Westinghouse Non-Proprietary Class 3

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Revision 2

Westinghouse Setpoint Methodology for Protection Systems Watts Bar Unit 1 Eagle 21 Version

Westinghouse Energy Systems

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Rev. 2

WESTINGHOUSE SETPOINT METHODOLOGY FOR PROTECTION SYSTEMS WATTS BAR UNIT 1 EAGLE 21 VERSION

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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 references the current Watts Bar Technical Specifications 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,

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

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(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):

SCA = [
SMTE =
SPE =
STE =
SD =]$^{+a,c}$

excerpting the sensor portion of Equation 2.1 results in;

$$\{(SCA + SMTE + SD)^2 + (SPE)^2 + (STE)^2\}^{1/2}$$

- or -

[ ]$^{+a,c}$ = 2.12%

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

$$\{(SCA)^2 + (SMTE)^2 + (SD)^2 + (SPE)^2 + (STE)^2\}^{1/2} \qquad \text{(Eq. 2.2)}$$

- or -

[ ]$^{+a,c}$ = 1.41%

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:

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

excerpting the rack portion of Equation 2.1 results in;

$$\{(RCA + RMTE + RCSA + RD)^2 + (RTE)^2\}^{1/2}$$

- or -

$$[\qquad]^{+a,c} = 1.94\%$$

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

$$\{(RCA)^2 + (RMTE)^2 + (RCSA)^2 + (RD)^2 + (RTE)^2\}^{1/2} \qquad \text{(Eq. 2.3)}$$

- or -

$$[\qquad]^{+a,c} = 1.26\%$$

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.

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[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:

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

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 ± 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) radiation 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 stratafication 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 ± 1.0% span for 30 days for analog racks and [ ]+a,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 [ ]+a,c is used for analog channel temperature effects and [ ]+a,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 a 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 [ ]+a,c. Utilizing Westinghouse recommendations for RTD cross-calibration, this accuracy is typically [ ]+a,c 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 [ ]+a,c 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.

TVAs 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 [$]^{+a,c}$ with an allowance of [$]^{+a,c}$ 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 [$]^{+a,c}$.

- 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 [$]^{+a,c}$ with a maximum assumed change of 50 °F (or an STE value of [$]^{+a,c}$). 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
TA	9% RTP

If the instrument span = 120% RTP, then

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

■ *Pressurizer Pressure - Low*

SAL	1910 psig
NTS	- 1970 psig
TA	60 psig

If the instrument span = 800 psig, then

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

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.

SAMA	ISA
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	[ ]+a,c
[ ]+a,c	
Primary Element Accuracy	
Sensor Calibration	
[ ]+a,c	
Sensor Pressure Effects	
Sensor Temperature Effects	
[ ]+a,c	
Sensor Drift	
[ ]+a,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 =

[ ]+a,c

TABLE 3-2

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

Parameter	**Allowance***
Process Measurement Accuracy	[ ] +a,c
[ ] +a,c	
Primary Element Accuracy	
Sensor Calibration	
[ ] +a,c	
Sensor Pressure Effects	
Sensor Temperature Effects	
[ ] +a,c	
Sensor Drift	
[ ] +a,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 =

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

TABLE 3-5 (Continued)

OVERTEMPERATURE ΔT

Parameter	Allowance*
Rack Temperature Effects	
[ ]+a,c	[ ]+a,c
Rack Drift	
[ ]+a,c	

* In percent ΔT span (Tavg - 100 °F, Pressure - 800 psi, Power - 150% RTP, ΔT - 91.5 °F, ΔI - ±60% ΔI)

** 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
[ ]+a,c
[ ]+a,c
[ ]+a,c
[ ]+a,c
[ ]+a,c
[ ]+a,c
[ ]+a,c

Primary Element Accuracy

Sensor Calibration
[ ]+a,c

Sensor Measurement & Test Equipment Accuracy
[ ]+a,c

Sensor Pressure Effects

Sensor Temperature Effects

Sensor Drift
[ ]+a,c

Environmental Allowance
Cable IR (0.46°F per TVA letter No. W-7237)

Bias Values

Rack Calibration
[ ]+a,c

Rack Measurement & Test Equipment Accuracy
[ ]+a,c

Rack Temperature Effects
[ ]+a,c

Rack Drift
[ ]+a,c

[ ]+a,c

TABLE 3-6 (Continued)
OVERPOWER ΔT

* In percent ΔT span (Tavg - 100 °F, Power - 150% RTP, ΔT - 91.5 °F)

** See Table 3-23 for gain and conversion calculations

\# Number of Hot Leg RTDs used

\#\# Number of Cold Leg RTDs used

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-7

PRESSURIZER PRESSURE - LOW AND HIGH REACTOR TRIP

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

[ ]+a,c

Channel Statistical Allowance = Pressurizer Pressure - Low

[ ]+a,c

TABLE 3-8

PRESSURIZER WATER LEVEL - HIGH

Parameter	Allowance*
Process Measurement Accuracy	+a,c
[ ] +a,c	
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 =

[ ] +a,c

TABLE 3-9
REACTOR COOLANT FLOW - LOW REACTOR TRIP

Parameter | **Allowance*** [ ]+a,c

Process Measurement Accuracy
[ ]+a,c

Primary Element Accuracy
[ ]+a,c

Sensor Calibration
[ ]+a,c

Sensor Measurement and Test Equipment Accuracy
[ ]+a,c

Sensor Pressure Effects
[ ]+a,c

Sensor Temperature Effects
[ ]+a,c

Sensor Drift
[ ]+a,c

Environmental Allowance

Bias Values

Rack Calibration
[ ]+a,c

Measurement & Test Equipment Accuracy
[ ]+a,c

Rack Temperature Effects
[ ]+a,c

Rack Drift
[ ]+a,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 = 90%
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 =

[ ]+a,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

$$\{(0.0)^2 + (0.0)^2 + (0.5 + 0.5 + 1.0)^2 + (0.5)^2 +$$

$$(0.5)^2 + (0.2 + 0.2 + 0.0 + 0.3)^2 + (0.3)^2\}^{1/2} +$$

$$6.0 + 3.0 + 0.3 + 0.5 = 12.0\% \text{ span}$$

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 [a,c]	[a,c]
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 [a,c]

TABLE 3-11

UNDERVOLTAGE**
GE/12NGV12B21A @

Parameter	Allowance*
Process Measurement Accuracy	0.0
Primary Element Accuracy	±0.4
Sensor Calibration	0.0
Measurement & Test Equipment Accuracy	0.0
Sensor Pressure Effects	0.0
Sensor Temperature Effects	0.0
Sensor Drift	0.0
Environmental Allowance	0.0
Bias	±0.5
Rack Calibration	±2.4
Measurement & Test Equipment Accuracy	±1.1
Rack Comparator Setting Accuracy	±1.1
Rack Temperature Effects Included in RCA	0.0
Rack Drift Included in RCA	0.0

* In percent of setpoint
** Not processed by Eagle-21 racks

@ All uncertainties are from TVA calculation - WBPE0689009007

Channel Statistical Allowance =

$$\{(0.0)^2 + (0.4)^2 + (0.0 + 0.0 + 0.0)^2 + (0.0)^2 + (0.0)^2 + (2.4 + 1.1 + 1.1 + 0.0)^2 + (0.0)^2\}^{1/2} + 0.5 =$$

5.1% of setpoint

TABLE 3-12

UNDERFREQUENCY**
ABB/422B1295 @

Parameter	Allowance*
Process Measurement Accuracy	0.0
Primary Element Accuracy	0.0
Sensor Calibration	0.0
Measurement & Test Equipment Accuracy	0.0
Sensor Pressure Effects	0.0
Sensor Temperature Effects	0.0
Sensor Drift	0.0
Environmental Allowance	0.0
Rack Calibration	±0.01
Measurement & Test Equipment Accuracy	±0.07
Rack Comparator Setting Accuracy	±0.09
Rack Temperature Effects	±0.01
Rack Drift	±0.96

* In percent of setpoint
** Not processed by Eagle-21 racks

@ All uncertainties are from TVA calculation WBPE0689009008

Channel Statistical Allowance =

$$\{(0.0)^2 + (0.0)^2 + (0.0 + 0.0 + 0.0)^2 + (0.0)^2 + (0.0)^2 + (0.01 + 0.07 + 0.09 + 0.96)^2 + (0.01)^2\}^{1/2} + 0.0 =$$

1.13% of setpoint

TABLE 3-13

CONTAINMENT PRESSURE - HIGH, HIGH-HIGH

Parameter	Allowance*
Process Measurement Accuracy	
Primary Element Accuracy	
Sensor Calibration	
Measurement & Test Equipment Accuracy	
Sensor Pressure Effects	
Sensor Temperature Effects	
Sensor Drift	
Environmental Allowance	
Bias Cable IR - per TVA calculation WBPEVAR9103004, R0	
Rack Calibration	
Measurement & Test Equipment Accuracy	
Rack Temperature Effects	
Rack Drift	

* In percent span (17 psi)

TVA Sensor Tag #s PDT-30-42G, 43F, 44E, 45D

Channel Statistical Allowance =

TABLE 3-14

PRESSURIZER PRESSURE - LOW, SAFETY INJECTION

Parameter	Allowance*
Process Measurement Accuracy	[ ]+a,c
Primary Element Accuracy	
Sensor Calibration	
Measurement & Test Equipment Accuracy	
Sensor Pressure Effects	
Sensor Temperature Effects	
Sensor Drift	
Environmental Allowance	
Bias Cable IR - per TVA calculation WBPEVAR9103004, R0	
Rack Calibration	
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 =

[ ]+a,c

TABLE 3-15

STEAMLINE PRESSURE - LOW

Parameter	Allowance*
Process Measurement Accuracy	
Primary Element Accuracy	
Sensor Calibration	
Measurement & Test Equipment Accuracy	
Sensor Pressure Effects	
Sensor Temperature Effects	
Barton	
Foxboro	
Sensor Drift	
Environmental Allowance	
Barton	
Foxboro	
Bias	
Cable IR - per TVA calculation WBPEVAR9103004, R0	
Rack Calibration	
Measurement & Test Equipment Accuracy	
Rack Temperature Effects	
Rack Drift	

* In percent span (1300 psi)

TVA Sensor Tag #s PT-1-2A-D, 2B-E, 5G, 9A-D, 9B-E, 12F, 20A-D, 20B-E, 23F, 27A-D, 27B-E, 30G

TABLE 3-15 (continued)

STEAMLINE PRESSURE - LOW

Channel Statistical Allowance =

BARTON

[ ] +a,c

FOXBORO

[ ] +a,c

TABLE 3-16

STEAM GENERATOR WATER LEVEL - HIGH-HIGH

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

Channel Statistical Allowance =

[ ] +a,c

TABLE 3-17

NEGATIVE STEAMLINE PRESSURE RATE - HIGH

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

* In percent span (1300 psig)

TVA Sensor Tag #s PT-1-2A-D, 2B-E, 5G, 9A-D, 9B-E, 12F, 20A-D, 20B-E, 23F, 27A-D, 27B-E, 30G

TABLE 3-17 (continued)

NEGATIVE STEAMLINE PRESSURE RATE - HIGH

Channel Statistical Allowance =

[ ] a,c

TABLE 3-18

RWST LEVEL - LOW LOW

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

* In percent span (100% span)

TVA Sensor Tag #s LT-63-50D, 51E, 52F, 53G

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-19

CONTAINMENT SUMP LEVEL - HIGH/AUTO SWITCHOVER

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

* In percent span (100% span)

TVA Sensor Tag #s LT-63-50D, 51E, 52F, 53G, 180, 181, 182, 183

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-20

VESSEL ΔT EQUIVALENT TO POWER

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

* In percent span (Power - 150% RTP, ΔT - 91.5 °F)
** See Table 3-23 for gain and conversion calculations

\# Number of Hot Leg RTDs used
\#\# Number of Cold Leg RTDs used

TVA Sensor Tag #s - See Table 3-5; Vessel T_H ≤618.7 °F + indication uncertainties, Vessel T_C ≥557.7 °F - indication uncertainties, confirmed on the same periodic basis as surveillance of ΔT_0 values for OTΔT and OPΔT.

TABLE 3-20 (continued)

VESSEL ΔT EQUIVALENT TO POWER

Channel Statistical Allowance =

$[\quad]^{+a,c}$

TABLE 3-21 (Rev.7)
REACTOR TRIP SYSTEM / ENGINEERED SAFETY FEATURES ACTUATION SYSTEM CHANNEL ERROR ALLOWANCES
WATTS BAR UNIT 1 EAGLE 21

		SENSOR								INSTRUMENT RACK											
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
	PROTECTION CHANNEL	PROCESS MEASUREMENT ACCURACY (1)	PRIMARY ELEMENT ACCURACY (1)	CALIBRATION ACCURACY (1)	MEASUREMENT & TEST EQUIPMENT ACCURACY (1)	PRESSURE EFFECTS (1)	TEMPERATURE EFFECTS (1)	DRIFT (1)	ENVIRON-MENTAL ALLOWANCE (1)	CALIBRATION ACCURACY (1)	MEASUREMENT & TEST EQUIPMENT ACCURACY (1)	COMPARATOR SETTING ACCURACY (1)	TEMPERATURE EFFECTS (1)	DRIFT (1)	SAFETY ANALYSIS LIMIT (2)	ALLOWABLE VALUE (3)	TRIP SETPOINT (3)	TOTAL ALLOWANCE (1)	CHANNEL STATISTICAL ALLOWANCE (1)	MARGIN (1)	
1	POWER RANGE, NEUTRON FLUX - HIGH SETPOINT													1.0	118 % RTP	111.4 % RTP	109 % RTP	7.5			1
2	POWER RANGE, NEUTRON FLUX - LOW SETPOINT													1.0	35 % RTP	27.1 % RTP	25 % RTP	8.3			2
3	POWER RANGE, NEUTRON FLUX - HIGH POSITIVE RATE													0.5	(8)	6.3 % RTP/2 SEC	5.0 % RTP/2 SEC	—			3
4	POWER RANGE, NEUTRON FLUX - HIGH NEGATIVE RATE													0.5	6.9 % RTP/2 SEC	6.3 % RTP/2 SEC	5.0 % RTP/2 SEC	1.6			4
5	INTERMEDIATE RANGE, NEUTRON FLUX													(9)		(9)	(9)	—			5
6	SOURCE RANGE, NEUTRON FLUX													(9)		(9)	(9)	—			6
7	OVERTEMPERATURE ΔT ΔT CHANNEL TAVG CHANNEL PRESSURIZER PRESSURE CHANNEL ΔI CHANNEL														FUNCTION (13)	FUNCTION (14) +1.2 % ΔT SPAN	FUNCTION (14)	8.3			7
8	OVERPOWER ΔT ΔT CHANNEL TAVG CHANNEL														FUNCTION (13)	FUNCTION (14) +1.0 % ΔT SPAN	FUNCTION (14)	4.2			8
9	PRESSURIZER PRESSURE - LOW, REACTOR TRIP														1910 PSIG	1964.6 PSIG	1970 PSIG	7.5			9
10	PRESSURIZER PRESSURE - HIGH														2445 PSIG	2390.2 PSIG	2385 PSIG	7.5			10
11	PRESSURIZER WATER LEVEL - HIGH														(8)	92.7 % SPAN	92 % SPAN	—			11
12	REACTOR COOLANT FLOW - LOW,REACTOR TRIP														87 % FLOW	89.6 % FLOW	90 % FLOW	2.7			12
13	STEAM GENERATOR WATER LEVEL - LOW-LOW (OUTSIDE CONTAINMENT)														0 % SPAN	16.4 % SPAN	17.0 % SPAN	17.0			13
14	STEAM GENERATOR WATER LEVEL - LOW-LOW (INSIDE CONTAINMENT) (26)	0.5 (23), 0.3 (24), 0.0 (25)	—	0.5	0.5	0.5	0.5	1.0	6.0 & 3.0 (19) & 0.0 (20)	0.2	0.2	—	0.3	0.3	0 % SPAN	16.4 % SPAN	17.0 % SPAN	17.0	12.0	+5.0	14
15	UNDERVOLTAGE - RCP (28)	—	0.4	—	—	—	—	—	0.5	2.4	1.1	1.1	—	—	78.2 V	78.9 V	90.0 V	(28)	(28)	(28)	15
16	UNDERFREQUENCY - RCP (29)	—	—	—	—	—	—	—	—	0.01	0.07	0.09	0.01	0.96	56.8 HZ	56.9 HZ	57.5 HZ	1.2	1.13	+0.09	16
17	CONTAINMENT PRESSURE - HIGH														2.2 PSIG	1.6 PSIG	1.5 PSIG	3.9			17
18	CONTAINMENT PRESSURE - HIGH-HIGH														3.5 PSIG	2.9 PSIG	2.8 PSIG	4.1			18
19	PRESSURIZER PRESSURE - LOW, SI														1685 PSIG	1864.6 PSIG	1870 PSIG	23.1			19
20	STEAMLINE PRESSURE - LOW BARTON FOXBORO														343.5 PSIG	666.6 PSIG	675 PSIG	25.5 25.5			20
21	NEGATIVE STEAMLINE PRESSURE RATE - HIGH														(8)	108.5 PSI	100 PSI	—			21
22	STEAM GENERATOR WATER LEVEL - HIGH-HIGH														100.0 % SPAN	83.1 % SPAN	82.4 % SPAN	17.6			22
23	VESSEL ΔT EQUIVALENT TO POWER ΔT CHANNEL														59 % RTP	≤52.5 % RTP	RCS Loop ΔT Variable Input ≤ 50% of RTP	6.0			23
24	RWST - LOW-LOW LEVEL														28.7 % SPAN	34.0 % SPAN	34.6 % SPAN	5.9			24
25	CONTAINMENT SUMP LEVEL - HIGH / AUTO SWITCHOVER														0.42 % SPAN	13.2 % SPAN	13.4 % SPAN	13.0			25

NOTES:

1. ALL VALUES IN PERCENT OF SPAN.
2. AS NOTED FOR INFORMATION IN TABLE 15.1-3 OF THE FSAR.
3. AS CALCULATED USING THE APPROVED METHODOLOGY AND NOTED ON TABLE 4-2 OF THIS REPORT
4. [ ]
5. [ ]
6. [ ]
7. [ ]
8. NOT USED IN THE SAFETY ANALYSIS
9. CALCULATIONS PROVIDED BY TVA, 1-NMD-92-131
10. [ ]
11. ... / EXCORE (ΔI) COMPARISON AS NOTED IN PLANT TECHNICAL SPECIFICATIONS
12. [ ]
13. ...ED FOR INFORMATION IN FIGURE 15.1-1 OF THE FSAR
14. AS NOTED IN TABLE 3.3.1-1 OF THE TECHNICAL SPECIFICATIONS
15. [ ]
16. [ ]
17. [ ]
18. [ ]
19. [ ]
20. CABLE INSULATION RESISTANCE DEGRADATION - PROVIDED BY TVA AND TREATED AS A BIAS
21. [ ]
22. [ ]
23. [ ]
24. [ ]
25. [ ]
26. CALCULATION PERFORMED PER TVA INSTRUCTIONS. TVA IS RESPONSIBLE FOR FEEDLINE BREAK INSIDE CONTAINMENT ANALYSIS.
27.
28. CALCULATIONS PROVIDED BY TVA - WBPE0689009007, WITH ALL VALUES IN PERCENT OF SETPOINT.
29. CALCULATIONS PROVIDED BY TVA - WBPE0689009008, WITH ALL VALUES IN PERCENT OF SETPOINT.
30. [ ]
31. [ ]
32. [ ]
33. [ ]
34. NOMINAL 5% RTP VALUE - NORMALIZE TO LOOP SPECIFIC 50% RTP VALUE.
35. [ ]
36. [ ]
37. [ ]

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TABLE 3-22
OVERTEMPERATURE ΔT CALCULATIONS

- The equation for Overtemperature ΔT:

$$\textit{Overtemperature}\ \Delta T\ \left(\frac{1+\tau_4 S}{1+\tau_5 S}\right) \le$$

$$\Delta T_O \left\{ K_1 - K_2 \left(\frac{1+\tau_1 S}{1+\tau_2 S}\right) [T - T'] + K_3(P - P') - f_1(\Delta I) \right\}$$

K_1 (nominal) = 1.16 As noted in the Technical Specifications
K_1 (max) = [ )]$^{+a,c}$
K_2 = 0.0183/°F
K_3 = 0.000900/psi
Vessel T_H ≤ 618.7 °F + indication uncertainties
Vessel T_C ≥ 557.7 °F - indication uncertainties
confirmed on the same periodic basis as surveillance of ΔT_0 values

Pressurizer Pressure ≥ 2235 psig - indication uncertainties
ΔI gain = 1.96% (for ΔI > +10%)

- Full power ΔT calculation:

ΔT span = [ ]$^{+a,c}$
ΔT span_pwr = 150% RTP

- Process Measurement Accuracy Calculations:

[ ]$^{+a,c}$

[ ]$^{+a,c}$

[ ]$^{+a,c}$

ΔI - Incore / Excore Mismatch

[ ]$^{+a,c}$

ΔI - Incore Map Delta-I Uncertainty

[ ]$^{+a,c}$

* As noted for information in Surveillance Item SR 3.3.1.3 of the Technical Specifications.

TABLE 3-22 (Continued)
OVERTEMPERATURE ΔT CALCULATIONS

- Pressure Channel Uncertainties

Gain = [ ] +a,c

SCA = [ ] +a,c

SMTE =

STE =

SD =

RCA = [ ] +a,c

RMTE =

RTE =

RD =

- ΔI Channel Uncertainties

Gain = [ ] +a,c

RCA = [ ] +a,c

RMTE =

RTE =

RD =

- Total Allowance

[ ] +a,c

TABLE 3-23

OVERPOWER ΔT CALCULATIONS

- The equation for Overpower ΔT:

$$\textit{Overpower } \Delta T \left(\frac{1 + \tau_4 S}{1 + \tau_5 S}\right) \leq$$

$$\Delta T_O \left\{ K_4 - K_5 \left(\frac{\tau_3 S}{1 + \tau_3 S}\right) T - K_6 \left[T - T''\right] - f_2(\Delta I) \right\}$$

K_4 (nominal)	=	1.10 As noted in the Technical Specifications
K_4 (max)	=	[ ]+a,c
K_5	=	0 for decreasing average temperature
K_5	=	0.02/°F for increasing average temperature
K_6	=	0.00162/°F
Vessel T_H	≤	618.7 °F + indication uncertainties
Vessel T_C	≥	557.7 °F - indication uncertainties

confirmed on the same periodic basis as surveillance of ΔT_o values.

- Full power ΔT calculation:

]+a,c

ΔT span_pwr = 150% RTP

- Process Measurement Accuracy Calculations:

[ ]+a,c

[ ]+a,c

[ ]+a,c

- Total Allowance

[ ]+a,c

TABLE 3-24

ΔP MEASUREMENTS EXPRESSED IN FLOW UNITS

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

$(F_N)^2 = \Delta P_N$ where N = Nominal Flow

$2F_N \partial F_N = \partial \Delta P_N$

thus $\partial F_N = \dfrac{\partial \Delta P_N}{2F_N}$ Eq. 3-24.1

Error at a point (not in percent) is:

$$\frac{\partial F_N}{F_N} = \frac{\partial \Delta P_N}{2(F_N)^2} = \frac{\partial \Delta P_N}{2\Delta P_N} \qquad \text{Eq. 3-24.2}$$

and

$$\frac{\Delta P_N}{\Delta P_{max}} = \frac{(F_N)^2}{(F_{max})^2} \qquad \text{Eq. 3-24.3}$$

where max = maximum flow and the transmitter ΔP error is:

$$\frac{\partial \Delta P_N}{\Delta P_{max}}(100) = \text{percent error in Full Scale } \Delta P \ (\% \ \varepsilon \ FS \ \Delta P) \qquad \text{Eq. 3-24.4}$$

therefore:

$$\frac{\partial F_N}{F_N} = \frac{\Delta P_{max}\left[\dfrac{\% \ \varepsilon \ FS \ \Delta P}{100}\right]}{2\Delta P_{max}\left[\dfrac{F_N}{F_{max}}\right]^2} = \left[\frac{\% \ \varepsilon \ FS \ \Delta P}{(2)(100)}\right]\left[\frac{F_{max}}{F_N}\right]^2 \qquad \text{Eq. 3-24.5}$$

TABLE 3-24 (Continued)

ΔP MEASUREMENTS EXPRESSED IN FLOW UNITS

Error in flow units is:

$$\partial F_{v} = F_{v} \left[\frac{\%\ \varepsilon\ FS\ \Delta P}{(2)(100)}\right] \left[\frac{F_{max}}{F_{N}}\right]^{2} \qquad \text{Eq. 3-24.6}$$

Error in percent nominal flow is:

$$\frac{\partial F_{v}}{F_{v}}(100) = \left[\frac{\%\ \varepsilon\ FS\ \Delta P}{2}\right] \left[\frac{F_{max}}{F_{N}}\right]^{2} \qquad \text{Eq. 3-24.7}$$

Error in percent full span is:

$$\frac{\partial F_{N}}{F_{max}}(100) = \left[\frac{F_{N}}{F_{max}}\right] \left[\frac{\%\ \varepsilon\ FS\ \Delta P}{(2)(100)}\right] \left[\frac{F_{max}}{F_{N}}\right]^{2} (100)$$

$$= \left[\frac{\%\ \varepsilon\ FS\ \Delta P}{2}\right] \left[\frac{F_{max}}{F_{N}}\right] \qquad \text{Eq. 3-24.8}$$

Equation 3-24.8 is used to express errors in percent full span in this document.

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4.0 APPLICATION OF THE SETPOINT METHODOLOGY

4.1 HISTORY

The original "Vendor" or "Custom" Technical Specifications did not allow for rack drift in setpoint requirements. This type of instrument Technical Specification contains only one number, the Nominal Trip Setpoint (NTS). If, during the surveillance interval associated with a function, the channel setpoint drifted non-conservatively past the NTS, the plant was required to file a Licensee Event Report (LER), or equivalent, in addition to correcting the instrumentation.

In November 1974, the D. C. Cook Unit 1 Standardized Technical Specifications were issued by the NRC. Included in these specifications was a new concept, the Allowable Value (AV). Exceeding the NTS while remaining within the bounds of the Allowable Value was not considered a reportable event. With the advent of the Allowable Value, it was no longer necessary to set the bistable as far into the operational margin. At this time, the Allowable Value included an allowance for rack drift (and only rack drift).

In November, 1975, the original version of Regulatory Guide 1.105 was issued for comment. The Reg. Guide addressed NRC concerns associated with the frequent drift of protection system setpoints past the NTS limit. The NRC defined version of the Allowable Value in this Reg. Guide allowed for a certain amount of "drift". In 1976, Regulatory Guide 1.105 Rev. 1 was issued noting minor changes. This was the first opportunity for many plants to include uncertainties in the calculation of an Allowable Value.

In 1977, the NRC requested that several utilities provide responses to questions concerning protection function setpoint methodology. In order to answer these questions, Westinghouse expanded their setpoint related efforts. Westinghouse also changed summation techniques; from arithmetic summation to Square Root of the Sum of the Squares (SRSS). In June of 1978, D. C. Cook Unit 2 was the first plant to implement the new methodology and responded to the NRC request for information relative to details of the Westinghouse Setpoint Methodology. Salem Unit 1 and North Anna Unit 1 soon followed.

In 1981, the V. C. Summer setpoint study was formally reviewed by the NRC. During this process, Westinghouse proposed the five column methodology which was subsequently approved containing provisions which would provide some operating flexibility. If a plant identified that an Allowable Value had been exceeded, the five column methodology included provisions which, in some cases, could eliminate the need for a formal Licensee Event Report (LER). NUREG 0717 Supplement No. 4, August, 1982, documents the NRC Safety Evaluation Report (SER) which approves the Westinghouse methodology.

In 1983 10 CFR 50.73 was issued by the Nuclear Regulatory Commission. This regulation changed the filing requirements associated with an LER. According to 10 CFR 50.73, filing an LER would not be required as a response to the loss of a single channel. Only as a result of the loss of a function would an LER be required. This important position change meant, among other things, that benefits associated with the Westinghouse five column methodology were no longer necessary to avoid filing an LER.

Revision 2 of Regulatory Guide 1.105 was issued in February, 1986. It used the calculational methods associated with 1.105 Rev. 1 and it endorsed the Instrument Society of America (ISA) standard ISA-S67.04-1982. This standard was created to address the establishment and maintenance of setpoints for safety-related instrument channels.

4.2 THE ALLOWABLE VALUE

- History

Originally, in the "Vendor" or "Custom" Technical Specifications, the Nominal Trip Setpoint (NTS) was the only value noted and it was defined as the absolute limit for determination of reportablility. With only one value noted with either ≥ or ≤ inequalities, the plant had no choice but to use a bistable field setting conservative with respect to the value in the Technical Specifications. This was necessary to account for drift and calibration errors. This resulted in the loss of some operational margin, for example:

NIS Power Range - High

NTS = ≤109% RTP | Operating Margin Loss = 1% RTP
Bistable = 108% RTP |

As noted, Regulatory Guide 1.105 Rev. 1 represented the first opportunity for many plants to include uncertainties in the calculation of an Allowable Value. With NRC acceptance of the Allowable Value concept, it was no longer necessary to set the bistable into the operational margin.

Unfortunately, the only uncertainty term that could be used in the calculation of this Allowable Value was the rack drift term. No allowances were made for calibration errors. The 1981 NRC review of the V. C. Summer setpoint study resulted in several modifications to the Allowable Value calculation which incorporated calibration errors. It was during this review that the Allowable Value took on its current shape.

While there are many different industry definitions used for the Allowable Value, the Westinghouse version has always been limited to process rack errors. The following derivation has been based on the Westinghouse methodology and is accepted in the V. C. Summer SER. The Westinghouse determined Allowable Value provides the utility with operational flexibility, the conservatism associated with a 95 percent probability calculation, and the NRC acceptance precedent.

With the NRC approval of the Westinghouse setpoint approach in the V. C. Summer Technical Specifications, it became feasible to have an "as left" setpoint equal to the Nominal Trip Setpoint. This was made possible by permitting the Allowable Value to include, rack drift, calibration and M&TE uncertainties. When the uncertainty calculations have sufficient margin to permit it, the difference between the Allowable Value and the Nominal Trip Setpoint is large enough to encompass all three uncertainties. If, on the other hand, the constraints represented by Safety Analysis and by operational considerations are such that there is little tolerance for channel uncertainty, the difference between the Nominal Trip Setpoint and the Allowable Value is determined considering additional uncertainty terms, as described below.

Provisions in the methodology include a series of equations used to determine the most acceptable Allowable Value. These "trigger" calculations are described below.

- Trigger Values for a <u>Single</u> Input Function

When determining the Allowable Value for a single input function, Westinghouse evaluates two different scenarios and uses the most limiting, or conservative, value calculated. The trigger variables used in this calculation are T_1 and T_2. The smaller of the two trigger values is the one which defines the function's Allowable Value. In other words,

$$\text{Allowable Value} = \text{Minimum of } \{ T_1 , T_2 \}$$

The first trigger value is defined as follows:

- $T_1 = RCA + RMTE + RCSA + RD$ (4.1)

The equation for T_1 is a simple arithmetic combination of the rack uncertainties for which surveillance is performed on a monthly or quarterly basis. Note that in plants with digital process instrumentation, RCSA will be [ ]+a,c since this is a value held in memory for which [ ]+a,c with its setting. This calculation accounts for operational concerns (equipment design and calibration procedure criteria) and is based on several assumptions:

1) the "as left" condition was at the maximum allowed by the calibration procedure,

2) the measurement and test equipment uncertainty was at the maximum allowed and

3) a process loop found within this value is operating within the drift tolerance.

This scenario (calibration at its allowed extreme with the test equipment at their allowed extremes) would not be considered a "nominal" condition, but would be considered an "allowed" condition.

The second trigger value is defined as follows:

$$\square\ T_2 = TA - \{(PMA)^2+(PEA)^2+(SCA+SMTE+SD)^2+(SPE)^2+(STE)^2+(RTE)^2\}^{\frac{1}{2}} - EA \quad (4.2)$$

Note that the Total Allowance calculation is detailed in section 3.0 of this report. T_2 is determined by an evaluation of what uncertainties the Safety Analyses can tolerate, based on the Total Allowance (TA). This calculation accounts for the channel flexibility associated with the channel's Safety Analysis Limits assuming that:

1) the sensor is calibrated in an acceptable manner,

2) the sensor drifts in a random manner and

3) the parameters not evaluated on a periodic basis also experience random variations.

This calculation is basically the subtraction of the above noted parameters from the Total Allowance (TA). What remains is the acceptable rack drift and calibration allowance.

- Trigger Values for a <u>Multiple</u> Input Function

When determining the Allowable Value for a multiple input function, Westinghouse evaluates two different scenarios and uses the most limiting, or conservative, value calculated. The trigger variables used in this calculation are T_2 and T_3. Here again, the smaller and therefore more conservative of the two trigger values is the one which defines the function's Allowable Value.

$$\text{Allowable Value} = \text{Minimum of } \{\ T_2\ ,\ T_3\ \}$$

The first of these two trigger values, T_2 is essentially the same as equation 4.2, and defined as follows:

$$\square\ T_2 = TA - \{(PMA)^2+(PEA)^2+(SCA_1+SMTE_1+SD_1)^2+(SPE_1)^2+(STE_1)^2+ (SCA_2+SMTE_2+SD_2)^2+(SPE_2)^2+(STE_2)^2+(RTE)^2\}^{\frac{1}{2}} - EA \quad (4.3)$$

Note that the Total Allowance calculation is detailed in section 3.0 of this report and the subscripts 1 and 2 indicate the different channels. In this case, the equation utilizies the entire range of sensor terms (SCA, SMTE, SD, STE, SPE) for more than one sensor. Each sensor is an independent device and its uncertainties are, therefore, treated by SRSS. T_2 is determined by an evaluation of what the Safety Analyses can tolerate, based on Total Allowance. This calculation allows for the channel flexibility associated with multiple sensors and the channel's Safety Analysis assuming that:

1) the sensors are calibrated in an acceptable manner,

2) the sensors drift in a random manner and

3) the parameters not evaluated on a periodic basis also experience random variations.

This calculation is basically the subtraction of the above noted parameters (and the Environmental Allowance) from the Total Allowance (TA). What remains is the acceptable rack drift and calibration allowance.

The second trigger value for a multiple input function, T_3 is defined as follows:

$$\square\ T_3 = \{(RCA_1+RMTE_1+RCSA_1+RD_1)^2 + (RCA_2+RMTE_2+RCSA_2+RD_2)^2\}^{1/2} \quad (4.4)$$

As in the T_2 equation, the subscripts 1 and 2 in T_3 indicate the two different input channels. Note that in plants with digital process instrumentation, RCSA will be [$]^{+a,c}$ since this is a value held in memory for which [

$]^{+a,c}$ with its setting. T_3 is the evaluation from the operational side for multiple input protection functions. An operational evaluation accounts for equipment design and for calibration procedure criteria.

Thus three equations T_1, T_2, and T_3 are used to calculate the Allowable Value. T_1 is used for a single input protection function and evaluated from the operational side. T_2 is used for either a single or multiple input protection function and evaluated from the Safety Analyses side. T_3 is used for a multiple input protection function and evaluated from the operational side. If the Allowable Value is determined by the operational side, exceeding it would indicate that the process instrument loop is potentially operating outside of its design constraints, i.e., a module may be starting to fail - as indicated by a large amount of drift. If the Allowable Value is determined by the analysis side, exceeding it would indicate that the process loop is potentially operating outside of the constraints imposed by the analyses assumptions. In summary, when the uncertainty calculations have sufficient margin to permit it, the difference between the Allowable Value and the Nominal Trip Setpoint is large enough to encompass the rack drift, calibration, and M&TE uncertainties.

4.3 THE TECHNICAL SPECIFICATIONS

Provided below is a description and discussion of the three different types of acceptable setpoint licensing approaches. These sections are provided for informational purposes only. Suggestions for inclusion in the Technical Specifications are located in Section 4.4.

- NOMINAL TRIP SETPOINT ONLY

In the early "Vendor" or "Custom" Technical Specifications, the Reactor Trip System (RTS) and the Engineered Safety Features Actuation System (ESFAS) setpoints contained a single value for each function (the Nominal Trip Setpoint). This value was, for the most part, based on engineering judgement accounting for known instrument uncertainties. If the NTS was exceeded, the channel was declared inoperable and the plant had to submit an Licensee Event Report (LER) to the NRC. To avoid this situation, the plant used engineering judgement to set the bistable (the field setting) conservative with respect to the Technical Specification value. As discussed in section 4.2, this practice imposed restrictions on the plant by infringing upon operating margin. This method was not as effective as others for avoiding the reporting requirements because the conservative treatment was voluntary, not used by many plants, and based on engineering judgement which was in conflict with operational desires. As a result of these practices, a significant number of LERs were filed with the NRC. To address this issue, the NRC issued Regulatory Guide 1.105 in 1976 and approved the concept of an Allowable Value.

- TWO COLUMN SPECIFICATIONS

Two column Technical Specifications contain an NTS and an Allowable Value. While the bistable (field setting) is at or near the NTS, the channel may drift up to the Allowable Value during the surveillance interval and still be considered operable. Exceeding this Allowable Value, however, was considered a reportable event until 10 CFR 50.73 was issued by the NRC in 1983.

The two column format was intended to reduce the number of LERs by giving the plant a way to accommodate some process rack drift between surveillances. The early versions of the Allowable Value included Rack Drift but, unfortunately, only Rack Drift, no allowances were made for calibration error. While this was of some benefit to the plants, there were still problems. As explained in NUREG-0452, Revision 4, this methodology still resulted in the plant setting the bistable conservative with respect to the Technical Specification setpoint by an amount equal to the calibration uncertainty. The potential for an inadvertent LER still remained, but the probability of such an event had been reduced.

It took the 1981 NRC review of the V. C. Summer setpoint study to extend the Allowable Value into a less restrictive form. The current Westinghouse Allowable Value is derived from the equations defined in Section 4.2 and provides the plant with increased operational flexibility, the conservatism associated with a 95 percent probability calculation, and NRC acceptance.

Unlike earlier versions of the Two Column Specifications, the current version provides the plant more operational flexibility by setting the bistable equal to the NTS. When using the current two column methodology, determining conformance with the Technical Specifications is a straight forward process. For each analog or digital Channel Operational Test (Channel Functional Test), the trip setpoint is determined by measuring the magnitude of the signal, injected at the input to the process racks, which provides actuation of the bistable at the output of the process racks. Three criteria for these tests are applicable:

1) If the "as found" trip setpoint is less than the calibration tolerance, and thus the Allowable Value, the channel may be operable and no further action is required.

2) If the "as found" trip setpoint is greater than the calibration tolerance, but less than the Allowable Value, the channel may be operable, but must be recalibrated to within the calibration tolerance.

3) If the "as found" trip setpoint is greater than the Allowable Value, the channel is declared inoperable and appropriate action shall be taken. The channel is not considered operable until the "as left" trip setpoint is within the calibration tolerance.

- THE FIVE COLUMN SPECIFICATIONS

The V. C. Summer setpoint study introduced the Westinghouse five column methodology. The five column methodology contains, in addition to the NTS and Allowable Value of the two column method, three additional parameters (TA, Z, and S). This five column methodology was designed to reduce the number of LERs by allowing the plant the opportunity to prove that a channel was operable, even though the Allowable Value has been exceeded. When the NRC issued 10 CFR 50.73, the filing requirements associated with a LER were significantly changed. An LER must now be filed <u>only</u> in cases where the unit has experienced loss of a function, not just a single channel. This important position change means, among other things, that benefits associated with the five column methodology are no longer necessary to avoid filing an LER. While Westinghouse does not now recommend the Five Column Methodology, an explanation of the approach is provided here for information. Note that the Technical Specification parameters associated with the Five Column Methodology are listed in Table 4-2 for reference and use in determining channel operability on a refueling basis with the sensor errors included.

Using the five column methodology, determining conformance with the Technical Specifications is a slightly more involved process. For each analog or digital Channel Operational Test (Channel Functional Test), the trip setpoint is determined by measuring the magnitude of the signal, injected at the input to the process racks, which provides actuation at the output of the process racks. Three criteria for these tests are applicable (the first two acceptance criteria are the same as noted previously):

1) If the "as found" trip setpoint is less than the calibration tolerance, and thus the Allowable Value, the channel may be operable and no further action is required.

2) If the "as found" trip setpoint is greater than the calibration tolerance, but less than the Allowable Value, the channel may be operable, but must be recalibrated to within the calibration tolerance.

3) If the "as found" trip setpoint is greater than the Allowable Value, channel operability is determined by satisfying the equation (4.5) listed below. Following the investigation, the channel must be recalibrated to within the calibration tolerance.

- EQUATIONS

The five column methodology is based on satisfaction of equation (4.5). Using the definitions listed below, channel operability can be determined, even if the Allowable Value has been exceeded, by verifying that the "as found" errors for the channel, not just the process racks, satisfy this equation:

$$TA \geq Z + R + S \qquad (4.5)$$

where:

$$Z = \{(PMA)^2+(PEA)^2+(SPE)^2+(STE)^2+(RTE)^2\}^{1/2} + EA \qquad (4.6)$$

or

$$Z = (A)^{1/2} + EA \qquad (4.7)$$

and

$$A = (PMA)^2 + (PEA)^2 + (SPE)^2 + (STE)^2 + (RTE)^2 \qquad (4.8)$$

$$R = RCA + RMTE + RCSA + RD \qquad (4.9)$$

$$S = SCA + SMTE + SD \qquad (4.10)$$

or, for multiple input functions,

$$R = R_1 + R_2 \qquad (4.11)$$

where

$$R_1 = RCA_1 + RMTE_1 + RCSA_1 + RD_1$$

and

$$R_2 = RCA_2 + RMTE_2 + RCSA_2 + RD_2$$

$$S = S_1 + S_2 \qquad (4.12)$$

$$S_1 = SCA_1 + SMTE_1 + SD_1$$

and

$$S_2 = SCA_2 + SMTE_2 + SD_2$$

TABLE 4-1
FIVE COLUMN METHODOLOGY EXAMPLE

- SAMPLE PARAMETER UNCERTAINTIES (in percent span)

[ ]+a,c

PMA =
PEA =
SCA =
SMTE =
SPE =
STE =
SD =
EA =
BIAS =
RCA =
RMTE =
RCSA =
RTE =
RD =

Instrument Range = 0.00 TO 100.00% SPAN
Safety Analysis Limit = 100.00% SPAN
Nominal Trip Setpoint = 92.00% SPAN

- SAMPLE CALCULATION RESULTS**

Allowable Value = 93.9% SPAN

S = 3.10	A = [ ]+a,c	Z = 2.96
T1 = [ ]+a,c	T2 = [ ]+a,c	T = 1.9
TA = 8.00	CSA = [ ]+a,c	MAR = [ ]+a,c

**Please note that Westinghouse typically reports these numbers to only <u>one</u> decimal place. They are listed in this table with two decimal places only to demonstrate the calculations associated with the methodology.

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TABLE 4-2 (Rev.7)
REACTOR TRIP SYSTEM / ENGINEERED SAFETY FEATURES ACTUATION SYSTEM CHANNEL / 5 COLUMN METHODOLOGY RESULTS
WATTS BAR UNIT 1 EAGLE 21

	PROTECTION CHANNEL	TOTAL ALLOWANCE (TA)(8)(9)	A (1)(9)	S (2)(9)	T (3)(9)	Z (4)(9)	INSTRUMENT SPAN	TRIP SETPOINT	ALLOWABLE VALUE (Non-conservative side)	ALLOWABLE VALUE (Conservative side)	MAXIMUM VALUE (7)	
1	POWER RANGE, NEUTRON FLUX - HIGH SETPOINT	7.5	[	0.0	2.0	4.6	120 % RTP	109 % RTP	111.4 % RTP	106.6 % RTP	[	1
2	POWER RANGE, NEUTRON FLUX - LOW SETPOINT	8.3		0.0	2.0	4.6	120 % RTP	25 % RTP	27.4 % RTP	22.6 % RTP		2
3	POWER RANGE, NEUTRON FLUX HIGH POSITIVE RATE	1.6		0.0	1.1	0.5	120 % RTP/2 SEC	5 % RTP/2 SEC	6.3 % RTP/2 SEC	3.7 % RTP/2 SEC		3
4	POWER RANGE, NEUTRON FLUX - HIGH NEGATIVE RATE	1.6		0.0	1.1	0.5	120 % RTP/2 SEC	5 % RTP/2 SEC	6.3 % RTP/2 SEC	3.7 % RTP/2 SEC		4
5	INTERMEDIATE RANGE, NEUTRON FLUX	(10)		(10)	(10)	(10)	(10)	(10)	(10)	(10)		5
6	SOURCE RANGE, NEUTRON FLUX	(10)		(10)	(10)	(10)	(10)	(10)	(10)	(10)		6
7	OVERTEMPERATURE ΔT	8.3		1.0	1.2	7.0	(5)	FUNCTION (8)	FUNCTION (8) +1.2 % ΔT SPAN	FUNCTION (8) -1.2 % ΔT SPAN		7
8	OVERPOWER ΔT	4.2		0.0	1.0	3.3	(6)	FUNCTION (8)	FUNCTION (8) +1.0 % ΔT SPAN	FUNCTION (8) -1.0 % ΔT SPAN		8
9	PRESSURIZER PRESSURE - LOW, REACTOR TRIP	7.5		2.0	0.7	0.6	800 PSIG	1970 PSIG	1964.8 PSIG	1975.2 PSIG		9
10	PRESSURIZER PRESSURE - HIGH	7.5		1.0	0.7	4.8	800 PSIG	2385 PSIG	2390.2 PSIG	2379.8 PSIG		10
11	PRESSURIZER WATER LEVEL - HIGH	8.0		2.0	0.7	3.3	100 % SPAN	92 % SPAN	92.7 % SPAN	91.3 % SPAN		11
12	REACTOR COOLANT FLOW - LOW,REACTOR TRIP	2.7		0.9	0.4	1.5	110 % DESIGN FLOW	90 % FLOW	89.6 % FLOW	90.4 % FLOW		12
13	STEAM GENERATOR WATER LEVEL - LOW-LOW (OUTSIDE CONTAINMENT)	17.0	]	2.0	0.7	1.6	100 % SPAN	17 % SPAN	16.4 % SPAN	17.6 % SPAN	]	13
14	STEAM GENERATOR WATER LEVEL - LOW-LOW (INSIDE CONTAINMENT) (13)	17.0	0.6	2.0	0.7	10.6	100 % SPAN	17 % SPAN	16.4 % SPAN	17.6 % SPAN	12.6 % SPAN	14
15	UNDERVOLTAGE - RCP	(11)	(11)	(11)	(11)	(11)	(11)	90.0 V	(11)	(11)	(11)	15
16	UNDERFREQUENCY - RCP	(12)	(12)	(12)	(12)	(12)	(12)	57.5 Hz	(12)	(12)	(12)	16
17	CONTAINMENT PRESSURE - HIGH	3.9	[	2.0	0.4	2.1	17 PSIG	1.5 PSIG	1.6 PSIG	1.4 PSIG	[	17
18	CONTAINMENT PRESSURE - HIGH-HIGH	4.1		2.0	0.5	2.1	17 PSIG	2.8 PSIG	2.9 PSIG	2.7 PSIG		18
19	PRESSURIZER PRESSURE LOW, S.I.	23.1		2.0	0.7	10.6	800 PSIG	1870 PSIG	1864.8 PSIG	1875.2 PSIG		19
20	STEAMLINE PRESSURE - LOW (BARTON) (FOXBORO)	25.5 25.5		2.0 2.0	0.7 0.7	10.6 11.3	1300 PSIG 1300 PSIG	675 PSIG 675 PSIG	666.6 PSIG 666.6 PSIG	683.4 PSIG 683.4 PSIG		20
21	STEAM GENERATOR WATER LEVEL - HIGH-HIGH	17.6		2.0	0.7	13.7	100 % SPAN	82.4 % SPAN	83.1 % SPAN	81.7 % SPAN		21
22	NEGATIVE STEAMLINE PRESSURE RATE - HIGH	1.9		0.0	0.7	0.3	1300 PSI	100 PSI	108.5 PSI	91.5 PSI		22
23	VESSEL ΔT EQUIVALENT TO POWER	6.0		0.0	1.7	2.7	150 % RTP	RCS Loop ΔT Variable Input ≤ 50 % of RTP	≤52.6 % RTP	≤47.4 % RTP		23
24	RWST LEVEL	5.9		2.0	0.7	1.6	100 % SPAN	34.6 % SPAN	34.0 % SPAN	35.2 % SPAN		24
25	CONTAINMENT SUMP LEVEL	13.0	]	2.0	0.2	11.3	100 % SPAN	13.4 % SPAN	13.2 % SPAN	13.6 % SPAN	]	25

ANSTEC APERTURE CARD

Also Available on Aperture Card

NOTES:

(1) [ ]

(2) [ ]

(3) [ ]

(4) [ ]

(5) TAVG - 100°F
PRESS - 800 PSI
ΔT - 150% RTP
ΔI - ±60% ΔI

(6) TAVG - 100°F, ΔT - 150% RTP

(7) [ ]

(8) AS NOTED IN TABLE 3.3.1-1 OF THE TECHNICAL SPECIFICATIONS.

(9) ALL VALUES IN PERCENT SPAN EXCEPT A WHICH IS (% SPAN)².

(10) SEE TVA CALCULATION 1-NMD-92-131

(11) CALCULATIONS PROVIDED BY TVA - WBPE0689009007, WITH ALL VALUES IN PERCENT OF SETPOINT.

(12) CALCULATIONS PROVIDED BY TVA - WBPE0689009008, WITH ALL VALUES IN PERCENT OF SETPOINT.

(13) CALCULATION PERFORMED PER TVA INSTRUCTIONS. TVA IS RESPONSIBLE FOR FEEDLINE BREAK INSIDE CONTAINMENT ANALYSIS.

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4.4 WESTINGHOUSE RECOMMENDATIONS

As noted throughout this document, the Westinghouse Reactor Protection System Setpoint Methodology has evolved over a period of years. This methodology provides a well defined basis for the RTS and ESFAS setpoints contained in the Technical Specifications. In implementing the RTS and ESFAS setpoints defined in the Technical Specifications, Westinghouse recommends the following:

1. The assumptions made in determining the RTS and ESFAS setpoints identified in this document and supporting references should be validated and implemented.

2. The Technical Specification format should adopt the two column approach with a Nominal Trip Setpoint (NTS) and an Allowable Value (Non-conservative).

3. Changes in hardware, plant procedures, safety analysis, etc., should be evaluated under the plant change control and 10CFR50.59 process to determine if there is an impact on the assumptions and results of this Reactor Protection System Setpoint Study.

PROP

DRP-013

PROPRIETARY INFORMATION

NOTICE

THE ATTACHED DOCUMENT CONTAINS OR IS CLAIMED TO CONTAIN PROPRIETARY INFORMATION AND SHOULD BE HANDLED AS NRC SENSITIVE UNCLASSIFIED INFORMATION. IT SHOULD NOT BE DISCUSSED OR MADE AVAILABLE TO ANY PERSON NOT REQUIRING SUCH INFORMATION IN THE CONDUCT OF OFFICIAL BUSINESS AND SHOULD BE STORED, TRANSFERRED, AND DISPOSED OF BY EACH RECIPIENT IN A MANNER WHICH WILL ASSURE THAT ITS CONTENTS ARE NOT MADE AVAILABLE TO UNAUTHORIZED PERSONS.

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