Attachment 2

13-JC-RJ-0205

Core Operating Limit Supervisory System (COLSS) and Core Protection Calculator (CPC) Measurement Channel Uncertainties, Revision 7

NUCLEAR GENERATING STATION	Calculation	Calculation Number 13-JC-RJ-0205	Rev. 7
	Quality Class: Q [X] QAG [ ] NQR [ ]	Pages Affected by Revision: 9-12, 21-29	

Title

Core Operating Limit Supervisory System (COLSS) and Core Protection Calculator (CPC) Measurement Channel Uncertainties

Initiating Document(s)	Pending Plant Modifications
CRDR 9-6-0493 EDC 98-00358 Rev. C EDC 99-00278 Rev. A	DMWO 00746729 DMWO 00841399

This revision incorporated information for new loop components, in support of the Digital Feedwater Control System (DFWCS) upgrade project per EDC 98-00358 Rev. C.

Verified that changes made via EDC 99-00278 Rev. A were incorporated in 13-JC-RJ-0205 Rev. 6.

This revision also updated information from various input calculations due to the impact of CRDR 9-6-0493, which addressed environmental temperature effects on M&TE. The following input calculations updates are captured in this revision:
13-JC-MT-0200 (Rev. 1), 13-JC-RC-0210 (Rev. 3), 13-JC-RC-0211 (Rev. 7), 13-JC-RC-0212 (Rev. 5), 13-JC-SG-0208 (Rev. 5), 13-JC-SG-0209 (Rev. 8), 13-JC-SG-0216 (Rev. 2), 13-JC-SG-0217 (Rev. 3).

Transition: Incorporated Addendum A, which is a Transition portion of this Calculation. Information in Addendum A shall not be used to support current plant operations. The Transition portion of this Calculation is only to be used for continuing design work associated with the Unit 2 Steam Generator Replacement/Power Uprate Project. No change bars are used in Addendum A.

EDC Incorporation: [X] Direct Revision: [X] No SWMS Associations Changes: [ ] Category B Software: [ ]

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Civil Reviewer: NA	Reviewer*: NA
Electrical Reviewer: NA	Independent Verifier: Adrian Abbate [signature] 8-17-01
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*Cross-Discipline or Other, specify organization

Table of Contents

List of Tables

Revision History

Rev.	Responsible Engineer Independent Verifier Other Reviewers, Dept. Approver	Approval Date	Reason for and Description of Change
0	Kent R. Bjornn Ali A. Khanpour Paul M. Clifford: NFM Trnsnt Anl Thomas R. Albrigo	02 Nov 95	The setpoint project has determined the uncertainties of many measurement channels, including the CPC and COLSS input channels. Some of the uncertainties are different from previous analyses. This calculation consolidates the information and presents the results in a manner similar to that expected by other organizations previously. This calculation supersedes CE document 14373-TS-005, "PVNGS - 1, 2, &3 COLSS Measurement Channel Uncertainties" (no PVNGS number) and 14273-ICE-3642 "COLSS Measurement Channel Uncertainties for ANPP Palo Verde Units 1, 2, & 3" (no PVNGS number) and CE document 14273-TS-050, "PVNGS CPC Input Data Channel Uncertainty Calculation" (N001-13.03-1785-2).
1	Kent R. Bjornn Ali A. Khanpour Thomas R. Albrigo	07 Mar 96	(1) Various input calculations have been revised. The revision of this calculation shows the current revision level for the input calculations. The uncertainty changes are shown with change bars in Table 1 and Table 2. (2) CRDR 9-5-0962 has been completed and the results included in the support calculations and the results do not need to be separately considered in this calculation (what was section 3.9 in Rev. 0).
2	Adrian H. Abbate Ali A. Khanpour Panos Paramithas	10 Apr 97	Per resolution to CRDR 961370, the high pressure heaters A/B outlet header pressure instrument (FWN-P-0121) does not and never has fed COLSS. This calculation is revised to remove this input. Also, the uncertainty for the Ex-Core Linear Channel has slightly increased due to revised calculation 13-JC-SE-202, Rev. 4. The appropriate sections of this calculation have been revised accordingly.
3	Adrian Abbate Glenn Foster: NFM Stewart Hall Panos Paramithas	21 May 98	Updated pressurizer pressure uncertainty to reflect the latest revision of calculation 13-JC-RC-207 (Rev. 4), and updated feedwater temperature uncertainty components to reflect the latest revision of 13-JC-SG-217 (Rev. 2). Note that although the feedwater temperature individual uncertainty components changed, the final overall uncertainties remain unchanged and the relative uncertainties decreased. Also, a note was added stating that the CIDSAL document is no longer active; however, references to that document will be retained for historical purposes.
4	Stewart Hall Adrian Abbate Dave Medek - NFM Panos Paramithas	02 Apr 99	Calculation revised to include provisions for the use of a Rosemount 1154 transmitter in place of a Barton 763A transmitter, for narrow range pressurizer pressure instrument loops 1J-RCC-P-0101C, 1J-RCD-P-0101D, and 2J-RCC-P-0101C. Rosemount transmitters have been installed under TMODs 1-98-RC-003, 1-98-RC-008, and 2-98-RC-004, respectively.

Rev.	Responsible Engineer Independent Verifier Other Reviewers, Dept. Approver	Approval Date	Reason for and Description of Change
5	Stewart Hall Adrian Abbate Tai Shin - NFM Panos Paramithas	03 Feb 00	Calculation revised to include provisions for the use of a Rosemount 1152 transmitter in place of a Barton 763A transmitter, pressurizer pressure control instrument loops J-RCN-P-100X & Y. Also, transferred uncertainty values from Table 17 (for Barton 100X/Y relative Presssurizer Pressure uncertainties) to summary Table 2.
6	David A. Willis Adrian Abbate Tai Shin : NFM - TA Panos Paramithas	05 Oct 00	Calculation is revised to include new uncertainty information for Steam Generator Total Feedwater Flow Loops SGN-F-1189 & SGN-F-1190. Upon installation of modification 226818, control room personel will have the ability to select COLSS feedwater flow input from the venturi based instrument loops (SGN-F-1112/1122) or from the ultrasonic based instrument loops (SGN-F-1189/1190). This revision removed the need to address both Rosemount 1154 and Barton 763A transmitters for narrow range pressurizer pressure instrument loops RCx-P-101x, (x = A,B,C,D). The Rosemount 1154 transmitters are presently installed in Units 1&3 and are being installed in 2R9, so this provision is no longer required. This revision also updated feedwater flow (SGN-F-1112/1122) uncertainty to reflect the latest revison of calculation 13-JC-SG-0208 (Rev. 4), and updated steam flow (SGN-F-1011/1021) uncertainty to reflect the latest revision of calculation 13-JC-SG-0209 (Rev. 7).
7	David A. Willis Adrian Abbate Tai Shin : NFM - TA Panos Paramithas	29 Aug 01	This revision incorporated information for new loop components, in support of the Digital Feedwater Control System (DFWCS) upgrade project per EDC 98-00358 Rev. C. Also verified that EDC 99-00287 Rev. A was incorporated into Rev. 6 of this calculation. This revision also updated information from various input calculations due to the impact of CRDR 9-6-0493, which addressed environmental temperature effects on M&TE. The following input calculations updates are captured in this revision: 13-JC-MT-0200 (Rev. 1), 13-JC-RC-0210 (Rev. 3), 13-JC-RC-0211 (Rev. 7), 13-JC-RC-0212 (Rev. 5), 13-JC-SG-0208 (Rev. 5), 13-JC-SG-0209 (Rev. 8), 13-JC-SG-0216 (Rev. 2), 13-JC-SG-0217 (Rev. 3). **Transition:** Incorporated Addendum A, which is a Transition portion of this Calculation. Information in Addendum A shall not be used to support current plant operations. The Transition portion of this Calculation is only to be used for continuing design work associated with the Unit 2 Steam Generator Replacement/Power Uprate Project. No change bars are used in Addendum A.

1 OBJECTIVE

The setpoint project has determined the uncertainties of many measurement channels, including the CPC and COLSS input channels. Some of the uncertainties are different from previous analyses. This calculation provides the input uncertainties which should be used as part of the CPC and COLSS uncertainty analyses. Provided in the summary section are the uncertainties from various NFM and CE documents and the corresponding uncertainties from approved PVNGS documents. This calculation consolidates the information and presents the results in a manner similar to that expected by other organizations previously.

Note: The CIDSAL document [Ref.5.1] discussed in this calculation is no longer active. References 5.33, 5.34, and 5.35 now contain/use the setpoint uncertainty information previously contained/used in the CIDSAL. References to the CIDSAL will remain in this calculation for historical purposes.

This calculation supersedes CE document 14373-TS-005, "PVNGS - 1, 2, &3 COLSS Measurement Channel Uncertainties" (13-N001-13.08-440) and 14273-ICE-3642 "COLSS Measurement Channel Uncertainties for ANPP Palo Verde Units 1, 2, & 3" (no PVNGS number) and CE document 14273-TS-050, "PVNGS CPC Input Data Channel Uncertainty Calculation" (N001-13.03-1785-2).

2 SUMMARY and CONCLUSIONS

The uncertainties which should be used as the basis for CPC inputs are given in the column labeled PVNGS. The CE uncertainties are provided for easy comparison of "old" versus "new" uncertainties. Several references have been used to determine which uncertainties are needed.

No evaluation is provided that the uncertainties presented below have been or will be used correctly. The intent is to provide uncertainties similar in concept to what was used in the CE documents, but based on more recent or complete information.

All "±" values from the PVNGS calculations presented below are considered to be for a normal distribution with at least 95% confidence (2σ). An uncertainty with the format "±x – y" or "±x + y" means that "x" is a 2σ normally distributed random uncertainty and "y" is a bias. If any uncertainties need to be converted to a 1σ value, the bias term should not be changed (e.g. "±x – y" becomes "±(x/2) – y"). Values in the CE documents are given variously as 1σ normal, 2σ normal, and 1σ uniform. For simplicity in comparison all normal values are listed here as 2σ values. That is, any 1σ values from a CE document has been doubled. For uniform distributions the 1σ values are copied directly and marked as "(U)". Note that Ref. 5.2 indicates that normal 2σ values should be used for analyses.

The order of the parameters listed generally follows the CIDSAL [Ref.5.1] with additions as needed and then additional parameters afterwards. Some of the rows in the CIDSAL tables are not input type uncertainties and therefore, are not presented here.

The uncertainties presented in this calculation are based on values developed by Design I&C and should not be changed without consultation with I&C and corresponding revisions to the calculations on which these uncertainties are based.

Table 1. CPC Input Uncertainties

Parameter	Type[a]	Tag Number of Input x = A,B,C,D	PVNGS Normal	PVNGS Reference	CE Uncertainty	CE Reference
Pressurizer P monitoring[b]	abs	RCx-P-101x	±14.3 +0.2, -0.1 psia	Sect. 4.2 Ref. 5.10	±25 psi	Ref. 5.1
Pressurizer P	abs		±19.4, +0.2 -0.1 psia		+26.1 psi –56.1 psi[c]	
Inlet T monitoring	abs	RCx-T-112Cx RCx-T-122Cx	±1.6°F	Sect. 4.3 Ref. 5.9	±2.0°F	
Inlet T	abs		±2.72°F		±2.4°F	
Control Element Assembly (CEA) position through CPC[d]	abs	SFx-Z-nx "n" varies	±1.13, +0.86, -0.84 in	Sect. 4.4 Ref. 5.12	±3.0 in	
	dev		±2.29 in		±3.4 in	
Control Element Assembly (CEA) position through CEAC	abs		±1.22, +0.86, -0.84 in		±3.570 in	Ref. 5.4
	dev		±2.4 in		±5.027 in	
Ex-Core Linear Subchannels	abs	SEx-J-1x	±1.38% pwr.	Sect. 4.6 Ref. 5.13	±1.566% pwr	Ref. 5.1
Ex-Core Detector deviation from Linearity	part		1.05% pwr		1.06% pwr[e]	
Reactor Coolant Pump (RCP) Shaft Speed	abs	RCx-S-113x RCx-S-123x RCx-S-133x RCx-S-143x	±1.904 rpm	Sect. 4.5 Ref. 5.11	±1.920 rpm[f]	Ref. 5.4
	part[g]		±1.428 rpm		±0.12% reference flow	Ref. 5.1
RCS temperature, HOT	abs	RCx-T-112Hx RCx-T-122Hx	±3.5°F	Sect. 4.7 Ref. 5.9	+3.470°F –3.506°F	Ref. 5.4

a. Type of uncertainties are abs - absolute error from a standard; dev - deviation of an individual from a groups; rep - repeatability of a measurement compared to a previous reading (considers primarily drift type terms); part - a part of the overall absolute uncertainty.
b. Note that the uncertainties are for the control board indicators from Ref. 5.10, since the operators use them to monitor pressure [Ref.5.32] rather than the CPC displays.
c. This uncertainty includes a 30 psi bias due to a defect in the Barton transmitters. The transmitters have been replaced with Rosemount 1154 and the bias no longer needs to be included.
d. First row is uncertainty for absolute position; second row is uncertainty for position deviations. Absolute in TS-050 [Ref.5.4] is ±3.539 in, deviation in TS-050 is ±3.572 in
e. This is converted from a 1σ fraction (0.0053) to a 2σ percent (1.06%) for consistency.
f. The CIDSAL [Ref.5.1] has the term "CPC Flow Calibration Uncertainty" given as ±0.5% rated speed, which would be 5.95 rpm, using the rated speed of 1190 rpm as found in Ref. 5.11.
g. This is the probe-to-disk interface error only.

Note that for COLSS measurement channel uncertainties in the table below there are cases where the same parameter appears more than once in the CIDSAL [Ref.5.1]. These duplicate lines are presented here with a pointer to the previously presented PVNGS uncertainties. The uncertainties from the CIDSAL [Ref.5.1] are different, perhaps for different bounding cases.

Table 2. COLSS Input Uncertainties

Parameter	Type[a]	Tag Number of Input	PVNGS		CE	
			Uncertainty	Reference	Uncertainty	Reference
COLSS Sensor & Input Uncertainties						
CEA Group Position	abs		—	—	±2.0 in (U)[b]	Ref. 5.1
Incore Detector signal	abs		—	—	6.8% pwr[c]	Ref. 5.1
Pressurizer pressure	abs	RCN-P-100X, RCN-P-100Y	±15.6, +1.8, -3.9 psi (with Barton Transmitter) ±26.3 psi (with Rosemount Transmitter)	Sect. 4.11 Ref. 5.16	+23.0, −53.0 psi (U)	Ref. 5.1
Wide Range Inlet Temperature	abs	RCA-T-115 RCB-T-125	±6.6°F	Sect. 4.8 Ref. 5.14	±5.18°F	Ref. 5.1
Feedwater Flow transmitter ΔP[d]	abs	SGN-F-1112X, 1122X	±7.28 in wc[e]	Sect. 4.12 Ref. 5.18	±19.20 in wc	Ref. 5.1
		SGN-F-1189, 1190	±19.0 in wc	Sect. 4.13 Ref. 5.19	±19.20 in wc	Ref. 5.1
Feedwater Temperature	abs	SGN-T-7X, 8X	±1.5 °F	Sect. 4.14 Ref. 5.21	±5.10 °F	Ref. 5.1
Secondary Steam Pressure	abs	SGN-P-1024, 1027	±17.16 psi	Sect. 4.15 Ref. 5.23	±29.6 psi	Ref. 5.1
Steam Flow Transmitter ΔP	abs	SGN-F-1011,1012, 1021, 1022	±22.70 in wc[f]	Sect. 4.16	±32.0 in H_2O	Ref. 5.1
Blowdown Mass Flow	abs	—	—	—	±40.0 klbm/hr (U)	Ref. 5.1
Steam Generator Pressure	See Secondary Steam Pressure above				±50.0 psi	Ref. 5.1
Turbine first stage pressure	abs	MTN-P-10	±10.6 psi	Sect. 4.17 Ref. 5.22	—	—[g]
Secondary Side Data at 80% Power						
Blowdown Mass Flow (80% pwr)	abs	—	—	—	±55.2 klbm/hr[h]	Ref. 5.1
COLSS Flow Components						
Inlet Temperature (RCS cold leg) (narrow range)	abs	RCN-T-111Y RCN-T-121Y	±2.82°F	Sect. 4.9 Ref. 5.15	±2.358°F	Ref. 5.1
Inlet Temperature (wide range)	See Wide Range Inlet Temperature above				±5.968°F	Ref. 5.1
Pump Differential Pressure (RCP ΔP)	abs	RCN-PD-11n, 12n; n = 0,1,2,3	±2.45, +0, −0.5 psi	Sect. 4.18 Ref. 5.17	±1.502 psid	Ref. 5.1

Table 2. COLSS Input Uncertainties (Continued)

Parameter	Type[a]	Tag Number of Input	PVNGS		CE	
			Uncertainty	Reference	Uncertainty	Reference
Pump Speed (RCP Shaft Speed)	abs	RCN-S-154,155, 164, 165, 174, 175, 184, 185	±1.36 rpm	Ref. 5.29	±1.572 rpm	Ref. 5.1
Pressurizer Pressure	See Pressurizer Pressure above				±22.18 psi	Ref. 5.1
Uncertainties for Primary Calorimetric Power Error for COLSS [Ref.5.3][i]						
RCS Hot Leg Temperature (nr)	abs	RCN-T-111X RCN-T-121X	±2.82°F	Sect. 4.10 Ref. 5.15	±2.042°F	Ref. 5.3
RCS Cold Leg Temperature (wr)	rel	RCA-T-115 RCB-T-125	±4.5°F	Sect. 4.8	±1.599°F	
RCS Cold Leg Temperature (nr)	rel	RCN-T-111Y RCN-T-121Y	±0.9°F	Sect. 4.9	±0.509°F	
Pressurizer Pressure	rel	RCN-P-100X, RCN-P-100Y	±14.1, +1.8, -3.9 psi (with Barton Transmitter) ±16.6 psi (with Rosemount Transmitter)	Sect. 4.11	±24.755 psi – 15 psi	Ref. 5.3
RCP ΔP	rel	RCN-PD-11n, 12n; n = 0,1,2,3	±1.6, +0, –0.5 psi	Sect. 4.18	±3.210 psi	
RCP speed	rel[j]	RCN-S-154,155, 164, 165, 174, 175, 184, 185	±1.36 rpm	Ref. 5.29	±1.36 rpm	
Uncertainties for Turbine Power Calculation						
Turbine first stage pressure	rel	MTN-P-10	±7.8 psi	Sect. 4.17	±12.1752psi	Ref. 5.1

a. Type of uncertainties are abs - absolute error from a standard; dev - deviation of an individual from a groups; rel - relative uncertainty (repeatability) of a measurement compared to a previous reading (considers primarily drift type terms); part - a part of the overall absolute uncertainty.

b. TS-005 [Ref.5.5], which is basis for CIDSAL [Ref.5.1], gives uncertainties as ±2.0 in for CEA group position and ±3.0 for CEA group deviation.

c. This is converted from a 1σ fraction (0.034) to a 2σ percent (6.8%) for consistency.

d. Upon installation of modification 226818, control room personel will have the ability to select COLSS feedwater flow ΔP input from the either the venturi based instrument loops (SGN-F-1112/1122) or from the ultrasonic based instrument loops (SGN-F-1189/1190).

e. This is without the venturi uncertainty. The uncertainty provided in the table is usable over the full range of flow, with slight conservatism at flows less than 100% CS. Including the venturi uncertainty at 100% flow results in an overall uncertainty of 8.48 "H_2O.

f. This is without the venturi uncertainty. The uncertainty provided in the table is usable over the full range of flow, with slight conservatism at flows less than 100% CS. Including the venturi uncertainty at 100% flow results in an overall uncertainty of 41.47 "H_2O [Ref.5.20]. Note that 100% CS is greater than 100% power.

g. The uncertainty given in the CIDSAL [Ref.5.1] is a relative uncertainty, as seen by examining Ref. 5.6. The relative uncertainty is given later in this table.

h. CIDSAL [Ref.5.1] doesn't state distribution, but value for 100% power is given as uniform.

i. The final values given in Ref. 5.3 have been divided by √3 as if the instrument uncertainties were uniform and the standard deviation needed to be determined from the range of the distribution. In accordance with Ref. 5.2, the uncertainty before division by √3 will be reported here (called 2σ values in Ref. 5.2).

j. No change between absolute and relative uncertainties for this parameter.

3 CRITERIA and ASSUMPTIONS

3.1 This calculation captures the output of several other calculations and is used as input to various NFM analyses. Because the adequacy of the uncertainties is determined by NFM, there are no specific licensing or design criteria associated with this calculation. Additionally, any design and licensing criteria that might exist for a given channel is addressed in the specific channel calculation.

3.2 Some applications of COLSS inputs do not need the absolute uncertainty from a standard quantity. Instead the uncertainty needed is the possible difference from a previous measurement. This then is the relative uncertainty, or repeatability, of a measurement. Generally the measurements which are absolute (e.g. comparison to absolute definition of a parameter) would occur during power ascension testing to measure primary and secondary power. During power operations between refueling the measurement of concern is the comparison to the power measured during power ascension testing. In this time interval the factors which would affect this relative uncertainty are basic repeatability of the instrument, drift, humidity and temperature variations in the room and instrument cabinet, and voltage variation from the power supply. The M&TE error is effectively fixed when the calibration is done and would remain unchanged until the next calibration. Linearity need not be considered if power operation is near one of the power calibration points used during power ascension testing.

3.3 For determination of a relative uncertainty (channel repeatability) for COLSS inputs, the repeatability term in place of the effective accuracy is needed for each instrument. The instruments for which this type of uncertainty is needed are converters, specifically current-to-voltage (I/V), voltage-to-current (V/I), voltage-to-voltage (V/V), millivolt-to-voltage (mV/V), and resistance-to-voltage (R/V). However, only the voltage-to-current converter provides a separate repeatability term, which is 0.1% CS [Ref.5.25.1]. A more generic document [Ref.5.25.2] indicates that this repeatability value is also applicable to the I/V, mV/V, and R/V converters. For the voltage-to-voltage converter, which is a voltage-to-current converter with a resistor (see Ref. 5.7), the repeatability would be the same. The repeatability for the all types of converters is assumed to be 0.1% CS.

3.4 All calibrations are 18 months + 25% = 22.5 months (see Ref. 5.9 through Ref. 5.23). This will be used in Sect. 4.1 in determination of the relative uncertainty for Foxboro instruments.

3.5 The uncertainty for analog-to-digital converter determined in Ref. 5.8 is an absolute uncertainty; however, the uncertainty is small and will be used unchanged in the determination of relative uncertainty also. The uncertainty of the analog-to-digital converters has been determined in Ref. 5.8 and is 0.10% CS, which is the same value which has been used in channel uncertainty calculations.

3.6 The magnitude of some terms is dependent on the magnitude of the signal. These are show as "% IV" in the channel uncertainty calculations. For simplicity and conservatism, the signal is assumed to be 100% CS. This effectively converts the uncertainties to "%CS" and allows the direct combination of these "%IV" terms at the value stated in the channel uncertainty calculation with other terms which are already "%CS".

3.7 The vendor stated accuracy of Barton transmitters is 0.5% CS (see Ref. 5.27 and PVNGS uncertainty calculations). Half of this, 0.25% CS, is considered to be a reasonable estimate of the transmitter repeatability. This assumption is based on engineering judgement.

3.8 The vendor stated accuracy of Rosemount transmitters is 0.25% CS (see Ref. 5.28 and PVNGS uncertainty calculations). A value of 0.20% CS is considered a reasonable estimate of transmitter repeatability, based on engineering judgement. The transmitter used for feedwater flow is a different model with a much better overall accuracy (0.075% CS) [Ref.5.18]. Since the accuracy is much better it will also be used for the relative uncertainty.

3.9 The stability specification (drift) for the Rosemount model 1151 pressure and differential pressure transmitters is stated as ±0.25% URL for six months [Ref.5.28]. Other Rosemount models have previously had a similar specification, but have had the specification changed to include a longer interval after further testing by Rosemount [Ref.5.28.4]. The instruments themselves had not changed, only the knowledge of their performance. Assuming that the model 1151 transmitters are essentially similar to the models derived from the same basic design, the drift specification will be extended to 30 months rather than six months, and the value for drift during that time will remain as previously stated, ±0.25% URL.

3.10 Foxboro Field Bus Modules (FBM's) act as A/D and D/A converters to transmit process signals from sensing devices to the Foxboro I/A System, which acts as the plant's Digital Feedwater Control System (DFWCS), and then to COLSS. For simplicity, the reference accuracies of the FBM's will be used for the repeatability uncertainty.

3.11 For simplicity, the reference accuracies of the Weed type 615D-1B-A RTD's will be used for the repeatability uncertainty.

4 INPUT DATA and CALCULATIONS

Provided below are various factors which affect instrument uncertainty. For the most part the information is already determined in various verified channel uncertainty calculations (see Ref. 5.9 through Ref. 5.23), but is copied here for ease of comparison.

For some of the instruments the relative uncertainty has not been determined in any other PVNGS calculation. The appropriate effects are copied from original PVNGS calculation and then combined in the same manner as the original calculation.

4.1 Foxboro I/V, V/I, V/V, R/V, and mV/V Converter Uncertainties

The overall uncertainties for the Foxboro converter cards have been determined in Ref. 5.7 and component information is duplicated here. A relative or repeatability uncertainty is determined here. All terms for the Foxboro instruments are random.

Table 3. Foxboro Current-to-Voltage (I/V) Converter Uncertainty

Parameter	Basis	Overall Uncertainty % CS	Relative Uncertainty % CS
Effective Accuracy	Ref. 5.7	±0.50	—
Repeatability	Sect. 3.3	—	±0.10

Table 3. Foxboro Current-to-Voltage (I/V) Converter Uncertainty (Continued)

Parameter		Basis	Overall Uncertainty % CS	Relative Uncertainty % CS
Humidity Effect		Ref. 5.7	±0.222	
M&TE Uncertainty	in		±0.15	—
M&TE Uncertainty	out		±0.05	—
Drift			±0.438	
Temperature Effect			±0.10	
Voltage Stability Effect			±0.043	
I/V Uncertainty			±0.73	±0.51

Table 4. Foxboro Voltage-to-Current (V/I) Converter Uncertainty

Parameter		Basis	Overall Uncertainty % CS	Relative Uncertainty % CS
Effective Accuracy		Ref. 5.7	±0.50	—
Repeatability		Ref. 5.25.1	—	±0.10
Humidity Effect		Ref. 5.7	±0.222	
M&TE Uncertainty	in		±0.05	—
M&TE Uncertainty	out		±0.15	—
Drift			±0.438	
Temperature Effect			±0.10	
Voltage Stability Effect			±0.108	
V/I Uncertainty			±0.73	±0.52

Table 5. Foxboro Voltage-to-Voltage (V/V) Converter Uncertainties

Parameter		Basis	Overall Uncertainty % CS	Relative Uncertainty % CS
Effective Accuracy		Ref. 5.7	±0.50	—
Repeatability		Sect. 3.3	—	±0.10
Humidity Effect		Ref. 5.7	±0.222	
M&TE Uncertainty	in		±0.05	—
M&TE Uncertainty	out		±0.05	—
Drift			±0.438	
Temperature Effect			±0.10	
Voltage Stability Effect			±0.108	
V/V Uncertainty			±0.72	±0.52

The overall uncertainty of the R/V converter is dependent on the input span in resistance. The standard required accuracy of resistance M&TE is 0.12Ω, but the conversion to %CS requires knowing the input span of the R/V converter which can vary for each application. Therefore, the overall uncertainty for the R/V converter in a given application will be taken from the appropriate channel uncertainty calculation. The relative uncertainty does not need the input M&TE uncertainty therefore can be determined below and used later in this calculation.

Table 6. Foxboro Resistance-to-Voltage (R/V) Converter Uncertainties

Parameter		Basis	Overall Uncertainty % CS	Relative Uncertainty % CS
Effective Accuracy		Ref. 5.7	±0.50	—
Repeatability		Sect. 3.3	—	±0.10
Humidity Effect		Ref. 5.7	±0.236	±0.236
M&TE Uncertainty	in	Ref. 5.7	channel dependent	—
M&TE Uncertainty	out	Ref. 5.7	±0.05	—
Drift		Ref. 5.7	±0.438	±0.438
Temperature Effect		Ref. 5.7	±0.127	±0.127
Voltage Stability Effect		Ref. 5.7	±0.075	±0.075
R/V Uncertainty			> ±0.7224[a]	±0.53

a. See explanation above.

Table 7. Foxboro Millivolt-to-Voltage (mV/V) Converter Uncertainties

Parameter		Basis	Overall Uncertainty % CS	Relative Uncertainty % CS
Effective Accuracy		Ref. 5.21	±0.50	—
Repeatability		Sect. 3.3	—	±0.10
Humidity Effect		Ref. 5.21	—	—
M&TE Uncertainty	in	Ref. 5.21	±0.20	—
M&TE Uncertainty	out	Ref. 5.21	±0.05	—
Drift		Ref. 5.21	±0.219	±0.219
Temperature Effect		Ref. 5.21	±0.109	±0.109
Voltage Stability Effect		Ref. 5.21	±0.054	±0.054
mV/V Uncertainty			±0.596	±0.27

4.2 CPC Pressurizer Pressure (RCx-P-101x, x = A, B, C, D)

The uncertainty for this parameter was determined in Ref. 5.10 and is repeated here. The calibrated span (CS) is 1500 - 2500 psia.

Table 8. RCx-P-101x, x = A, B, C, D (CPC) Uncertainty

Parameter	Basis	Overall Uncertainty % CS (w/Barton Transmitter)	Overall Uncertainty % CS (w/Rosemount Transmitter)[a]
Transmitter Uncertainty Components			
Effective Accuracy	Ref. 5.10	±0.50	±0.50
Repeatability	Sect. 3.7	—	—
M&TE Uncertainty in	Ref. 5.10	±1.000	±1.000
M&TE Uncertainty out		±0.250	±0.250
Radiation Effect		±0.000	±0.000
Drift		±1.875	±0.600
Temperature Effect		±0.500	±1.250
Reference Pressure Temperature Effect		+0.15, -0.15	—
Transmitter uncertainty	SRSS	±2.25 +0.15, -0.15	±1.80
I/V uncertainty	Sect. 4.1	±0.73	±0.73
A/D converter uncertainty	Sect. 3.5	±0.10	±0.10
Process Effects	Ref. 5.10	+0.015, –0.009	+0.015, –0.009
Channel Uncertainty (CS = 1000 psi)		±2.37 +0.165, -0.159% CS ±23.7 +1.7, –1.6 psi	±1.94 +0.015, -0.009%CS ±19.4 +0.2, -0.1 psi

a. Uncertainties associated with the Rosemount 1154 transmitter apply for EQIDs 1J-RCC-PT-0101C, 1J-RCD-PT-0101D, and 2J-RCC-PT-0101C, which were installed under TMODs 1-98-RC-003, 1-98, RC-008, and 2-98-RC-004, respectively.

There are four channels for monitoring pressurizer pressure; common practice would be to ensure that all channels are above or below, as appropriate, any particular limit. Therefore, the uncertainty of this method would be at least as good as ensuring that the average of all the channels was above or below the limit. The basic expression for determining the uncertainty of an average of several measurements of the *same* parameter is given below.

$$\sigma_{avg} = \frac{\sigma_i}{\sqrt{n}}$$

Where σ_i is the standard deviation of the individual measurements, n is the number of measurements, and σ_{avg} is the standard deviation of the average. Any biases are unaffected by averaging. Therefore, the uncertainty for pressure monitoring is as below. Note that the uncertainties for the control board indicators (2.82%CS = ±28.2 psi for loops with Barton transmitter, 2.47%CS = ±24.7 psi for loops with Rosemount transmitters) from Ref. 5.10 are used, since the operators use them to monitor pressure [Ref.5.32] rather than the CPC displays. The biases are from Ref. 5.10, which are the same as shown in Table 8 above. The average of three channels is used in the event one channel is not functioning as expected and is not used in the average.

$$U_{avg} = \frac{U_{random}}{\sqrt{n}} + U_{bias} = \frac{28.2}{\sqrt{3}} + 1.7 - 1.6 = \pm 16.3 + 1.7 - 1.6 \text{ psi (w/Barton xmtrs.)}$$

$$U_{avg} = \frac{U_{random}}{\sqrt{n}} + U_{bias} = \frac{24.7}{\sqrt{3}} + 0.2 - 0.1 = \pm 14.3 + 0.2 - 0.1 \text{ psi (w/Rosemount xmtrs.)}$$

4.3 CPC RCS Cold Leg Temperature (RCx-T-112Cx, 122Cx, x = A, B, C, D)

The uncertainty for this parameter was determined in Ref. 5.9 and is repeated here. The calibrated span (CS) is 465-615°F = 150°F.

Table 9. RCx-T-112Cx, 122Cx; x = A, B, C, D (CPC) Uncertainty

Parameter	Basis	Overall Uncertainty % CS
RTD Uncertainty Components		
Effective Accuracy	Ref. 5.9	±1.64
Drift	Ref. 5.9	±0.125
RTD uncertainty	SRSS	±1.64
R/V uncertainty	Ref. 5.9	±0.75
A/D converter uncertainty	Sect. 3.5	±0.10
Channel Uncertainty (CS = 150°F)		±1.81% CS 2.72°F

As explained in Ref. 5.9 (section 5.7) and used above in Section 4.2, the uncertainty of multiple channels is less than the uncertainty of a single channel. The basic expression for determining the uncertainty of an average of several measurements of the *same* parameter is given below.

$$\sigma_{avg} = \frac{\sigma_i}{\sqrt{n}}$$

Where the symbols are as described in Section 4.2. Therefore, the uncertainty for temperature monitoring is as below. The average of three channels is used in the event one channel is not functioning as expected and is not used in the average. Also provided is the uncertainty of the average when the control board indicators are used since presently the procedures [Ref.5.32] use them for temperature monitoring. The uncertainty of the indicators (±2.41% CS = ±3.62°F) is from Ref. 5.9.

$$U_{avg} = \frac{U_{random}}{\sqrt{n}} = \frac{2.72}{\sqrt{3}} = 1.57°F \quad \text{for CPC displays}$$

$$U_{avg} = \frac{U_{random}}{\sqrt{n}} = \frac{3.62}{\sqrt{3}} = 2.09°F \quad \text{for indicators}$$

4.4 CPC Control Element Assembly (CEA) Position (SFx-Z-nx, x = A, B, C, D)

The uncertainty for this parameter was determined in Ref. 5.12 and is repeated here. The notation U_A, U_B, etc. is from Ref. 5.12.

Table 10. SFx-Z-nx (CPC) Uncertainty

Parameter	Basis	Overall Uncertainty inches	Deviation Uncertainty % CS
RSPT power supply uncertainty (U_A)	Ref. 5.12	±0.179	—
RSPT Uncertainty (U_B)		±0.505, +0.858, –0.843	twice ±0.505 ±0.858
A/D Converter Uncertainty (U_C)		±0.178	twice ±0.178
Channel Uncertainty (SRSS is doubled to obtain 2σ)		±1.129, +0.858, –0.843 in	±2.289 in

Table 11. SFx-Z-nx (CEAC) Uncertainty

Parameter	Basis	Overall Uncertainty inches	Deviation Uncertainty % CS
RSPT power supply uncertainty (U_A)	Ref. 5.12	±0.179	twice ±0.179
RSPT Uncertainty (U_B)		±0.505, +0.858, –0.843	twice ±0.505 ±0.858
A/D Converter Uncertainty (U_C)		±0.178	twice ±0.178
CEA position isolation amplifier uncertainty (U_D)		±0.234	
Channel Uncertainty (SRSS is doubled to obtain 2σ)		±1.222, +0.858, –0.843 in	±2.390 in

4.5 CPC Reactor Coolant Pump Speed (RCx-S-1n3x; n = 1, 2, 3, 4; x = A, B, C, D)

The uncertainty for this parameter was determined in Ref. 5.11 and is repeated here. The calibrated span (CS) is 0-1190 rpm.

Table 12. RCx-S-1n3x; n = 1, 2, 3, 4; x = A, B, C, D (CPC) Uncertainty

Parameter	Basis	Overall Uncertainty % CS
Disk-to-Probe Interface Uncertainty Components		
Dimensional error	Ref. 5.11	±0.068
Radial vibration (parallel)		±0.023
Radial vibration (perpendicular)		±0.029

Table 12. RCx-S-1n3x; n = 1, 2, 3, 4; x = A, B, C, D (CPC) Uncertainty

Parameter	Basis	Overall Uncertainty % CS
Disk-to-Probe Interface Uncertainty	add	±0.120% CS ±1.428 rpm
Sensor to register error	Ref. 5.11	±0.04
Channel Uncertainty (CS = 1190 rpm) (add components)		±1.60% CS 1.904 rpm

4.6 CPC Ex-core Linear Subchannels (SEx-J-1x, x = A, B, C, D)

The uncertainty for this parameter was determined in Ref. 5.13 and is summarized here. The calibrated span (CS) is 0 - 200% power.

Ref. 5.13 shows the uncertainty to be random terms of 0.45% CS (independent of power level) and 1.00% IV (dependent on power level). At a point of interest of 105% power the uncertainty is

$$U = \sqrt{0.45^2 + \left(1.00\left(\frac{105}{200}\right)\right)^2} = \pm 0.691\%\ CS$$

When converted to % power, the uncertainty is ±1.38 %power.

The deviation from linearity is due to the detector uncertainty, which is 1.00% IV. At a power level of 105%, the uncertainty of the detector is 1.05% power.

The portion of the uncertainty which is independent of power level is due to sub-channel electronics and CPC input uncertainties.

4.7 CPC RCS Hot Leg Temperature (RCx-T-112Hx, 122Hx, x = A, B, C, D)

The uncertainty for this parameter was determined in Ref. 5.9 and is repeated here. The calibrated span (CS) is 375-675°F = 300°F.

Table 13. RCx-T-112Cx, 122Cx; x = A, B, C, D (CPC) Uncertainty

Parameter	Basis	Overall Uncertainty % CS
RTD Uncertainty Components		
Effective Accuracy	Ref. 5.9	±0.90
Drift	Ref. 5.9	±0.062
RTD uncertainty	SRSS	±0.90
R/V uncertainty	Ref. 5.9	±0.73
A/D converter uncertainty	Sect. 3.5	±0.10
Channel Uncertainty (CS = 150°F)		±1.16% CS 3.48°F

4.8 COLSS RCS Cold Leg Temperature (wide range) (RCA-T-115, RCB-T-125)

The overall uncertainty for this parameter was determined in Ref. 5.14; and is repeated here. The relative or repeatability uncertainty is determined below. The calibrated span (CS) is 0-600°F = 600°F.

Table 14. RCA-T-115, RCB-T-125 (COLSS) Uncertainty

Parameter	Basis	Overall Uncertainty % CS	Relative Uncertainty % CS
RTD Uncertainty Components			
Effective Accuracy	Ref. 5.14	±0.40	—
Repeatability	Ref. 5.26	—	±0.05[a]
Drift	Ref. 5.14	±0.031	
RTD Uncertainty	SRSS	±0.40	±0.06
R/V Converter Uncertainty	Ref. 5.14	±0.72	±0.53
V/V Converter Uncertainty	Sect. 4.1	±0.72	±0.52
A/D Converter Uncertainty	Sect. 3.5	±0.10	
Channel Uncertainty (CS = 600 °F)		±1.10% CS ±6.60 °F	±0.75% CS ±4.50 °F

a. The vendor information is 0.05% of measured temperature, which at maximum temperature converts directly to 0.05% CS.

4.9 COLSS RCS Cold Leg Temperature (narrow range) (RCN-T-111Y, 121Y)

The uncertainty for this parameter was determined in Ref. 5.15; however, the relative or repeatability uncertainty is determined below. The calibrated span (CS) is 500-650°F = 150°F.

Table 15. RCN-T-111Y, 121Y (COLSS) Uncertainty

Parameter	Basis	Overall Uncertainty % CS	Relative Uncertainty % CS
RTD Uncertainty Components			
Effective Accuracy	Ref. 5.15	±1.73	—
Repeatability	Ref. 5.26	—	±0.217[a]
Drift		±0.126	
RTD Uncertainty	SRSS	±1.73	±0.25
R/V Converter Uncertainty	Ref. 5.15	±0.74	±0.53
A/D Converter Uncertainty	Sect. 3.5	±0.10	
Channel Uncertainty (CS = 150 °F)		±1.88% CS ±2.82 °F	±0.59% CS ±0.89 °F

a. The vendor information is 0.05% of measured temperature, which at maximum temperature (0.05% of 650°F = 0.325°F) converts to 0.217% CS (CS = 150°F).

4.10 COLSS RCS Hot Leg Temperature (RCN-T-111X, 121X)

The uncertainty for this parameter was determined in Ref. 5.15; however, the relative or repeatability uncertainty is determined below. The calibrated span (CS) is 500-650°F = 150°F.

Table 16. RCN-T-111X, 121X (COLSS) Uncertainty

Parameter	Basis	Overall Uncertainty % CS	Relative Uncertainty % CS
RTD Uncertainty Components			
Effective Accuracy	Ref. 5.15	±1.73	—
Repeatability	Ref. 5.26	—	±0.217[a]
Drift		±0.126	
RTD Uncertainty	SRSS	±1.73	±0.25
R/V Converter Uncertainty	Ref. 5.15	±0.74	±0.53
A/D Converter Uncertainty	Sect. 3.5	±0.10	
Channel Uncertainty (CS = 150 °F)		±1.88% CS ±2.82 °F	±0.59% CS ±0.89 °F

a. The vendor information is 0.05% of measured temperature, which at maximum temperature (0.05% of 650°F = 0.325°F) converts to 0.217% CS (CS = 150°F).

4.11 COLSS Pressurizer Pressure (RCN-P-100X, Y)

The uncertainty for this parameter was determined in Ref. 5.16; however, the relative or repeatability uncertainty is determined below. The calibrated span (CS) is 1500-2500 psia = 1000 psi.

A drift study was done for Barton 763 transmitters and the results used in Ref. 5.16. The results included the effects of drift, radiation, M&TE uncertainty, basic accuracy, etc. This term combined with sensitivity and temperature effect gives the overall uncertainty, as shown in Ref. 5.16.

However, for relative uncertainty, the testing uncertainty term of Ref. 5.16 includes more effects than desired. The basic accuracy and the repeatability of the transmitter cannot be separated from the basic data of the drift study data. An estimate of the relative uncertainty for the transmitter can be determined by using the following steps. The repeatability of the transmitter is considered a random component of the vendor stated accuracy. The vendor stated accuracy is considered a random component of the overall testing uncertainty used in Ref. 5.16. An equation of the form shown below can describe the relation between the testing uncertainty, U, the accuracy, A, and all other components which make up the random part of testing uncertainty, X.

$$U_{test} = \sqrt{A^2 + X^2}$$

Once the quantity X has been determined it can be combined with the transmitter repeatability, r, sensitivity, S, and the temperature effect, TE, using SRSS.

$$U_{rel} = \sqrt{X^2 + r^2 + S^2 + TE^2} = \sqrt{U_{test}^2 - A^2 + r^2 + S^2 + TE^2}$$

The random term is then added to the bias terms.

Table 17. RCN-P-100X, Y (COLSS) Uncertainty

Parameter	Basis	With Barton Transmitter		With Rosemount Transmitter	
		Overall Uncertainty % CS	Relative Uncertainty % CS	Overall Uncertainty % CS	Relative Uncertainty % CS
Transmitter Uncertainty Components					
Testing Uncertainty random (U_{test})	Ref. 5.16	±1.287		—	—
M&TE, In		—	—	±1.89	—
M&TE, Out		—	—	±0.25	—
Accuracy		—	±0.50	±0.50	—
Drift		—	—	±0.60	
Sensitivity		±0.01		—	—
Temperature Effect		±0.50		±1.40	
Testing uncertainty, Bias		+0, –0.21		—	—
Temperature Effect Bias		+0.15, –0.15		—	—
Repeatability	Sect. 3.7 Sect. 3.8	—	±0.25	—	±0.25
Transmitter Uncertainty	see above	±1.38, +0.15, –0.36	±1.31, +0.15, –0.36	±2.49	±1.54
I/V Converter Uncertainty	Sect. 4.1	±0.73	±0.51	±0.73	±0.51
A/D Converter Uncertainty	Sect. 3.5	±0.10		±0.10	
Process Effects	Ref. 5.16	+0.03, –0.03 (bias)		+0.03, –0.03 (bias)	
Channel Uncertainty (CS = 1000 psi)		±1.56, +0.18, –0.39% CS ±15.6, +1.8, –3.9 psia	±1.41, +0.18, –0.39% CS ±14.1, +1.8, –3.9 psia	±2.63% CS, ±26.3 psia	±1.66% CS, ±16.6 psia

4.12 COLSS Feedwater Flow ΔP (SGN-F-1112X, 1122X)

The uncertainty for this parameter was determined in Ref. 5.18; however, the relative or repeatability uncertainty is determined below. The calibrated span (CS) is 0-856.3 inches water. The uncertainty determined in Ref. 5.18 is dependent on the flow rate for the magnitude of the uncertainty. The primary factor is the dependence of the venturi uncertainty on flow rate. The uncertainty below does not include the venturi, which is similar to the uncertainty method used in Ref. 5.5.

Table 18. SGN-F-1112X, SGN-F-1122X (COLSS) Uncertainty

Parameter	Basis	Overall Uncertainty % CS	Relative Uncertainty % CS
Transmitter Uncertainty Components			
Effective Accuracy	Ref. 5.18	±0.25	—
Repeatability	Sect. 3.8	—	±0.075
M&TE, In	Ref. 5.18	±0.634	—
M&TE, Out		±0.25	—
Static Pressure Effect		±0.154	—
Drift		±0.219	
Temperature Effect		±0.08	
Transmitter Uncertainty	SRSS	±0.78	±0.24
Flow Element Uncertainty	Ref. 5.18	—[a]	
Input FBM Components			
Effective Accuracy[b]	Ref. 5.18	±0.30	—
Repeatability	Sect. 3.10 Ref. 5.18	—	±0.30
M&TE, In	Ref. 5.18	±0.10	—
Temperature Effect		±0.0139	
Input FBM Uncertainty	SRSS	±0.32	±0.30
Output FBM Uncertainty	Ref. 5.18	±0.05	
A/D Converter Uncertainty	Sect. 3.5	±0.10	
Channel Uncertainty (CS = 856.3 "H_2O)		±0.85% CS ±7.28 "H_2O	±0.40% CS ±3.43 "H_2O

a. The Feedwater Flow uncertainty was requested without flow element (e.g. feedwater venturi) components. The flow element uncertainty is 0.50% IV [Ref.5.18], which at 100% span would be 0.50% CS, and the overall uncertainty would be 0.99% CS = 8.48 "H_2O (0.64% CS = 5.48 "H_2O for relative uncertainty).

b. The Feedwater Flow inputs to COLSS are provided by channels: 1112X & 1122X.

4.13 COLSS Ultrasonic based Feedwater Flow ΔP (SGN-F-1189, 1190)

Upon installation of modification 226818, control room personel will have the ability to select COLSS feedwater flow ΔP input from the subject ultrasonic based instrument loops or from the venturi based instrument loops covered in Section 4.12. The uncertainty for this parameter was determined in Ref. 5.19; however, the relative or repeatability uncertainty is determined below. The calibrated span (CS) is 0-856.3 inches water.

Table 19. SGN-F-1189, SGN-F-1190 (COLSS) Uncertainty

Parameter	Basis	Overall Uncertainty % CS	Relative Uncertainty % CS
Transmitter Uncertainty	Ref. 5.18	±2.03	
I/V Converter Uncertainty	Sect. 4.1	±0.73	±0.51
A/D Converter Uncertainty	Sect. 3.5	±0.10	
Channel Uncertainty (CS = 856.3 "H_2O)		±2.22% CS ±19.0 "H_2O	±2.10% CS ±18.0 "H_2O

4.14 COLSS Feedwater Temperature (SGN-T-7X,8X)

The uncertainty for this parameter was determined in Ref. 5.21; however, the relative or repeatability uncertainty is determined below. The calibrated span (CS) is 0 - 500°F.

Table 20. SGN-T-7X, 8X (COLSS) Uncertainty

Parameter	Basis	Overall Uncertainty % CS	Relative Uncertainty % CS
RTD Uncertainty Components			
Accuracy	Ref. 5.21	±0.10	—
Repeatability	Sect. 3.11	—	±0.10
RTD Uncertainty	SRSS	±0.10	
Input FBM Random Components			
Effective Accuracy	Ref. 5.21	±0.076	—
Repeatability	Sect. 3.10 Ref. 5.21	—	±0.076
M&TE, In	Ref. 5.21	±0.072	—
Temperature Effect		±0.100	—
Input FBM Random Uncertainty	SRSS	±0.145	±0.076
Input FBM Bias Components			
Conformity	Ref. 5.21	±0.090	—
Input FBM Bias Uncertainty	—	±0.090	—
Output FBM Uncertainty	Ref. 5.21	±0.05	
A/D Converter Uncertainty	Sect. 3.5	±0.10	
Channel Uncertainty (CS = 500 °F)		±0.30% CS ±1.5°F	±0.17% CS ±0.85°F

4.15 COLSS Secondary Steam Pressure (SGN-P-1024, 1027)

The uncertainty for this parameter was determined in Ref. 5.23; however, the relative or repeatability uncertainty is determined below. The calibrated span (CS) is 900 - 1300 psia = 400 psi.

Table 21. SGN-P-1024, 1027 (COLSS) Uncertainty

Parameter	Basis	Overall Uncertainty % CS	Relative Uncertainty % CS
Transmitter Uncertainty Components			
Effective Accuracy	Ref. 5.23	±0.50	
Repeatability	Sect. 3.8	—	±0.20
M&TE, In	Ref. 5.23	±3.03	—
M&TE, Out		±0.25	—
Drift		±1.875	
Temperature Effect		±2.210	
Transmitter Uncertainty	SRSS	±4.23	±2.91
I/V Converter Uncertainty	Sect. 4.1	±0.73	±0.51
A/D Converter Uncertainty	Sect. 3.5	±0.10	
Channel Uncertainty (CS = 400 psi)		±4.29% CS ±17.16 psi	±2.96% CS ±11.84 psi

4.16 COLSS Steam Flow Transmitter ΔP (SGN-F-1011, 1012, 1021, 1022)

The uncertainty for this parameter was determined in Ref. 5.20; however, the relative or repeatability uncertainty is determined below. The calibrated span (CS) is 61.6 psid (1706.75 "H_2O). The uncertainty determined in Ref. 5.20 is dependent on the flow rate for the magnitude of the uncertainty. The primary factor is the dependence of the venturi uncertainty on flow rate. The uncertainty below does not include the venturi, which is similar to the uncertainty method used in Ref. 5.5.

Table 22. SGN-F-1011, 1012, 1021, 1022 (COLSS) Uncertainty

Parameter	Basis	Overall Uncertainty % CS	Relative Uncertainty % CS
Transmitter Uncertainty Components			
Effective Accuracy	Ref. 5.20	±0.50	
Repeatability	Sect. 3.8	—	±0.20

Table 22. SGN-F-1011, 1012, 1021, 1022 (COLSS) Uncertainty (Continued)

Parameter	Basis	Overall Uncertainty % CS	Relative Uncertainty % CS
M&TE, In	Ref. 5.20	±0.873	—
M&TE, Out		±0.25	—
Static Pressure Correction		±0.238	—
Radiation Effect		±0.250	
Drift		±0.325	
Temperature Effect		±0.656	
Transmitter Uncertainty	SRSS	±1.32	±0.80
Flow Element Uncertainty	Ref. 5.20	—[a]	
Input FBM Components			
Effective Accuracy	Ref. 5.20	±0.11	—
Repeatability	Sect. 3.10 Ref. 5.20	—	±0.05
M&TE, In	Ref. 5.20	±0.10	—
Temperature Effect		±0.0139	—
Input FBM Uncertainty	SRSS	±0.15	±0.05
Output FBM Uncertainty	Ref. 5.20	±0.05	
A/D Converter Uncertainty	Sect. 3.5	±0.10	
Channel Uncertainty (CS = 61.6 psid = 1706.75 "H_2O)		±1.33% CS ±22.70 "H_2O	±0.81% CS ±13.82 "H_2O

a. The Steam Flow uncertainty was requested without flow element (e.g. steam venturi) components. The flow element uncertainty is 2.03% IV [Ref.5.20], which at 100% span would be 2.03% CS, and the overall uncertainty would be 2.43% CS = 41.47 "H_2O (2.19% CS = 37.38 "H_2O for relative uncertainty).

4.17 COLSS Turbine First Stage Pressure (MTN-P-10)

The uncertainty for this parameter was determined in Ref. 5.22; however, the relative or repeatability uncertainty is determined below. The calibrated span (CS) is 707 psig.

Table 23. MT-P-0010 (COLSS) Uncertainty

Parameter	Basis	Overall Uncertainty % CS	Relative Uncertainty % CS
Transmitter Uncertainty Components			
Effective Accuracy	Ref. 5.22	±0.50	

Table 23. MT-P-0010 (COLSS) Uncertainty (Continued)

Parameter	Basis	Overall Uncertainty % CS	Relative Uncertainty % CS
Repeatability	Sect. 3.8	—	±0.20
M&TE, In	Ref. 5.22	±0.87	—
M&TE, Out		±0.25	—
Drift	Ref. 5.22	±0.35	
Temperature Effect	Ref. 5.22	±0.63	
Voltage Stability		±0.0025	
Transmitter Uncertainty	SRSS	±1.26	±0.75
I/V Converter Uncertainty[a]	Ref. 5.22	±0.566	
Analog Isolation Card Uncertainty[b]	Ref. 5.22	±0.566	
A/D Converter Uncertainty	Sect. 3.5	±0.10	
Channel Uncertainty (CS = 707 psi)		±1.50% CS ±10.61 psi	±1.10% CS ±7.78 psi

a. I/V converter was supplied by General Electric, with insufficient data to determine repeatability.
b. Analog isolation card as supplied by General Electric, with insufficient data to determine repeatability.

4.18 COLSS RC Pump ΔP (RCN-PD-11n, 12n; n = 0, 1, 2, 3)

The uncertainty for this parameter was determined in Ref. 5.17; however, the relative or repeatability uncertainty is determined below. The calibrated span (CS) is 0 - 150 psid.

Table 24. PD-11n, 12n; n = 0,1,2,3 (COLSS) Uncertainty

Parameter	Basis	Overall Uncertainty % CS	Relative Uncertainty % CS
Transmitter Uncertainty Components			
Effective Accuracy	Ref. 5.17	±0.50	
Repeatability	Sect. 3.8	—	±0.20
M&TE, In	Ref. 5.17	±0.83	—
M&TE, Out		±0.25	—
Static Pressure Correction		±0.56[a]	—
Radiation Effect		±0.25	
Drift		±0.40	
Temperature Effect		±0.75	
Transmitter Uncertainty	SRSS	±1.45	±0.91
Process Bias	Ref. 5.17	+0, –0.31	
I/V Converter Uncertainty	Sect. 4.1	±0.73	±0.51
A/D Converter Uncertainty	Sect. 3.5	±0.10	

Table 24. PD-11n, 12n; n = 0,1,2,3 (COLSS) Uncertainty (Continued)

Parameter	Basis	Overall Uncertainty % CS	Relative Uncertainty % CS
Channel Uncertainty (CS = 150 psid)		±1.63, -0.31% CS ±2.45, -0.47 psi	±1.05, -0.31% CS ±1.58, -0.47 psi

a. In Ref. 5.17 this is shown as %IV. For simplicity, it is treated as %CS here, which is conservative for these purposes.

4.19 Feedwater Flow Venturi Dimensions

Part of the inputs to COLSS is the physical dimensions of the feedwater venturis. The information is from Ref. 5.24. Most of which is has been copied into Ref. 5.18 for use in that calculation. The table below summarizes the information for the feedwater venturis.

Table 25. Feedwater Flow Venturi Physical Dimensions

Quantity	Basis/Expression												Reference
	TAP 1						TAP 2						
	Unit 1		Unit 2		Unit 3		Unit 1		Unit 2		Unit 3		
	1112	1122	1112	1122	1112	1122	1112	1122	1112	1122	1112	1122	
D	20.634	20.671	20.707	20.704	20.652	20.694	20.634	20.671	20.707	20.704	20.652	20.694	Ref. 5.24
d	11.257	11.264	11.257	11.261	11.255	11.258	11.257	11.264	11.257	11.261	11.255	11.258	
b	0.5456	0.5449	0.5436	0.5439	0.5450	0.5440	0.5456	0.5449	0.5436	0.5439	0.5450	0.5440	
C	0.9855	0.9738	0.9814	0.9824	0.9820	0.9791	0.9854	0.9763	0.9793	0.9867	0.9782	0.9753	
σ_C[a]	0.0008	0.0009	0.0008	0.0016	0.0010	0.0011	0.0008	0.0011	0.0009	0.0014	0.0009	0.0008	
ΔP	864.7	883.8	873.2	870.0	871.9	876.7	864.9	879.3	876.9	862.4	878.7	883.6	Ref. 5.18

a. Standard deviation of the discharge coefficient.

5 REFERENCES

- **CE References**

5.1 "PVNGS Cycle Independent Data and Setpoint Assumptions List"; PV1-FE-0023, Rev. 03; PV2-FE-0005, Rev. 03; PV3-FE-0018, Rev. 03; table 6

5.2 CE memorandum: COLSS and CPC Uncertainty Summary for PVNGS Tube Plugging Analysis, PV-FE-0041, dated 15 March 1995, from W.L. Greene to B.K. McQuoid, footnote 1 of table 1.

5.3 "Primary Calorimetric Error for COLSS PVNGS", CE 14473-TS-006 Rev. 0, (summary on page 21).

5.4 "PVNGS CPC Input Data Channel Uncertainty Calculation", CE 14273-TS-050, Rev. 0 (18 Mar 87)

5.5 "PVNGS - 1, 2, & 3 COLSS Measurement Channel Uncertainties", 14373-TS-005, Rev. 1 (22 Jan 87).

5.6 "PVNGS Turbine Power Error", 14473-TS-009, Rev. 0 (29 May 87), page 16

- **General Instrument Uncertainty Calculations**

5.7 "Measurement Uncertainty of Foxboro Instruments in the Control Building Environment", 13-JC-ZZ-202, Rev. 1.

5.8 "Uncertainty of Analog-to-Digital Converters for Computer Input in the Control Building", 13-JC-ZZ-204, Rev. 2.

- **CPC Inputs**

5.9 "RCS Hot and Cold Leg Temperature Instrument (RCx-T-0112x & RCx-T-0122x) Uncertainty Calculation", 13-JC-RC-202, Rev. 6.

5.10 "Pressurizer Pressure (PPS High) Instrument (RCx-P-101x; x = A,B,C,D) Uncertainty and Setpoint Calculation", 13-JC-RC-207, Rev. 8.

5.11 "Reactor Coolant Pump Speed Instrument (RCA/B/C/D-S-0113A/B/C/D -0123A/B/C/D -0133A/B/C/D -0143A/B/C/D) Uncertainty Calculation", 13-JC-RC-221, Rev. 1, pages 6,11.

5.12 "Control Elements Assembly (CEA) Position Uncertainty Calculation", 13-JC-SF-202, Rev. 1.

5.13 "Ex-Core Safety Channel Linear Power Instrument (SEx-J-001x) Setpoint and Uncertainty Calculation (x = A, B, C, D)", 13-JC-SE-202, Rev. 7.

- **COLSS Inputs**

5.14 "RCS Cold Leg Temperature Instrument (RCA-T-115 & RCB-T-125) Setpoint and Uncertainty Calculation", 13-JC-RC-203, Rev. 6.

5.15 "RCS Hot & Cold Leg RTD Temperature (J-RCN-T-111X(Y) & -121X(Y)) Setpoint and Total Loop Uncertainty Calculation", 13-JC-RC-211, Rev. 7.

5.16 "Pressurizer Pressure Instrument (RCN-P-100X & Y) Setpoint and Uncertainty Calculation", 13-JC-RC-212, Rev. 5.

5.17 "RCP Differential Pressure Loops (J-RCN-PD-110, -111, -112, -113, -120, -121, -122, & -123) Uncertainty Calculation", 13-JC-RC-210, Rev. 3.

5.18 "Steam Generator Total Feedwater Flow Loop SGN-F-1112 & SGN-F-1122 Uncertainty and Setpoint Calculation", 13-JC-SG-209, Rev. 8.

5.19 Steam Generator Total Feedwater Flow Loops SGN-F-1189 & SGN-F-1190 Uncertainty Calculation", 13-JC-SG-0220, Rev. 0.

5.20 "Main Steam Flow Instrument (SGN-F-1011, -1012, -1021, -1022) Uncertainty Calculation", 13-JC-SG-208, Rev. 5.

5.21 "Feedwater Temperature Loop (SGN-T-0007 & SGN-T-0008) Setpoint and Uncertainty Calculation", 13-JC-SG-217, Rev. 3 .

5.22 "Loop MT-P-0010 (COLSS Input) Uncertainty Calculation", 13-JC-MT-200, Rev. 1.

5.23 "Main Steam Header Pressure Instrument (SGN-P-1024 & SGN-P-1027) Uncertainty Calculation", 13-JC-SG-216, Rev. 2.

- **Vendor Information**

5.24 "Instruction Manual SYS 80-Total Feedflow Elements", VTD-C490-0149-1, (VTM-C490-0034).

5.25 Foxboro Vendor Technical Manual VTM-F180-0004

5.25.1 "Foxboro Technical Information Voltage-to-Current Converter Model 2AO-VAI", Foxboro Company, VTD -F180-0144-1 (VTM-F180-0004 tab 58, Foxboro publication TI 2AO-130, October 1977)

5.25.2 "Foxboro Specification SPEC 200 Input Components", VTD-F180-0547-1 (VTM F180-0004 tab 42, Foxboro publication PSS 2E-1A1 A) (similar to attachment 1 to Ref. 5.21).

5.26 "RdF Corp. Instruction Manual for Model21458 Single Element, Fast Response Nuclear 1E Resistance Temperature Detectors ", RdF Corp., PVNGS number VTD-R135-0009-1 (VTM-R135-0001 tab 8, RdF Publication T-10581, Rev. 1, 1983)

5.27 Barton Vendor Manual VTM-I204-0001.

5.27.1 "Barton Nuclear Safety Gage Pressure Electronic Transmitter models 763 and 763A", VTD-I204-0022-2 (VTM tab 18, Barton Product Bulletin 763-3).

5.27.2 "Technical Manual Model 763 Gage Pressure Electronic Transmitter", VTD-I204-0023-2 (VTM tab 19, Barton Manual No. 83C3(A)).

5.27.3 "Barton Nuclear Safety ΔP Electronic Transmitter models 764", VTD-I204-0024-1 (VTM tab 20, Barton Product Bulletin 764-1).

5.27.4 "ITT Barton Installation and Operation Manual Model 764 Differential Pressure Electronic Transmitter", VTD-I204-0025-2 (VTM tab 21, Barton Manual No. 88C4).

5.28 Rosemount vendor manual VTM-R369-0001.

5.28.1 "Rosemount Model 1151 Alphaline Pressure Transmitters", VTD-R369-0068-1 (VTM tab 5, Rosemount Product Data Sheet PDS 4360, October 1992)

5.28.2 "Rosemount Alphaline Model 1151AP Absolute and Model 1151GP Gage Pressure Transmitters", VTD-R369-0004-2 (VTM tab 3, Rosemount publication 3260/4261, May 1987)

5.28.3 "Model 1152 Alphaline Pressure Transmitter for Nuclear Service, Product Manual", VTD-R369-0016-4 (VTM tab 12, Rosemount publication MAN 4235, October 1992).

5.28.4 "30 Month Stability Specification for Rosemount Model 1152, 1153, and 1154 Pressure Transmitters", Rosemount, VTD-R369-0044, Rev. 0 (Rosemount report D8900126 Rev. A, VTM-R369-0001, tab 23)

5.29 "Reactor Coolant Pump Shaft Speed Sensing System SYS 80-ICE-6003 Instruction Manual", VTD-B208-0001-2 (VTM-C490-0011 tab 5, Bently publication number 8029381).

5.30 ITT Barton Model 763 & 763A Gage Electronic Pressure Transmitter Equipment Qualification Files, EEQ-I204-002, tab F3 which describes problem. All have been replaced with Barton model 763A which corrects the problem. See also Ref. 5.27.2.

5.31 CRDR 9-5-0962 Dealing with letter from ITT Barton about affect of temperature on reference pressure of gage transmitters. See letter from ITT Barton included with CRDR documentation.

- **PVNGS Procedures**

5.32 "Operations Mode 1 Surveillance Logs", 40ST-9ZZM1, Rev. 4.
"Operations Mode 2 Surveillance Logs", 40ST-9ZZM2, Rev. 0.

- **PVNGS Nuclear Fuels Documents**

5.33 "Cycle Specific Non-LOCA Checklist Evaluation".

5.34 "Cycle Specific Setpoints Analysis Checklist Evaluation".

5.35 "Cycle Specific Master Setpoint Analysis".

Contingent Assumptions for Validation Prior to Clearing Transition Status

RSG / Power Uprate

Instructions: Listed below are all the Contingent Parameters and Assumptions pertaining to the following RSG/Power Uprate Transitional Addendum that must be cleared before structures, systems or components (SSC) to which they apply are put into service. The two types of Contingent Parameters and Assumptions are:

Internal Contingent Parameters/Assumptions (CP/A): The LRE has responsibility to clear

External Contingent Parameters/Assumptions (CP/A): The Project Manager has responsibility to clear

Contingent parameters/assumptions which are APS's responsibility shall be cleared by the Cognizant Engineer and Technical Reviewer using a mechanism consistent with APS procedures 81DP-4CC04 (Calculations) and 81DP-0CC05 (Design and Technical Document Control). A copy of this form is to be given to the Project Manager who is responsible for assuring that all contingent parameters/assumptions for the project are clear before implementation into an operating unit.

Type of Contingent Parameter/Assumption	Contingent Parameters/Assumptions
Closed	Verify DFWCS installed in Unit 2

ADDENDUM A

This calculation is arranged so that the sections within Addendum A apply only to the continuing design work associated with the Unit 2 Steam Generator Replacement/Power Uprate Project. Sections and References applicable to both current and future plant configurations will be identified and maintained in the preceding body of the calculation.

A-1 OBJECTIVE

The setpoint project has determined the uncertainties of many measurement channels, including the CPC and COLSS input channels. Some of the uncertainties are different from previous analyses. This calculation provides the input uncertainties which should be used as part of the CPC and COLSS uncertainty analyses. Provided in the summary section are the uncertainties from various NFM and CE documents and the corresponding uncertainties from approved PVNGS documents. This calculation consolidates the information and presents the results in a manner similar to that expected by other organizations previously.

Note: The CIDSAL document [Ref.5.1] discussed in this calculation is no longer active. References 5.33, 5.34, and 5.35 now contain/use the setpoint uncertainty information previously contained/used in the CIDSAL. References to the CIDSAL will remain in this calculation for historical purposes.

This calculation supersedes CE document 14373-TS-005, "PVNGS - 1, 2, &3 COLSS Measurement Channel Uncertainties" (13-N001-13.08-440) and 14273-ICE-3642 "COLSS Measurement Channel Uncertainties for ANPP Palo Verde Units 1, 2, & 3" (no PVNGS number) and CE document 14273-TS-050, "PVNGS CPC Input Data Channel Uncertainty Calculation" (N001-13.03-1785-2).

A-2 SUMMARY and CONCLUSIONS

The uncertainties which should be used as the basis for CPC inputs are given in the column labeled PVNGS. The CE uncertainties are provided for easy comparison of "old" versus "new" uncertainties. Several references have been used to determine which uncertainties are needed.

No evaluation is provided that the uncertainties presented below have been or will be used correctly. The intent is to provide uncertainties similar in concept to what was used in the CE documents, but based on more recent or complete information.

All "±" values from the PVNGS calculations presented below are considered to be for a normal distribution with at least 95% confidence (2σ). An uncertainty with the format "$\pm x - y$" or "$\pm x + y$" means that "x" is a 2σ normally distributed random uncertainty and "y" is a bias. If any uncertainties need to be converted to a 1σ value, the bias term should not be changed (e.g. "$\pm x - y$" becomes "$\pm(x/2) - y$"). Values in the CE documents are given variously as 1σ normal, 2σ normal, and 1σ uniform. For simplicity in comparison all normal values are listed here as 2σ values. That is, any 1σ values from a CE document has been doubled. For uniform distributions the 1σ values are copied directly and marked as "(U)". Note that Ref. 5.2 indicates that normal 2σ values should be used for analyses.

The order of the parameters listed generally follows the CIDSAL [Ref.5.1] with additions as needed and then additional parameters afterwards. Some of the rows in the CIDSAL tables are not input type uncertainties and therefore, are not presented here.

The uncertainties presented in this calculation are based on values developed by Design I&C and should not be changed without consultation with I&C and corresponding revisions to the calculations on which these uncertainties are based.

Table 26. CPC Input Uncertainties

Parameter	Type[a]	Tag Number of Input x = A,B,C,D	PVNGS		CE	
			Normal	Reference	Uncertainty	Reference
Pressurizer P monitoring[b]	abs	RCx-P-101x	±14.3 +0.2, -0.1 psia	Sect. 4.2 Ref. 5.10	±25 psi	Ref. 5.1
Pressurizer P	abs		±19.4, +0.2 -0.1 psia		+26.1 psi -56.1 psi[c]	
Inlet T monitoring	abs	RCx-T-112Cx RCx-T-122Cx	±1.6°F	Sect. 4.3 Ref. 5.9	±2.0°F	
Inlet T	abs		±2.72°F		±2.4°F	
Control Element Assembly (CEA) position through CPC[d]	abs	SFx-Z-nx "n" varies	±1.13, +0.86, -0.84 in	Sect. 4.4 Ref. 5.12	±3.0 in	
	dev		±2.29 in		±3.4 in	
Control Element Assembly (CEA) position through CEAC	abs		±1.22, +0.86, -0.84 in		±3.570 in	Ref. 5.4
	dev		±2.4 in		±5.027 in	
Ex-Core Linear Subchannels	abs	SEx-J-1x	±1.38% pwr.	Sect. 4.6 Ref. 5.13	±1.566% pwr	Ref. 5.1
Ex-Core Detector deviation from Linearity	part		1.05% pwr		1.06% pwr[e]	
Reactor Coolant Pump (RCP) Shaft Speed	abs	RCx-S-113x RCx-S-123x RCx-S-133x RCx-S-143x	±1.904 rpm	Sect. 4.5 Ref. 5.11	±1.920 rpm[f]	Ref. 5.4
	part[g]		±1.428 rpm		±0.12% reference flow	Ref. 5.1
RCS temperature, HOT	abs	RCx-T-112Hx RCx-T-122Hx	±3.5°F	Sect. 4.7 Ref. 5.9	+3.470°F -3.506°F	Ref. 5.4

a. Type of uncertainties are abs - absolute error from a standard; dev - deviation of an individual from a groups; rep - repeatability of a measurement compared to a previous reading (considers primarily drift type terms); part - a part of the overall absolute uncertainty.
b. Note that the uncertainties are for the control board indicators from Ref. 5.10, since the operators use them to monitor pressure [Ref.5.32] rather than the CPC displays.
c. This uncertainty includes a 30 psi bias due to a defect in the Barton transmitters. The transmitters have been replaced with Rosemount 1154 and the bias no longer needs to be included.
d. First row is uncertainty for absolute position; second row is uncertainty for position deviations. Absolute in TS-050 [Ref.5.4] is ±3.539 in, deviation in TS-050 is ±3.572 in
e. This is converted from a 1σ fraction (0.0053) to a 2σ percent (1.06%) for consistency.
f. The CIDSAL [Ref.5.1] has the term "CPC Flow Calibration Uncertainty" given as ±0.5% rated speed, which would be 5.95 rpm, using the rated speed of 1190 rpm as found in Ref. 5.11.
g. This is the probe-to-disk interface error only.

Note that for COLSS measurement channel uncertainties in the table below there are cases where the same parameter appears more than once in the CIDSAL [Ref.5.1]. These duplicate lines are presented here with a pointer to the previously presented PVNGS uncertainties. The uncertainties from the CIDSAL [Ref.5.1] are different, perhaps for different bounding cases.

Table 27. COLSS Input Uncertainties

Parameter	Type[a]	Tag Number of Input	PVNGS		CE	
			Uncertainty	Reference	Uncertainty	Reference
COLSS Sensor & Input Uncertainties						
CEA Group Position	abs		—	—	±2.0 in (U)[b]	Ref. 5.1
Incore Detector signal	abs		—	—	6.8% pwr[c]	Ref. 5.1
Pressurizer pressure	abs	RCN-P-100X, RCN-P-100Y	±15.6, +1.8, -3.9 psi (with Barton Transmitter) ±26.3 psi (with Rosemount Transmitter)	Sect. 4.11 Ref. 5.16	+23.0, −53.0 psi (U)	Ref. 5.1
Wide Range Inlet Temperature	abs	RCA-T-115 RCB-T-125	±6.6°F	Sect. 4.8 Ref. 5.14	±5.18°F	Ref. 5.1
Feedwater Flow transmitter ΔP[d]	abs	SGN-F-1112X, 1122X	±7.28 in wc[e]	Sect. 4.12 Ref. 5.18	±19.20 in wc	Ref. 5.1
		SGN-F-1189, 1190	±19.0 in wc	Sect. 4.13 Ref. 5.19	±19.20 in wc	Ref. 5.1
Feedwater Temperature	abs	SGN-T-7, 8	±1.5 °F	Sect. 4.14 Ref. 5.21	±5.10 °F	Ref. 5.1
Secondary Steam Pressure	abs	SGN-P-1024, 1027	±17.16 psi	Sect. 4.15 Ref. 5.23	±29.6 psi	Ref. 5.1
Steam Flow Transmitter ΔP	abs	SGN-F-1011,1012, 1021, 1022	±22.23 in wc[f]	Sect. A-4.16	±32.0 in H_2O	Ref. 5.1
Blowdown Mass Flow	abs	—	—	—	±40.0 klbm/hr (U)	Ref. 5.1
Steam Generator Pressure	See Secondary Steam Pressure above				±50.0 psi	Ref. 5.1
Turbine first stage pressure	abs	MTN-P-10	±10.7 psi	Sect. A-4.17 Ref. 5.22	—	—[g]
Secondary Side Data at 80% Power						
Blowdown Mass Flow (80% pwr)	abs	—	—	—	±55.2 klbm/hr[h]	Ref. 5.1
COLSS Flow Components						
Inlet Temperature (RCS cold leg) (narrow range)	abs	RCN-T-111Y RCN-T-121Y	±2.82°F	Sect. 4.9 Ref. 5.15	±2.358°F	Ref. 5.1
Inlet Temperature (wide range)	See Wide Range Inlet Temperature above				±5.968°F	Ref. 5.1
Pump Differential Pressure (RCP ΔP)	abs	RCN-PD-11n, 12n; n = 0,1,2,3	±2.45, +0, −0.5 psi	Sect. 4.18 Ref. 5.17	±1.502 psid	Ref. 5.1

Table 27. COLSS Input Uncertainties (Continued)

Parameter	Type[a]	Tag Number of Input	PVNGS		CE	
			Uncertainty	Reference	Uncertainty	Reference
Pump Speed (RCP Shaft Speed)	abs	RCN-S-154,155, 164, 165, 174, 175, 184, 185	±1.36 rpm	Ref. 5.29	±1.572 rpm	Ref. 5.1
Pressurizer Pressure	See Pressurizer Pressure above				±22.18 psi	Ref. 5.1
Uncertainties for Primary Calorimetric Power Error for COLSS [Ref.5.3][i]						
RCS Hot Leg Temperature (nr)	abs	RCN-T-111X RCN-T-121X	±2.82°F	Sect. 4.10 Ref. 5.15	±2.042°F	Ref. 5.3
RCS Cold Leg Temperature (wr)	rel	RCA-T-115 RCB-T-125	±4.5°F	Sect. 4.8	±1.599°F	
RCS Cold Leg Temperature (nr)	rel	RCN-T-111Y RCN-T-121Y	±0.9°F	Sect. 4.9	±0.509°F	
Pressurizer Pressure	rel	RCN-P-100X, RCN-P-100Y	±14.1, +1.8, -3.9 psi (with Barton Transmitter) ±16.6 psi (with Rosemount Transmitter)	Sect. 4.11	±24.755 psi – 15 psi	Ref. 5.3
RCP ΔP	rel	RCN-PD-11n, 12n; n = 0,1,2,3	±1.6, +0, –0.5 psi	Sect. 4.18	±3.210 psi	
RCP speed	rel[j]	RCN-S-154,155, 164, 165, 174, 175, 184, 185	±1.36 rpm	Ref. 5.29	±1.36 rpm	
Uncertainties for Turbine Power Calculation						
Turbine first stage pressure	rel	MTN-P-10	±7.9 psi	Sect. A-4.17	±12.1752psi	Ref. 5.1

a. Type of uncertainties are abs - absolute error from a standard; dev - deviation of an individual from a groups; rel - relative uncertainty (repeatability) of a measurement compared to a previous reading (considers primarily drift type terms); part - a part of the overall absolute uncertainty.

b. TS-005 [Ref.5.5], which is basis for CIDSAL [Ref.5.1], gives uncertainties as ±2.0 in for CEA group position and ±3.0 for CEA group deviation.

c. This is converted from a 1σ fraction (0.034) to a 2σ percent (6.8%) for consistency.

d. Upon installation of modification 226818, control room personel will have the ability to select COLSS feedwater flow ΔP input from the either the venturi based instrument loops (SGN-F-1112/1122) or from the ultrasonic based instrument loops (SGN-F-1189/1190).

e. This is without the venturi uncertainty. The uncertainty provided in the table is usable over the full range of flow, with slight conservatism at flows less than 100% CS. Including the venturi uncertainty at 100% flow results in an overall uncertainty of 8.48 "H_2O.

f. This is without the venturi uncertainty. The uncertainty provided in the table is usable over the full range of flow, with slight conservatism at flows less than 100% CS. Including the venturi uncertainty at 100% flow results in an overall uncertainty of 39.89 "H_2O [Ref.5.20]. Note that 100% CS is greater than 100% power.

g. The uncertainty given in the CIDSAL [Ref.5.1] is a relative uncertainty, as seen by examining Ref. 5.6. The relative uncertainty is given later in this table.

h. CIDSAL [Ref.5.1] doesn't state distribution, but value for 100% power is given as uniform.

i. The final values given in Ref. 5.3 have been divided by √3 as if the instrument uncertainties were uniform and the standard deviation needed to be determined from the range of the distribution. In accordance with Ref. 5.2, the uncertainty before division by √3 will be reported here (called 2σ values in Ref. 5.2).

j. No change between absolute and relative uncertainties for this parameter.

A-3 CRITERIA and ASSUMPTIONS

See Section 3.

A-4 INPUT DATA and CALCULATIONS

Provided below are various factors which affect instrument uncertainty. For the most part the information is already determined in various verified channel uncertainty calculations (see Ref. 5.9 through Ref. 5.23), but is copied here for ease of comparison.

For some of the instruments the relative uncertainty has not been determined in any other PVNGS calculation. The appropriate effects are copied from original PVNGS calculation and then combined in the same manner as the original calculation.

A-4.1 Foxboro I/V, V/I, V/V, R/V, and mV/V Converter Uncertainties

See Section 4.1.

A-4.2 CPC Pressurizer Pressure (RCx-P-101x, x = A, B, C, D)

See Section 4.2.

A-4.3 CPC RCS Cold Leg Temperature (RCx-T-112Cx, 122Cx, x = A, B, C, D)

See Section 4.3.

A-4.4 CPC Control Element Assembly (CEA) Position (SFx-Z-nx, x = A, B, C, D)

See Section 4.4.

A-4.5 CPC Reactor Coolant Pump Speed (RCx-S-1n3x; n = 1, 2, 3, 4; x = A, B, C, D)

See Section 4.5.

A-4.6 CPC Ex-core Linear Subchannels (SEx-J-1x, x = A, B, C, D)

See Section 4.6.

A-4.7 CPC RCS Hot Leg Temperature (RCx-T-112Hx, 122Hx, x = A, B, C, D)

See Section 4.7.

A-4.8 COLSS RCS Cold Leg Temperature (wide range) (RCA-T-115, RCB-T-125)

See Section 4.8.

A-4.9 COLSS RCS Cold Leg Temperature (narrow range) (RCN-T-111Y, 121Y)

See Section 4.9.

A-4.10 COLSS RCS Hot Leg Temperature (RCN-T-111X, 121X)

See Section 4.10.

A-4.11 COLSS Pressurizer Pressure (RCN-P-100X, Y)

See Section 4.11.

A-4.12 COLSS Feedwater Flow ΔP (SGN-F-1112X, 1122X)

See Section 4.12.

A-4.13 COLSS Ultrasonic based Feedwater Flow ΔP (SGN-F-1189, 1190)

See Section 4.13.

A-4.14 COLSS Feedwater Temperature (SGN-T-7X,8X)

See Section 4.14.

A-4.15 COLSS Secondary Steam Pressure (SGN-P-1024, 1027)

See Section 4.15.

A-4.16 COLSS Steam Flow Transmitter ΔP (SGN-F-1011, 1021)

The uncertainty for this parameter was determined in Ref. 5.20; however, the relative or repeatability uncertainty is determined below. The calibrated span (CS) is 59.0 psid (1634.7 "H_2O). The uncertainty determined in Ref. 5.20 is dependent on the flow rate for the magnitude of the uncertainty. The primary factor is the dependence of the venturi uncertainty on flow rate. The uncertainty below does not include the venturi, which is similar to the uncertainty method used in Ref. 5.5.

Table 28. SGN-F-1011, 1012, 1021, 1022 (COLSS) Uncertainty

Parameter	Basis	Overall Uncertainty % CS	Relative Uncertainty % CS
Transmitter Uncertainty Components			
Effective Accuracy	Ref. 5.20	±0.50	
Repeatability	Sect. 3.8	—	±0.20

Table 28. SGN-F-1011, 1012, 1021, 1022 (COLSS) Uncertainty (Continued)

Parameter	Basis	Overall Uncertainty % CS	Relative Uncertainty % CS
M&TE, In	Ref. 5.20	±0.909	—
M&TE, Out		±0.25	—
Static Pressure Correction		±0.255	—
Radiation Effect		±0.250	
Drift		±0.339	
Temperature Effect		±0.674	
Transmitter Uncertainty	SRSS	±1.35	±0.82
Flow Element Uncertainty	Ref. 5.20	—[a]	
Input FBM Components			
Effective Accuracy	Ref. 5.20	±0.11	—
Repeatability	Sect. 3.10 Ref. 5.20	—	±0.05
M&TE, In	Ref. 5.20	±0.10	—
Temperature Effect		±0.0139	—
Input FBM Uncertainty	SRSS	±0.15	±0.05
Output FBM Uncertainty	Ref. 5.20	±0.05	
A/D Converter Uncertainty	Sect. 3.5	±0.10	
Channel Uncertainty (CS = 59.0 psid = 1634.7 "H_2O)		±1.36% CS ±22.23 "H_2O	±0.83% CS ±13.57 "H_2O

a. The Steam Flow uncertainty was requested without flow element (e.g. steam venturi) components. The flow element uncertainty is 2.03% IV [Ref.5.20], which at 100% span would be 2.03% CS, and the overall uncertainty would be 2.44% CS = 39.89 "H_2O (2.19% CS = 35.78 "H_2O for relative uncertainty).

A-4.17 COLSS Turbine First Stage Pressure (MTN-P-10)

The uncertainty for this parameter was determined in Ref. 5.22; however, the relative or repeatability uncertainty is determined below. The calibrated span (CS) is 720 psig.

Table 29. MT-P-0010 (COLSS) Uncertainty

Parameter	Basis	Overall Uncertainty % CS	Relative Uncertainty % CS
Transmitter Uncertainty Components			
Effective Accuracy	Ref. 5.22	±0.50	
Repeatability	Sect. 3.8	—	±0.20

Table 29. MT-P-0010 (COLSS) Uncertainty (Continued)

Parameter	Basis	Overall Uncertainty % CS	Relative Uncertainty % CS
M&TE, In	Ref. 5.22	±0.86	—
M&TE, Out		±0.25	—
Drift	Ref. 5.22	±0.35	
Temperature Effect	Ref. 5.22	±0.62	
Voltage Stability		±0.0025	
Transmitter Uncertainty	SRSS	±1.25	±0.75
I/V Converter Uncertainty[a]	Ref. 5.22	±0.566	
Analog Isolation Card Uncertainty[b]	Ref. 5.22	±0.566	
A/D Converter Uncertainty	Sect. 3.5	±0.10	
Channel Uncertainty (CS = 720 psi)		±1.49% CS ±10.73 psi	±1.10% CS ±7.92 psi

a. I/V converter was supplied by General Electric, with insufficient data to determine repeatability.
b. Analog isolation card as supplied by General Electric, with insufficient data to determine repeatability.

A-4.18 COLSS RC Pump ΔP (RCN-PD-11n, 12n; n = 0, 1, 2, 3)

See Section A-4.18.

A-4.19 Feedwater Flow Venturi Dimensions

See Section A-4.19.