = \pm 0.118\%$$

Meaning that 99% of the average differentials established in this manner shall be within ±0.236% (2 x 0.118 due to square root relation) of the true one corresponding to the flow rate at which they were taken.

2.04 Page 4 indicates a largest possible error level of ±0.391% as well as it shows that -

99.7% of all "Cs" taken under such condition should fall within ±0.2932% (3σ) of their true value and

95.45% should fall within ±0.1955% (2σ).

2.05 Page 5 indicates a best possible largest error level of ±0.1196% as well as it shows that under these circumstances -

99.7% of all "Cs" should fall within ±0.0897% (3σ) of their true value and

95.45% shall fall within ±0.0598% (2σ).

2.06 Assuming 12 "Cs" (whose mean shall be the final "C" the 99% confidence level for this final "C" shall be

At Worst Condition

$\sigma = 0.0978$
$V = 12-1 = 11$
$N = 12$

$t_{.995} = 3.11$

$$t_{.995} \times \frac{\sigma}{\sqrt{N-1}} = \pm 3.11 \frac{0.0978}{\sqrt{11}} = \pm 0.0917\%$$

Meaning that 99% of the final "Cs" established in this manner should fall within ±0.0917% of the true value.

At Best Condition

$\sigma = 0.0299$
$V = 12 - 1 = 11$
$N = 12$

$t_{.995} = 3.11$

$$t_{.995} \times \frac{\sigma}{\sqrt{N-1}} = \pm \frac{3.11 \times 0.0299}{\sqrt{12-1}} = 0.0280\%$$

Meaning that 99% of the final "Cs" established in this manner should fall within ±0.0280% of the true value.

2.07 Based on the calculations and considerations presented above, the following questions should be answered.

2.071. According to what rule should bad calibration points be discarded.

2.072. How should they be replaced.

2.073. How many of those can be rerun without re-examining the calibration procedure.

2.071. Points in the constant region of the coefficient shall be considered "bad" if they fall further than ±0.2% of the mean coefficient value.

2.072. Bad points should be replaced by two new points taken at about the same R_D.

2.073. If more than two "bad" points should occur at the calibration of any meter, the calibration procedure should be thoroughly analyzed to reveal the cause of the error and the calibration should be repeated.

ATTACHMENT 2

%ΔP expressed in % Flow

TABLE 3-30

ΔP MEASUREMENTS EXPRESSED IN FLOW UNITS

The ΔP accuracy expressed as percent of span of the transmitter applies throughout the measured span, i.e., ±1.5% of 100 inches ΔP = ± 1.5 inches anywhere in the span. Because $F^2 = f(\Delta P)$ the same cannot be said for flow accuracies. When it is more convenient to express the accuracy of a transmitter in flow terms, the following method is used:

+a,c

$^{+a,c}$

Equation 3-30.8 is used to express errors in percent full span in this document.

Effect Factors listed in Tables 3 and 4.

[ ]$^{+a,c}$

ATTACHMENT 3

Probability Justification

IV. PROBABILITY JUSTIFICATION

As noted in Section III, it is Westinghouse's belief that the total uncertainty for Pressurizer Pressure, T_{avg}, Reactor Power, and RCS Flow are normal, two sided, 95+% probability distributions. This section will substantiate that position with a comparison between three approaches, the first being that noted in Section II, the second involves determination of the variance assuming a uniform probability distribution for each uncertainty and then determination of the 95% probability value assuming a one sided normal distribution, and the third involves determination of the variance assuming a normal, two sided probability distribution for each uncertainty and then determination of the 95% probability value assuming a two sided normal distribution.

Table 7b lists the results of the three approaches. Column 1 lists the values noted for CSA on Table 1b which are determined through the use of equations 1, 2, or 3, whichever is applicable to that particular function. Column 2 lists the variance for each function assuming the uncertainty for each of the parameters listed in Section 2 is a uniform probability distribution. For this assumption,

$$\sigma^2 = \frac{R^2}{12}$$ Eq. 9

where R equals the range of the parameter. The variance for the function equals the arithmetic sum of the parameter variances. From a safety point of view deviation in the direction of non-conservatism is important. Therefore, Column 3 lists the one sided 95% probability values based on the variances provided in Column 2, i.e., the one sided 95% probability value for a near normal distribution can be reasonably approximated by: $1.645\sqrt{\sigma^2}$.

Column 4 lists the variance for each function assuming the uncertainty for each of the parameters listed in Section 2 is a near normal, two sided probability distribution. Efforts have been made to conservatively determine the probability value for each of the parameters, see Table 8. For example, [SCA is noted on Table 8 as having a probability of 99%, i.e., Westinghouse has determined that SCA will have a value of 0.5% span or less 99% of the time. This is known to be conservative in that a sensor/transmitter must be calibrated to within ± 0.5% span or the calibration is rejected. Thus, in reality SCA has a probability value of 100% but for this analysis 99% was assumed.]$^{+a,c}$ The corresponding Z value listed on Table 8 is from the standard normal curve where:

$$Z = (x - \mu)/\sigma$$ Eq. 10

The variance for a parameter is then the square of the uncertainty divided by its Z value:

$$\sigma^2 = \left(\frac{\text{uncertainty}}{Z}\right)^2$$ Eq. 11

The variance for the function equals the arithmetic sum of the parameter variances. From the variance the two sided 95% probability value for a normal distribution can be calculated: $1.96\sqrt{\sigma^2}$.

To summarize; Column 1 is the results of Equations 1, 2, and 3. Column 2 is the total variance assuming uniform probabilty distributions, i.e.,

$$\sigma^2 = \frac{R_1^{\,2} + R_2^{\,2} + \ldots}{12} = \frac{(2\ \mathrm{unc}_1)^2 + (2\ \mathrm{unc}_2)^2 + \ldots}{12} \qquad \text{Eq. 12}$$

Column 3 is $1.645\sqrt{\sigma^2}$.

Column 4 is the total variance assuming near normal probability distributions, i.e.,

$$\sigma^2 = \left(\frac{\mathrm{unc}_1}{Z_1}\right)^2 + \left(\frac{\mathrm{unc}_2}{Z_2}\right)^2 + \ldots \qquad \text{Eq. 13}$$

Column 5 is $1.96\sqrt{\sigma^2}$.

A comparison of Columns 1, 3, and 5 will show that the approach used in Section 2 results in values more conservative than those of Columns 3 and 5. Thus, it can be concluded that the results presented in Section 3 are total uncertainties with probabilities in excess of 95%.

Confidence limits are applicable only to a particular data set, which in this case not available. Therefore, based on the relatively small number of reports indicating large values of deviation, i.e., the number of instances where a channel fails a functional test is very small as compared to the many thousands of functional tests performed, Westinghouse believes that the total uncertainties presented on Table 1b are 95% probability values at a high confidence level.

V. CONCLUSIONS

The preceding sections provide what is believed to be a reasonable means of accounting for instrument and measurement errors for four parameters used in the ITDP analysis. The assumptions used in this response are generic and conservative. It is the intent of this response to generically resolve any concerns with the measurement and control of Reactor Power, RCS Flow, Pressurizer Pressure and T_{avg} as they are applied to ITDP. As such, plant specific responses will provide only that information which indicates that, 1) the instrument and measurement uncertainties for that plant are consistent with or conservative with respect to those presented here, or 2) specific instrument and/or measurement uncertainties for that plant are not consistent with those presented. In the second case the impact of the inconsistency on the four parameters will be provided with corresponding new total uncertainties if the impact is sufficiently large.

TABLE 7b

COMPARISON OF STATISTICAL METHODS

+a,c

	1 Method 1	2 Variance Method 2	3 95% Probability Method 2	4 Variance Method 3	5 95% Probability Method 3
Pressurizer Pressure - Control					
T_{avg} - Control					
Steamline Pressure - Computer					
Feedwater Temperature - Computer					
Feedwater Pressure - Computer					
Feedwater Δp - Computer					
Pressurizer Pressure - DVM					
Steamline Pressure - DVM					
Feedwater Temperature - DVM					
T_H - DVM					
T_C - DVM					

Notes for Table 7b

1. Uncertainties presented in columns 1, 3, and 5 are in % span.
2. While values noted are listed to the second decimal place, values are accurate only to the first decimal place. Second place is noted for round-off purposes only.

TABLE 8

UNCERTAINTY PROBABILITIES

	Two Sided Normal Probability (%)	Two Sided Normal, Z Value
PMA		
PEA		
SCA		
SD		
STE		
SPE		
RCA		
RD		
RTE		
DVM		
ID		
A/D		
CA		

+a,c