WCAP-18083-NP
Revision 0

November 2016

Westinghouse Revised Thermal Design Procedure Uncertainty Calculations for the Wolf Creek Generating Station

Westinghouse

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November 2016

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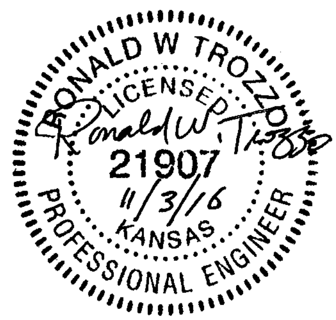

1 INTRODUCTION

This WCAP reflects four operating parameter uncertainties that are used in the uncertainty analysis of the Revised Thermal Design Procedure (RTDP) (Reference 1). These parameters are pressurizer pressure, primary coolant temperature (T_{avg}), reactor coolant system (RCS) flow and reactor power. They are frequently monitored and several are used for control purposes. Pressurizer pressure is a controlled parameter and the uncertainty reflects the control system. T_{avg} is a controlled parameter via the temperature input to the rod control system, and the uncertainty reflects this control system. Reactor power is monitored by the performance of a secondary side heat balance (power calorimetric) at least once every 24 hours. RCS flow is monitored by the performance of a RCS flow calorimetric measurement at the beginning of each cycle for verification of minimum measured flow (MMF) and every 12 hours for RCS flow degradation when in Mode 1. The loop RCS flow channels are normalized to the RCS flow calorimetrics and are used to satisfy the 12-hour RCS flow surveillance (with a small increase in uncertainty).

These calculations are based upon the uncertainty algorithms and setpoint methodology defined in WCAP-17504-P-A, Rev. 1, "Westinghouse Generic Setpoint Methodology" (Reference 2). These indicated and control uncertainties, when supported by appropriate plant procedures and equipment qualification, are considered to result in a total instrument loop uncertainty, termed Channel Statistical Allowance (CSA), at a 95% probability and 95% confidence level (95/95) as required by Reference 1.

This document is divided into four sections. Section 2 notes the current Westinghouse generalized algorithm for control functions (Eq. 2.1) and parameter indication (Eq. 2.2). The algorithms and their basis are described in Reference 2. All appropriate and applicable uncertainties, as defined by a review of the plant baseline design input documentation, have been included in each uncertainty calculation. WCAP-17504-P-A, Rev. 1 documents definitions of terms and associated acronyms used in the control and indication uncertainty calculations.

Section 3 includes a brief description of the uncertainty terms and values for each of the control and indication function uncertainty calculations performed by Westinghouse for the Wolf Creek Generating Station (WCGS). Section 3 also contains a listing of the sources of information for the determination of each of the uncertainty terms contained in the tables and the uncertainty calculations. Shown on each table is the function specific uncertainty algorithm which notes the appropriate combination of instrument uncertainties used to determine the CSA. Included for each control function is a listing of the following parameters: Safety Analysis Limit ([SAL] for initial conditions), Nominal Control Setpoint (NCS), Total Allowance (TA), Margin, and Operability criteria – As Left Tolerance (ALT) and As Found Tolerance (AFT), for both the sensor/transmitter and process racks.

2 METHODOLOGY

This section contains a brief description of the Westinghouse Uncertainty Methodology as applied to WCGS. A more detailed description is contained in Reference 2. The basic algorithms for control and indication used in the determination of the overall CSA are noted in Eq. 2.1 below. All appropriate and applicable uncertainties, as defined by a review of plant specific baseline design input documentation, are included in each control or indication function CSA calculation. See Reference 2 for the definitions of terms used in the algorithms.

The methodology used to combine the uncertainty components for a channel is an appropriate combination of those groups that are statistically and functionally independent. Those uncertainties considered dependent are conservatively treated by arithmetic summation and then systematically combined with the independent terms. The basic algorithm used is a square root of the sum of the squares (SRSS).

The generalized relationship between the uncertainty components and the calculated uncertainty for a control channel is noted in Eq. 2.1 (subscript IND denotes indication):

[ ] a,c

Eq. 2.1

The generalized relationship between the uncertainty components and the calculated uncertainty for an indication channel is noted in Eq. 2.2 (subscript IND denotes indication – control board meter or plant process computer):

[ ]a,c

Eq. 2.2

where,

CSA	=	Channel Statistical Allowance
PMA	=	Process Measurement Accuracy
PEA	=	Primary Element Accuracy
SRA	=	Sensor Reference Accuracy
SMTE	=	Sensor Measurement and Test Equipment Accuracy
SD	=	Sensor Drift
SCA	=	Sensor Calibration Accuracy
SPE	=	Sensor Pressure Effects
STE	=	Sensor Temperature Effects
RMTE	=	Rack Measurement and Test Equipment Accuracy
RD	=	Rack Drift
RCA	=	Rack Calibration Accuracy
RTE	=	Rack Temperature Effects
EA	=	Environmental Allowance
BIAS	=	One directional, known magnitude allowance
CA	=	Controller Accuracy
READOUT	=	Readout Device Accuracy

[ ]a,c

Each of the previous terms is defined in Reference 2. The basis for the above equations is provided in Reference 2.

The CSA values from Eq. 2.1 and Eq. 2.2 are considered to be determined at a 95% probability and at a 95% confidence level, consistent with the requirements of the RTDP (Reference 1).

3 INSTRUMENTATION UNCERTAINTIES

This section contains a discussion of the RTDP uncertainty functions. The first two sections, 3.1 and 3.2, include the two parameters which are controlled by Automatic Systems, Pressurizer Pressure and Tavg (through Rod Control). The next three sections, 3.3, 3.4 and 3.5, include the RCS Flow Calorimetric, Elbow Tap Indication and the Daily Power Calorimetric. Section 3.6 contains a listing of sources of information used for the uncertainties and Section 3.7 defines the type of information presented in the uncertainty tables.

3.1 PRESSURIZER PRESSURE UNCERTAINTIES

Pressurizer Pressure is controlled by comparison of the measured vapor space pressure and a reference value. Proper operation of the control system is verified through indication. Allowances are made for the transmitter and the process racks/indicators and controller. As noted on Table 3-1, the indicated higher than actual controller uncertainty for this function is **[ ]**^{a,c} which corresponds to an accuracy of **[ ]**^{a,c}. In addition to the controller accuracy, an allowance is made for pressure overshoot or undershoot due to the interaction and thermal inertia of the heaters and spray. Based on previous Westinghouse evaluation of typical plant operation, an allowance of **[ ]**^{a,c} was made for this effect. Therefore, a total control system uncertainty of **[ ]**^{a,c} is calculated, which results in a standard deviation of **[ ]**^{a,c} (assuming a normal, two sided probability distribution).

3.2 T_{avg} UNCERTAINTIES

T_{avg} is controlled by a closed loop control system that compares the auctioneered high T_{avg} from the loops with a reference derived from the First Stage Turbine Impulse Chamber Pressure. T_{avg} is the average of the narrow range T_H and T_C values. The highest loop T_{avg} is then used for rod control. Proper operation of the control system is verified through indication. Allowances are made (as noted on Table 3-2) for the Resistance Temperature Detectors (RTDs), transmitter and the process racks/indicators and controller. The CSA for this function is dependent on the type of RTD, pressure transmitter, and the location of the RTDs, i.e., in the hot and cold legs. Based on the assumption that three T_H and one T_C cross-calibrated RTDs are used to calculate T_{avg} and the RTDs are located in the hot and cold leg piping, the CSA for the instrumentation is **[ ]**^{a,c}. Assuming a normal, two sided probability distribution results in an instrumentation standard deviation of **[ ]**^{a,c}.

3.3 RCS FLOW CALORIMETRIC MEASUREMENT UNCERTAINTIES

WCGS Technical Specifications require a RCS flow calorimetric measurement to verify RCS flow at the beginning of every fuel cycle at or near 100% rated thermal power (RTP) operation. It is assumed that the RCS flow calorimetric measurement is performed with the use of the feedwater venturis for measurement of feedwater flow and the plant computer is used to measure all parameters. No allowance has been made for feedwater fouling.

The RCS flow calorimetric measurement is performed by determining the steam generator thermal output (corrected for the reactor coolant pump (RCP) heat input and the loop's share of primary system heat

losses) and the enthalpy rise (Δh) of the primary coolant. Assuming that the primary and secondary sides are in equilibrium, the RCS total vessel flow is the sum of the individual primary loop flows, i.e.,

$$W_{RCS} = \Sigma(W_L) \qquad \text{Eq. 3.1}$$

The individual primary loop volumetric flows are determined by correcting the thermal output of the steam generator for steam generator blowdown (if not secured), subtracting the RCP heat addition, adding the loop's share of the primary side system losses, dividing by the primary side enthalpy rise and multiplying by the cold leg specific volume. The equation for this calculation is:

$$W_L = \frac{(A)\ \{Q_{SG} - Q_P + Q_L\}\ (V_C)}{(h_H - h_C)} \qquad \text{Eq. 3.2}$$

where,

W_L	=	Loop flow (gpm)
A	=	Constant conversion factor 0.1247 gpm / (ft^3 / hr)
Q_{SG}	=	Steam generator thermal output (BTU / hr)
Q_P	=	RCP heat addition for primary system (BTU / hr)
Q_L	=	Primary system net heat losses (BTU / hr)
V_C	=	Specific volume of the cold leg at T_C (ft^3 / lb)
h_H	=	Hot leg enthalpy (BTU / lb)
h_C	=	Cold leg enthalpy (BTU / lb)

The thermal output of each steam generator is determined by a secondary side calorimetric measurement that is defined as:

$$Q_{SG} = (h_s - h_{fw})W_{fw} - (h_s - h_{bd})W_{bd} \qquad \text{Eq. 3.3}$$

where,

h_s	=	Steam enthalpy (BTU / lb)
h_{fw}	=	Feedwater enthalpy (BTU / lb)
W_{fw}	=	Feedwater flow (lb / hr)
h_{bd}	=	Steam generator blowdown enthalpy (BTU / lb)
W_{bd}	=	Steam generator blowdown flow (lb / hr)

The steam enthalpy is based on the measurement of steam generator outlet steam pressure, assuming saturated liquid conditions. The feedwater enthalpy is based on the measurement of feedwater temperature and a nominal feedwater pressure. The feedwater flow is determined by a venturi and a ΔP transmitter in each of four feedwater lines. The steam generator blowdown enthalpy is based on the measurement of steam generator outlet steam pressure, assuming saturated conditions. The total system steam generator blowdown flow is the sum of flow from the flash tank and the flow to the heat exchanger determined by orifices and ΔP transmitters.

For measurement of feedwater flow with the feedwater venturis, the feedwater flow is determined by a ΔP measurement and the following calculation:

$$W_{fw} = (K_{fw})(F_{a,fw})\sqrt{(\rho_{fw})(\Delta P_{fw})} \quad \text{Eq. 3.4}$$

where,

W_{fw}	=	Feedwater loop flow (lb / hr)
K_{fw}	=	Feedwater venturi flow coefficient
$F_{a,fw}$	=	Feedwater venturi correction for thermal expansion
ρ_{fw}	=	Feedwater density (lb / ft^3)
ΔP_{fw}	=	Feedwater venturi pressure drop (inches H_2O)

The feedwater venturi flow coefficient is the product of a number of constants including as-built dimensions of the venturi and calibration tests performed by the vendor. The thermal expansion correction is based on the coefficient of expansion of the venturi material and the difference between feedwater temperature and calibration temperature. Feedwater density is based on the measurement of feedwater temperature and a nominal feedwater pressure. The venturi pressure drop is obtained from the output of the differential pressure transmitter connected to the venturi.

For measurement of steam generator blowdown flow with the blowdown orifices, the blowdown flow is determined by a ΔP measurement and the following calculation:

$$W_{bd} = (K_{bd})\sqrt{(\rho_{bd})(\Delta P_{bd})} \quad \text{Eq. 3.5}$$

where,

W_{bd}	=	Steam generator blowdown (lb / ft)
K_{bd}	=	Steam generator blowdown orifice flow coefficient
ρ_{bd}	=	Steam generator blowdown density (lb / ft^3)
ΔP_{bd}	=	Steam generator blowdown orifices pressure drop (inches H_2O)

The blowdown orifice flow coefficient is the product of a number of constants including as-built dimensions of the orifice and calibration calculations performed by the vendor. Blowdown density is based on the measurement of steam pressure, assuming saturated conditions. The orifice pressure drop is obtained from the output of the differential pressure transmitter connected to the orifice.

RCP heat addition is determined by calculation, based on the best estimate of coolant flow, pump head, and pump hydraulic efficiency.

The primary system net heat losses are determined by calculation, considering the following system heat inputs and heat losses:

- Charging flow
- Letdown flow
- Seal injection flow
- RCP thermal barrier cooler heat removal
- Pressurizer surge line flow
- Component insulation heat losses
- Component support heat losses
- Control Rod Drive Mechanism (CRDM) heat losses.

A single calculated sum for 100% RTP operation is used for these losses and heat inputs.

The hot leg and cold leg enthalpies are based on the measurement of the hot leg temperature, the cold leg temperature and the pressurizer pressure. The cold leg specific volume is based on measurement of the cold leg temperature and the calculation of cold leg pressure based on the pressurizer pressure measurement.

The RCS flow calorimetric measurement is thus based on the following plant measurements via the plant computer:

- Steamline pressure (P_s)
- Feedwater temperature (T_{fw})
- Feedwater venturi differential pressure ($FW_{\Delta P}$)
- Hot leg temperature (T_H)
- Cold leg temperature (T_C)
- Pressurizer pressure (P_p)
- Steam generator blowdown orifice differential pressure ($SGB_{\Delta P}$)

and on the following calculated values:

- Feedwater venturi flow coefficient (FW) (a constant value)
- Feedwater venturi thermal expansion correction (FWF_a)
- Feedwater density (FW_ρ)
- Feedwater enthalpy (FW_h)
- Feedwater pressure (FW_p) (a constant value)
- Steam enthalpy (hs_p)
- Steam generator blowdown orifice flow coefficient ($SGBF_a$) (a constant value)
- Steam generator blowdown density (SGB_ρ)
- Steam generator blowdown enthalpy (SGB_h)
- Moisture carryover (impacts h_s)
- Primary system net heat losses (Q_L) (a constant value)
- RCP heat addition (Q_p) (a constant value)
- Hot leg enthalpy (h_H)
- Cold leg enthalpy (h_C)

The derivation of the measurement uncertainties and flow uncertainties on Table 3-3 are noted below.

Secondary Side

The secondary side uncertainties are in three principal areas:

- Feedwater flow
- Feedwater enthalpy
- Steam enthalpy

These areas are specifically identified on Table 3-3.

For the measurement of feedwater flow, each feedwater venturi is calibrated by the vendor in a hydraulics laboratory under controlled conditions to an accuracy of **[ ]^{a,c}**. The calibration data that substantiates this accuracy is provided to the plant by the vendor. An additional uncertainty factor of **[ ]^{a,c}** is included for installation effects, resulting in a conservative overall flow coefficient (FW) uncertainty of **[ ]^{a,c}**. Since RCS loop flow is proportional to steam generator thermal output that is proportional to feedwater flow, the flow coefficient uncertainty is expressed as **[ ]^{a,c}**. It should be noted that no allowance is made for venturi fouling. The venturis should be inspected, and cleaned if necessary, prior to performance of the calorimetric measurement. If fouling is present but not removed, its effects must be treated as a flow bias.

The uncertainty applied to the feedwater venturi thermal expansion correction (FWFa) is based on the uncertainties of the measured feedwater temperature and the coefficient of thermal expansion for the venturi material, usually 304 stainless steel. For this material, a change of ± 1 °F in the nominal feedwater temperature changes $FWFa_t$ by **[ ]^{a,c}** and the steam generator thermal output by the same amount.

An uncertainty in $FWFa_m$ of **[ ]^{a,c}** for the material variance of the composition of 304 stainless steel is used in this analysis. This results in an additional uncertainty of **[ ]^{a,c}** in feedwater flow. Westinghouse uses the conservative value of **[ ]^{a,c}** in the uncertainty calculation.

Using the IAPWS-95 Steam Tables, it is possible to determine the sensitivities of various parameters to changes in feedwater temperature and pressure. Table 3-3 notes the instrument uncertainties for the hardware used to perform the measurements and lists the various sensitivities. As can be seen on Table 3-3, feedwater temperature uncertainties have an impact on venturi $FWFa_t$, feedwater density and feedwater enthalpy. Feedwater pressure uncertainties impact feedwater density and feedwater enthalpy.

Feedwater venturi $FW_{\Delta P}$ uncertainties are converted to % feedwater flow using the following conversion factor:

$$\%\ \text{flow} = (\Delta P\ \text{uncertainty})\ (1/2)\ (\text{transmitter span} / 100)^2 \qquad \text{Eq. 3.6}$$

The feedwater flow transmitter span is **[ ]^{a,c}** nominal flow.

Using the IAPWS-95 Steam Tables again, it is possible to determine the sensitivity of steam enthalpy to changes in steam pressure and steam quality. Table 3-3 notes the uncertainty in steam pressure and provides the sensitivity. For steam quality, the Steam Tables were used to determine the sensitivity at a moisture content of **[ ]**^{a,c} in steam mass. This value is noted on Table 3-3.

An allowance of **[ ]**^{a,c} is used for the combined steam generator blowdown orifice flow coefficient.

The combined steam generator blowdown orifice $SGB_{\Delta P}$ uncertainties are converted to % steam generator blowdown flow using the following conversion factor:

$$\% \text{ flow} = (\Delta P \text{ uncertainty})\ (1/2)\ (\text{transmitter span} / 100)^2 \qquad \text{Eq. 3.7}$$

The combined steam generator blowdown flow transmitter span is **[ ]**^{a,c} nominal flow.

Primary Side

The primary side uncertainties are in four principal areas, hot leg enthalpy, cold leg enthalpy, cold leg specific volume, and net pump heat addition. These are specifically noted on Table 3-3. Three primary side parameters are measured, T_H, T_C and pressurizer pressure by the plant computer. Hot leg enthalpy is influenced by T_H, pressurizer pressure, and hot leg temperature streaming. The uncertainties for the instrumentation and the sensitivities are provided on Table 3-3. The hot leg temperature streaming is split into loop and systematic components. For WCGS, the RTDs are located in the hot leg and cold leg thermowells (3 RTDs in the hot leg and 1 RTD in the cold leg: the RTD bypass manifolds are eliminated). A plant-specific evaluation has been performed that results in a hot leg temperature streaming uncertainty of **[ ]**^{a,c} for the loop and **[ ]**^{a,c} for the systematic components.

The cold leg enthalpy and specific volume uncertainties are impacted by T_C and the measured cold leg pressure (via Pressurizer Pressure). Table 3-3 provides the T_C instrument uncertainty and the sensitivities.

The net pump heat addition uncertainty is derived from the combination of the primary system net heat losses and the RCP heat addition. The uncertainty is summarized as follows:

− System heat losses
− Component conduction and convection losses
\+ Pump heat adder
= Net heat input to RCS = 14 MWt

The uncertainty on system heat losses that is essentially all due to charging and letdown flows has been estimated to be **[ ]**^{a,c} of the calculated value. Since direct measurements are not possible, the uncertainty on component conduction and convection losses is assumed to be **[ ]**^{a,c} of the calculated value. Reactor coolant pump hydraulics are known to a relatively high confidence level, supported by system hydraulic tests performed by Prairie Island Unit 2 and by input power measurements from several other plants. Therefore, the uncertainty for the RCP heat addition is estimated to be **[ ]**^{a,c} of the best estimate value. Considering these parameters as one combined uncertainty, designated as the net pump heat addition (NPHA) uncertainty, the combined effect is estimated to be less

than [ ]^{a,c} of the net heat input of 14 MWt. So, the overall uncertainty is less than [ ]^{a,c} of RCS flow.

Parameter dependent effects are identified on Table 3-3. Westinghouse has determined the dependent sets in the calculation and the direction of interactions, i.e., whether components in a dependent set are additive or subtractive with respect to a conservative calculation of RCS flow. As a result, the calculation explicitly accounts for dependent effects with credit taken for sign (or direction of impact).

3.4 LOOP RCS FLOW MEASUREMENT UNCERTAINTIES

As noted in Section 1.0, RCS flow calorimetric is used as the reference for the normalized loop RCS flow control board indicators from the cold leg elbow tap ΔP transmitters. The required Technical Specification 12-hour surveillance can then be performed by reading the loop RCS flow indicators. Table 3-4 notes the instrument uncertainties of the loop RCS flow indicators, assuming the average of three loop RCS flow channels per RCS loop. The ΔP transmitter uncertainties are converted to % flow using the following conversion factor:

$$\%\ \text{flow} = (\Delta P\ \text{uncertainty})\ (1/2)\ (\text{transmitter span} / 100)^2 \qquad \text{Eq. 3.8}$$

The loop RCS flow transmitter span is [ ]^{a,c} of nominal flow.

The loop RCS flow channel uncertainty is then combined with the RCS flow calorimetric measurement uncertainty.

The total four loop RCS flow uncertainty is [ ]^{a,c} assuming a normal, two-sided probability distribution results in a standard deviation of [ ]^{a,c}.

3.5 REACTOR POWER MEASUREMENT UNCERTAINTIES

A daily power calorimetric measurement is performed with the use of the feedwater venturis for feedwater flow measurement, and the plant computer to measure all plant parameters.

Assuming that the primary and secondary sides are in equilibrium, the core power is determined by summing the thermal output of the steam generators, correcting the total secondary power for steam generator blowdown, subtracting the RCP heat addition, adding the primary side system losses, and dividing by the core BTU / hr at rated full power. The equation for this calculation is:

$$RP = \frac{\{(\sum Q_{SG}) + Q_L - Q_P\}(100)}{H} \qquad \text{Eq. 3.9}$$

where,

RP	=	Core power (% RTP)
Q_{SG}	=	Steam generator thermal output (BTU / hr) as defined earlier
Q_P	=	RCP heat addition (BTU / hr) as defined earlier
Q_L	=	Primary system net heat losses (BTU / hr) as defined earlier
H	=	Rated core power (BTU / hr).

For the purposes of this uncertainty analysis (and based on H noted above) it is assumed that the plant is at 100% RTP when the measurement is taken. Measurements performed at lower power levels will result in different uncertainty values.

The thermal output of the steam generator is determined by a secondary side calorimetric measurement. The equation for this calculation was given previously, (Eq. 3.3), but is repeated here for convenience.

$$Q_{SG} = (h_s - h_{fw})W_{fw} - (h_s - h_{bd})W_{bd}$$

where,

h_s	=	Steam enthalpy (BTU / lb)
h_{fw}	=	Feedwater enthalpy (BTU / lb)
W_{fw}	=	Feedwater flow (lb / hr)
h_{bd}	=	Steam generator blowdown enthalpy (BTU / lb)
W_{bd}	=	Steam generator blowdown flow (lb / hr)

The steam enthalpy is based on the measurement of steam generator outlet pressure assuming saturated conditions. The feedwater enthalpy is based on the measurement of feedwater temperature and calculated feedwater pressure. Steam generator blowdown enthalpy is based on the measurement of steam generator outlet pressure assuming saturated conditions.

The (daily) power calorimetric measurement is based on the following plant measurements via the plant computer:

- Steamline pressure (P_s)
- Feedwater temperature (T_{fw})
- Feedwater venturi differential pressure ($FW_{\Delta P}$)
- Steam generator blowdown orifice differential pressure ($SGB_{\Delta P}$)

and by the following calculated values:

- Feedwater venturi flow coefficient (FW) (a constant value)
- Feedwater venturi thermal expansion correction (FWF_a)
- Feedwater density (FW_ρ)
- Feedwater enthalpy (FW_h)

- Feedwater pressure (FW_p) (a constant value)
- Steam enthalpy (hs_p)
- Steam generator blowdown orifice flow coefficient ($SGBF_a$) (a constant value)
- Steam generator blowdown density (SGB_ρ)
- Steam generator blowdown enthalpy (SGB_h)
- Moisture carryover (impacts h_s)
- Primary system net heat losses (Q_L) (a constant value)
- RCP heat addition (Q_p) (a constant value)

The derivation of the measurement uncertainties and power uncertainties are shown on Table 3-5.

Secondary Side

The secondary side uncertainties are in three principal areas:

- Feedwater flow
- Feedwater enthalpy
- Steam enthalpy

These areas are specifically identified on Table 3-5.

For the measurement of feedwater flow, each feedwater venturi is calibrated by the vendor in a hydraulics laboratory under controlled conditions to an accuracy of **[ ]**^{a,c}. The calibration data that substantiates this accuracy is provided to the plant by the vendor. An additional uncertainty factor of **[ ]**^{a,c} is included for installation effects, resulting in a conservative overall flow coefficient (FW) uncertainty of **[ ]**^{a,c}. Since the calculated steam generator thermal output is proportional to feedwater flow, the flow coefficient uncertainty is expressed as **[ ]**^{a,c}. It should be noted that no allowance is made for venturi fouling. The effect of fouling results in an indicated power higher than actual which is conservative.

Feedwater venturi ΔP uncertainties are converted to % feedwater flow using the following conversion factor:

$$\% \text{ flow} = (\Delta P \text{ uncertainty})\ (1/2)\ (\text{transmitter span} / 100)^2 \qquad \text{Eq. 3.10}$$

The feedwater flow transmitter span is **[ ]**^{a,c} of nominal flow.

Parameter dependent effects are identified on Table 3-5. Westinghouse has determined the dependent set in the calculation and the direction of interactions. This is the same as that performed for the RCS flow calorimetric measurement, but applicable only to power.

The total four loop Daily Power Calorimetric uncertainty is **[ ]**^{a,c}. Assuming a normal two-sided probability distribution results in a standard deviation of **[ ]**^{a,c}.

3.6 UNCERTAINTY SOURCES

This section contains the sources of information utilized in the uncertainty calculations.

Noted below is a listing of the principal sources of information for the instrument channel uncertainty calculations performed by Westinghouse. These sources include information from the following areas:

- NRC Documents
- Westinghouse Safety Analyses
- Vendor Documents
- Scaling Procedure
- Calibration Procedures (listed as a typical example)
- Surveillance Procedures (listed as a typical example)
- Additional WCGS Documents

The following sources represent the equipment currently being used at WCGS. These sources may change in the future if equipment is replaced due to obsolescence, etc.

Given the information noted below and design inputs from WCNOC, e.g., M&TE to be utilized, Westinghouse performed the setpoint uncertainty calculations documented in Tables 3-1 through 3-5.

a,c

1. Rosemount, the Rosemount logotype, and Alphaline are registered trademarks of Rosemount, Inc.

a,c

3.7 INSTRUMENT CHANNEL UNCERTAINTY CALCULATIONS

Tables 3-1 through 3-5 document individual parameter uncertainties and instrument channel uncertainty CSA calculations for the RTDP functions. Each table includes a listing of the applicable terms for the function uncertainty and setpoint calculation:

- Model of sensor/transmitter
- Type of process rack
- Listing of each uncertainty parameter, noting
  - Value (% span) or applicability
  - Notes applicable to the parameter, including the Source Listing number from Section 3.6
- Algorithm utilized
- Algorithm with parameter values (% span) filled in
- Source Material for SCA, SD, RCA and RD (where applicable)
- Safety Analysis Limit (engineering units), including the Source
- Nominal Control Setpoint (engineering units), including the Source
- Instrument span, including the Source
- Total Allowance (% span)
- CSA (% span)
- Margin (% span)
- Transmitter operability criteria
  - As Left Tolerances (ALT) (% span)
  - As Found Tolerances (AFT) (% span)
- Process rack operability criteria
  - As Left Tolerances (% span)
  - As Found Tolerances (% span)

Westinghouse reports TA, CSA and Margin values to one decimal place using the technique of:

- Rounding down values < 0.05% span
- Rounding up values ≥ 0.05% span, as defined in Reference 2

Parameters reported as:

- “N/A” are not applicable, i.e., have no value for that channel
- “0” are applicable but are included in other terms, e.g., normalized parameters
- “0.0” are applicable with a value less than 0.05% span

Table 3-1. Pressurizer Pressure – Control

Rosemount 1154SH9 Transmitters, Westinghouse Process 7300 Instrumentation, VX-252 Meter

Parameter	**Allowance***
Process Measurement Accuracy (PMA) [ ]a,c	[ ]a,c
Primary Element Accuracy (PEA)	
Sensor Reference Accuracy (SRA) (Source Listing 3)	
Sensor Calibration Accuracy (SCA) (Source Listing 3) Value controlled by #, consistent with SRA	
Sensor Measurement & Test Equipment Accuracy (SMTE) (Source Listing 10) [ ]a,c Value controlled by #	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE) (Source Listing 3)	
Sensor Drift (SD) Value controlled by #	
Environmental Allowance (EA) (Source Listing 3) [ ]a,c	
Bias [ ]a,c	
Indicator Calibration Accuracy (RCA_{IND}) (Source Listing 8) Value controlled by ##	
Indicator Measurement & Test Equipment Accuracy ($RMTE_{IND}$) (Source Listing 10) [ ]a,c Value controlled by ##	
Indicator Temperature Effect (RTE_{IND}) (Source Listing 5)	
Indicator Drift (RD_{IND}) Value controlled by ##	
Indicator ($READOUT_{IND}$) (Source Listing 6) Control board meter readability	
Controller Accuracy (CA)	

*In % span (800 psi)

Table 3-1. Pressurizer Pressure – Control (cont.)

Rosemount 1154SH9 Transmitters, Westinghouse Process 7300 Instrumentation, VX-252 Meter

Channel Statistical Allowance **[** **]**^{a,c} (indicated lower than actual) =

[ ]a,c

[ ]a,c

[ ]a,c

Function specific source material for SCA, SD, RCA, RD, and Instrument span

STS IC-502A, "Calibration of Pressurizer Pressure Transmitters," (procedure controls transmitter drift magnitude determined from drift data evaluation process, see transmitter AFT).

STS IC-502B, "Channel Calibration of 7300 Process Instrumentation," (typical for this function).

Table 3-1. Pressurizer Pressure – Control (cont.)

Rosemount 1154SH9 Transmitters, Westinghouse Process 7300 Instrumentation, VX-252 Meter

Channel Statistical Allowance [ ]a,c (indicated higher than actual) =

[ ]a,c

[ ]a,c

[ ]a,c

Function specific source material for SCA, SD, RCA, RD, and instrument span

STS IC-502A, "Calibration of Pressurizer Pressure Transmitters," (procedure controls transmitter drift magnitude determined from drift data evaluation process, see transmitter AFT).

STS IC-502B, "Channel Calibration of 7300 Process Instrumentation," (typical for this function).

Table 3-1. Pressurizer Pressure – Control (cont.)

Rosemount 1154SH9 Transmitters, Westinghouse Process 7300 Instrumentation, VX-252 Meter

Nominal Control Setpoint (NCS) (Source Listing 1) = [ ]a,c

Instrument Span (Source #) = 1700 to 2500 psig = 800 psi / 4 - 20 mA = 16mA

Safety Analysis Initial Condition (Source Listing 1)
(indicated higher than actual) = [ ]a,c

Total Allowance
(indicated higher than actual) = [ ]a,c

CSA (indicated higher than actual) = [ ]a,c

Margin (indicated higher than actual) = [ ]a,c

Safety Analysis Initial Condition (Source Listing 1)
(indicated lower than actual) = [ ]a,c

Total Allowance
(indicated lower than actual) = [ ]a,c

CSA (indicated lower than actual) = [ ]a,c

Margin (indicated lower than actual) = [ ]a,c

a,c

Transmitter +As Left Tolerance (ALT) = [
Transmitter –ALT =
Transmitter +As Found Tolerance (AFT) =
Transmitter -AFT =]

Table 3-1. Pressurizer Pressure – Control (cont.)

Rosemount 1154SH9 Transmitters, Westinghouse Process 7300 Instrumentation, VX-252 Meter

a,c

Process Racks (controller) +ALT = [ ]
Process Racks (controller) -ALT = [ ]
Process Racks (controller) +AFT = [ ]
Process Racks (controller) -AFT = [ ]

a,c

Process Racks (Indicator) +ALT = [ ]
Process Racks (Indicator) -ALT = [ ]
Process Racks (Indicator) +AFT = [ ]
Process Racks (Indicator) -AFT = [ ]

Table 3-2. Tavg – Control

Tavg Input
Weed N9004E RTD, Westinghouse 7300 Process Racks, VX-252 Indicator

Parameter **Allowance***

[ ]a,c

Process Measurement Accuracy (PMA)

[ ]a,c

Primary Element Accuracy (PEA)

Sensor Reference Accuracy (SRA_{RTD}) (Source Listing 4)

Sensor Calibration Accuracy (SCA_{RTD}) (Source Listing 7)
Value controlled by #

Sensor Measurement & Test Equipment Accuracy ($SMTE_{RTD}$)
[ ]a,c

Sensor Pressure Effects (SPE_{RTD})

Sensor Temperature Effects (STE_{RTD})

Sensor Drift (SD_{RTD})
Value controlled by #

RTD Lead Imbalance (RTD_{LI}) (Source Listing 9)

Environmental Allowance (EA_{RTD})

Bias

Indicator Calibration Accuracy (RCA_{IND}) (Source Listing 8)
Value controlled by ##

Indicator Measurement & Test Equipment Accuracy ($RMTE_{IND}$) (Source Listing 10)
[ ]a,c
Value controlled by ##

Indicator Temperature Effect (RTE_{IND}) (Source Listing 5)

Indicator Drift (RD_{IND})
Value controlled by ##

* In Tavg span (100°F)

Table 3-2. Tavg – Control (cont.)

Tavg Input
Weed N9004E RTD, Westinghouse 7300 Process Racks, VX-252 Indicator

Parameter	**Allowance***
Indicator Control Board Meter Readability ($READOUT_{IND}$) (Source Listing 6)	[ ] a,c
Controller Accuracy (CA)	

*In Tavg span (100°F)

Function specific source material for SCA, SD, RCA, RD, instrument span

\# STS RE-014, "Cross Calibration of Wide and Narrow Range RTDs."

\## STS IC-500D, "Channel Calibration DT/Tavg Instrumentation Loop 1," (typical for this function).

Table 3-2. Tavg – Control (cont.)

Turbine Impulse Pressure Input
Rosemount 1153GB8RA Transmitter, Westinghouse 7300 Process Racks

Parameter	**Allowance****
Process Measurement Accuracy (PMA_{TP})	[ ]a,c
Primary Element Accuracy (PEA)	
Sensor Reference Accuracy (SRA_{TP}) (Source Listing 3)	
Sensor Calibration Accuracy (SCA_{TP}) (Source Listing 3) Value controlled by #, consistent with SRA	
Sensor Measurement & Test Equipment Accuracy ($SMTE_{TP}$) (Source Listing 10) [ ]a,c Value controlled by #	
Sensor Pressure Effects (SPE_{TP})	
Sensor Temperature Effects (STE_{TP})	
Sensor Drift (SD_{TP}) Value controlled by #	
Environmental Allowance (EA_{TP}) (Source Listing 3) [ ]a,c	
Bias	
Turbine Pressure Sensitivity (TP_Sen)	
Rack Calibration Accuracy (RCA_{TP}) (Source Listing 8) Value controlled by ##	
Rack Measurement & Test Equipment Accuracy ($RMTE_{TP}$) (Source Listing 10) [ ]a,c Value controlled by ##	

**In Turbine Pressure span (900 psi)

***Sensitivity of Tref to Turbine Pressure uncertainties is based on the relationship between Turbine Pressure and Tref from no load to full power. It is used to convert Turbine Impulse Pressure uncertainties to Tavg Span.

Table 3-2. Tavg – Control (cont.)

Turbine Impulse Pressure Input
Rosemount 1153GB8RA Transmitter, Westinghouse 7300 Process Racks

Parameter	**Allowance****
Rack Temperature Effects (RTE_{TP}) (Source Listing 5)	[ ]a,c
Rack Drift (RD_{TP}) Value controlled by ##	

** In Turbine Pressure span (900 psi)

Function specific source material for SCA, SD, RCA, RD, instrument span

STS IC-506A, "Channel Calibration – Impulse Chamber Pressure," (procedure controls transmitter drift magnitude determined from drift data evaluation process, see transmitter AFT).

STS IC-506B, "Calibration of 7300 Process Turbine Impulse Pressure," (typical for this function).

Table 3-2. Tavg – Control (cont.)

Weed N9004E RTD, Rosemount 1153GB8RA Transmitter, Westinghouse 7300 Process Racks, VX-252 Indicator

N_H = Number of hot leg RTDs = 3
N_C = Number of cold leg RTDs = 1
[ ]a,c

Channel Statistical Allowance =

[ ]a,c

Table 3-2. Tavg – Control (cont.)

Weed N9004E RTD, Rosemount 1153GB8RA Transmitter, Westinghouse 7300 Process Racks, VX-252 Indicator

Channel Statistical Allowance =

[ ]a,c

However, this does not include the controller deadband of **[ ]**a,c. The controller uncertainty is the combination of the electronics uncertainty and the deadband. The probability distribution for the deadband has been determined to be **[ ]**a,c. The variance for the deadband uncertainty is then:

$$(s_2)^2 = [\quad]^{a,c}.$$

Combining the variance for the electronics and the variance for the deadband results in a controller variance of:

$$(s_C)^2 = (s_1)^2 + (s_2)^2 = [\quad]^{a,c}$$

The controller standard deviation s_C = **[ ]**a,c results in a total random uncertainty of **[ ]**a,c and a total bias of **[ ]**a,c.

Table 3-2. Tavg – Control (cont.)

Weed N9004E RTD, Rosemount 1153GB8RA Transmitter, Westinghouse 7300 Process Racks, VX-252 Indicator

Nominal Full Power Control Setpoint (NCS) (Source Listing 1)	= 588.4°F[1]
Instrument Span (Tavg) (Source #)	= 530°F to 630°F
Instrument Span (Turbine Pressure) (Source #)	= 0 to 900 psig = 900 psi / 4-20 mA = 16 mA

Safety Analysis Initial Condition (indicated lower than actual) (Source Listing 1)	= 594.9°F
Total Allowance (indicated lower than actual)	= [ ]a,c
CSA (indicated lower than actual)	= [ ]a,c
Margin (indicated lower than actual)	= [ ]a,c

Safety Analysis Initial Condition (indicated higher than actual) (Source Listing 1)	= 584.4°F
Total Allowance (indicated higher than actual)	= [ ]a,c
CSA (indicated higher than actual)	= [ ]a,c
Margin (indicated higher than actual)	= [ ]a,c

RTD Input

RTD +ALT =

RTD -ALT =

RTD +AFT =

RTD -AFT =

[ ]a,c

1. This analysis covers a Tavg operating window of 570.7°F to 588.4°F. The highest full power Tavg is shown and is the most limiting for this analysis. If the full power Tavg for the current operating cycle is different than this value then the calculations in this analysis will change.

Table 3-2. Tavg – Control (cont.)

Weed N9004E RTD, Rosemount 1153GB8RA Transmitter, Westinghouse 7300 Process Racks, VX-252 Indicator

Turbine Pressure

Transmitter +ALT = [ ]a,c

Transmitter -ALT =

Transmitter +AFT =

Transmitter -AFT =

Westinghouse 7300 Process Racks

Analog Input Process Racks (controller) +ALT = [ ]a,c

Analog Input Process Racks (controller) -ALT =

Analog Input Process Racks (controller) +AFT =

Analog Input Process Racks (controller) -AFT =

Tavg

Indicator +ALT = [ ]a,c

Indicator -ALT =

Indicator +AFT =

Indicator -AFT =

Table 3-3. RCS Flow Calorimetric Measurement

Feedwater Temperature
100Ω RTD, Plant Computer

Parameter	Allowance*
Process Measurement Accuracy (PMA)	[ ]a,c
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA) [ ]a,c	
Sensor Reference Accuracy (SRA) [ ]a,c	
Sensor Measurement & Test Equipment Accuracy (SMTE)	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE)	
Sensor Drift (SD) [ ]a,c	
Environmental Allowance (EA)	
Bias	
RTD Lead Imbalance (RTD_{LI}) [ ]a,c	
Rack Calibration Accuracy (RCA_{COMP}) [ ]a,c (Source Listing 8) Value controlled by #	
Rack Measurement & Test Equipment Accuracy ($RMTE_{COMP}$) [ ]a,c [ ]a,c Value controlled by #	
Rack Temperature Effect (RTE_{COMP}) [ ]a,c	
Rack Drift (RD_{COMP}) [ ]a,c Value controlled by #	
RTD Interchangeability (RTD_I) [ ]a,c	
RTD Non-Linearity (RTD_{NL}) [ ]a,c	

* In % span (500°F)

Table 3-3. RCS Flow Calorimetric Measurement (cont.)

Feedwater Temperature
100Ω RTD, Plant Computer

Channel Statistical Allowance =

[ ]a,c

[ ]a,c

Number of RTDs used: 1 per loop

Function specific source material for RCA, RD, and instrument span

STS IC-011, "Precision Calorimetric Loop Instrumentation Calibration Check."

Table 3-3. RCS Flow Calorimetric Measurement (cont.)

Feedwater Flow
Rosemount 1152DP6N, Westinghouse 7300 Process Racks, Plant Computer

Parameter	**Allowance***
Process Measurement Accuracy (PMA) [ ]^{a,c}	
Primary Element Accuracy (PEA) [ ]^{a,c}	
Sensor Calibration Accuracy (SCA) (Source Listing 7) Value controlled by #, consistent with SRA	
Sensor Reference Accuracy (SRA) (Source Listing 3)	
Sensor Measurement & Test Equipment Accuracy (SMTE) [ ]^{a,c} [ ]^{a,c} Value controlled by #	
Sensor Pressure Effects (SPE) (Source Listing 3) [ ]^{a,c}	
Sensor Temperature Effects (STE) (Source Listing 3)	
Sensor Drift (SD) Value controlled by #	
Environmental Allowance (EA) (Source Listing 3) [ ]^{a,c}	
Bias	

[ ]^{a,c}

* In % dp span

Table 3-3. RCS Flow Calorimetric Measurement (cont.)

Feedwater Flow
Rosemount 1152DP6N, Westinghouse 7300 Process Racks, Plant Computer

Parameter	**Allowance***
Rack Calibration Accuracy (RCA_{COMP}) (Source Listing 8) Value controlled by ##	[ ]a,c
Rack Measurement & Test Equipment Accuracy ($RMTE_{COMP}$) [ ]a,c Value controlled by ##	
Rack Temperature Effect (RTE_{COMP})	
Rack Drift (RD_{COMP}) Value controlled by ##	

* In % dp span

Table 3-3. RCS Flow Calorimetric Measurement (cont.)

Feedwater Flow
Rosemount 1152DP6N, Westinghouse 7300 Process Racks, Plant Computer

Channel Statistical Allowance =

[ ]a,c

[ ]a,c

[ ]a,c

N = Number of Feedwater Flow Channels used: 2 per loop

Function specific source material for SCA, SD, RCA, RD, and instrument span

STS IC-417E "Calibration of Feedwater Flow Transmitters," (procedure controls transmitter drift magnitude determined from drift data evaluation process, see transmitter AFT).

STN IC-417A, "Channel Calibration of Feedwater, Steamflow, and Related Steam Generator A Level Process Instrumentation," (typical for this function).

Table 3-3. RCS Flow Calorimetric Measurement (cont.)

Steam Pressure
Barton 763, Westinghouse 7300 Process Racks, Plant Computer

Parameter	**Allowance***
	a,c
Process Measurement Accuracy (PMA)	
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA) (Source Listing 2) Value controlled by #, consistent with SRA	
Sensor Reference Accuracy (SRA) (Source Listing 2)	
Sensor Measurement & Test Equipment Accuracy (SMTE) [ ]^{a,c} [ ]^{a,c} Value controlled by #	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE) (Source Listing 2)	
Sensor Drift (SD) Value controlled by #	
Environmental Allowance (EA) [ ]^{a,c}	
Bias [ ]^{a,c} (Bias1)	
Rack Calibration Accuracy (RCA_{COMP}) (Source Listing 8) Value controlled by ##	
Rack Measurement & Test Equipment Accuracy ($RMTE_{COMP}$) [ ]^{a,c} Value controlled by ##	
Rack Temperature Effect (RTE_{COMP})	
Rack Drift (RD_{COMP}) Value controlled by ##	

* In % span (1300 psi)

Table 3-3. RCS Flow Calorimetric Measurement (cont.)

Steam Pressure
Barton 763, Westinghouse 7300 Process Racks, Plant Computer

Channel Statistical Allowance =

[ ]a,c

[ ]a,c

N = Number of Steam Pressure Channels used: 3 per loop

Function specific source material for SCA, SD, RCA, RD, and instrument span

STS IC-507A, "Calibration Steam Line Pressure Transmitters," (procedure controls transmitter drift magnitude determined from drift data evaluation process, see transmitter AFT).

STS IC-507D, "Channel Calibration Steamline Pressure Instrumentation Protection Set I," (typical for this function).

Table 3-3. RCS Flow Calorimetric Measurement (cont.)

Steam Generator Blowdown Flow
Rosemount 1151DP4E, Foxboro SPEC 200, Plant Computer

Parameter	Allowance*
Process Measurement Accuracy (PMA)	[ ]a,c
Primary Element Accuracy (PEA) [ ]a,c	
Sensor Calibration Accuracy (SCA) (Source Listing 7) Value controlled by #, consistent with SRA	
Sensor Reference Accuracy (SRA) (Source Listing 3)	
Sensor Measurement & Test Equipment Accuracy (SMTE) [ ]a,c [ ]a,c Value controlled by #	
Sensor Pressure Effects (SPE) (Source Listing 3) [ ]a,c	
Sensor Temperature Effects (STE) (Source Listing 3)	
Sensor Drift (SD) Value controlled by #	
Environmental Allowance (EA) (Source Listing 3) [ ]a,c	
Bias	

* In % dp span

Table 3-3. RCS Flow Calorimetric Measurement (cont.)

Steam Generator Blowdown Flow
Rosemount 1151DP4E, Foxboro SPEC 200, Plant Computer

Parameter	**Allowance***
Rack Calibration Accuracy (RCA_{COMP}) (Source Listing 8) Value controlled by #	[ ]a,c
Rack Measurement & Test Equipment Accuracy ($RMTE_{COMP}$) [ ]a,c Value controlled by #	
Rack Temperature Effect (RTE_{COMP})	
Rack Drift (RD_{COMP}) Value controlled by #	

* In % dp span

Table 3-3. RCS Flow Calorimetric Measurement (cont.)

Steam Generator Blowdown Flow
Rosemount 1151DP4E, Foxboro SPEC 200, Plant Computer

Channel Statistical Allowance =

[ ]a,c

[ ]a,c

[ ]a,c

Number of SG Blowdown Flow Channels used: System SG Blowdown flow is the combined steam flow from the flash tank and flow to the heat exchanger. Instrument errors doubled.

Function specific source material for SCA, SD, RCA, RD, and instrument span

\# STN IC-225 "Steam Generator Blowdown System Flow Channel Calibration," (procedure controls transmitter drift magnitude determined from drift data evaluation process, see transmitter AFT).

Table 3-3. RCS Flow Calorimetric Measurement (cont.)

Pressurizer Pressure
Rosemount 1154SH9RA, Westinghouse 7300 Process Racks, Plant Computer

Parameter	**Allowance***
	[ ]a,c
Process Measurement Accuracy (PMA)	
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA) (Source Listing 7) Value controlled by #, consistent with SRA	
Sensor Reference Accuracy (SRA) (Source Listing 3)	
Sensor Measurement & Test Equipment Accuracy (SMTE) [ ]a,c [ ]a,c Value controlled by #	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE) (Source Listing 3)	
Sensor Drift (SD) Value controlled by #	
Environmental Allowance (EA) (Source Listing 3) [ ]a,c	
Bias [ ]a,c (Bias1)	
Rack Calibration Accuracy (RCA_{COMP}) (Source Listing 8) Value controlled by ##	
Rack Measurement & Test Equipment Accuracy ($RMTE_{COMP}$) [ ]a,c Value controlled by ##	
Rack Temperature Effect (RTE_{COMP})	
Rack Drift (RD_{COMP}) Value controlled by ##	

* In % span (800 psi)

Table 3-3. RCS Flow Calorimetric Measurement (cont.)

Pressurizer Pressure
Rosemount 1154SH9RA, Westinghouse 7300 Process Racks, Plant Computer

Channel Statistical Allowance =

[ ]a,c

[ ]a,c

N = Number of Pressurizer Pressure Channels used: 4

Function specific source material for SCA, SD, RCA, RD, and instrument span

STS IC-502A, "Calibration of Pressurizer Pressure Transmitters," (procedure controls transmitter drift magnitude determined from drift data evaluation process, see transmitter AFT).

STS IC-502B, "Channel Calibration of 7300 Process Pressurizer Pressure Instrumentation."

Table 3-3. RCS Flow Calorimetric Measurement (cont.)

RCS Thot Temperature
Weed N9004E RTD, Westinghouse 7300 Process Racks, Plant Computer

Parameter	Allowance*
Process Measurement Accuracy (PMA) [ ]a,c	a,c
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA) [ ]a,c (Source Listing 9) Value controlled by #	
Sensor Reference Accuracy (SRA) [ ]a,c (Source Listing 4)	
Sensor Measurement & Test Equipment Accuracy (SMTE) [ ]a,c	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE)	
Sensor Drift (SD) [ ]a,c	
Environmental Allowance (EA)	
Bias	
RTD Lead Imbalance (RTD_{LI}) [ ]a,c	
Rack Calibration Accuracy (RCA_{COMP}) [ ]a,c (Source Listing 8) Value controlled by ##	
Rack Measurement & Test Equipment Accuracy ($RMTE_{COMP}$) [ ]a,c [ ]a,c Value controlled by ##	
Rack Temperature Effect (RTE_{COMP}) [ ]a,c	
Rack Drift (RD_{COMP}) [ ]a,c Value controlled by ##	

* In % span (120°F)

Table 3-3. RCS Flow Calorimetric Measurement (cont.)

RCS Thot Temperature
Weed N9004E RTD, Westinghouse 7300 Process Racks, Plant Computer

Channel Statistical Allowance =

a,c

a,c

N = Number of RTDs used: 3 per loop

Function specific source material for SCA, RCA, RD, and instrument span

\# STS RE-014, "Cross Calibration of Wide and Narrow Range RTDs."

\## STS IC-500D, "Channel Calibration DT/Tavg Instrumentation Loop 1," (typical for this function).

Table 3-3. RCS Flow Calorimetric Measurement (cont.)

RCS Tcold Temperature
Weed N9004E RTD, Westinghouse 7300 Process Racks, Plant Computer

Parameter	Allowance*
Process Measurement Accuracy (PMA)	a,c
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA) [ ]^{a,c} (Source Listing 9) Value controlled by #	
Sensor Reference Accuracy (SRA) [ ]^{a,c} (Source Listing 4)	
Sensor Measurement & Test Equipment Accuracy (SMTE) [ ]^{a,c}	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE)	
Sensor Drift (SD) [ ]^{a,c}	
Environmental Allowance (EA)	
Bias	
RTD Lead Imbalance (RTD_{LI}) [ ]^{a,c}	
Rack Calibration Accuracy (RCA_{COMP}) [ ]^{a,c} (Source Listing 8) Value controlled by ##	
Rack Measurement & Test Equipment Accuracy ($RMTE_{COMP}$) [ ]^{a,c} [ ]^{a,c} Value controlled by ##	
Rack Temperature Effect (RTE_{COMP}) [ ]^{a,c}	
Rack Drift (RD_{COMP}) [ ]^{a,c} Value controlled by ##	

* In % span (120°F)

Table 3-3. RCS Flow Calorimetric Measurement (cont.)

RCS Tcold Temperature
Weed N9004E RTD, Westinghouse 7300 Process Racks, Plant Computer

Channel Statistical Allowance =

[ ]a,c

[ ]a,c

Number of RTDs used: 1 per loop

Function specific source material for SCA, RCA, RD, and instrument span

\# STS RE-014, "Cross Calibration of Wide and Narrow Range RTDs."

\## STS IC-500D, "Channel Calibration DT/Tavg Instrumentation Loop 1," (typical for this function).

Table 3-3. RCS Flow Calorimetric Measurement (cont.)

Nominal Parameters

a,c

FEEDWATER TEMPERATURE	=	
FEEDWATER PRESSURE	=	
FEEDWATER FLOW	=	
STEAM PRESSURE	=	
HOT LEG TEMPERATURE	=	
COLD LEG TEMPERATURE	=	
PRESSURIZER PRESSURE	=	

Table 3-3. RCS Flow Calorimetric Measurement (cont.)

RCS Flow Calorimetric Sensitivities
(Using Feedwater Venturis)

		a,c
FEEDWATER FLOW		
F_a		
TEMPERATURE	=	
MATERIAL	=	
DENSITY		
TEMPERATURE	=	
PRESSURE	=	
FEEDWATER ENTHALPY		
TEMPERATURE	=	
PRESSURE	=	
h_s	=	
h_f	=	
Δh (SG)	=	
STEAM ENTHALPY		
PRESSURE	=	
MOISTURE	=	
SG BLOWDOWN		
DENSITY		
PRESSURE	=	
ENTHALPY		
PRESSURE	=	
FLOW		
F_a		
TEMPERATURE	=	
MATERIAL	=	
ΔP	=	

Table 3-3. RCS Flow Calorimetric Measurement (cont.)

RCS Flow Calorimetric Sensitivities
(Using Feedwater Venturis)

a,c

HOT LEG ENTHALPY		
TEMPERATURE	=	
PRESSURE	=	
h_H	=	
h_C	=	
Δh (VESS)	=	
COLD LEG ENTHALPY		
TEMPERATURE	=	
PRESSURE	=	
COLD LEG SPECIFIC VOLUME		
TEMPERATURE	=	
PRESSURE	=	

Table 3-3. RCS Flow Calorimetric Measurement (cont.)

RCS Flow Calorimetric Measurement Uncertainty (Using Feedwater Venturis)

COMPONENT	INSTRUMENT UNCERTAINTY	FLOW UNCERTAINTY % Flow
FEEDWATER FLOW		a,c
VENTURI (FWv)		
THERMAL EXPANSION COEFFICIENT		
TEMPERATURE ($FWFa_t$)		
MATERIAL ($FWFa_m$)		
DENSITY		
TEMPERATURE ($FW\rho_t$)		
PRESSURE ($FW\rho_p$)		
ΔP ($FW_{\Delta P}$)		
FEEDWATER ENTHALPY		
TEMPERATURE (FWh_t)		
PRESSURE (FWh_p)		
STEAM ENTHALPY		
PRESSURE (hs_p)		
MOISTURE (hs_{moist})		
NET PUMP HEAT ADDITION (NPHA)		
SG BLOWDOWN FLOW		
DENSITY ($SGB\rho_p$)		
ENTHALPY ($SGBh_p$)		
THERMAL EXPANSION COEFFICIENT		
TEMPERATURE ($SGBFa_t$)		
MATERIAL ($SGBFa_m$)		
ΔP ($SGB_{\Delta P}$)		

*, **, +, ++, Indicates sets of dependent parameters.

Table 3-3. RCS Flow Calorimetric Measurement (cont.)

RCS Flow Calorimetric Measurement Uncertainty (Using Feedwater Venturis)

COMPONENT	INSTRUMENT UNCERTAINTY	FLOW UNCERTAINTY % Flow
HOT LEG ENTHALPY		a,c
TEMPERATURE (HLh_t)		
STREAMING RANDOM (HLh_{sr})		
STREAMING SYSTEMATIC (HLh_{ss})		
PRESSURE (HLh_p)		
COLD LEG ENTHALPY		
TEMPERATURE (CLh_t)		
PRESSURE (CLh_p)		
COLD LEG SPECIFIC VOLUME		
TEMPERATURE (CLv_t)		
PRESSURE (CLv_p)		
BIASES		
BIAS($FF_{Seismic}$)		

*, **, +, ++, Indicates sets of dependent parameters.

Table 3-3. RCS Flow Calorimetric Measurement (cont.)

RCS Flow Calorimetric Measurement Uncertainty
(Using Feedwater Venturis)

Using the flow uncertainty values, the 4 loop uncertainty equation is as follows:

Flow = Channel Statistical Allowance

[ ] a,c

[ ] a,c

[ ] a,c

Table 3-3. RCS Flow Calorimetric Measurement (cont.)

RCS Flow Calorimetric Measurement Uncertainty
(Using Feedwater Venturis)

Safety Analysis Uncertainty	=	N/A
CSA	=	[ ]a,c
Margin	=	N/A

Feedwater Flow

Rosemount 1152DP6N, Westinghouse 7300 Process Racks, Plant Computer
Instrument Span (Source #) 0 to 129.2% Flow / 4 – 20 mA = 16 mA

Transmitter +ALT	=	[ ]a,c
Transmitter -ALT	=	
Transmitter +AFT	=	
Transmitter -AFT	=	

Process Racks (7300 Process Racks/Plant Computer) +ALT	=	[ ]a,c
Process Racks (7300 Process Racks/Plant Computer) -ALT	=	
Process Racks (7300 Process Racks/Plant Computer) +AFT	=	
Process Racks (7300 Process Racks/Plant Computer) -AFT	=	

Feedwater Temperature

100Ω RTD, Plant Computer
Instrument Span = 500°F (Source #)

Process Racks (Plant Computer) +ALT	=	[ ]a,c
Process Racks (Plant Computer) -ALT	=	
Process Racks (Plant Computer) +AFT	=	
Process Racks (Plant Computer) -AFT	=	

Table 3-3. RCS Flow Calorimetric Measurement (cont.)

RCS Flow Calorimetric Measurement Uncertainty (Using Feedwater Venturis)

Feedwater Pressure

Feedwater Pressure is not a measured parameter.

Steam Pressure

Barton 763, Westinghouse 7300 Process Racks, Plant Computer
Instrument Span (Source #) 0 to 1300 psig = 1300 psi

Transmitter +ALT	=	[ ] a,c
Transmitter -ALT	=	
Transmitter +AFT	=	
Transmitter -AFT	=	

Process Racks (7300 Process Racks/Plant Computer) +ALT	=	[ ] a,c
Process Racks (7300 Process Racks/Plant Computer) -ALT	=	
Process Racks (7300 Process Racks/Plant Computer) +AFT	=	
Process Racks (7300 Process Racks/Plant Computer) -AFT	=	

SG Blowdown Flow

Rosemount 1151DP4E, Foxboro SPEC 200, Plant Computer
Instrument Span (Source #) 0 to 100 in H_2O / 4 - 20 mA = 16 mA

Transmitter +ALT	=	[ ] a,c
Transmitter -ALT	=	
Transmitter +AFT	=	
Transmitter -AFT	=	

Process Racks (Foxboro Spec 200) +ALT	=	[ ] a,c
Process Racks (Foxboro Spec 200) -ALT	=	
Process Racks (Foxboro Spec 200) +AFT	=	
Process Racks (Foxboro Spec 200) -AFT	=	

Table 3-3. RCS Flow Calorimetric Measurement (cont.)

RCS Flow Calorimetric Measurement Uncertainty (Using Feedwater Venturis)

Pressurizer Pressure

Rosemount 1154SH9RA, Westinghouse 7300 Process Racks, Plant Computer
Instrument Span (Source #) 1700 to 2500 psig = 800 psi / 4 - 20 mA = 16 mA

[ ]a,c

Transmitter +ALT =
Transmitter -ALT =
Transmitter +AFT =
Transmitter -AFT =

[ ]a,c

Process Racks (7300 Process Racks/Plant Computer) +ALT =
Process Racks (7300 Process Racks/Plant Computer) -ALT =
Process Racks (7300 Process Racks/Plant Computer) +AFT =
Process Racks (7300 Process Racks/Plant Computer) -AFT =

Hot Leg Temperature

Weed N9004E, Westinghouse 7300 Process Racks, Plant Computer
Instrument Span (Source #) 540°F to 660°F

[ ]a,c

RTD +ALT =
RTD -ALT =
RTD +AFT =
RTD -AFT =

[ ]a,c

Process Racks (7300 Process Racks/Plant Computer) +ALT =
Process Racks (7300 Process Racks/Plant Computer) -ALT =
Process Racks (7300 Process Racks/Plant Computer) +AFT =
Process Racks (7300 Process Racks/Plant Computer) -AFT =

Table 3-3. RCS Flow Calorimetric Measurement (cont.)

RCS Flow Calorimetric Measurement Uncertainty
(Using Feedwater Venturis)

Cold Leg Temperature

Weed N9004E, Westinghouse 7300 Process Racks, Plant Computer
Instrument Span (Source #) 520°F to 640°F

a,c

RTD +ALT =
RTD -ALT =
RTD +AFT =
RTD -AFT =

a,c

Process Racks (7300 Process Racks/Plant Computer) +ALT =
Process Racks (7300 Process Racks/Plant Computer) -ALT =
Process Racks (7300 Process Racks/Plant Computer) +AFT =
Process Racks (7300 Process Racks/Plant Computer) -AFT =

Table 3-4. RCS Flow – Cold Leg Elbow Tap Indication

Rosemount 1153HD5RC Transmitters, Westinghouse 7300 Process Racks, VX-252 Meter

Parameter **Allowance***

[ ]a,c

Process Measurement Accuracy (PMA)
[ ]a,c

Primary Element Accuracy (PEA)
[ ]a,c

Sensor Calibration Accuracy (SCA)
[ ]a,c

Sensor Reference Accuracy (SRA) (Source Listing 3)
[ ]a,c

Sensor Measurement & Test Equipment Accuracy (SMTE)
[ ]a,c

Sensor Pressure Effects (SPE)
[ ]a,c

Sensor Temperature Effects (STE)
[ ]a,c

Sensor Drift (SD)
[ ]a,c
Value controlled by #

Environmental Allowance (EA) (Source Listing 3)
[ ]a,c

Bias
[ ]a,c

Indicator Calibration Accuracy (RCA_{IND}) (Source Listing 8)
Value controlled by ##

Indicator Measurement & Test Equipment Accuracy ($RMTE_{IND}$) (Source Listing 10)
[ ]a,c
Value controlled by ##

Indicator Temperature Effect (RTE_{IND}) (Source Listing 5)
[ ]a,c

* In % flow

Table 3-4. RCS Flow – Cold Leg Elbow Tap Indication (cont.)

Rosemount 1153HD5RC Transmitters, Westinghouse 7300 Process Racks, VX-252 Meter

Parameter	**Allowance***
Indicator Drift (RD_{IND}) [ ][a,c] Value controlled by ##	[ ][a,c]
Indicator ($READOUT_{IND}$) (Source Listing 6) Control board meter readability	

* In % flow

Table 3-4. RCS Flow – Cold Leg Elbow Tap Indication (cont.)

Rosemount 1153HD5RC Transmitters, Westinghouse 7300 Process Racks, VX-252 Meter

Channel Statistical Allowance =

[ ] a,c

Channel Statistical Allowance for **[**
][a,c]

[ ] a,c

[ ] a,c

Function specific source material for SCA, SD, RCA, RD, and instrument span

\# STS IC-504B, "Reactor Coolant Flow Transmitter Calibration," (procedure controls transmitter drift magnitude determined from drift data evaluation process, see transmitter AFT).

\## STS IC-504C, "Channel Calibration of 7300 Process Reactor Coolant Flow," (typical for this function).

Table 3-4. RCS Flow – Cold Leg Elbow Tap Indication (cont.)

Rosemount 1153HD5RC Transmitters, Westinghouse 7300 Process Racks, VX-252 Meter

<u>RCS Flow – Low</u>

Instrument Span (Source ##)	=	120% flow / 4 – 20 mA = 16 mA
CSA	=	[ ]a,c
Transmitter +ALT	=	[ ]a,c
Transmitter -ALT	=	
Transmitter +AFT	=	
Transmitter -AFT	=	
Process Racks (Indicator) +ALT	=	[ ]a,c
Process Racks (Indicator) –ALT	=	
Process Racks (Indicator) +AFT	=	
Process Racks (Indicator) -AFT	=	

Table 3-5. Daily Power Calorimetric Measurement

Feedwater Temperature
100Ω RTD, Plant Computer

Parameter	**Allowance***
Process Measurement Accuracy (PMA)	[ ]a,c
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA) [ ]a,c	
Sensor Reference Accuracy (SRA) [ ]a,c	
Sensor Measurement & Test Equipment Accuracy (SMTE)	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE)	
Sensor Drift (SD) [ ]a,c	
Environmental Allowance (EA)	
Bias	
RTD Lead Imbalance (RTD_{LI}) [ ]a,c	
Rack Calibration Accuracy (RCA_{COMP}) [ ]a,c (Source Listing 8) Value controlled by #	
Rack Measurement & Test Equipment Accuracy ($RMTE_{COMP}$) [ ]a,c [ ]a,c Value controlled by #	
Rack Temperature Effect (RTE_{COMP}) [ ]a,c	
Rack Drift (RD_{COMP}) [ ]a,c Value controlled by #	
RTD Interchangeability (RTD_I) [ ]a,c	
RTD Non-Linearity (RTD_{NL}) [ ]a,c	

* In % span (500°F)

Table 3-5. Daily Power Calorimetric Measurement (cont.)

Feedwater Temperature
100Ω RTD, Plant Computer

Channel Statistical Allowance =

[ ]a,c

[ ]a,c

Number of RTDs used: 1 per loop

Function specific source material for RCA, RD, and instrument span

STS IC-011, "Precision Calorimetric Loop Instrumentation Calibration Check."

Table 3-5. Daily Power Calorimetric Measurement (cont.)

Feedwater Flow
Rosemount 1152DP6N, Westinghouse 7300 Process Racks, Plant Computer

Parameter	**Allowance***
Process Measurement Accuracy (PMA) [ ][a,c]	
Primary Element Accuracy (PEA) [ ][a,c]	
Sensor Calibration Accuracy (SCA) (Source Listing 7) Value controlled by #, consistent with SRA	
Sensor Reference Accuracy (SRA) (Source Listing 3)	
Sensor Measurement & Test Equipment Accuracy (SMTE) [ ][a,c] [ ][a,c] Value controlled by #	
Sensor Pressure Effects (SPE) (Source Listing 3) [ ][a,c]	
Sensor Temperature Effects (STE) (Source Listing 3)	
Sensor Drift (SD) Value controlled by #	
Environmental Allowance (EA) (Source Listing 3) [ ][a,c]	
Bias (Source Listing 4) [ ][a,c]	

a,c

* In % dp span

Table 3-5. Daily Power Calorimetric Measurement (cont.)

Feedwater Flow
Rosemount 1152DP6N, Westinghouse 7300 Process Racks, Plant Computer

Parameter	Allowance*
	a,c
Rack Calibration Accuracy (RCA_{COMP}) (Source Listing 8) Value controlled by ##	
Rack Measurement & Test Equipment Accuracy ($RMTE_{COMP}$) [ ]a,c Value controlled by ##	
Rack Temperature Effect (RTE_{COMP})	
Rack Drift (RD_{COMP}) Value controlled by ##	

* In % dp span

Table 3-5. Daily Power Calorimetric Measurement (cont.)

Feedwater Flow
Rosemount 1152DP6N, Westinghouse 7300 Process Racks, Plant Computer

Channel Statistical Allowance =

[ ]a,c

[ ]a,c

[ ]a,c

Number of Feedwater Flow Channels used: 1 per loop

Function specific source material for SCA, SD, RCA, RD, and instrument span

STS IC-417E "Calibration of Feedwater Flow Transmitters," (procedure controls transmitter drift magnitude determined from drift data evaluation process, see transmitter AFT).

STN IC-417A, "Channel Calibration of Feedwater, Steamflow, and Related Steam Generator A Level Process Instrumentation," (typical for this function).

Table 3-5. Daily Power Calorimetric Measurement (cont.)

Steam Pressure
Barton 763, Westinghouse 7300 Process Racks, Plant Computer

Parameter	**Allowance***
Process Measurement Accuracy (PMA)	[ ]a,c
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA) (Source Listing 7) Value controlled by #, consistent with SRA	
Sensor Reference Accuracy (SRA) (Source Listing 2)	
Sensor Measurement & Test Equipment Accuracy (SMTE) [ ]a,c [ ]a,c Value controlled by #	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE) (Source Listing 2)	
Sensor Drift (SD) Value controlled by #	
Environmental Allowance (EA) [ ]a,c	
Bias [ ]a,c (Bias1)	
Rack Calibration Accuracy (RCA_{COMP}) (Source Listing 8) Value controlled by ##	
Rack Measurement & Test Equipment Accuracy ($RMTE_{COMP}$) [ ]a,c Value controlled by ##	
Rack Temperature Effect (RTE_{COMP})	
Rack Drift (RD_{COMP}) Value controlled by ##	

* In % span (1300 psi)

Table 3-5. Daily Power Calorimetric Measurement (cont.)

Steam Pressure
Barton 763, Westinghouse 7300 Process Racks, Plant Computer

Channel Statistical Allowance =

[ ] a,c

[ ] a,c

N = Number of Steam Pressure Channels used: 2 per loop

Function specific source material for SCA, SD, RCA, RD, and instrument span

STS IC-507A, "Calibration Steam Line Pressure Transmitters," (procedure controls transmitter drift magnitude determined from drift data evaluation process, see transmitter AFT).

STS IC-507D, "Channel Calibration Steamline Pressure Instrumentation Protection Set I," (typical for this function).

Table 3-5. Daily Power Calorimetric Measurement (cont.)

Steam Generator Blowdown Flow
Rosemount 1151DP4E, Foxboro SPEC 200, Plant Computer

Parameter	Allowance*
Process Measurement Accuracy (PMA)	[ ]a,c
Primary Element Accuracy (PEA) [ ]a,c	
Sensor Calibration Accuracy (SCA) (Source Listing 7) Value controlled by #, consistent with SRA	
Sensor Reference Accuracy (SRA) (Source Listing 3)	
Sensor Measurement & Test Equipment Accuracy (SMTE) [ ]a,c [ ]a,c Value controlled by #	
Sensor Pressure Effects (SPE) (Source Listing 3) [ ]a,c	
Sensor Temperature Effects (STE) (Source Listing 3)	
Sensor Drift (SD) Value controlled by #	
Environmental Allowance (EA) (Source Listing 3) [ ]a,c	
Bias	

* In % dp span

Table 3-5. Daily Power Calorimetric Measurement (cont.)

Steam Generator Blowdown Flow
Rosemount 1151DP4E, Foxboro SPEC 200, Plant Computer

Parameter	**Allowance***
Rack Calibration Accuracy (RCA_{COMP}) (Source Listing 8) Value controlled by #	[ ]a,c
Rack Measurement & Test Equipment Accuracy ($RMTE_{COMP}$) [ ]a,c Value controlled by #	
Rack Temperature Effect (RTE_{COMP})	
Rack Drift (RD_{COMP}) Value controlled by #	

* In % dp span

Table 3-5. Daily Power Calorimetric Measurement (cont.)

Steam Generator Blowdown Flow
Rosemount 1151DP4E, Foxboro SPEC 200, Plant Computer

Channel Statistical Allowance =

[ ]a,c

[ ]a,c

[ ]a,c

Number of SG Blowdown Flow Channels used: System SG Blowdown flow is the combined steam flow from the flash tank and flow to the heat exchanger. Instrument errors doubled.

Function specific source material for SCA, SD, RCA, RD, and instrument span

\# STN IC-225 "Steam Generator Blowdown System Flow Channel Calibration," (procedure controls transmitter drift magnitude determined from drift data evaluation process, see transmitter AFT).

Table 3-5. Daily Power Calorimetric Measurement (cont.)

Nominal Parameters

FEEDWATER TEMPERATURE	=		a,c
FEEDWATER PRESSURE	=		
FEEDWATER FLOW	=		
STEAM PRESSURE	=		

Table 3-5. Daily Power Calorimetric Measurement (cont.)

Power Calorimetric Sensitivities (Using Feedwater Venturis)

FEEDWATER FLOW		
F_a		a,c
TEMPERATURE	=	
MATERIAL	=	
DENSITY		
TEMPERATURE	=	
PRESSURE	=	
FEEDWATER ENTHALPY		
TEMPERATURE	=	
PRESSURE	=	
h_s	=	
h_f	=	
Δh (SG)	=	
STEAM ENTHALPY		
PRESSURE	=	
MOISTURE	=	
SG BLOWDOWN		
DENSITY		
PRESSURE	=	
ENTHALPY		
PRESSURE	=	
FLOW		
F_a		
TEMPERATURE	=	
MATERIAL	=	
ΔP	=	

Table 3-5. Daily Power Calorimetric Measurement (cont.)

Power Calorimetric Measurement Uncertainty
(Using Feedwater Venturis)

COMPONENT	INSTRUMENT UNCERTAINTY	POWER UNCERTAINTY % RTP
FEEDWATER FLOW		a,c
VENTURI (FWv)		
THERMAL EXPANSION COEFFICIENT		
TEMPERATURE ($FWFa_t$)		
MATERIAL ($FWFa_m$)		
DENSITY		
TEMPERATURE ($FW\rho_t$)		
PRESSURE ($FW\rho_p$)		
ΔP ($FW_{\Delta P}$)		
FEEDWATER ENTHALPY		
TEMPERATURE (FWh_t)		
PRESSURE (FWh_p)		
STEAM ENTHALPY		
PRESSURE (hs_p)		
MOISTURE (hs_{moist})		
NET PUMP HEAT ADDITION (NPHA)		
SG BLOWDOWN FLOW		
DENSITY ($SGB\rho_p$)		
ENTHALPY ($SGBh_p$)		

*, **, Indicates sets of dependent parameters.

Table 3-5. Daily Power Calorimetric Measurement (cont.)

Power Calorimetric Measurement Uncertainty (Using Feedwater Venturis)

COMPONENT	INSTRUMENT UNCERTAINTY	POWER UNCERTAINTY % RTP
THERMAL EXPANSION COEFFICIENT		a,c
TEMPERATURE (SGBFa$_t$)		
MATERIAL (SGBFa$_m$)		
ΔP (SGB$_{\Delta P}$)		
BIASES		
BIAS(FF$_{SPE}$)		
BIAS(FF$_{Seismic}$)		
BIAS(Sh$_{SP}$)		

*, **, Indicates sets of dependent parameters.

Table 3-5. Daily Power Calorimetric Measurement (cont.)

Power Calorimetric Measurement Uncertainty
(Using Feedwater Venturis)

Using the power uncertainty values, the 4 loop uncertainty equation is as follows:

Power = Channel Statistical Allowance

[ ]a,c

[ ]a,c

[ ]a,c

Table 3-5. Daily Power Calorimetric Measurement (cont.)

Power Calorimetric Measurement Uncertainty (Using Feedwater Venturis)

Safety Analysis Uncertainty, Total Power (Source Listing 1)	=	[ ] a,c
CSA	=	[ ] a,c
Margin	=	[ ] a,c

Feedwater Flow

Rosemount 1152DP6N, Westinghouse 7300 Process Racks, Plant Computer
Instrument Span (Source #) 0 to 129.2% Flow / 4 - 20 mA = 16 mA

Transmitter +ALT =
Transmitter -ALT =
Transmitter +AFT =
Transmitter -AFT =

[ ] a,c

Process Racks (7300 Process Racks/Plant Computer) +ALT =
Process Racks (7300 Process Racks/Plant Computer) -ALT =
Process Racks (7300 Process Racks/Plant Computer) +AFT =
Process Racks (7300 Process Racks/Plant Computer) -AFT =

[ ] a,c

Feedwater Temperature

100Ω RTD, Plant Computer
Instrument Span = 500°F (Source #)

Process Racks (Plant Computer) +ALT =
Process Racks (Plant Computer) -ALT =
Process Racks (Plant Computer) +AFT =
Process Racks (Plant Computer) -AFT =

[ ] a,c

Table 3-5. Daily Power Calorimetric Measurement (cont.)

Power Calorimetric Measurement Uncertainty
(Using Feedwater Venturis)

Feedwater Pressure

Feedwater Pressure is not a measured parameter.

Steam Pressure

Barton 763, Westinghouse 7300 Process Racks, Plant Computer
Instrument Span (Source #) 0 to 1300 psig / 4 - 20mA = 16 mA

Transmitter +ALT =
Transmitter -ALT =
Transmitter +AFT =
Transmitter -AFT =
[ ] a,c

Process Racks (7300 Process Racks/Plant Computer) +ALT =
Process Racks (7300 Process Racks/Plant Computer) -ALT =
Process Racks (7300 Process Racks/Plant Computer) +AFT =
Process Racks (7300 Process Racks/Plant Computer) -AFT =
[ ] a,c

SG Blowdown Flow

Rosemount 1151DP4E, Foxboro SPEC 200, Plant Computer
Instrument Span (Source #) 0 to 100 in H_2O / 4 - 20 mA = 16 mA

Transmitter +ALT =
Transmitter -ALT =
Transmitter +AFT =
Transmitter -AFT =
[ ] a,c

Process Racks (Foxboro Spec 200) +ALT =
Process Racks (Foxboro Spec 200) -ALT =
Process Racks (Foxboro Spec 200) +AFT =
Process Racks (Foxboro Spec 200) -AFT =
[ ] a,c

4 RESULTS/CONCLUSIONS

The preceding sections provide the methodology to account for pressure, temperature, RCS flow measurement, and power measurement uncertainties for the RTDP analysis. The uncertainty calculations have been performed for WCGS utilizing plant specific information and instrumentation and calibration procedures. The following or more conservative values are used in the WCGS RTDP analysis.

[ ]a,c

5 REFERENCES

1. WCAP-11397-P-A, “Revised Thermal Design Procedure,” Westinghouse Electric Company LLC, April, 1989.

2. WCAP-17504-P-A, Rev. 1, “Westinghouse Generic Setpoint Methodology,” Westinghouse Electric Company LLC, October, 2016.