

ENCLOSURE 2

WCAP-13721

REVISION 1

WESTINGHOUSE SETPOINT METHODOLOGY FOR PROTECTION SYSTEM
WATTS BAR UNITS 1 AND 2
EAGLE 21 VERSION

(Non-Proprietary)

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Revision 1

**WESTINGHOUSE SETPOINT METHODOLOGY
FOR PROTECTION SYSTEMS
WATTS BAR UNITS 1 AND 2
EAGLE 21 VERSION**

May 1994

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1.0 INTRODUCTION

In March of 1977, the NRC requested several utilities with Westinghouse Nuclear Steam Supply Systems to reply to a series of questions concerning the methodology for determining instrument setpoints. A revised methodology was developed in response to those questions with a corresponding defense of the technique used in determining the overall allowance for each setpoint.

The basic underlying assumption used is that several of the error components and their parameter assumptions act independently, e.g., rack versus sensors and pressure/temperature assumptions. This allows the use of a statistical summation of the various components instead of a strictly arithmetic summation. A direct benefit of the use of this technique is increased margin in the total allowance. For those parameter assumptions known to be interactive, the technique uses the standard, conservative approach, arithmetic summation, to form independent quantities, e.g., drift and calibration error. An explanation of the overall approach is provided in Section 2.0.

Section 3.0 provides a description, or definition, of each of the various components in the setpoint parameter breakdown, to allow a clear understanding of the methodology. Also provided is a detailed example of each setpoint uncertainty calculation demonstrating the methodology and noting how each parameter value is derived. In all cases, sufficient margin exists between the summation and the total allowance.

Section 4.0 notes what the current MERITS Technical Specifications use for setpoints and an explanation of the impact of the Westinghouse approach on them. Detailed examples of how to determine the Technical Specification setpoint values are also provided.

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2.0 COMBINATION OF ERROR COMPONENTS

2.1 METHODOLOGY

The methodology used to combine the error components for a channel is basically the appropriate combination of those groups of components which are statistically independent, i.e., not interactive. Those errors which are not independent are placed arithmetically into groups. The groups themselves are independent effects which can then be systematically combined.

The methodology used for this combination is the "square root of the sum of the squares" which has been utilized in other Westinghouse reports. This technique, or other approaches of a similar nature, has been used in WCAP-10395⁽¹⁾ and WCAP-8567⁽²⁾. WCAP-8567 has been approved by the NRC staff thus noting the acceptability of statistical techniques for the application requested. In addition, various ANSI, American Nuclear Society, and Instrument Society of America standards approve of the use of probabilistic and statistical techniques in determining safety-related setpoints⁽³⁾⁽⁴⁾. The methodology used in this report is essentially the same as that used for V. C. Summer, which was approved in NUREG-0717, Supplement No. 4⁽⁵⁾.

The relationship between the error components and the total error allowance for a channel is noted in Eq. 2.1,

$$CSA = \{ (PMA)^2 + (PEA)^2 + (SCA+SMTE+SD)^2 + (SPE)^2 + (STE)^2 + \\ (RCA+RMTE+RCSA+RD)^2 + (RTE)^2 \}^{1/2} + EA \quad (Eq. 2.1)$$

(1) Grigsby, J. M., Spier, E. M., Tuley, C. R., "Statistical Evaluation of LOCA Heat Source Uncertainty," WCAP-10395 (Proprietary), WCAP-10396 (Non-Proprietary), November, 1983.

(2) Chelemer, H., Boman, L. H., and Sharp, D. R., "Improved Thermal Design Procedure," WCAP-8567 (Proprietary), WCAP-8568 (Non-Proprietary), July, 1975.

(3) ANSI/ANS Standard 58.4 - 1979, "Criteria for Technical Specifications for Nuclear Power Stations."

(4) ISA Standard S67.04, 1987, "Setpoints for Nuclear Safety-Related Instrumentation Used in Nuclear Power Plants."

(5) NUREG-0717, Supplement No. 4, "Safety Evaluation Report Related to Operation of Virgil C. Summer Nuclear Station, Unit No. 1," Docket No. 50-395, August, 1982.

where:

CSA	=	Channel Statistical Allowance
PMA	=	Process Measurement Accuracy
PEA	=	Primary Element Accuracy
SCA	=	Sensor Calibration Accuracy
SMTE	=	Sensor Measurement and Test Equipment Accuracy
SD	=	Sensor Drift
SPE	=	Sensor Pressure Effects
STE	=	Sensor Temperature Effects
RCA	=	Rack Calibration Accuracy
RMTE	=	Rack Measurement and Test Equipment Accuracy
RCSA	=	Rack Comparator Setting Accuracy
RD	=	Rack Drift
RTE	=	Rack Temperature Effects
EA	=	Environmental Allowance

This equation was originally designed to address analog process racks with bistables. Digital process racks generally operate in a different manner by simulating a bistable. The protection function setpoint is a value held in memory. The digital process racks compare the function's value with the value stored in memory. A trip is initiated when the input to the calculation is compared to and corresponds to the value in memory. Thus, with the absence of a physical bistable, the RCSA term can be redefined. Depending on the function, the RMTE term can also be redefined. The calculations for the protection functions noted in this document reflect the use of either analog or digital process racks (whichever is appropriate) and the corresponding values for RCSA and RMTE as required.

As can be seen in Equation 2.1, drift and calibration accuracy allowances are interactive and thus not independent. The environmental allowance is not necessarily considered interactive with all other parameters, but as an additional degree of conservatism is added to the statistical sum. It should be noted that for this document, it is assumed that the accuracy effect on a channel due to cable degradation in an accident environment is less than 0.1 percent of span. This impact has been considered negligible and is not

factored into the analysis. An error due to this cause, found to be in excess of 0.1 percent of span must be directly added as an environmental error. Several functions were identified by TVA as having cable IR error in excess of 0.1 percent span. These errors have been incorporated into the calculations.

The Westinghouse setpoint methodology results in a value with a 95 percent probability with a high confidence level. Analog Rack Drift and sensor drift are assumed based on a survey of reported plant LERs. Digital Rack Drift is based on system design, and Process Measurement Accuracy terms are considered to be conservative values.

2.2 SENSOR ALLOWANCES

Five parameters are considered to be sensor allowances, SCA, SMTE, SD, STE, and SPE (see Table 3-21). Of these parameters, two are considered to be statistically independent, STE and SPE, and three are considered interactive, SCA, SMTE and SD. STE and SPE are considered to be independent due to the manner in which the instrumentation is checked, i.e., the instrumentation is calibrated and drift determined under conditions in which pressure and temperature are assumed constant. An example of this would be as follows; assume a sensor is placed in some position in the containment during a refueling outage. After placement, an instrument technician calibrates the sensor. This calibration is performed at ambient pressure and temperature conditions. Some time later with the plant shutdown, an instrument technician checks for sensor drift. Using the same technique as for calibrating the sensor, the technician determines if the sensor has drifted or not. The conditions under which this determination is made are again at ambient pressure and temperature conditions. Thus the temperature and pressure have no impact on the drift determination and are, therefore, independent of the drift allowance.

SCA, SMTE and SD are considered to be interactive for the same reason that STE and SPE are considered independent, i.e., due to the manner in which the instrumentation is checked. When calibrating a sensor, the sensor output is checked to determine if it is representing accurately the input. The same is performed for a determination of the sensor drift. Thus unless "as left/as found" data is recorded and used, it is impossible to determine the

differences between calibration errors and drift when a sensor is checked the second or any subsequent time. Based on this reasoning, SCA, SMTE and SD have been added to form an independent group which is then factored into Equation 2.1. An example of the impact of this treatment for a level transmitter is (sensor parameters only):

$$\begin{array}{l} \text{SCA} \\ \text{SMTE} \\ \text{SPE} \\ \text{STE} \\ \text{SD} \end{array} = \left[\begin{array}{c} \\ \\ \\ \\ \end{array} \right]^{+a,c}$$

excepting the sensor portion of Equation 2.1 results in;

$$\begin{array}{l} \{(SCA + SMTE + SD)^2 + (SPE)^2 + (STE)^2\}^{1/2} \\ - \text{ or -} \\ [\hspace{15em}]^{+a,c} = 2.12\% \end{array}$$

Assuming no interactive effects for any of the parameters results in the following:

$$\begin{array}{l} \{(SCA)^2 + (SMTE)^2 + (SD)^2 + (SPE)^2 + (STE)^2\}^{1/2} \\ - \text{ or -} \\ [\hspace{15em}]^{+a,c} = 1.41\% \end{array} \quad (\text{Eq. 2.2})$$

Thus it can be seen that the approach represented by Equation 2.1, which accounts for interactive parameters, results in a more conservative summation of the allowances.

2.3 RACK ALLOWANCES

Five parameters, as noted by Table 3-21, are considered to be rack allowances, RCA, RMTE, RCSA, RTE, and RD. Four of these parameters are considered to be interactive (for much the same reason outlined for sensors in 2.2), RCA, RMTE, RCSA, and RD. When calibrating or determining drift in the racks for a specific channel, the processes are performed at essentially constant

temperature, i.e., ambient temperature. Because of this, the RTE parameter is considered to be independent of any factors for calibration or drift.

However, the same cannot be said for the other rack parameters. As noted in 2.2, when calibrating or determining drift for a channel, the same end result is desired, that is, at what point does the bistable change state. After initial calibration, without recording and using "as left/as found" data, it is not possible to distinguish the difference between a calibration error, rack drift or a comparator setting error. Based on this logic, these factors have been added to form an independent group. This group is then factored into Equation 2.1. The impact of this approach (formation of an independent group based on interactive components) is significant. For a level transmitter channel, using the same approach outlined in Equations 2.1 and 2.2 and using analog process rack uncertainties results in the following:

$$\begin{array}{l} \text{RCA} \\ \text{RMTE} \\ \text{RCSA} \\ \text{RTE} \\ \text{RD} \end{array} = \left[\begin{array}{c} \\ \\ \\ \\ \end{array} \right]^{+a,c}$$

excerpting the rack portion of Equation 2.1 results in;

$$\begin{aligned} & \{ (RCA + RMTE + RCSA + RD)^2 + (RTE)^2 \}^{1/2} \\ & \text{- or -} \\ & [\qquad \qquad \qquad]^{+a,c} = 1.94\% \end{aligned}$$

Assuming no interactive effects for any of the parameters yields the following less conservative results;

$$\begin{aligned} & \{ (RCA)^2 + (RMTE)^2 + (RCSA)^2 + (RD)^2 + (RTE)^2 \}^{1/2} \qquad \qquad \qquad (\text{Eq. 2.3}) \\ & \text{- or -} \\ & [\qquad \qquad \qquad]^{+a,c} = 1.26\% \end{aligned}$$

Thus, the impact of the use of Equation 2.1 is even greater in the area of rack effects than for sensor effects. Similar results, with different magnitudes, would be arrived at using digital process rack uncertainties.

Therefore, accounting for interactive effects in the treatment of these allowances insures a conservative result.

2.4 PROCESS ALLOWANCES

Finally, the PMA and PEA parameters are considered to be independent of both sensor and rack parameters. PMA provides allowances for the non-instrument related effects, e.g., neutron flux, calorimetric power error assumptions, fluid density changes, and temperature stratification assumptions. PMA may consist of more than one independent error allowance. Recently, an improved understanding of the ΔP level measurement system errors has led to two additional PMA error components being applied to the steam generator level channels. One for reference leg temperature changes from calibrated temperature, and one for downcomer subcooling. These error components are not considered to be random in nature, and should be treated as biases. PEA accounts for errors due to metering devices, such as elbows and venturis. Thus, these parameters have been factored into Equation 2.1 as independent quantities.

2.5 MEASUREMENT AND TEST EQUIPMENT ACCURACY

Westinghouse was informed by Watts Bar that the equipment used for calibration and functional testing of the transmitters and racks did not meet SAMA standard PMC 20.1-1973 with regards to allowed exclusion from the calculation⁽¹⁾. This implies that test equipment without an accuracy of 10 percent or less of the calibration accuracy (referenced in 3.2.6.a or 3.2.7.a.) is required to be included in the uncertainty calculations of equations 2.1 and 3.1. Based on values provided by Watts Bar, these additional uncertainties were included in the calculations, as noted on the tables included in this report, with minor impact on the final results. On Table 3-22, the values for SMTE and RMTE are specifically identified.

⁽¹⁾Scientific Apparatus Manufacturers Association, Standard PMC 20.1-1973. "Process Measurement and Control Technology."

3.0 PROTECTION SYSTEM SETPOINT METHODOLOGY

3.1 MARGIN CALCULATION

As noted in Section 2.0, Westinghouse utilizes the square root of the sum of the squares for summation of the various components of the channel uncertainty. This approach is valid where no dependency is present. An arithmetic summation is required where an interaction between two parameters exists. The equation used to determine the margin, and thus the acceptability of the parameter values used, is:

$$\text{Margin} = \text{TA} - \{(\text{PMA})^2 + (\text{PEA})^2 + (\text{SCA} + \text{SMTE} + \text{SD})^2 + (\text{SPE})^2 + (\text{STE})^2 + (\text{RCA} + \text{RMTE} + \text{RCSA} + \text{RD})^2 + (\text{RTE})^2\}^{1/2} - \text{EA} \quad (\text{Eq. 3.1})$$

where:

TA = Total Allowance (Safety Analysis Limit - Nominal Trip Setpoint), and

all other parameters are as defined for Equation 2.1.

Again, please note that Equation 3.1 is representative for a channel with analog process racks. Use of digital process racks results in modification of the RCSA term. The magnitude of the RMTE term is typically different for digital process racks when compared to typical values for analog process racks.

Tables 3-1 through 3-20 provide individual component uncertainties and CSA calculations for all protection functions utilizing appropriate values for the process rack equipment. Table 3-21 provides a summary of the previous 20 tables and includes Safety Analysis and Technical Specification values, Total Allowance and Margin.

3.2 DEFINITIONS FOR PROTECTION SYSTEM SETPOINT TOLERANCES

To insure a clear understanding of the channel uncertainty values used in this report, the following definitions are noted:

- A/D

Electronic circuit module that converts a continuously variable analog signal to a discrete digital signal via a prescriptive algorithm.

- Allowable Value

A bistable trip setpoint (analog function) or CPU trip output (digital function) in plant Technical Specifications, which allows for deviation, e.g., Rack Drift, from the Nominal Trip Setpoint. A bistable trip setpoint found non-conservative with respect to the Allowable Value requires some action for restoration by plant operating personnel.

- As Found

The condition a transmitter, process rack module or process instrument loop is found in after a period of operation. Typically this condition is better than the allowance for drift (see (Rack Drift) and (Sensor Drift)), e.g., after a period of operation, a transmitter was found to deviate from the ideal condition by (- 0.5) % span. This would be the "as found" condition.

- As Left

The condition a transmitter, process rack module or process instrument loop is left in after calibration or bistable trip setpoint verification. This condition is better than the calibration accuracy for that piece of equipment, e.g., the permitted calibration accuracy for a transmitter may be $\pm 0.5\%$ of span; after calibration, the worst measured deviation from the ideal condition is + 0.1% span. In this instance, if the calibration was stopped at this point, no additional efforts were made to decrease the deviation, the "as left" error would be + 0.1% span.

- Channel

The sensing and process equipment, i.e., transmitter to bistable (analog function) or transmitter to CPU trip output (digital function), for one input to the voting logic of a protection function. Westinghouse designs protection

functions with voting logic made up of multiple channels, e.g. 2/3 Steam Generator Level - Low-Low channels must have bistables in the tripped condition for a Reactor Trip to be initiated.

■ Channel Statistical Allowance (CSA)

The combination of the various channel uncertainties via SRSS. It includes both instrument (sensor and process rack) uncertainties and non-instrument related effects (Process Measurement Accuracy). This parameter is compared with the Total Allowance for determination of instrument channel margin.

■ Environmental Allowance (EA)

The change in a process signal (transmitter or process rack output) due to adverse environmental conditions from a limiting accident condition. Where appropriate, a value is explicitly noted. For functions not required to operate in an adverse condition, a value of zero is assigned. Typically this value is determined from a conservative set of enveloping conditions and may represent the following:

- a) temperature effects on a transmitter,
- b) vibration effects on a transmitter,
- c) seismic effects on a transmitter,
- d) temperature effects on a level transmitter reference leg,
- e) temperature effects on signal cable insulation and
- f) seismic effects on process racks.

■ Margin

The calculated difference (in % instrument span) between the Total Allowance and the Channel Statistical Allowance.

■ Nominal Trip Setpoint (NTS)

A bistable trip setpoint (analog function) or CPU trip output (digital function) in plant Technical Specifications. This value is the nominal value to which the bistable is set, as accurately as reasonably achievable (analog

function) or the defined input value for the CPU trip output setpoint (digital function).

- Normalization

The process of establishing a relationship, or link, between a process parameter and an instrument channel. This is in contrast with a calibration process. A calibration process is performed with independent known values, i.e., a bistable is calibrated to change state when a specific voltage is reached. This voltage corresponds to a process parameter magnitude with the relationship established through the scaling process. A normalization process typically involves an indirect measurement, e.g., determination of Steam Flow via the Δp drop across a flow restrictor. The flow coefficient is not known for this condition, effectively an orifice, therefore a mass balance between Feedwater Flow and Steam Flow can be made. With the Feedwater Flow known, through measurement via the venturi, the Steam Flow is normalized.

- Primary Element Accuracy (PEA)

Error due to the use of a metering device, e.g., venturi, orifice, or elbow. Typically, this is a calculated or measured accuracy for the device.

- Process Loop (Instrument Process Loop)

The process equipment for a single channel of a protection function.

- Process Measurement Accuracy (PMA)

Allowance for non-instrument related effects which have a direct bearing on the accuracy of an instrument channel's reading, e.g., temperature stratification in a large diameter pipe, fluid density in a pipe or vessel.

- Process Racks

The analog or digital modules downstream of the transmitter or sensing device, which condition a signal and act upon it prior to input to a voting logic system. For Westinghouse process systems, this includes all the equipment

contained in the process equipment cabinets, e.g., conversion resistor, transmitter power supply, R/E, lead/lag, rate, lag functions, function generator, summator, control/protection isolator, and bistable for analog functions; conversion resistor, transmitter power supply, signal conditioning-A/D converter and CPU for digital functions. The go/no go signal generated by the bistable is the output of the last module in the analog process rack instrument loop and is the input to the voting logic. The CPU trip output signal is the input to the voting logic from a digital system.

■ R/E

Resistance (R) to voltage (E) conversion module. The RTD output (change in resistance as a function of temperature) is converted to a process loop working parameter (voltage) by this analog module. Westinghouse 7300 and Eagle-21 Process Instrumentation Systems utilize R/E converters for treatment of RTD output signals.

■ R/I

Resistance (R) to current (I) conversion module. The RTD output (change in resistance as a function of temperature) is converted to a process loop working parameter (current) by this analog module. Foxboro, Hagan and Westinghouse 7100 Process Instrumentation Systems utilize R/I converters for treatment of RTD output signals.

■ Rack Calibration Accuracy (RCA)

The reference (calibration) accuracy, as defined by SAMA Standard PMC 20.1-1973^[1] for a process loop string. Inherent in this definition is the verification of the following under a reference set of conditions; 1) conformity^[2], 2) hysteresis^[3] and 3) repeatability^[4]. The Westinghouse definition of a process loop includes all modules in a specific channel. Also it is assumed that the individual modules are calibrated to a particular tolerance and that the process loop as a string is verified to be calibrated to a specific tolerance. The tolerance for the string is typically less than the arithmetic sum or SRSS of the individual module tolerances. This forces calibration of the process loop without a systematic bias in the individual

module calibrations, i.e., as left values for individual modules must be compensating in sign and magnitude.

For an analog channel, an individual module is typically calibrated to within []^{a,c}, with the entire process loop typically calibrated to within []^{a,c}. For simple process loops where a power supply (not used as a converter) is the only rack module, this accuracy may be ignored. However, it is Westinghouse practice to include this accuracy for these simple loops as a degree of conservatism.

For a Westinghouse supplied digital channel, RCA represents calibration of the signal conditioning - A/D converter providing input to the CPU. Typically there is only one module present in the digital process loop, thus compensation between multiple modules for errors is not possible. However, for protection functions with multiple inputs, compensation between multiple modules for errors is possible. Each signal conditioning - A/D converter module is calibrated to within an accuracy of []^{a,c} for functions with process rack inputs of 4 - 20 mA or 10 - 50 mA, or []^{a,c} for RTD inputs.

■ Rack Comparator Setting Accuracy (RCSA)

The reference (calibration) accuracy, as defined by SAMA Standard PMC 20.1-1973^[1] of the instrument loop comparator (bistable). Inherent in this definition is the verification of the following under a reference set of conditions; 1) conformity^[2], 2) hysteresis^[3] and 3) repeatability^[4]. The tolerances assumed for Watts Bar (based on input from TVA) are as follows:

- a.) Fixed setpoint with a single input - []^{a,b,c} percent accuracy. This assumes that comparator nonlinearities are compensated by the setpoint.
- b.) Dual input - an additional []^{a,b,c} percent must be added for comparator nonlinearities between two inputs. Total []^{a,b,c} percent accuracy.

In many plants, calibration of the bistable is included as an integral part of the rack calibration, i.e., string calibration. Westinghouse supplied digital channels do not have an electronic comparator, therefore no uncertainty is included for this term for these channels.

■ Rack Drift (RD)

The change in input-output relationship over a period of time at reference conditions, e.g., at constant temperature. Typical values assumed for this parameter are $\pm 1.0\%$ span for 30 days for analog racks and []^{%.c} for 90 days for digital racks.

■ Rack Measurement & Test Equipment Accuracy (RMTE)

The accuracy of the test equipment (typically a transmitter simulator, voltage or current power supply, and DVM) used to calibrate a process loop in the racks. When the magnitude of RMTE meets the requirements of SAMA PMC 20.1-1973^[5] it is considered an integral part of RCA. Magnitudes in excess of the 10:1 limit are explicitly included in Westinghouse calculations.

■ Rack Temperature Effects (RTE)

Change in input-output relationship for the process rack module string due to a change in the ambient environmental conditions (temperature, humidity, voltage and frequency) from the reference calibration conditions. It has been determined that temperature is the most significant, with the other parameters being second order effects. For Westinghouse supplied process instrumentation, a value of []^{%.c} is used for analog channel temperature effects and []^{%.c} is used for digital channels. It is assumed that calibration is performed at a nominal ambient temperature of + 70 °F with an upper extreme of + 120 °F (+ 50 °F ΔT) and a lower extreme of + 40 °F.

■ Range

The upper and lower limits of the operating region for a device, e.g., for a Pressurizer Pressure transmitter, 0 to 3000 psig, for Steam Generator Level, 0

to 500 inches of water column. This is not necessarily the calibrated span of the device, although quite often the two are close. For further information see SAMA PMC 20.1-1973^[6].

■ Safety Analysis Limit (SAL)

The parameter value assumed in an accident analysis at which a reactor trip or actuation function is initiated.

■ Sensor Calibration Accuracy (SCA)

The reference (calibration) accuracy for a sensor or transmitter as defined by SAMA Standard PMC 20.1-1973^[1]. Inherent in this definition is the verification of the following under a reference set of conditions; 1) conformity^[2], 2) hysteresis^[3] and 3) repeatability^[4]. For Westinghouse supplied transmitters, this accuracy is typically []^{±0.5%}. Utilizing Westinghouse recommendations for RTD cross-calibration, this accuracy is typically []^{±0.5%} for the Hot Leg and Cold Leg RTDs.

■ Sensor Drift (SD)

The change in input-output relationship over a period of time at reference calibration conditions, e.g., at constant temperature. Typical allowance for a Westinghouse supplied transmitter is []^{±0.5%} for 18 calendar months.

■ Sensor Measurement & Test Equipment Accuracy (SMTE)

The accuracy of the test equipment (typically a high accuracy local readout gauge and DVM) used to calibrate a sensor or transmitter in the field or in a calibration laboratory. When the magnitude of SMTE meets the requirements of SAMA PMC 20.1-1973^[5] it is considered an integral part of SCA. Magnitudes in excess of the 10:1 limit are explicitly included in Westinghouse calculations.

TVA's policy of using a 1:1 criteria at Watts Bar has been incorporated into this analysis.

■ Sensor Pressure Effects (SPE)

The change in input-output relationship due to a change in the static head pressure from the calibration conditions (if calibration is performed at line pressure) or the accuracy to which a correction factor is introduced for the difference between calibration and operating conditions for a Δp transmitter. For Westinghouse supplied transmitters, a typical SPE value is [

] [±] with an allowance of [] [±] variance from calibration conditions (if performed at line pressure). If a correction is introduced, e.g., for calibration at atmospheric pressure conditions, it is assumed the correction factor is introduced with an accuracy of [] [±].

■ Sensor Temperature Effects (STE)

The change in input-output relationship due to a change in the ambient environmental conditions (temperature, humidity, voltage and frequency) from the reference calibration conditions. It has been determined that temperature is the most significant, with the other parameters being second order effects. For Westinghouse supplied transmitters, the temperature effect is typically [] [±] with a maximum assumed change of 50 °F (or an STE value of [] [±]). It is assumed that calibration is performed at a nominal ambient temperature of + 70 °F with an upper extreme of + 120 °F and a lower extreme of + 40 °F. For specific devices, a maximum temperature of + 130 °F is acceptable, which then requires a calibration temperature of greater than or equal to + 80 °F. Higher calibration temperatures are acceptable, but the maximum operating temperature is limited to 120 °F and 130 °F after Westinghouse evaluation.

■ Span

The region for which a device is calibrated and verified to be operable, e.g., for a Pressurizer Pressure transmitter, 800 psig. For Pressurizer Pressure, considerable suppression of the zero and turndown of the operating range is exhibited.

■ SRSS

Square root of the sum of the squares, i.e.,

$$\epsilon = \sqrt{(a)^2 + (b)^2 + (c)^2}$$

as approved for use in setpoint calculations by ISA Standard S67.04-1987^[7].

■ Total Allowance (TA)

The calculated difference between the Safety Analysis Limit and the Nominal Trip Setpoint (SAL - NTS) in % instrument span. Two examples of the calculation of TA are:

■ NIS Power Range Neutron Flux - High

SAL	118% RTP
NTS	- 109% RTP
	9% RTP
TA	

If the instrument span = 120% RTP, then

$$TA = \frac{(9\% \text{ RTP})(100\% \text{ span})}{(120\% \text{ RTP})} = 7.5\% \text{ span}$$

■ Pressurizer Pressure - Low

SAL	1910 psig
NTS	- 1970 psig
	60 psig
TA	

If the instrument span = 800 psig, then

$$TA = \frac{(60 \text{ psig})(100\% \text{ span})}{(800 \text{ psig})} = 7.5\% \text{ span}$$

3.3 CROSS REFERENCE - SAMA PMC 20.1-1973 AND ANSI/ISA-S51.1-1979

SAMA Standard PMC 20.1-1973, "Process Measurement & Control Terminology" is no longer in print and thus is unavailable from SAMA. It has been replaced by ANSI/ISA S51.1-1979, "Process Instrumentation Terminology" and is available from the Instrument Society of America. Noted below is a cross reference listing of equivalent definitions between the two standards for terms used in this document. Even though the SAMA standard is no longer available, Westinghouse prefers and continues to use the SAMA definitions.

<u>SAMA</u>	<u>ISA</u>
Reference Accuracy ^[1]	Accuracy Rating ^[8]
Conformity ^[2]	Conformity, independent ^[9]
Hysteresis ^[3]	Hysteresis ^[10]
Repeatability ^[4]	Repeatability ^[11]
Test Cycle ^[5]	Calibration Cycle ^[12]
Test Procedures ^[5]	Test Procedures ^[12]
Range ^[6]	Range ^[13]

3.4 REFERENCES / STANDARDS

- [1] Scientific Apparatus Makers Association Standard PMC 20.1-1973, "Process Measurement & Control Terminology", p 4, 1973.
- [2] Ibid, p 5.
- [3] Ibid, p 19.
- [4] Ibid, p 28.
- [5] Ibid, p 36.
- [6] Ibid, p 27.
- [7] Instrument Society of America Standard S67.04-1987, "Setpoints for Nuclear Safety-Related Instrumentation", p 12, 1987.
- [8] Instrument Society of America Standard S51.1-1979, "Process Instrumentation Terminology", p 6, 1979.
- [9] Ibid, p 8.
- [10] Ibid, p 20.
- [11] Ibid, p 27.
- [12] Ibid, p 33.
- [13] Ibid, p 25.

3.5 METHODOLOGY CONCLUSION

The Westinghouse setpoint methodology results in a value with a 95 percent probability. Analog Rack Drift and Sensor Drift are assumed based on a survey of reported plant LERs, digital Rack Drift is based on system design, and Process Measurement Accuracy terms are considered conservative values.

TABLE 3-1

POWER RANGE, NEUTRON FLUX - HIGH AND LOW SETPOINTS**

Parameter		Allowance*
Process Measurement Accuracy	[]** _c	[]** _c
Primary Element Accuracy		
Sensor Calibration	[]** _c	
Sensor Pressure Effects		
Sensor Temperature Effects	[]** _c	
Sensor Drift	[]** _c	
Environmental Allowance		
Rack Calibration		
Rack Accuracy		
Measurement & Test Equipment Accuracy		
Comparator		
One input		
Rack Temperature Effects		
Rack Drift		

* In percent span (120 percent Rated Thermal Power)

** Not processed by Eagle-21 racks.

TVA Sensor Tag #s NMD-92-NE41-D, 42-E, 43-F, 44-G

Channel Statistical Allowance =

[]	[]** _c
-----	--------------------

TABLE 3-2

POWER RANGE, NEUTRON FLUX - HIGH POSITIVE RATE
AND HIGH NEGATIVE RATE**

Parameter		Allowance*
Process Measurement Accuracy	[] **c	[] **c
Primary Element Accuracy		
Sensor Calibration	[] **c	
Sensor Pressure Effects		
Sensor Temperature Effects	[] **c	
Sensor Drift		
Environmental Allowance	[] **c	
Rack Calibration Rack Accuracy Measurement & Test Equipment Accuracy		
Comparator One input		
Rack Temperature Effects		
Rack Drift		

* In percent span (120 percent Rated Thermal Power)
 ** Not processed by Eagle-21 racks.
 TVA Sensor Tag #s NMD-92-NE41-D, 42-E, 43-F, 44-G
 Channel Statistical Allowance =

[]	[] **c
-----	---------

TABLE 3-3

INTERMEDIATE RANGE, NEUTRON FLUX**

See TVA calculation 1-NMD-92-131

** Not processed by EAGLE-21 racks

TABLE 3-4

SOURCE RANGE, NEUTRON FLUX**

See TVA calculation 1-NMD-92-131

** Not processed by EAGLE-21 racks

TABLE 3-5
OVERTEMPERATURE ΔT

Parameter	Allowance*
Process Measurement Accuracy [	]**,c
Primary Element Accuracy	
Sensor Calibration [	]**,c
Measurement & Test Equipment Accuracy [	]**,c
Sensor Pressure Effects	
Sensor Temperature Effects [	]**,c
Sensor Drift [	]**,c
Environmental Allowance	
Bias Values [	]**,c
Rack Calibration [	]**,c
Measurement & Test Equipment Accuracy [	]**,c

TABLE 3-5 (Continued)

OVERTEMPERATURE ΔT

Parameter

Allowance*

Total Rack Calibration Accuracy

[

]

[†]a, c

Rack Temperature Effects

[

]

[†]a, c

Rack Drift

ΔT
Pressure
 ΔI

[[†]a, c]

* In percent span (Tavg - 100 °F, Pressure - 800 psi, Power - 150% RTP, ΔT - 87.3 °F, ΔI - $\pm 60\% \Delta I$)

** See Table 3-22 for gain and conversion calculations

Number of Hot Leg RTDs used

Number of Cold Leg RTDs used

TVA Sensor Tag #s

NIS NMD-92-NE41-D, 42-E, 43-F, 44-G

Pressure PT-68-322G, 323F, 334E, 340D

Temperature TE-68-2B1, -2B2, -2B3, -14A, -14B, -25B1, -25B2, -25B3, -37A, -37B, -44B1, -44B2, -44B3, -56A, -56B, -67B1, -67B2, -67B3, -79A, -79B.

Channel Statistical Allowance =

[

]

[†]a, c

TABLE 3-6
OVERPOWER ΔT

Parameter		Allowance*
Process Measurement Accuracy [] **c	<div style="border: 1px solid black; width: 100px; height: 100px; margin: auto;"></div>
Primary Element Accuracy		
Sensor Calibration [	] **c
Sensor Pressure Effects		
Sensor Temperature Effects		
Sensor Drift [	] **c
Environmental Allowance Cable IR (per TVA letter No. W-7237)		
Bias Values [	] **c
Rack Calibration [	] **c
Measurement & Test Equipment Accuracy [	] **c
Total Rack Accuracy [	] **c
Rack Temperature Effects [	] **c
Rack Drift [	] **c

TABLE 3-7

PRESSURIZER PRESSURE - LOW AND HIGH REACTOR TRIP

Parameter	Allowance*	
Process Measurement Accuracy	<div style="display: flex; align-items: center; justify-content: center;"> <div style="border-left: 1px solid black; border-right: 1px solid black; border-bottom: 1px solid black; width: 80px; height: 400px;"></div> <div style="margin-left: 5px; text-align: right;">**c</div> </div>	
Primary Element Accuracy		
Sensor Calibration		
Measurement & Test Equipment Accuracy		
Sensor Pressure Effects		
Sensor Temperature Effects		
Sensor Drift		
{		} **c
{		} **c
Environmental Allowance		
Rack Calibration		
Rack Accuracy		
Measurement & Test Equipment Accuracy		
Rack Temperature Effects		
Rack Drift		

* In percent span (800 psi)
 TVA Sensor Tag #s PT-68-322G, 323F, 334E, 340D

Channel Statistical Allowance = Pressurizer Pressure - High

**c

Channel Statistical Allowance = Pressurizer Pressure - Low

**c

TABLE 3-8

PRESSURIZER WATER LEVEL - HIGH

Parameter	Allowance*
Process Measurement Accuracy	<div style="text-align: right; margin-right: 5px;">**c</div>
Primary Element Accuracy	
Sensor Calibration	
Measurement & Test Equipment Accuracy	
Sensor Pressure Effects	
Sensor Temperature Effects	
Sensor Drift	
Environmental Allowance	
Rack Calibration	
Rack Accuracy	
Measurement & Test Equipment Accuracy	
Rack Temperature Effects	
Rack Drift	

* In percent span (100 percent of span)
 TVA Sensor Tag #s LT-68-320-F, 335-E, 339-D
 Channel Statistical Allowance =

[] **c

TABLE 3-9
LOSS OF FLOW

Parameter		Allowance*
Process Measurement Accuracy		[]**c
[	]**c
Primary Element Accuracy		
[	]**c
Sensor Calibration		
[	]**c
Sensor Pressure Effects		
[	]**c
Sensor Temperature Effects		
[	]**c
Sensor Drift		
[	]**c
Environmental Allowance		
Rack Calibration		
[	]**c
Measurement & Test Equipment Accuracy		
[	]**c
Rack Temperature Effects		
[	]**c
Rack Drift		
[	]**c

* In percent flow span (110% Thermal Design Flow). Percent ΔP span converted to flow span via Equation 3-24.8, with $F_{max} = 110\%$ and $F_N = 100\%$
TVA Sensor Tag #s - FT-68-6A-D, 6B-E, 6D-F, 29A-D, 29B-E, 29D-F, 48A-D, 48B-E, 48D-F, 71A-D, 71B-E, 71D-F.

Channel Statistical Allowance =

[		]**c
]]

TABLE 3-10

STEAM GENERATOR WATER LEVEL - LOW-LOW
(INSIDE CONTAINMENT)

Parameter	Allowance*
Process Measurement Accuracy	
Process Pressure effects - treated as a Bias	+0.3
Reference Leg temperature effects - treated as a Bias	0.0
Downcomer Subcooling and Fluid velocity effects - treated as a Bias	+0.5
Primary Element Accuracy	0.0
Sensor Calibration	±0.5
Measurement & Test Equipment Accuracy	±0.5
Sensor Pressure Effects	±0.5
Sensor Temperature Effects	±0.5
Sensor Drift	±1.0
Environmental Allowance	
Temperature Effects ONLY, no Radiation Effects	±6.0
Reference Leg Heatup (per Watts Bar letter W-7228)	±3.0
TTD reset - Incorporated into deadband (3.5%).	±0.0
Bias	
Cable IR - Per TVA Calculation WBPEVAR9103004, R0	±0.0
Rack Calibration	±0.2
Measurement & Test Equipment Accuracy	±0.2
Rack Temperature Effects	±0.3
Rack Drift	±0.3

* In percent span (100 percent span)

TVA Sensor Tag #s LT-3-38E, 39F, 42G, 51D, 52F, 55G, 93D, 94F, 97G, 106E, 107F, 110G

TABLE 3-10 (continued)

**STEAM GENERATOR WATER LEVEL - LOW-LOW
(INSIDE CONTAINMENT)**

Channel Statistical Allowance = Steam Generator Water Level - LOW-LOW

$$\begin{aligned} & \{(0.0)^2 + (0.0)^2 + (0.5 + 0.5 + 1.0)^2 + (0.5)^2 + \\ & (0.5)^2 + (0.2 + 0.2 + 0.0 + 0.3)^2 + (0.3)^2\}^{1/2} + \\ & 6.0 + 3.0 + 0.3 + 0.5 = 12.0\% \text{ span} \end{aligned}$$

CALCULATIONS PERFORMED PER TVA INSTRUCTIONS (LETTER WAT(JWI)-3627)

TABLE 3-10a

STEAM GENERATOR WATER LEVEL - LOW-LOW
(OUTSIDE CONTAINMENT)

Parameter	Allowance*
Process Measurement Accuracy	<div style="text-align: right; margin-right: 10px;">**c</div> <div style="border-left: 1px solid black; border-right: 1px solid black; height: 500px; margin: 0 auto;"></div>
[
Primary Element Accuracy	
Sensor Calibration	
Measurement & Test Equipment Accuracy	
Sensor Pressure Effects	
Sensor Temperature Effects	
Sensor Drift	
Environmental Allowance	
Bias	
Rack Calibration	
Measurement & Test Equipment Accuracy	
Rack Temperature Effects	
Rack Drift	

* In percent span (100 percent span)

TVA Sensor Tag #s LT-3-38E, 39F, 42G, 51D, 52F, 55G, 93D, 94F, 97G, 106E, 107F, 110G

TABLE 3-10a (continued)

**STEAM GENERATOR WATER LEVEL - LOW-LOW
(OUTSIDE CONTAINMENT)**

Channel Statistical Allowance = Steam Generator Water Level - LOW-LOW

--	--

**c