ATTACHMENT C-5

Beaver Valley Power Station, Unit No. 2
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Westinghouse Setpoint Methodology for Protection Systems

Beaver Valley Power Station – Unit 2

Westinghouse Electric Company LLC

WCAP-15408

WESTINGHOUSE
SETPOINT METHODOLOGY
FOR PROTECTION SYSTEMS

BEAVER VALLEY POWER STATION
UNIT 2

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TABLE OF CONTENTS

Section **Title** **Page**

1.0 INTRODUCTION 1
- 1.1 References / Standards 2

2.0 COMBINATION OF UNCERTAINTY COMPONENTS 3
- 2.1 Methodology 3
- 2.2 Sensor Allowances 5
- 2.3 Rack Allowances 6
- 2.4 Process Allowances 8
- 2.5 Measurement and Test Equipment Accuracy 8
- 2.6 References / Standards 9

3.0 PROTECTION SYSTEM SETPOINT METHODOLOGY 10
- 3.1 Instrument Channel Uncertainty Calculations 10
- 3.2 Definitions For Protection System Setpoint Tolerances 10
- 3.3 References / Standards 19

4.0 APPLICATION OF THE SETPOINT METHODOLOGY 76
- 4.1 Uncertainty Calculation Basic Assumptions/Premises 76
- 4.2 Process Rack Operability Determination Program and Criteria 77
- 4.3 Application to the Plant Technical Specifications 78
- 4.4 Determination of Allowable Value 79
- 4.5 References/Standards 80

APPENDIX A SAMPLE BEAVER VALLEY POWER STATION UNIT 2 SETPOINT TECHNICAL SPECIFICATIONS A-1

LIST OF TABLES

Table **Title** **Page**

TABLE 3-1 POWER RANGE, NEUTRON FLUX - HIGH & LOW SETPOINTS ... 20

TABLE 3-2 POWER RANGE, NEUTRON FLUX - HIGH POSITIVE AND NEGATIVE RATES ... 22

TABLE 3-3 INTERMEDIATE RANGE, NEUTRON FLUX ... 24

TABLE 3-4 SOURCE RANGE, NEUTRON FLUX ... 26

TABLE 3-5 OVERTEMPERATURE ΔT REACTOR TRIP ... 28

TABLE 3-6 OVERPOWER ΔT REACTOR TRIP ... 32

TABLE 3-7 PRESSURIZER PRESSURE - LOW, REACTOR TRIP ... 35

TABLE 3-8 PRESSURIZER PRESSURE - HIGH, REACTOR TRIP ... 37

TABLE 3-9 PRESSURIZER PRESSURE - LOW, SI ... 39

TABLE 3-10 PRESSURIZER WATER LEVEL - HIGH ... 41

TABLE 3-11 RCS LOSS OF FLOW ... 43

TABLE 3-12 STEAM GENERATOR WATER LEVEL - LOW-LOW ... 45

TABLE 3-13 STEAM GENERATOR WATER LEVEL - HIGH-HIGH ... 47

TABLE 3-14 STEAMLINE PRESSURE - LOW ... 49

TABLE 3-15 NEGATIVE STEAM PRESSURE RATE - HIGH ... 51

TABLE 3-16 CONTAINMENT PRESSURE - HIGH, INTERMEDIATE HIGH-HIGH, HIGH-HIGH... 53

TABLE 3-17 RWST LEVEL - EXTREME LOW ... 55

TABLE 3-18 REACTOR COOLANT PUMP - UNDERFREQUENCY ... 57

TABLE 3-19 REACTOR COOLANT PUMP - UNDERVOLTAGE ... 59

TABLE 3-20 4.16 kV EMERGENCY BUS UNDERVOLTAGE - DEGRADED VOLTAGE RELAY .. 61

TABLE 3-21 4.16 kV EMERGENCY BUS UNDERVOLTAGE - TRIP FEED AND START DIESEL 63

TABLE 3-22 480 V EMERGENCY BUS UNDERVOLTAGE - DEGRADED VOLTAGE RELAY ... 65

TABLE 3-23 EMERGENCY TRIP HEADER - LOW PRESSURE ... 67

TABLE 3-24 REACTOR TRIP SYSTEM / ENGINEERED SAFETY FEATURES ACTUATION SYSTEM CHANNEL ERROR ALLOWANCES ... 69

TABLE 3-25 OVERTEMPERATURE ΔT CALCULATIONS ... 71

TABLE 3-26 OVERPOWER ΔT CALCULATIONS ... 73

TABLE 3-27 ΔP MEASUREMENTS EXPRESSED IN FLOW UNITS ... 74

1.0 INTRODUCTION

This report has been prepared to document the instrument uncertainty calculations for the Reactor Trip System (RTS) and Engineered Safety Features Actuation System (ESFAS) trip functions identified on Table 3-24 of this report for Beaver Valley Power Station Unit 2 (BVPS 2).

This document is divided into four sections. Section 2.0 identifies the general algorithm used as a base to determine the overall instrument uncertainty for an RTS/ESFAS trip function. This approach is defined in a Westinghouse paper presented at an Instrument Society of America/Electric Power Research Institute (ISA/EPRI) conference in June, 1992[1]. This approach is consistent with ISA S67.04, Part I, 1994[2]. The basic uncertainty algorithm is the square-root-sum-of-the-squares (SRSS) of the applicable uncertainty terms, which is endorsed by the ISA standard. All appropriate and applicable uncertainties, as defined by a review of the plant baseline design input documentation, have been included in each RTS/ESFAS trip function uncertainty calculation. ISA S67.04, Part II, 1994[3] was utilized as a general guideline, but each uncertainty and its treatment is based on Westinghouse methods which are consistent or conservative with respect to this document. The latest version of NRC Regulatory Guide 1.105 (Revision 3[4]) endorses the 1994 version of ISA S67.04, Part I. Westinghouse has evaluated this NRC document and has determined that the RTS/ESFAS trip function uncertainty calculations contained in this report are consistent with the guidance contained in Revision 3[4]. It is believed that the total channel uncertainty (Channel Statistical Allowance or CSA) represents a 95/95 value as requested in Regulatory Guide 1.105[4].

Section 3.0 of this report provides a list of the defined terms and associated acronyms used in the RTS/ESFAS trip function uncertainty calculations. Appropriate references to industry standards have been provided where applicable. Included in this section are detailed tables of the uncertainty terms and values for each RTS/ESFAS trip function uncertainty calculation performed by Westinghouse. Provided on each table is the function specific uncertainty algorithm which notes the appropriate combination of instrument uncertainties to determine the Channel Statistical Allowance. A summary Table (3-24) is provided which includes a listing of the Safety Analysis Limit, the Nominal Trip Setpoint, the Total Allowance (the difference between the Safety Analysis Limit and Nominal Trip Setpoint, in % span), margin, and the Allowable Value. In all cases, it was determined that positive margin exists between the Safety Analysis Limit and the Nominal Trip Setpoint after accounting for the channel instrument uncertainties.

Section 4.0 provides a description of the methodology utilized in the determination of the BVPS 2 Technical Specifications with regards to an explanation of the relationship between a trip setpoint and the allowable value.

1.1 References / Standards

[1] Tuley, C. R., Williams, T. P., "The Significance of Verifying the SAMA PMC 20.1-1973 Defined Reference Accuracy for the Westinghouse Setpoint Methodology," Instrumentation, Controls and Automation in the Power Industry, Vol. 35, Proceedings of the Thirty-Fifth Power Instrumentation Symposium (2nd Annual ISA/EPRI Joint Controls and Automation Conference), Kansas City, Mo., June, 1992, p. 497.

[2] ISA Standard S67.04, Part I, 1994, "Setpoints for Nuclear Safety-Related Instrumentation," 1994.

[3] ISA Standard S67.04, Part II, 1994, "Methodologies for the Determination of Setpoints for Nuclear Safety-Related Instrumentation," 1994.

[4] Regulatory Guide 1.105 Revision 3, "Setpoints for Safety-Related Instrumentation," 1999.

2.0 COMBINATION OF UNCERTAINTY COMPONENTS

This section describes the Westinghouse setpoint methodology for the combination of the uncertainty components utilized for BVPS 2. The methodology used in the determination of the overall CSA, for the functions listed in Table 3-24 of this report, is in Section 2.1 below. All appropriate and applicable uncertainties, as defined by a review of the BVPS 2 baseline design input documentation have been included in each RTS/ESFAS trip function CSA calculation.

2.1 Methodology

The methodology used to combine the uncertainty components for a channel is an appropriate combination of those groups which are statistically and functionally independent. Those uncertainties which are not independent are conservatively treated by arithmetic summation and then systematically combined with the independent terms.

The basic methodology used is the square-root-sum-of-the-squares technique. This technique, or others of a similar nature, has been used in WCAP-10395[1] and WCAP-8567[2]. WCAP-8567 is approved by the NRC noting acceptability of statistical techniques for the application requested. Also, various American National Standards Institute (ANSI), American Nuclear Society (ANS), and Instrument Society of America standards approve the use of probabilistic and statistical techniques in determining safety-related setpoints[3,4]. The basic methodology used in this report is essentially the same as that identified in a Westinghouse paper presented at an ISA/EPRI conference in June, 1992[5]. Differences between the algorithm presented in this paper and the equations presented in Tables 3-1 through 3-23 are due to BVPS 2 specific characteristics in design and should not be construed as differences in approach.

The generalized relationship between the uncertainty components and the calculated uncertainty for a channel is noted in Eq. 2.1:

$$\begin{aligned} CSA = \{&(PMA)^2 + (PEA)^2 + (SRA)^2 + (SMTE + SD)^2 + (SMTE + SCA)^2 + \\ &(SPE)^2 + (STE)^2 + (RRA)^2 + (RMTE + RD)^2 + (RMTE + RCA)^2 + \\ &(RMTE + RCSA)^2 + (RTE)^2\}^{1/2} + EA + BIAS \end{aligned} \qquad (Eq.\ 2.1)$$

where:

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

Each of the above terms is defined in Section 3.2, Definitions for Protection System Setpoint Tolerances.

Eq. 2.1 is based on the following: 1) The sensor and rack measurement and test equipment uncertainties are treated as dependent parameters with their respective drift and calibration accuracy allowances. 2) While the environmental allowances are not considered statistically dependent with all other parameters, the equipment qualification testing generally results in large magnitude, non-random terms that are conservatively treated as limits of error which are added to the statistical summation. Westinghouse generally considers a term to be a limit of error if the term is a bias with an unknown sign. The term is added to the SRSS in the direction of conservatism. 3) Bias terms are one directional with known magnitudes (which may result from several sources, e.g., drift or calibration data evaluations) and are also added to the statistical summation. 4) The calibration terms are treated in the same radical with the other terms based on the assumption that general trending, i.e., drift and calibration data are evaluated on a periodic and timely basis. This evaluation should confirm that the distribution function characteristics assumed as part of treatment of the terms are still applicable. 5) BVPS 2 has identified that trending of the "as left" and "as found" data for the sensors and process racks will be performed on a periodic basis. This commitment results in a net reduction of the CSA magnitude (over that which would be determined if trending was not performed). Consistent with the request of Regulatory Guide 1.105[6], the CSA value from Eq. 2.1 is believed to have been determined at a 95 % probability at a 95 % confidence level (95/95).

2.2 Sensor Allowances

Seven parameters are considered to be sensor allowances: SRA, SCA, SMTE, SD, STE, SPE and EA. Three of these parameters are considered to be independent, two-sided, unverified (by plant calibration or drift determination processes), vendor supplied terms (SRA, STE and SPE). Based on vendor supplied data, typically product data sheets and qualification reports, these parameters are treated as 95/95 values unless specified otherwise by the vendor. Three of the remaining parameters are considered dependent with at least one other term, are two-sided, and are the result of the plant calibration and drift determination process (SCA, SMTE and SD). The SCA and SD terms are treated as 95/95 values based on the calibration and drift data evaluations. The SMTE term is treated as a 95/95 value based on vendor product data sheets.

The EA term is associated with the sensor exposure to adverse environmental conditions (elevated temperature and radiation) due to mass and energy loss from a break in the primary or secondary side piping, or adverse effects due to seismic events. Where appropriate, e.g., steambreak, only the elevated temperature term may be used for this uncertainty. For sensors provided by Westinghouse, the EA term magnitudes are conservatively treated as limits of error and each individual device was verified by testing to be bounded by the EA temperature component. For sensors not provided by Westinghouse, the EA term magnitudes and characteristics (elevated temperature, radiation and seismic) were provided by BVPS 2 for use in the calculations.

SRA is the manufacturer's reference accuracy that is achievable by the device. This term is introduced to address repeatability and hysteresis effects when performing only a single pass calibration, i.e., one up and one down[5]. 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. For example, assume a sensor is placed in some position in the containment during a refueling outage. After placement, an instrument technician calibrates the sensor 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 used for calibrating the sensor. The conditions under which this drift determination is made are again ambient pressure and temperature. The temperature and pressure should be essentially the same at both measurements. Thus, they should have no significant impact on the drift determination and are, therefore, independent of the drift allowance.

SCA and SD are considered to be dependent with SMTE due to the manner in which the instrumentation is evaluated. A transmitter is calibrated by providing a known process input (measured with a high accuracy gauge) and evaluating the electrical output with a digital multimeter (DMM) or digital voltmeter (DVM). The gauge and DVM accuracies form the SMTE terms. The transmitter response is known, at best, to within the accuracy of the measured input and measured output. Thus the calibration accuracy (SCA) is functionally dependent with the measurement and test equipment (SMTE). Since the gauge and DVM are independent of each other (they operate on two different physical principles), the two SMTE terms may be combined by SRSS prior to addition with the SCA term. Transmitter drift is determined using the same process used to perform a transmitter calibration. That is, a known process input (measured with a high accuracy gauge) is provided and the subsequent electrical output is measured with a DMM or DVM. In most cases the same measurement and test equipment is used for both calibration and drift determination. Thus the drift value (SD) is functionally dependent with the measurement and test equipment (SMTE) and is treated in the same manner as SMTE and SCA.

While the data is gathered in the same manner, SD is independent of SCA in that they are two different parameters. SCA is the difference between the "as left" value and the desired value. SD is the difference between the "as found" value and the "as left" value. It is assumed that a mechanistic cause and effect relationship between SCA and SD has not been demonstrated, and that the data evaluation determined the distribution function characteristics for both SCA and SD and confirmed that SD is random and independent of SCA.

2.3 Rack Allowances

Six parameters are considered to be rack allowances: RRA, RCA, RMTE, RCSA, RTE, and RD. RRA is the manufacturer's reference accuracy that is achievable by the process rack instrument string. This term is introduced to address repeatability and hysteresis effects when performing only a single pass calibration, i.e., one up and one down[5]. Review of a sample of BVPS 2 specific calibration procedures has concluded that the calibration tolerance identified in the procedures is sufficient to encompass "as left" deviation and the hysteresis and repeatability effects without an additional allowance. Thus this term has been included in the RCA term in the uncertainty calculations. RTE is considered to be an independent, two-sided, unverified (by plant calibration or drift determination processes), vendor supplied parameter. Process racks are typically located in areas with ambient temperature control, making consistency with the rack evaluation temperature easy to achieve. Based on vendor data, this parameter is treated as a 95/95 value.

RCA, RD, and RCSA are considered to be two-sided terms dependent with RMTE. The functional dependence is due to the manner in which the process racks are evaluated. The RCA, RCSA and RD terms are treated as 95/95 values based on calibration and drift data evaluations performed by BVPS 2. The RMTE term is treated as a two-sided, 95/95 value based on vendor product data sheets. To calibrate or determine drift for the process rack portion of a channel, a known input (in the form of a voltage, current or resistance) is provided and the point at which the trip bistable changes state is measured. The input parameter is either measured by the use of a DMM or DVM (for a current or voltage signal) or is known to some degree of precision by use of precision equipment, e.g., a precision decade box for a resistance input. For simple channels, only a DMM or DVM is necessary to measure the input and the state change is noted by a light or similar device. For more complicated channels, multiple DVMs may be used or a DVM in conjunction with a decade box. The process rack response is known at best to within the accuracy of the measured input and indicated output. Thus the calibration accuracy (RCA or RCSA) is functionally dependent with the measurement and test equipment (RMTE). In those instances where multiple pieces of measurement and test equipment are utilized, the uncertainties are combined via SRSS when appropriate.

The RCA term represents the total calibration uncertainty for the channels which are evaluated as a single string and includes the RCSA term. For channels that have been evaluated in sections (for example the negative steam pressure rate-high trip), the RCA terms represent the calibration uncertainty for the modules upstream of the bistable. The bistable, or modules downstream of those represented by the RCA term(s), is then represented by the RCSA term (for multiple modules this term primarily reflects the accuracy of the bistable). Drift for the process racks is determined using the same process used to perform the rack calibration and in most cases utilizes the same measurement and test equipment. Thus the drift value (RD) is also functionally dependent with the measurement and test equipment (RMTE) and is treated in the same manner as RMTE and RCA or RMTE and RCSA.

While the data is gathered in the same manner, RD is independent of RCA and RCSA in that they are different parameters. RCA and RCSA are the difference between the "as left" value and the desired value. RD is the difference between the "as found" and the "as left" values. The RD term represents the drift for all process rack modules in an instrument string, regardless of the channel complexity. For multiple instrument strings there may be multiple RD terms, e.g., Overtemperature ΔT. It is assumed that a mechanistic cause and effect relationship between RCA or RCSA and RD is not demonstrated and that any data evaluation will determine the distribution function characteristics for RCA, RCSA and RD will confirm that RD is random and independent of RCA and RCSA.

2.4 Process Allowances

The PMA and PEA parameters are considered to be independent of both sensor and rack parameters. The PMA terms provide allowances for the non-instrument related effects; e.g., neutron flux, calorimetric power uncertainty assumptions and fluid density changes. There may be more than one independent PMA uncertainty allowance for a channel if warranted. The PEA term typically accounts for uncertainties due to metering devices, such as elbows, venturis, and orifice plates. In this report, this type of uncertainty is limited in application by Westinghouse to RCS Flow (Cold Leg Elbow Taps) and potential transformers for undervoltage relays. In these two specific applications, the PEA terms have been determined to be independent of the sensors and process racks. It should be noted that treatment as an independent parameter does not preclude determination that a PMA or PEA term should be treated as a bias. If that is determined appropriate, Equation 2.1 would be modified such that the affected term would be treated by arithmetic summation with appropriate determination and application of the sign of the uncertainty.

2.5 Measurement and Test Equipment Accuracy

A sample of BVPS 2 procedures was reviewed to determine the measurement and test equipment used for calibration and functional testing of the transmitters and racks. Westinghouse review of BVPS 2 procedures concludes that while the measurement and test equipment accuracies are reasonable, the ANSI/ISA S51.1 - 1979[7] criterion for M&TE deletion (10 to 1 ratio of calibration accuracy magnitude to measurement and test equipment accuracy magnitude) is typically not satisfied. As a result, the measurement and test equipment accuracy terms for transmitters and process racks (SMTE and RMTE) may not be deleted in the uncertainty calculations. Vendor specification sheets were utilized to determine the appropriate uncertainty for each function evaluated. These M&TE uncertainties were included in the calculations, as noted on the function specific tables included in this document.

2.6 References / Standards

[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, Part I, 1994, "Setpoints for Nuclear Safety-Related Instrumentation."

[5] Tuley, C. R., Williams, T. P., "The Significance of Verifying the SAMA PMC 20.1-1973 Defined Reference Accuracy for the Westinghouse Setpoint Methodology," Instrumentation, Controls and Automation in the Power Industry, Vol. 35, Proceedings of the Thirty-Fifth Power Instrumentation Symposium (2nd Annual ISA/EPRI Joint Controls and Automation Conference), Kansas City, Mo., June, 1992, p. 497.

[6] Regulatory Guide 1.105 Revision 3, "Setpoints for Safety Related Instrumentation", 1999.

[7] ANSI/ISA Standard S51.1, 1979 (Reaffirmed 1993), "Process Instrumentation Terminology," p. 32.

3.0 PROTECTION SYSTEM SETPOINT METHODOLOGY

This section contains a list of defined terms used in the BVPS 2 RTS/ESFAS trip function uncertainty calculations. Also included in this section are detailed tables and a summary table of the uncertainty terms and values for each calculation that Westinghouse performed. It was determined that in all cases sufficient margin exists between the nominal trip setpoint and the safety analysis limit after accounting for uncertainties.

3.1 Instrument Channel Uncertainty Calculations

Tables 3-1 through 3-23 provide individual component uncertainties and CSA calculations for the protection functions noted in Tables 2.2-1 and 3.3-4 of the BVPS 2 Technical Specifications. Table 3-24 of this report provides a summary of the Reactor Trip System / Engineered Safety Features Actuation System Channel Uncertainty Allowances for BVPS 2. This table lists the Safety Analysis Limit, Nominal Trip Setpoint, and Allowable Value (in engineering units), and Channel Statistical Allowance, Margin, Total Allowance and Calibration Accuracy (in % span). The instrument span is also shown in the table. Westinghouse reports the values in Tables 3-1 through 3-23 and Table 3-24 to one decimal place using the technique of rounding down values less than 0.05 % span and rounding up values greater than or equal to 0.05 % span. Parameters reported as "0.0" have been identified as having a value of ≤ 0.04 % span. Parameters reported as "0" in the tables are not applicable (i.e., have no value) for that channel.

3.2 Definitions For Protection System Setpoint Tolerances

For the channel uncertainty values used in this report, the following definitions are provided in alphabetical order:

- As Found

  The condition in which a transmitter, process rack module, or process instrument loop is found after a period of operation. For example, after one cycle of operation, a Steam Generator Level transmitter's output at 50 % span was measured to be 12.05 mA. This would be the "as found" condition.

- As Left

  The condition in which a transmitter, process rack module, or process instrument loop is left after calibration or bistable trip setpoint verification. This condition is typically better than the calibration accuracy for that piece of equipment. For example, the calibration point for a Steam Generator Level transmitter at 50 % span is 12.0 ± 0.04 mA. A measured "as left" condition of 12.03 mA would satisfy this calibration tolerance. In this instance, if the calibration was stopped at this point (i.e., no additional efforts were made to decrease the deviation) the "as left" error would be + 0.03 mA or + 0.19 % span, assuming a 16 mA (4 to 20 mA) instrument span.

- Channel

  The sensing and process equipment, i.e., transmitter to bistable, 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 out of 3 Steam Generator Level - Low-Low channels for one steam generator must have their bistables in the tripped condition for a Reactor Trip to be initiated.

- Channel Statistical Allowance (CSA)

  The combination of the various channel uncertainties via square-root-of-the-sum-of-the-squares (SRSS) and algebraic techniques. It includes instrument (sensor and process rack) uncertainties and non-instrument related effects (Process Measurement Accuracy), see Eq. 2.1. 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 or seismic event. Typically this value is determined from a conservative set of enveloping conditions and may represent the following:

  · temperature effects on a transmitter
  · radiation effects on a transmitter
  · seismic effects on a transmitter
  · temperature effects on a level transmitter reference leg
  · temperature effects on signal cable insulation

· seismic effects on process racks

- Margin

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

  Margin = TA - CSA

- Nominal Trip Setpoint (NTS)

  A bistable trip setpoint in plant Technical Specifications or plant administrative procedures. This value is the nominal value to which the bistable is set, as accurately as reasonably achievable.

- 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 for this device, (effectively an orifice which has not been calibrated in a laboratory setting), is not known. Therefore a mass balance between Feedwater Flow and Steam Flow must be made. The mass Feedwater Flow is known through measurement via the Δp across the venturi, Feedwater Pressure and Feedwater Temperature. Presuming no mass losses prior to the measurement of the Steam Flow, the mass Steam Flow can be claimed to equal the mass Feedwater Flow. Measurement of the Steam Flow Δp and the Steam Pressure (to correct for density) can then be utilized to translate to a volumetric flow.

- Primary Element Accuracy (PEA)

  Uncertainty due to the use of a metering device. In Westinghouse calculations, this parameter is limited to use on a venturi, orifice, elbow or potential transformer. 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 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 7300 analog process systems, this includes all the equipment contained in the process equipment cabinets, e.g., conversion resistor, loop power supply, R/E, lead/lag, rate, lag functions, function generator, summator, control/protection isolator, and bistable. 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.

- 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.

- Rack Calibration Accuracy (**RCA**)

  Rack calibration accuracy is defined as the two-sided calibration tolerance of the process racks as reflected in the plant calibration procedures.

  It is assumed that the individual modules in a loop 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 is typically less than the arithmetic sum or SRSS of the individual module tolerances. This forces calibration of the process loop in such a manner as to exclude a systematic bias in the individual module calibrations, i.e., as left values for individual modules must be compensating in sign and magnitude when considered as an instrument string.

Review of a sample of BVPS 2 specific calibration procedures concluded that the calibration process and the identified RCA allowance is sufficient to encompass the as left deviation and the hysteresis and repeatability effects without an additional RRA allowance.

- Rack Comparator Setting Accuracy (**RCSA**)

The calibration accuracy of the instrument loop (RCA) assumes that the individual modules are calibrated to a particular tolerance and that the section as a string (including the bistable) 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 modules in such a manner as to exclude a systematic bias in the individual module calibrations, i.e., as left values for individual modules must be compensating in sign and magnitude when considered as an instrument string.

For example, when an analog channel is calibrated in sections it is assumed that an individual module is calibrated to within [$]^{+a,c}$, with the entire section calibrated to within [$]^{+a,c}$.

Review of a sample of BVPS 2 specific calibration procedures concluded that many of the calibration procedures include the bistable as part of the instrument string. In this instance, there is no additional allowance for an RCSA term. However, there are some procedures that result in the calibration of the bistable as a separate module. In this instance, there is an explicit allowance identified for an RCSA term.

- Rack Drift (**RD**)

The change in input-output relationship over a period of time at reference conditions, e.g., at constant temperature. A typical allowance value assumed for this parameter is [$]^{+a,c}$ span. For example, assume that a Steam Generator Water Level channel at 50 % span (presuming a 0 to 10 VDC span) has an "as found" value of 5.05 VDC and an "as left" value of 5.0 VDC. The magnitude of the drift would be {(5.05 - 5.0)(100/10) = + 0.5 % span} in the positive direction.

- 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 Standard PMC 20.1-1973[9] or ANSI/ISA S51.1, 1979 (reaffirmed 1993)[10] it is considered an integral part of RCA. Uncertainties due to M&TE that are 10 times more accurate than the device being calibrated are considered insignificant and are not included in the uncertainty calculations.

- Rack Reference Accuracy (**RRA**)

  Rack Reference Accuracy is the reference accuracy, as defined by SAMA Standard PMC 20.1-1973[1] for a process loop string. It is defined as the reference accuracy or accuracy rating that is achievable by the instrument string as specified in the manufacturer's specification sheets. Inherent in this definition is the verification of the following under a reference set of conditions; 1) conformity[2] or [6], 2) hysteresis[3] or [7] and 3) repeatability[4] or [8]. An equivalent to the SAMA definition of reference accuracy is the ANSI/ISA S51.1, 1979 (reaffirmed 1993)[5] term "accuracy rating," specifically as applied to Note 2 and Note 3.

  Review of a sample of BVPS 2 specific calibration procedures and calibration assumptions concludes that the identified calibration allowance is sufficient to encompass the Rack Reference Accuracy without an additional allowance.

- 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), and 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 7300 process instrumentation, a typical value of [ ]$^{+a,c}$ is used for analog channel temperature effects. 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, 1704 to 2504 psig, and for a Steam Generator Level transmitter, 140 to 36 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 ANSI/ISA S51.1, 1979 (reaffirmed 1993)[11].

- Safety Analysis Limit (**SAL**)

  The parameter value in the UFSAR safety analysis or other plant operating limit at which a reactor trip or actuation function is assumed to be initiated.

- Sensor Calibration Accuracy (**SCA**)

  The calibration accuracy for a sensor or transmitter as defined by the BVPS 2 calibration procedures. For transmitters, this accuracy is typically [$]^{+a,c}$. Utilizing Westinghouse recommendations for RTD cross-calibration, this accuracy is typically [$]^{+a,c}$ for the Hot 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. For example, assume a Steam Generator Level transmitter at 50 % level (presuming a 4 to 20 mA span) has an "as found" value of 12.05 mA and an "as left" value of 12.01 mA. The magnitude of the drift would be $\{(12.05 - 12.01)(100/16) = + 0.25\ \%\ \text{span}\}$ in the positive direction.

- 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 ANSI/ISA S51.1, 1979 (reaffirmed 1993)[10] it is considered an integral part of SCA. Uncertainties due to M&TE that are 10 times more accurate than the device being calibrated are considered insignificant and are not included in the uncertainty calculations.

- Sensor Pressure Effects (**SPE**)

  The change in input-output relationship due to a change in the static head pressure from the calibration conditions or the accuracy to which a correction factor is introduced for the difference between calibration and operating conditions for a Δp transmitter.

- Sensor Reference Accuracy (**SRA**)

  The reference accuracy that is achievable by the device as specified in the manufacturer's specification sheets. This term is introduced into the uncertainty calculation to address repeatability effects when performing only a single pass calibration, i.e., one up and one down, or repeatability and hysteresis when performing a single pass calibration in only one direction.

- Sensor Temperature Effects (**STE**)

  The change in input-output relationship due to a change in the ambient environmental conditions (temperature, humidity), and 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.

- Span

  The region for which a device is calibrated and verified to be operable, e.g., for a Pressurizer Pressure transmitter, 800 psi, and for Steam Generator Level, 104 inches of water column.

- Square-Root-of-the-Sum-of-the-Squares (**SRSS**)

  That is,

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

  as approved for use in setpoint calculations by ISA Standard S67.04, Part I, 1994[12].

- Total Allowance (**TA**)

  The absolute value of the difference (in % instrument span) between the Safety Analysis Limit and the Nominal Trip Setpoint.

  $$\mathrm{TA} = |\,\mathrm{SAL} - \mathrm{NTS}\,|$$

Two examples of the calculation of TA are:

■ *Steam Generator Level - Low-Low*

SAL	0.0 % Level
NTS	-16.5 % Level
TA	|-16.5 % Level | = 16.5 % Level

If the instrument span = 100 % Level, then

$$TA = \frac{(16.5\%\ level) * (100\%\ span)}{(100\%\ level)} = 16.5\ \%\ span$$

■ *Pressurizer Pressure - Low Trip*

SAL	1920 psig
NTS	-1945 psig
TA	| -25 psig | = 25 psig

If the instrument span = 800 psi, then

$$TA = \frac{(25\ psig) * (100\%\ span)}{(800\ psig)} = 3.1\ \%\ span$$

3.3 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] ANSI/ISA Standard S51.1, 1979 (reaffirmed 1993), "Process Instrumentation Terminology," p 6, 1979.

[6] Ibid, p 8.

[7] Ibid, p 20.

[8] Ibid, p 27.

[9] Scientific Apparatus Makers Association Standard PMC 20.1-1973, "Process Measurement & Control Terminology," p 36, 1973.

[10] ANSI/ISA Standard S51.1, 1979 (reaffirmed 1993), "Process Instrumentation Terminology," p 32, 1979.

[11] Ibid, p 25.

[12] ISA Standard S67.04, Part I, 1994, "Setpoints for Nuclear Safety-Related Instrumentation," p 18, 1994.

TABLE 3-1 POWER RANGE, NEUTRON FLUX - HIGH & LOW SETPOINTS

Parameter	**Allowance***
Process Measurement Accuracy [ ]$^{+a,c}$ (PMA$_1$) [ ]$^{+a,c}$ (PMA$_2$)	[ ]$^{+a,c}$
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA) [ ]$^{+a,c}$	
Sensor Reference Accuracy (SRA)	
Sensor Measurement & Test Equipment Accuracy (SMTE)	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE) [ ]$^{+a,c}$	
Sensor Drift (SD) [ ]$^{+a,c}$	
Rack Calibration Accuracy - Amplifier (RCA)	
Rack Comparator Setting Accuracy (RCSA)	
Rack Measurement & Test Equipment Accuracy (RMTE)	
Rack Temperature Effect (RTE)	
Rack Drift - Amplifier (RD$_1$)	
Rack Drift - Comparator (RD$_2$)	

---

* In percent span (120 % RTP)

TABLE 3-1 (continued)
POWER RANGE, NEUTRON FLUX - HIGH & LOW SETPOINTS

Channel Statistical Allowance =

$$\sqrt{\begin{aligned}&PMA_1^2 + PMA_2^2 + PEA^2 + (SMTE + SD)^2 + (SMTE + SCA)^2 + SRA^2 + SPE^2 + STE^2 + \\ &(RMTE + RD_1)^2 + (RMTE + RCA)^2 + RTE^2 + (RMTE + RCSA)^2 + (RMTE + RD_2)^2\end{aligned}}$$

+a,c

TABLE 3-2 POWER RANGE, NEUTRON FLUX - HIGH POSITIVE AND NEGATIVE RATES

Parameter	**Allowance***
Process Measurement Accuracy (PMA) [ ]$^{+a,c}$	[ ]$^{+a,c}$
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA) [ ]$^{+a,c}$	
Sensor Reference Accuracy (SRA)	
Sensor Measurement & Test Equipment Accuracy (SMTE)	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE) [ ]$^{+a,c}$	
Sensor Drift (SD) [ ]$^{+a,c}$	
Rack Calibration Accuracy - Amplifier (RCA)	
Rack Comparator Setting Accuracy (RCSA)	
Rack Measurement & Test Equipment Accuracy (RMTE)	
Rack Temperature Effect (RTE)	
Rack Drift - Amplifier (RD_1)	
Rack Drift - Comparator (RD_2)	

---

* In percent span (120 % RTP)

TABLE 3-2 (continued)
POWER RANGE, NEUTRON FLUX - HIGH POSITIVE AND NEGATIVE RATES

Channel Statistical Allowance =

$$\sqrt{\begin{array}{l} PMA^2 + PEA^2 + (SMTE + SD)^2 + (SMTE + SCA)^2 + SRA^2 + SPE^2 + STE^2 + \\ (RMTE + RD_1)^2 + (RMTE + RCA)^2 + RTE^2 + (RMTE + RCSA)^2 + (RMTE + RD_2)^2 \end{array}}$$

+a,c

TABLE 3-3 INTERMEDIATE RANGE, NEUTRON FLUX

Parameter	**Allowance***
Process Measurement Accuracy (PMA) [ ]$^{+a,c}$	[
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA)	
Sensor Reference Accuracy (SRA)	
Sensor Measurement & Test Equipment Accuracy (SMTE)	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE) [ ]$^{+a,c}$	
Sensor Drift (SD) [ ]$^{+a,c}$	
Rack Calibration Accuracy (RCA)	
Rack Measurement & Test Equipment Accuracy (RMTE)	
Rack Temperature Effect (RTE)	
Rack Drift (RD)	]$^{+a,c}$

---

* In percent span (120 % RTP)

TABLE 3-3 (continued)
INTERMEDIATE RANGE, NEUTRON FLUX

Channel Statistical Allowance =

$$\sqrt{PMA^2 + PEA^2 + (SMTE + SD)^2 + (SMTE + SCA)^2 + SRA^2 + SPE^2 + STE^2 + (RMTE + RD)^2 + (RMTE + RCA)^2 + RTE^2}$$

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

TABLE 3-4 SOURCE RANGE, NEUTRON FLUX

Parameter	**Allowance***
Process Measurement Accuracy (PMA) [ ]$^{+a,c}$	[ ]$^{+a,c}$
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA)	
Sensor Reference Accuracy (SRA)	
Sensor Measurement & Test Equipment Accuracy (SMTE)	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE) [ ]$^{+a,c}$	
Sensor Drift (SD) [ ]$^{+a,c}$	
Rack Calibration Accuracy (RCA)	
Rack Measurement & Test Equipment Accuracy (RMTE)	
Rack Temperature Effect (RTE)	
Rack Drift (RD)	

---

* In percent span (10^6 cps)

TABLE 3-4 (continued)
SOURCE RANGE, NEUTRON FLUX

Channel Statistical Allowance =

$$\sqrt{\begin{array}{l} PMA^2 + PEA^2 + (SMTE + SD)^2 + (SMTE + SCA)^2 + SRA^2 + SPE^2 + STE^2 \\ (RMTE + RD)^2 + (RMTE + RCA)^2 + RTE^2 \end{array}}$$

+a,c

TABLE 3-5 OVERTEMPERATURE ΔT REACTOR TRIP

Assumes Re-normalization of ΔTo, T'

Parameter **Allowance***

Process Measurement Accuracy

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

Primary Element Accuracy (PEA)

Sensor Calibration Accuracy

[ ]$^{+a,c}$

Sensor Reference Accuracy

[ ]$^{+a,c}$

Sensor Measurement & Test Equipment

[ ]$^{+a,c}$

Sensor Temperature Effects

[ ]$^{+a,c}$

Sensor Pressure Effects (SPE_P)

Sensor Drift

[ ]$^{+a,c}$

TABLE 3-5 (continued)
OVERTEMPERATURE ΔT REACTOR TRIP

Parameter	**Allowance***
Environmental Allowance	[ ]$^{+a,c}$
Seismic	
[ ]$^{+a,c}$	
Rack Calibration Accuracy	
[ ]$^{+a,c}$	
Rack Measurement & Test Equipment Accuracy	
[ ]$^{+a,c}$	
Rack Temperature Effect	
[ ]$^{+a,c}$	

TABLE 3-5 (continued)
OVERTEMPERATURE ΔT REACTOR TRIP

Rack Drift

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

---

* In percent ΔT span (Tavg – 100 °F, pressure - 800 psi, power – 150 % RTP, ΔT – 90.0 °F = 150 % RTP, ΔI – 120 % ΔI)

** See Table 3-25 for gain and conversion calculations

TABLE 3-5 (continued)
OVERTEMPERATURE ΔT REACTOR TRIP

Hot Leg RTDs = 2/Loop (1 RTD assumed failed)
@Cold Leg RTDs = 1/Loop

Channel Statistical Allowance =

$$\{ (PMA_1)^2 + (PMA_2)^2 + (PMA_7)^2 + (PEA)^2 + (SCA_T)^2 + (SD_T)^2 + [\{\frac{(SRA_T)^2}{2^{\#}} + \frac{(SRA_T)^2}{1^{@}}\}^{1/2}]^2 +$$

$$(SMTE_P + SCA_P)^2 + (SMTE_P + SD_P)^2 + (SRA_P)^2 + (STE_P)^2 + (SPE_P)^2 + [\{\frac{(RE_{LIN})^2}{2^{\#}} + \frac{(RE_{LIN})^2}{1^{@}}\}^{1/2}]^2 +$$

$$(RMTE_{\Delta T} + RCA_{\Delta T})^2 + (RMTE_{\Delta T} + RD_{\Delta T})^2 + (RTE_{\Delta T})^2 +$$

$$(RMTE_{Tavg} + RCA_{Tavg})^2 + (RMTE_{Tavg} + RD_{Tavg})^2 +$$

$$(RMTE_P + RCA_P)^2 + (RMTE_P + RD_P)^2 + (RMTE_{\Delta I} + RCA_{\Delta I})^2 + (RMTE_{\Delta I} + RD_{\Delta I})^2 +$$

$$(RMTE_{NIS} + RCA_{NIS})^2 + (RMTE_{NIS} + RD_{NIS})^2 + (RTE_{NIS})^2 + (\alpha)^2 \}^{1/2} +$$

$$PMA_3 + PMA_4 + Seis_{\Delta I} + PMA_5 + PMA_6$$

+a,c

TABLE 3-6 OVERPOWER ΔT REACTOR TRIP
Assumes Re-normalization of ΔTo, T”

Parameter | **Allowance***

[ ]$^{+a,c}$

Process Measurement Accuracy

[ ]$^{+a,c}$

Primary Element Accuracy (PEA)

Sensor Calibration Accuracy

[ ]$^{+a,c}$

Sensor Reference Accuracy

[ ]$^{+a,c}$

Sensor Drift

[ ]$^{+a,c}$

Environmental Allowance (EA)

Rack Calibration Accuracy

[ ]$^{+a,c}$

TABLE 3-6 (continued)
OVERPOWER ΔT REACTOR TRIP

Parameter	**Allowance**[*]
Rack Measurement & Test Equipment Accuracy $[\quad]^{+a,c}$	$[\quad]^{+a,c}$
Rack Temperature Effect $[\quad]^{+a,c}$	
Rack Drift $[\quad]^{+a,c}$	

---

* In percent ΔT span (Tavg – 100 °F, power – 150 % RTP, ΔT – 90.0 °F = 150 % RTP)

** See Table 3-26 for gain and conversion calculations

TABLE 3-6 (continued)
OVERPOWER ΔT REACTOR TRIP

Hot Leg RTDs = 2/Loop (1 RTD assumed failed)
@Cold Leg RTDs = 1/Loop

Channel Statistical Allowance =

$$\{(PMA_5)^2 + (PEA)^2 + (SCA_T)^2 + (SD_T)^2 + \left[\left\{\frac{(SRA_T)^2}{2^{\#}} + \frac{(SRA_T)^2}{1^{@}}\right\}^{1/2}\right]^2 +$$

$$\left[\left\{\frac{(RE_{LIN})^2}{2^{\#}} + \frac{(RE_{LIN})^2}{1^{@}}\right\}^{1/2}\right]^2 + (RMTE_{\Delta T} + RCA_{\Delta T})^2 + (RMTE_{\Delta T} + RD_{\Delta T})^2 + (RTE_{\Delta T})^2 +$$

$$(RMTE_{Tavg} + RCA_{Tavg})^2 + (RMTE_{Tavg} + RD_{Tavg})^2 + (\alpha)^2\}^{1/2} + PMA_1 + PMA_2 + PMA_3 + PMA_4$$

+a,c

TABLE 3-7 PRESSURIZER PRESSURE - LOW, REACTOR TRIP

Parameter	**Allowance*** +a,c
Process Measurement Accuracy (PMA)	
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA)	
Sensor Reference Accuracy (SRA)	
Sensor Measurement & Test Equipment Accuracy (SMTE)	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE)	
Sensor Drift (SD)	
Rack Calibration Accuracy (RCA)	
Rack Measurement & Test Equipment Accuracy (RMTE)	
Rack Temperature Effect (RTE)	
Rack Drift (RD)	

---

* In percent span (800 psi)

TABLE 3-7 (continued)
PRESSURIZER PRESSURE - LOW, REACTOR TRIP

Channel Statistical Allowance =

$$\sqrt{\begin{aligned}&PMA^2 + PEA^2 + (SMTE + SD)^2 + (SMTE + SCA)^2 + SRA^2 + SPE^2 + STE^2 + \\ &(RMTE + RD)^2 + (RMTE + RCA)^2 + RTE^2\end{aligned}}$$

+a,c

[ ]

TABLE 3-8 PRESSURIZER PRESSURE - HIGH, REACTOR TRIP

Parameter	Allowance* +a,c
Process Measurement Accuracy (PMA)	
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA)	
Sensor Reference Accuracy (SRA)	
Sensor Measurement & Test Equipment Accuracy (SMTE)	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE)	
Sensor Drift (SD)	
Bias	
Temperature compensation effect (Bias)	
Rack Calibration Accuracy (RCA)	
Rack Measurement & Test Equipment Accuracy (RMTE)	
Rack Temperature Effect (RTE)	
Rack Drift (RD)	

---

* In percent span (800 psi)

TABLE 3-8 (continued)
PRESSURIZER PRESSURE - HIGH, REACTOR TRIP

Channel Statistical Allowance =

$$\sqrt{\begin{array}{l} PMA^2 + PEA^2 + (SMTE + SD)^2 + (SMTE + SCA)^2 + SRA^2 + SPE^2 + STE^2 + \\ (RMTE + RD)^2 + (RMTE + RCA)^2 + RTE^2 \end{array}}$$

$$+ BIAS$$

+a,c

[

]

TABLE 3-9 PRESSURIZER PRESSURE - LOW, SI

Parameter	**Allowance*** +a,c
Process Measurement Accuracy (PMA)	
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA)	
Sensor Reference Accuracy (SRA)	
Sensor Measurement & Test Equipment Accuracy (SMTE)	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE)	
Sensor Drift (SD)	
Environmental Allowance	
Combined effects of Radiation and Temperature (EA)	
Cable IR effects (IR)	
Rack Calibration Accuracy (RCA)	
Rack Measurement & Test Equipment Accuracy (RMTE)	
Rack Temperature Effect (RTE)	
Rack Drift (RD)	

---

* In percent span (800 psi)

TABLE 3-9 (continued)
PRESSURIZER PRESSURE - LOW, SI

Channel Statistical Allowance =

$$\sqrt{PMA^2 + PEA^2 + (SMTE + SD)^2 + (SMTE + SCA)^2 + SRA^2 + SPE^2 + STE^2 + (RMTE + RD)^2 + (RMTE + RCA)^2 + RTE^2}$$

$$+ EA + IR$$

+a,c

TABLE 3-10 PRESSURIZER WATER LEVEL - HIGH

Parameter	**Allowance***
Process Measurement Accuracy	+a,c
Process Pressure Variations treated as a bias (PMA_1)	
Reference Leg Variations treated as a bias (PMA_2)	
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA)	
Sensor Reference Accuracy (SRA)	
Sensor Measurement & Test Equipment Accuracy (SMTE)	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE)	
Sensor Drift (SD)	
Rack Calibration Accuracy (RCA)	
Rack Measurement & Test Equipment Accuracy (RMTE)	
Rack Temperature Effect (RTE)	
Rack Drift (RD)	

---

* In percent span (100 % level)

TABLE 3-10 (continued)
PRESSURIZER WATER LEVEL - HIGH

Channel Statistical Allowance =

$$\sqrt{\begin{array}{l} PEA^2 + (SMTE + SD)^2 + (SMTE + SCA)^2 + SRA^2 + SPE^2 + STE^2 + \\ (RMTE + RD)^2 + (RMTE + RCA)^2 + RTE^2 \end{array}}$$

$$+ PMA_1 + PMA_2$$

+a,c

TABLE 3-11 RCS LOSS OF FLOW

Parameter	**Allowance***
	$^{+a,c}$
Process Measurement Accuracy	
[ ]$^{+a,c}$ (PMA$_1$)	
[ ]$^{+a,c}$ (PMA$_2$)	
Primary Element Accuracy	
[ ]$^{+a,c}$ (PEA)	
Sensor Calibration Accuracy	
[ ]$^{+a,c}$ (SCA)	
Sensor Reference Accuracy [ ]$^{+a,c}$ (SRA)	
Sensor Measurement & Test Equipment Accuracy	
[ ]$^{+a,c}$ (SMTE)	
Sensor Pressure Effects	
[ ]$^{+a,c}$ (SPE)	
Sensor Temperature Effects	
[ ]$^{+a,c}$ (STE)	
Sensor Drift [ ]$^{+a,c}$ (SD)	
Bias [ ]$^{+a,c}$(Bias$_1$)	
Rack Calibration Accuracy [ ]$^{+a,c}$ (RCA)	
Rack Measurement & Test Equipment Accuracy [ ]$^{+a,c}$ (RMTE)	
Rack Temperature Effect [ ]$^{+a,c}$ (RTE)	
Rack Drift [ ]$^{+a,c}$ (RD)	

---

* In percent span (120 % flow)

TABLE 3-11 (continued)
RCS LOSS OF FLOW

Channel Statistical Allowance =

$$\sqrt{PMA_1^2 + PMA_2^2 + PEA^2 + (SMTE + SD)^2 + (SMTE + SCA)^2 + SRA^2 + SPE^2 + STE^2 + (RMTE + RD)^2 + (RMTE + RCA)^2 + RTE^2}$$

$$+ BIAS_1$$

+a,c

TABLE 3-12 STEAM GENERATOR WATER LEVEL - LOW-LOW

Parameter	**Allowance***
Process Measurement Accuracy	+a,c
+a,c	
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA)	
Sensor Reference Accuracy (SRA)	
Sensor Measurement & Test Equipment Accuracy (SMTE)	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE)	
Sensor Drift (SD)	
Environmental Allowance (FLB Only)	
Transmitter Temperature Error (EA_1)	
Reference Leg Heatup (EA_2)	
IR Degradation (IR)	
Rack Calibration Accuracy (RCA)	
Rack Measurement & Test Equipment Accuracy (RMTE)	
Rack Temperature Effect (RTE)	
Rack Drift (RD)	

---

* In percent span (100 %)

TABLE 3-12 (continued)
STEAM GENERATOR WATER LEVEL - LOW-LOW

Channel Statistical Allowance =

$$\sqrt{PEA^2 + (SMTE + SD)^2 + (SMTE + SCA)^2 + SRA^2 + SPE^2 + STE^2 + (RMTE + RD)^2 + (RMTE + RCA)^2 + RTE^2}$$

$$+ PMA_1 + PMA_2 + PMA_3 + PMA_4$$

For FLB (includes EA_1, EA_2, and IR)

+a,c

For LONF and SLB

+a,c

TABLE 3-13 STEAM GENERATOR WATER LEVEL - HIGH-HIGH

Parameter	**Allowance***
Process Measurement Accuracy	
+a,c	+a,c
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA)	
Sensor Reference Accuracy (SRA)	
Sensor Measurement & Test Equipment Accuracy (SMTE)	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE)	
Sensor Drift (SD)	
Rack Calibration Accuracy (RCA)	
Rack Measurement & Test Equipment Accuracy (RMTE)	
Rack Temperature Effect (RTE)	
Rack Drift (RD)	

---

[*] In percent span (100 %)

TABLE 3-13 (continued)
STEAM GENERATOR WATER LEVEL - HIGH-HIGH

Channel Statistical Allowance =

$$\sqrt{PEA^2 + (SMTE + SD)^2 + (SMTE + SCA)^2 + SRA^2 + SPE^2 + STE^2 + (RMTE + RD)^2 + (RMTE + RCA)^2 + RTE^2}$$

$$+ PMA_1 + PMA_2 + PMA_3 + PMA_4$$

+a,c

TABLE 3-14 STEAMLINE PRESSURE - LOW

Parameter	Allowance[*] +a,c
Process Measurement Accuracy (PMA)	
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA)	
Sensor Reference Accuracy (SRA)	
Sensor Measurement & Test Equipment Accuracy (SMTE)	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE)	
Sensor Drift (SD)	
Rack Calibration Accuracy (RCA)	
Rack Measurement & Test Equipment Accuracy (RMTE)	
Rack Temperature Effect (RTE)	
Rack Drift (RD)	

---

[*] In percent span (1200 psig)

TABLE 3-14 (continued)
STEAMLINE PRESSURE - LOW

Channel Statistical Allowance =

$$\sqrt{\begin{array}{l} PMA^2 + PEA^2 + (SMTE + SD)^2 + (SMTE + SCA)^2 + SRA^2 + SPE^2 + STE^2 + \\ (RMTE + RD)^2 + (RMTE + RCA)^2 + RTE^2 \end{array}}$$

+a,c

TABLE 3-15 NEGATIVE STEAM PRESSURE RATE - HIGH

Parameter	**Allowance***
Process Measurement Accuracy (PMA)	[ ]$^{+a,c}$
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA) [ ]$^{+a,c}$	
Sensor Reference Accuracy (SRA) [ ]$^{+a,c}$	
Sensor Measurement & Test Equipment Accuracy (SMTE)	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE) [ ]$^{+a,c}$	
Sensor Drift (SD) [ ]$^{+a,c}$	
Rack Calibration Accuracy - Loop Power Supply (RCA_{LP})	
Rack Calibration Accuracy - Lead/Lag (RCA_{LL})	
Rack Measurement & Test Equipment Accuracy (RMTE)	
Rack Comparator Setting Accuracy (Required due to separate NAL card calibration) (RCSA)	
Rack Temperature Effect (RTE)	
Rack Drift (RD)	

---

* In percent span (1200 psig)

TABLE 3-15 (continued)
NEGATIVE STEAM PRESSURE RATE - HIGH

Channel Statistical Allowance =

$$\sqrt{\begin{array}{l} PMA^2 + PEA^2 + (SMTE + SD)^2 + (SMTE + SCA)^2 + SRA^2 + SPE^2 + STE^2 + \\ (RMTE + RD)^2 + (RMTE + RCA_{LP})^2 + (RMTE + RCA_{LL})^2 + \ RTE^2 + (RCSA + RMTE)^2 \end{array}}$$

+a,c

TABLE 3-16 CONTAINMENT PRESSURE - HIGH, INTERMEDIATE HIGH-HIGH, HIGH-HIGH

Parameter	**Allowance*** +a,c
Process Measurement Accuracy (PMA)	
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA)	
Sensor Reference Accuracy (SRA)	
Sensor Measurement & Test Equipment Accuracy (SMTE)	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE)	
Sensor Drift (SD)	
Rack Calibration Accuracy (RCA)	
Rack Measurement & Test Equipment Accuracy (RMTE)	
Rack Temperature Effect (RTE)	
Rack Drift (RD)	

---

* In percent span (60 psi)

TABLE 3-16 (continued)
CONTAINMENT PRESSURE - HIGH, INTERMEDIATE HIGH-HIGH, HIGH-HIGH

Channel Statistical Allowance =

$$\sqrt{PMA^2 + PEA^2 + (SMTE + SD)^2 + (SMTE + SCA)^2 + SRA^2 + SPE^2 + STE^2 + (RMTE + RD)^2 + (RMTE + RCA)^2 + RTE^2}$$

+a,c

TABLE 3-17 RWST LEVEL - EXTREME LOW

Parameter	**Allowance*** $^{+a,c}$
Process Measurement Accuracy (PMA_1) [ ]$^{+a,c}$	
Process Measurement Accuracy (PMA_2) Bias [ ]$^{+a,c}$	
Process Measurement Accuracy (PMA_3) Bias [ ]$^{+a,c}$	
Process Measurement Accuracy (PMA_4) Bias [ ]$^{+a,c}$	
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA)	
Sensor Reference Accuracy (SRA)	
Sensor Measurement & Test Equipment Accuracy (SMTE)	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE)	
Sensor Drift (SD)	
Environmental Allowance Seismic Effect (EA)	
Rack Calibration Accuracy (RCA)	
Rack Measurement & Test Equipment Accuracy (RMTE)	
Rack Temperature Effect (RTE)	
Rack Drift (RD)	

---

* In percent span (12 ft)

TABLE 3-17 (continued)
RWST LEVEL - EXTREME LOW

Channel Statistical Allowance =

$$\sqrt{\begin{aligned}&PMA_1^2 + PEA^2 + (SMTE + SD)^2 + (SMTE + SCA)^2 + SRA^2 + SPE^2 + STE^2 + \\ &(RMTE + RD)^2 + (RMTE + RCA)^2 + RTE^2\end{aligned}}$$

$$+ EA + PMA_2 + PMA_3 + PMA_4$$

+a,c

TABLE 3-18 REACTOR COOLANT PUMP - UNDERFREQUENCY

Parameter	Allowance* +a,c
Process Measurement Accuracy (PMA)	
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA)	
Sensor Reference Accuracy (SRA)	
Sensor Measurement & Test Equipment Accuracy (SMTE)	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE)	
Sensor Drift (SD)	
Rack Calibration Accuracy (RCA)	
Rack Reference Accuracy (RRA)	
Rack Measurement & Test Equipment Accuracy (RMTE)	
Rack Temperature Effects (RTE)	
Rack Drift (RD)	

---

* In frequency (Hz)

TABLE 3-18 (Continued)
REACTOR COOLANT PUMP - UNDERFREQUENCY

Channel Statistical Allowance =

$$\sqrt{\begin{array}{l} PMA^2 + PEA^2 + (SMTE + SD)^2 + (SMTE + SCA)^2 + SRA^2 + SPE^2 + STE^2 + \\ (RMTE + RD)^2 + (RMTE + RCA)^2 + RRA^2 + RTE^2 \end{array}}$$

+a,c

TABLE 3-19 REACTOR COOLANT PUMP - UNDERVOLTAGE

Parameter	Allowance* +a,c
Process Measurement Accuracy (PMA)	
Primary Element Accuracy Allowance for Transformer Accuracy (PEA$_1$)	
Primary Element Accuracy Power Supply Variation (PEA$_2$)	
Sensor Calibration Accuracy (SCA)	
Sensor Reference Accuracy (SRA)	
Sensor Measurement & Test Equipment Accuracy (SMTE)	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE)	
Sensor Drift (SD)	
Rack Calibration Accuracy (RCA)	
Rack Reference Accuracy (RRA)	
Rack Measurement & Test Equipment Accuracy (RMTE)	
Rack Temperature Effects (RTE)	
Rack Drift (RD)	

---

* In percent span (118.9 vac secondary PT span)

TABLE 3-19 (Continued)
REACTOR COOLANT PUMP - UNDERVOLTAGE

Channel Statistical Allowance =

$$\sqrt{\begin{array}{l}PMA^2 + PEA_1^2 + PEA_2^2 + (SMTE + SD)^2 + (SMTE + SCA)^2 + SRA^2 + SPE^2 + STE^2 + \\ (RMTE + RD)^2 + (RMTE + RCA)^2 + RRA^2 + RTE^2\end{array}}$$

+a,c

TABLE 3-20 4.16 kV EMERGENCY BUS UNDERVOLTAGE - DEGRADED VOLTAGE RELAY

Parameter	**Allowance**[*] +a,c
Process Measurement Accuracy Power Supply Variations (PMA)	
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA)	
Sensor Reference Accuracy (SRA)	
Sensor Measurement & Test Equipment Accuracy (SMTE)	
Sensor Pressure Effect (SPE)	
Sensor Temperature Effect (STE)	
Sensor Drift (SD)	
Rack Calibration Accuracy (RCA)	
Rack Reference Accuracy (RRA)	
Rack Measurement & Test Equipment Accuracy (RMTE)	
Rack Temperature Effects (RTE)	
Rack Drift (RD)	

---

[*] In percent span (118.9 vac secondary PT span)

TABLE 3-20 (continued)
4.16 kV EMERGENCY BUS UNDERVOLTAGE - DEGRADED VOLTAGE RELAY

Channel Statistical Allowance =

$$\sqrt{\begin{aligned}&PMA^2 + PEA^2 + (SMTE + SD)^2 + (SMTE + SCA)^2 + SRA^2 + SPE^2 + STE^2 + \\ &(RMTE + RD)^2 + (RMTE + RCA)^2 + RTE^2 + RRA^2\end{aligned}}$$

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

TABLE 3-21 4.16 kV EMERGENCY BUS UNDERVOLTAGE - TRIP FEED AND START DIESEL

Parameter	Allowance* +a,c
Process Measurement Accuracy (PMA)	
Primary Element Accuracy Allowance for Transformer Accuracy (PEA_1)	
Primary Element Accuracy Power Supply Variations (PEA_2)	
Sensor Calibration Accuracy (SCA)	
Sensor Reference Accuracy (SRA)	
Sensor Measurement & Test Equipment Accuracy (SMTE)	
Sensor Temperature Effects (STE)	
Sensor Pressure Effects (SPE)	
Sensor Drift (SD)	
Rack Calibration Accuracy (RCA)	
Rack Reference Accuracy (RRA)	
Rack Measurement & Test Equipment Accuracy (RMTE)	
Rack Temperature Effects (RTE)	
Rack Drift (RD)	

---

* In percent span (118.9 vac secondary PT span)

TABLE 3-21 (Continued)
4.16 kV EMERGENCY BUS UNDERVOLTAGE: TRIP FEED AND START DIESEL

Channel Statistical Allowance =

$$\sqrt{\begin{array}{l} PMA^2 + PEA_1^2 + PEA_2^2 + (SMTE + SD)^2 + (SMTE + SCA)^2 + SRA^2 + STE^2 + \\ SPE^2 + (RMTE + RD)^2 + (RMTE + RCA)^2 + RRA^2 + RTE^2 \end{array}}$$

+a,c

TABLE 3-22 480 V EMERGENCY BUS UNDERVOLTAGE - DEGRADED VOLTAGE RELAY

Parameter	Allowance* +a,c
Process Measurement Accuracy	
Power Supply Variations (PMA)	
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA)	
Sensor Reference Accuracy (SRA)	
Sensor Measurement & Test Equipment Accuracy (SMTE)	
Sensor Pressure Effect (SPE)	
Sensor Temperature Effect (STE)	
Sensor Drift (SD)	
Rack Calibration Accuracy (RCA)	
Rack Reference Accuracy (RRA)	
Rack Measurement & Test Equipment Accuracy (RMTE)	
Rack Temperature Effects (RTE)	
Rack Drift (RD)	

---

* In percent span (120 vac secondary PT span)

TABLE 3-22 (continued)
480 V EMERGENCY BUS UNDERVOLTAGE - DEGRADED VOLTAGE RELAY

Channel Statistical Allowance =

$$\sqrt{\begin{aligned}&PMA^2 + PEA^2 + (SMTE + SD)^2 + (SMTE + SCA)^2 + SRA^2 + SPE^2 + STE^2 + \\ &(RMTE + RD)^2 + (RMTE + RCA)^2 + RTE^2 + RRA^2\end{aligned}}$$

+a,c

TABLE 3-23 EMERGENCY TRIP HEADER - LOW PRESSURE

Parameter	Allowance* +a,c
Process Measurement Accuracy (PMA)	
Primary Element Accuracy (PEA)	
Sensor Calibration Accuracy (SCA)	
Sensor Reference Accuracy (SRA)	
Sensor Measurement & Test Equipment Accuracy (SMTE)	
Sensor Pressure Effects (SPE)	
Sensor Temperature Effects (STE)	
Sensor Drift (SD)	
Rack Calibration Accuracy (RCA)	
Rack Reference Accuracy (RRA)	
Rack Measurement & Test Equipment Accuracy (RMTE)	
Rack Temperature Effect (RTE)	
Rack Drift (RD)	

---

* In percent span (2800 psi)

TABLE 3-23 (continued)
EMERGENCY TRIP HEADER - LOW PRESSURE

Channel Statistical Allowance =

$$\sqrt{\begin{array}{l} PMA^2 + PEA^2 + (SMTE + SD)^2 + (SMTE + SCA)^2 + SRA^2 + SPE^2 + STE^2 + \\ (RMTE + RD)^2 + (RMTE + RCA)^2 + RRA^2 + RTE^2 \end{array}}$$

+a,c

TABLE 3-24
REACTOR TRIP SYSTEM/ENGINEERED SAFETY FEATURES ACTUATION SYSTEM CHANNEL ERROR ALLOWANCES
BEAVER VALLEY UNIT 2

				SENSOR							INSTRUMENT RACK											
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
	PROTECTION CHANNEL	PROCESS MEASUREMENT ACCURACY (1)	PRIMARY ELEMENT ACCURACY (1)	CALIBRATION ACCURACY (1)	SENSOR REFERENCE 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	[													]$^{+a,c}$	118% RTP	109.5% RTP	109% RTP	7.5	[	]$^{+a,c}$	1
2	POWER RANGE, NEUTRON FLUX - LOW SETPOINT															35% RTP	25.5% RTP	25% RTP	8.3			2
3	POWER RANGE, NEUTRON FLUX - HIGH POSITIVE RATE															(5)	5.5% RTP	5.0% RTP	---			3
4	POWER RANGE, NEUTRON FLUX - HIGH NEGATIVE RATE															6.9% RTP (9)	5.5% RTP	5.0% RTP	1.6			4
5	INTERMEDIATE RANGE, NEUTRON FLUX															(5)	27.9% RTP	25% RTP	---			5
6	SOURCE RANGE, NEUTRON FLUX															(5)	1.3E+05 CPS	1.0E+05 CPS	---			6
7	OVERTEMPERATURE ΔT ΔT CHANNEL (WEED) TAVG CHANNEL (WEED) PRESSURIZER PRESSURE CHANNEL f(ΔI) CHANNEL NIS CHANNEL															FUNCTION(6)	FUNCTION(7)	FUNCTION(7)	6.5			7
8	OVERPOWER ΔT - ΔT CHANNEL (WEED) Tavg CHANNEL (WEED)															FUNCTION(6)	FUNCTION(8)	FUNCTION(8)	3.2			8
9	PRESSURIZER PRESSURE - LOW, REACTOR TRIP (BARTON XMITTER)															1920 PSIG	1941 PSIG	1945 PSIG	3.1			9
10	PRESSURIZER PRESSURE - HIGH (BARTON XMITTER)															2405 PSIG	2379 PSIG	2375 PSIG	3.8			10
11	PRESSURIZER WATER LEVEL - HIGH (BARTON XMITTER)															(5)	92.5% SPAN	92% SPAN	---			11
12	LOSS OF FLOW (BARTON XMITTER)															87% FLOW	89.6% FLOW	90% FLOW	2.5			12
13	STEAM GENERATOR WATER LEVEL - LOW-LOW FLB (BARTON XMITTER) SLB (BARTON XMITTER)															0% SPAN 0% SPAN	16.0% SPAN 16.0% SPAN	16.5% SPAN 16.5% SPAN	16.5 16.5			13
14	STEAM GENERATOR WATER LEVEL - LOW-LOW LONF (BARTON XMITTER)															10% SPAN	16.0% SPAN	16.5% SPAN	6.5			14
15	UNDERVOLTAGE - RCP (GOULD RELAY)															(12)	71.2% BUS VOLTAGE	75% BUS VOLTAGE	---			15
16	UNDERFREQUENCY - RCP (E-MAX RELAY)															57.0 Hz	57.45 Hz	57.5 Hz	0.5 Hz			16
17	PRESSURIZER PRESSURE LOW - SI (BARTON XMITTER)															1745 PSIG	1852 PSIG	1856 PSIG	13.9			17
18	STEAMLINE PRESSURE - LOW (BARTON XMITTER)															445 PSIG	494.0 PSIG	500.0 PSIG	4.6			18
19	CONTAINMENT PRESSURE HIGH (BARTON XMITTER)															3.3 PSIG	1.8 PSIG	1.5 PSIG	3.0			19
20	CONTAINMENT PRESSURE HIGH-HIGH (BARTON XMITTER)															10.0 PSIG	8.3 PSIG	8.0 PSIG	3.3			20
21	CONTAINMENT PRESSURE INTERMEDIATE HIGH-HIGH (BARTON XMITTER)															5.0 PSIG	3.3 PSIG	3.0 PSIG	3.3			21
22	NEGATIVE STEAM PRESSURE RATE - HIGH (BARTON XMITTER)															(5)	103.6 PSI	100 PSI	---			22
23	STEAM GENERATOR WATER LEVEL - HIGH-HIGH (BARTON XMITTER)															86.3% SPAN	81.1% SPAN	80.6% SPAN	5.7			23
24	RWST LEVEL - EXTREME LOW (ROSEMOUNT XMITTER)															(5)	37Ft - 11In	38Ft - 0In	---			24
25	4.16 KV EMERGENCY BUS UNDERVOLTAGE - TRIP FEED (GOULD RELAY)															(5)	71.2% BUS VOLTAGE	75% BUS VOLTAGE	---			25
26	4.16 KV EMERGENCY BUS UNDERVOLTAGE - START DIESEL (GOULD RELAY)															(5)	71.2% BUS VOLTAGE	75% BUS VOLTAGE	---			26
27	4.16 KV EMERGENCY BUS UNDERVOLTAGE - DEGRADED VOLTAGE (ABB RELAY)															(5)	93.1% BUS VOLTAGE	93.4% BUS VOLTAGE	---			27
28	480V EMERGENCY BUS UNDERVOLTAGE - DEGRADED VOLTAGE (ABB RELAY)															(5)	93.1% BUS VOLTAGE	93.4% BUS VOLTAGE	---			28
29	EMERGENCY TRIP HEADER - LOW PRESSURE (UNITED ELECTRIC)															(5)	958 PSIG	1000 PSIG	---			29

NOTES:
1. ALL VALUES IN PERCENT OF SPAN.
2. AS NOTED IN TABLE 15.0-4 OF THE UFSAR.
3. AS NOTED IN TABLES 2.2-1 AND 3.3-4 OF THE PLANT TECHNICAL SPECIFICATIONS.
4. [ ]$^{+a,c}$
5. NOT USED IN SAFETY ANALYSIS.
6. AS NOTED IN FIGURE 15.0-1 OF THE UFSAR
7. AS NOTED IN TABLE 2.2-1, NOTES 1 AND 2 OF THE PLANT TECHNICAL SPECIFICATIONS.
8. AS NOTED IN TABLE 2.2-1, NOTES 3 AND 4 OF THE PLANT TECHNICAL SPECIFICATIONS.
9. NOT USED IN TABLE 15.0-4 OF UFSAR BUT USED IN THE SAFETY ANALYSIS.
10. [ ]$^{+a,c}$
11. [ ]$^{+a,c}$
12. [ ]$^{+a,c}$
13. [ ]$^{+a,c}$
14. [ ]$^{+a,c}$
15. [ ]$^{+a,c}$
16. INCORE / EXCORE f(ΔI) COMPARISON AS NOTED IN TABLE 4.3-1 OF THE PLANT TECHNICAL SPECIFICATIONS.
17. [ ]$^{+a,c}$
18. [ ]$^{+a,c}$
19. [ ]$^{+a,c}$
20. [ ]$^{+a,c}$
21. [ ]$^{+a,c}$
22. [ ]$^{+a,c}$
23. [ ]$^{+a,c}$
24. [ ]$^{+a,c}$
25. ALLOWANCE FOR TRANSFORMER ACCURACY
26. INSULATION RESISTANCE DEGRADATION - TREATED AS A BIAS
27. VARIATION IN DROPOUT VOLTAGE vs DC CONTROL
28. [ ]$^{+a,c}$
29. % OF SECONDARY-SIDE VOLTAGE
30. [ ]$^{+a,c}$
31. [ ]$^{+a,c}$
32. [ ]$^{+a,c}$
33. [ ]$^{+a,c}$
34. RELAY / SWITCH REFERENCE ACCURACY
35. [ ]$^{+a,c}$
36. SEE CHANNEL SPECIFIC TABLE FOR BREAKDOWN OF RACK TERMS
37. [ ]$^{+a,c}$
38. [ ]$^{+a,c}$
39. [ ]$^{+a,c}$
40. [ ]$^{+a,c}$
41. [ ]$^{+a,c}$

TABLE 3-25 OVERTEMPERATURE ΔT CALCULATIONS

The equation for Overtemperature ΔT is :

$$\Delta T \frac{(1+\tau_1 S)}{(1+\tau_2 S)} \frac{1}{(1+\tau_3 S)} \leq \Delta T_0 \left\{ K_1 - K_2 \frac{(1+\tau_4 S)}{(1+\tau_5 S)} \left[T \frac{1}{(1+\tau_6 S)} - T' \right] + K_3 (P - P') - f_1(\Delta I) \right\}$$

K_1 (nominal) = 1.311 Technical Specification value
K_1 (max) = [ ]$^{+a,c}$
K_2 = 0.0183 Technical Specification value
K_3 = 0.00082 Technical Specification value
vessel ΔT = 60.0 °F smallest ΔT based on evaluation of temperature data
ΔI gain = 1.56 % Technical Specification value

PMA conversions:

[ ]$^{+a,c}$

ΔI (PMA$_1$) =
ΔI (PMA$_2$) =
ΔT (PMA$_3$) =
Tavg (PMA$_4$) =
Power Cal. (PMA$_5$) =

[ ]$^{+a,c}$

Pressure gain =
Pressure (SCA$_P$) =
Pressure (SRA$_P$) =
Pressure (SMTE$_P$) =
Pressure (STE$_P$) =
Pressure (SD$_P$) =
Pressure (RCA$_P$) =
Pressure (RMTE$_P$) =
Pressure (RD$_P$) =

TABLE 3-25 (continued)
OVERTEMPERATURE ΔT CALCULATIONS

ΔI conversion = [
ΔI (RCA$_{\Delta I}$) =
ΔI (RMTE$_{\Delta I}$) =
ΔI (RD$_{\Delta I}$) =
ΔI (Seis$_{\Delta I}$) =]$^{+a,c}$

Tavg conversion = [
Tavg (RCA$_{Tavg}$) =
Tavg (RMTE$_{Tavg}$) =
Tavg (RD$_{Tavg}$) =]$^{+a,c}$

Total Allowance = [ ]$^{+a,c}$ = 6.5 % ΔT span

*Accounted for in safety analyses

TABLE 3-26 OVERPOWER ΔT CALCULATIONS

The equation for Overpower ΔT is :

$$\Delta T\frac{(1+\tau_1 S)}{(1+\tau_2 S)}\frac{1}{(1+\tau_3 S)} \le \Delta T_0\left[K_4 - K_5\frac{\tau_7 S}{(1+\tau_7 S)}\frac{1}{(1+\tau_6 S)}T - K_6\left(T\frac{1}{(1+\tau_6 S)} - T"\right)\right]$$

K_4 (nominal) = 1.094 Technical Specification value
K_4 (max) = [ ]$^{+a,c}$
K_5 = 0.020 Technical Specification value
K_6 = 0.0012 Technical Specification value
vessel ΔT = 60.0 °F smallest ΔT based on evaluation of temperature data

PMA conversions:

ΔT (PMA_1) = [
Tavg (PMA_2) =
Power Cal. (PMA_5) =]$^{+a,c}$

Tavg conversion = [
Tavg (RCA_{Tavg}) =
Tavg ($RMTE_{Tavg}$) =
Tavg (RD_{Tavg}) =]$^{+a,c}$

Total Allowance = [ ]$^{+a,c}$ = 3.2% ΔT span

*Accounted for in safety analyses

TABLE 3-27 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

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

thus

$$\partial F_N = \frac{\partial \Delta P_N}{2 F_N} \qquad \text{Eq. 3-27.1}$$

Error at a point (not in percent) is:

$$\frac{\partial F_N}{F_N} = \frac{\partial \Delta P_N}{2(F_N)^2} = \frac{\partial \Delta P_N}{2 \Delta P_N} \qquad \text{Eq. 3-27.2}$$

and

$$\frac{\Delta P_N}{\Delta P_{\max}} = \frac{(F_N)^2}{(F_{\max})^2} \qquad \text{Eq. 3-27.3}$$

where max = maximum flow and

the transmitter ΔP error is:

$$\frac{\partial \Delta P_N}{\Delta P_{\max}}(100) = \text{percent error in Full Scale } \Delta P \ (\% \ \varepsilon \text{ FS } \Delta P) \qquad \text{Eq. 3-27.4}$$

TABLE 3-27 (continued)
ΔP MEASUREMENTS EXPRESSED IN FLOW UNITS

therefore:

$$\frac{\partial F_N}{F_N} = \frac{\Delta P_{\max}\left[\frac{\%\,\varepsilon\, FS\, \Delta P}{100}\right]}{2\Delta P_{\max}\left[\frac{F_N}{F_{\max}}\right]^2} = \left[\frac{\%\,\varepsilon\, FS\, \Delta P}{(2)(100)}\right]\left[\frac{F_{\max}}{F_N}\right]^2 \qquad \text{Eq. 3-27.5}$$

Error in flow units is:

$$\partial F_N = F_N\left[\frac{\%\,\varepsilon\, FS\, \Delta P}{(2)(100)}\right]\left[\frac{F_{\max}}{F_N}\right]^2 \qquad \text{Eq. 3-27.6}$$

Error in percent nominal flow is:

$$\frac{\partial F_N}{F_N}(100) = \left[\frac{\%\,\varepsilon\, FS\, \Delta P}{2}\right]\left[\frac{F_{\max}}{F_N}\right]^2 \qquad \text{Eq. 3-27.7}$$

Error in percent full span is:

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

$$= \left[\frac{\%\,\varepsilon\, FS\, \Delta P}{2}\right]\left[\frac{F_{\max}}{F_N}\right] \qquad \text{Eq. 3-27.8}$$

Equation 3-27.8 is used to express errors in percent full span in this document.

4.0 APPLICATION OF THE SETPOINT METHODOLOGY

4.1 Uncertainty Calculation Basic Assumptions/Premises

The equations noted in Sections 2 and 3 are based on several premises. These are:

1) The instrument technicians make reasonable attempts to achieve the Nominal Trip Setpoint as an "as left" condition at the start of each process rack's surveillance interval.

2) The process rack drift will be evaluated (probability distribution function characteristics and drift magnitude) over multiple surveillance intervals.

3) The process rack calibration accuracy will be evaluated (probability distribution function characteristics and calibration magnitude) over multiple surveillance intervals.

4) The process racks, including the bistables, are verified/functionally tested in a string or loop process.

It should be noted for (1) above that it is not necessary for the instrument technician to recalibrate a device or channel if the "as left" condition is not exactly at the nominal condition but is within the plus or minus of nominal "as left" procedural tolerance. As noted above, the uncertainty calculations assume that the "as left" tolerance (conservative and non-conservative direction) is satisfied on a reasonable, statistical basis, not that the nominal condition is satisfied exactly. This evaluation assumes that the RCA and RD parameters values noted in Tables 3-1 through 3-23 are satisfied on at least a 95 % probability / 95 % confidence level basis. It is therefore necessary for the plant to periodically reverify the continued validity of these assumptions. This prevents the institution of non-conservative biases due to a procedural basis without the plant staff's knowledge and appropriate treatment.

In summary, a process rack channel is considered to be "calibrated" when the two-sided "as left" calibration procedural tolerance is satisfied. An instrument technician may determine to recalibrate if near the extremes of the "as left" procedural tolerance, but it is not required. Recalibration is explicitly required any time the "as found" condition of the device or channel is outside of the "as left" procedural tolerance. A device or channel may not be left outside the "as left" tolerance without declaring the channel "inoperable" and appropriate action taken. Thus an "as left" tolerance may be considered as an outer limit for the purposes of calibration and instrument uncertainty calculations.

4.2 Process Rack Operability Determination Program and Criteria

As a result of the review of a sample of plant procedures, the equations noted in Sections 2 and 3 are significantly different from those used in previous Westinghouse uncertainty calculations. One aspect of the equations easily noted is the significance of the calibration process, i.e., it is treated as statistically independent of the drift determination. Another aspect is that if drift and calibration are independent processes, then the determination of equipment operability is changed, i.e., it is not the arithmetic sum of the two uncertainties. The parameter of most interest as a first pass operability criterion is drift ("as found" – "as left") found to be within RD, where RD is the 95/95 drift value assumed for that channel. However, this would require the instrument technician to record both the "as left" and "as found" conditions and perform a calculation in the field. This field calculation has been determined to be impracticable at this time since it would require having the "as left" value for that device at the time of drift determination and thus becomes a records availability/control problem. An alternative for the process racks is the use of a fixed magnitude, two-sided "as found" tolerance about the nominal trip setpoint. It would be reasonable for this "as found" tolerance to be RMTE + RD, where RD is the actual statistically determined 95/95 drift value and RMTE is defined in the BVPS 2 procedures. However, comparison of this value with the "as left" tolerance utilized in the plant procedures and the Westinghouse uncertainty calculations would yield a value where the "as found" tolerance is less than the "as left" tolerance. This is due to RD being defined as a relative drift magnitude as opposed to an absolute drift magnitude and the process racks being very stable, i.e., no significant drift. Thus, it is not reasonable to use this criterion as an "as found" tolerance in an absolute sense, as it conflicts with the second criterion for operability determination. That is, a channel could be left near zero, found outside the absolute drift criterion, yet be inside the calibration criterion and not exceeding the relative drift criterion. Therefore, a more reasonable approach for the plant staff was determined. The "as found" criterion based on absolute magnitude is the same as the "as left" criterion, i.e., the allowed deviation from the Nominal Trip Setpoint on an absolute indication basis is plus or minus the "as left" tolerance. A process loop found inside the "as left" tolerance on an indicated basis is considered to be operable. A channel found outside the "as left" tolerance is evaluated and recalibrated. If the channel can be returned to within the "as left" tolerance, the channel is considered to be operable. This criterion can then be incorporated into plant, function specific calibration and drift procedures as the defined "as found" tolerance about the Nominal Trip Setpoint. At a later date, once the "as found" data is compiled, the relative drift ("as found" – "as left") can be calculated and compared against the RD value. This comparison can then be utilized to ensure consistency with the assumptions of the uncertainty calculations documented in Tables 3-1 through 3-23. A channel found to exceed this criterion multiple times should trigger a more comprehensive evaluation of the operability of the channel.

It is believed that a BVPS 2 systematic program of drift and calibration review proposed for the process racks is acceptable as a set of first pass criteria. More elaborate evaluation and monitoring may be included, as necessary, if the drift is found to be excessive or the channel is found difficult to calibrate. Based on the above, it is believed that the total process rack program proposed for BVPS 2 will provide a more comprehensive evaluation of operability than a simple determination of an acceptable "as found".

4.3 Application to the Plant Technical Specifications

The drift operability criteria suggested for the process racks in Section 4.2 would be based on a statistical evaluation of the performance of the installed hardware. Thus this criterion would change if the Measurement and Test Equipment is changed, or the procedures used in the surveillance process are changed significantly and particularly if the process rack modules themselves are changed, e.g., from pure analog to a mixture of analog and ASIC (Application Specific Integrated Circuit) modules. Therefore, the operability criteria are not expected to be static. In fact they are expected to change as the characteristics of the equipment change. This does not imply that the criteria can increase due to increasingly poor performance of the equipment over time. But rather just the opposite. As new and better equipment and processes are instituted, the operability criteria magnitudes would be expected to decrease to reflect the increased capabilities of the replacement equipment. For example, if the plant purchased some form of equipment that allowed the determination of relative drift in the field, it would be expected that the rack operability would then be based on the RD value.

Sections 4.1 and 4.2 are basically consistent with the recommendations of the Westinghouse paper presented at the June 1994, ISA/EPRI conference in Orlando, FL[1]. Therefore, consistent with the paper, Westinghouse recommends revision of Specifications 2.2.1, "Limiting Safety System Settings – Reactor Trip System Instrumentation Setpoints", Specification 3.3.2, "Engineered Safety Features Actuation System Instrumentation – Limiting Condition for Operation", Table 2.2-1 "Reactor Trip System Instrumentation Setpoints" and Table 3.3-4, "Engineered Safety Features Actuation System Instrumentation Trip Setpoints". Appendix A provides the Westinghouse recommendations for revision of these two specifications and tables. Table 3-24 (Column 16) of this document provides the recommended Nominal Trip Setpoint for each RTS/ESFAS protection function, which was utilized in the Westinghouse uncertainty calculations and determined to be acceptable for use. Table 3-24 also notes the Westinghouse recommended allowable value for each RTS/ESFAS protection function process rack channel. These recommendations are specific to each input for multiple input functions and should be placed in the plant procedures and maintained under plant administrative control. This is consistent with the bases sections for the two specifications provided in Appendix A. In addition, the plant operability determination processes described in Sections 4.2 and 4.3 are consistent with the basic intent of the ISA paper [2] and the bases sections for the two specifications provided in Appendix A.

4.4 Determination of Allowable Value

The Allowable Values for the BVPS 2 Technical Specifications are determined by adding (or subtracting) the calibration accuracy of the device tested during the Channel Operational Test to the NTS in the non-conservative direction (i.e., toward or closer to the SAL) for the application. For those channels that provide trip actuation via a bistable in the process racks, the calibration accuracy is defined by the Rack Calibration Accuracy term. For a limited number of channels that provide trip actuation without being processed via the process racks (e.g., Auto Stop Oil Pressure) the allowable value is defined by device drift or repeatability. The magnitude of the calibration accuracy term is as specified in the station procedures.

Two examples of the Allowable Value calculations are as follows:

- *Steam Generator Level - Low-Low*

NTS = 16.5 % span
SAL = 0 % span
RCA = 0.5 % span
SPAN = 100 % Level

AV = NTS - RCA

AV = 16.5 % - 0.5 %

AV = 16.0 % span

- *Pressurize Pressure High*

NTS = 2375 psig
SAL = 2405 psig
RCA = 4.0 psig (0.5 % span)
SPAN = 800 psig

AV = NTS + RCA

AV = 2375 psig + 4.0 psig

AV = 2379 psig

4.5 References/Standards

[1] Tuley, C. R., Williams, T. P., "The Allowable Value in the Westinghouse Setpoint Methodology – Fact or Fiction?" presented at the Thirty-Seventh Power Instrumentation Symposium (4th Annual ISA/EPRI Joint Controls and Automation Conference), Orlando, FL, June, 1994.

[2] Ibid

APPENDIX A

SAMPLE BEAVER VALLEY POWER STATION UNIT 2
SETPOINT TECHNICAL SPECIFICATIONS

2.2 LIMITING SAFETY SYSTEM SETTINGS

REACTOR TRIP SYSTEM INSTRUMENTATION SETPOINTS

2.2.1 The Reactor Trip System Instrumentation Channel and Interlock Channel shall be OPERABLE.

APPLICABILITY: As shown for each channel in Table 3.3-1.

ACTION:

a. With a Reactor Trip System Instrumentation Channel or Interlock Channel Nominal Trip Setpoint inconsistent with the value shown in the Nominal Trip Setpoint column of Table 2.2-1, adjust the Setpoint consistent with the Nominal Trip Setpoint value. (1)(2)

b. With a Reactor Trip System Instrumentation Channel or Interlock Channel found to be inoperable, declare the channel inoperable and apply the applicable ACTION statement requirement of Specification 3.3.1 until the channel is restored to OPERABLE status.

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(1) A Trip Setpoint may be set more conservative than the Nominal Trip Setpoint as necessary in response to plant conditions or revised analysis. Allowable Value(s) shall be adjusted accordingly.

(2) The Trip Setpoint value stated for Functional Unit number 17.b in Table 2.2-1 is not a nominal value. Adjust the setpoint consistent with the Trip Setpoint value in lieu of adjusting the setpoint within the established calibration tolerance band of the Nominal Trip Setpoint.

TABLE 2.2-1
REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

Functional Unit	Nominal Trip Setpoint	Allowable Value
1. Manual Reactor Trip	N.A.	N.A.
2. Power Range, Neutron Flux,		
High Setpoint	109% of RTP*	≤ 109.5% of RTP*
Low Setpoint	25% of RTP*	≤ 25.5% of RTP*
3. Power Range, Neutron Flux, High Positive Rate	5% of RTP* with a time constant ≥ 2 seconds	≤ 5.5% RTP* with a time constant ≥ 2 seconds
4. Power Range, Neutron Flux, High Negative Rate	5% of RTP* with a time constant ≥ 2 seconds	≤ 5.5% RTP* with a time constant ≥ 2 seconds
5. Intermediate Range, Neutron Flux	25% of RTP*	≤ 27.9% of RTP*
6. Source Range, Neutron Flux	10^{+5} cps	≤ 1.3 x 10^{+5} cps
7. Overtemperature ΔT	See note 1	See note 2
8. Overpower ΔT	See note 3	See note 4
9. Pressurizer Pressure - Low	1945 psig**	≥ 1941 psig**
10. Pressurizer Pressure - High	2375 psig	≤ 2379 psig
11. Pressurizer Water Level - High	92% of instrument span	≤ 92.5% of instrument span
12. Loss of Flow	90% of indicated loop flow	≥ 89.6% of indicated loop flow

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* RTP - Rated Thermal Power

** Nominal time constants utilized in the lead-lag controller for Pressurizer Pressure-Low are 2 seconds for lead and 1 second for lag. Channel calibration shall ensure that these time constants are adjusted to within the calibration tolerance band for those values.

TABLE 2.2-1 (Continued)
REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

Functional Unit	Nominal Trip Setpoint*	Allowable Value
13. Steam Generator Water Level - Low-Low	16.5% of narrow range instrument span	≥ 16% of narrow range instrument span
14. DELETED		
15. Undervoltage - Reactor Coolant Pumps	75% of nominal bus voltage - each bus	≥ 71.2% of nominal bus voltage - each bus
16. Underfrequency - Reactor Coolant Pumps	57.5 Hz - each bus	≥ 57.45 Hz - each bus
17. Turbine Trip		
a. Emergency Trip Header Low Pressure	1000 psig	≥ 958 psig
b. Turbine Stop Valve Closure	≥ 1% open	≥ 1% open
18. Safety Injection Input from ESF	N.A.	N.A.
19. Reactor Coolant Pump Breaker Position Trip	N.A.	N.A.
20. Reactor Trip Breakers	N.A.	N.A.
21. Automatic Trip and Interlock Logic	N.A.	N.A.
22. Reactor Trip System Interlocks		
a. Intermediate Range Neutron Flux, P-6	1×10^{-10} amps	$\geq 9.0 \times 10^{-11}$ amps
b. Power Range Neutron Flux, P-8	30% RTP**	≤ 30.5 % RTP**
c. Power Range Neutron Flux, P-9	49% of RTP**	≤ 49.5 % RTP**

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* With the exception of functional unit number 17.b

** RTP – Rated Thermal Power

TABLE 2.2-1 (Continued)
REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

Functional Unit	Nominal Trip Setpoint	Allowable Value
d. Power Range Neutron Flux, P-10 (Input to P-7)	10% of RTP*	≥ 9.5% RTP* on increasing power ≤ 10.5% RTP* on decreasing power
e. Turbine Impulse Chamber Pressure, P-13 (Input to P-7)	10% of RTP* Turbine Impulse Pressure Equivalent	≤ 10.5% of RTP* Turbine Impulse Pressure Equivalent

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* RTP - Rated Thermal Power

TABLE 2.2-1 (Continued)

TABLE NOTATION

NOTE 1: OVERTEMPERATURE ΔT

$$\Delta T\frac{(1+\tau_1 S)}{(1+\tau_2 S)}\left(\frac{1}{1+\tau_3 S}\right)=\Delta T_0\left\{K_1-K_2\frac{(1+\tau_4 S)}{(1+\tau_5 S)}\left[T\left(\frac{1}{1+\tau_6 S}\right)-T'\right]+K_3(P-P')-f(\Delta I)\right\}$$

Where: ΔT is measured Reactor Coolant System ΔT, °F;

$\frac{1+\tau_1 S}{1+\tau_2 S}$ is the function generated by the Lead-lag compensator for measured ΔT;

τ_1 and τ_2 are the time constants utilized in the lead-lag compensator for ΔT, $\tau_1 \geq$ 8secs., $\tau_2 \leq$ 3secs;

$\frac{1}{1+\tau_3 S}$ is the function generated by the Lag compensator for measured ΔT;

τ_3 is the time constant utilized in the lag compensator for ΔT, $\tau_3 \leq$ 0secs;

ΔT_0 is loop specific indicated ΔT at RATED THERMAL POWER, °F;

K_1	Value specified in the COLR;
K_2	Value specified in the COLR;

$\frac{1+\tau_4 S}{1+\tau_5 S}$ is the function generated by the lead-lag compensator for T_{avg};

τ_4 and τ_5 are the time constants utilized in lead-lag compensator for T_{avg}, $\tau_4 \geq$ 30secs., $\tau_5 \leq$ 4secs;

TABLE 2.2-1 (Continued)
TABLE NOTATION (Continued)

NOTE 1: (continued)

T is measured Reactor Coolant System average temperature, °F;

$\frac{1}{1+\tau_6 S}$ is the function generated by the Lag compensator for T_{avg};

τ_6 is the time constant utilized in the Lag compensator for T_{avg}, $\tau_6 \leq 0$secs;

T' is Tavg at RATED THERMAL POWER, ≤576.2 °F;

K_3 Value specified in the COLR

P is measured pressurizer pressure, psia;

P' is nominal pressurizer pressure, ≥2250 psia;

S is the Laplace transform operator, $\sec^{-1}$;

And f(ΔI) is a function of the indicated difference between top and bottom detectors of the power range nuclear ion chambers as specified in the COLR.

NOTE 2:
The Overtemperature ΔT function Allowable Value shall not exceed the nominal Trip Setpoint by more than 0.5% ΔT span for the ΔT channel, 0.5% ΔT span for the Tavg channel, 0.5% ΔT span for the Pressurizer Pressure channel and 0.5% ΔT span for the f(ΔI) channel.

TABLE 2.2-1 (Continued)
TABLE NOTATION (Continued)

NOTE 3: OVERPOWER ΔT

$$\Delta T \frac{(1+\tau_1 S)}{(1+\tau_2 S)} \frac{(1)}{(1+\tau_3 S)} = \Delta T_0 \left\{ K_4 - K_5 \frac{(\tau_7 S)}{(1+\tau_7 S)} \frac{(1)}{(1+\tau_6 S)} T \quad - K_6 \left[T \frac{(1)}{(1+\tau_6 S)} - T'' \right] \Big] \right\}$$

Where: ΔT is measured Reactor Coolant System ΔT, °F;

$\frac{1+\tau_1 S}{1+\tau_2 S}$ is the function generated by the Lead-lag compensator for measured ΔT;

τ_1 and τ_2 are the time constants utilized in the lead-lag compensator for ΔT, $\tau_1 \geq 8$secs., $\tau_2 \leq 3$secs;

$\frac{1}{1+\tau_3 S}$ is the function generated by the Lag compensator for measured ΔT;

τ_3 is the time constant utilized in the lag compensator for ΔT, $\tau_3 \leq 0$s;

ΔT_0 is loop specific indicated ΔT at RATED THERMAL POWER, °F;

K_4	Value specified in the COLR;
K_5	Value specified in the COLR;

$\frac{\tau_7 S}{1+\tau_7 S}$ is the function generated by the rate-lag compensator for T_{avg},

τ_7 is the time constant utilized in rate-lag compensator for T_{avg}, $\tau_7 \geq 10$secs;

TABLE 2.2-1 (Continued)

TABLE NOTATION (Continued)

NOTE 3: (continued)

$\frac{1}{1+\tau_6 S}$ is the function generated by the Lag compensator for T_{avg};

τ_6 is the time constant utilized in the lag compensator for T_{avg}, $\tau_6 \leq 0$secs;

K_6 Value specified in the COLR;

T is measured Reactor Coolant System average temperature, °F;

T" is T_{avg} at RATED THERMAL POWER, ≤ 576.2°F;

S is the Laplace transform operator, sec^{-1};

NOTE 4: The Overpower ΔT function Allowable Value shall not exceed the nominal Trip Setpoint by more than 0.5% ΔT span for the ΔT channel and 0.5% ΔT span for the Tavg channel.

2.2 LIMITING SAFETY SYSTEM SETTINGS

BASES

2.2.1 REACTOR TRIP SYSTEM INSTRUMENTATION SETPOINTS

The Nominal Trip Setpoints specified in Table 2.2-1 are the nominal values at which the reactor trips are set for each functional unit. The Allowable Values (Nominal Trip Setpoints ± the calibration tolerance) are considered the Limiting Safety System Settings as identified in 10CFR50.36 and have been selected to ensure that the core and Reactor Coolant System are prevented from exceeding their safety limits during normal operation and design basis anticipated operational occurrences and to assist the Engineered Safety Features Actuation System in mitigating the consequences of accidents. The Setpoint for a Reactor Trip System or interlock function is considered to be consistent with the nominal value when the measured "as left" Setpoint is within the administratively controlled (±) calibration tolerance identified in plant procedures (which specifies the difference between the Allowable Value and Nominal Trip Setpoint). Additionally, the Nominal Trip Setpoints may be adjusted in the conservative direction provided the delta between the Nominal Trip Setpoint and the Allowable Value remains unchanged.

Measurement and Test Equipment accuracy is administratively controlled by plant procedures and is included in the plant uncertainty calculations. Operability determinations are based on the use of Measurement and Test Equipment that conforms with the accuracy used in the plant uncertainty calculation. Measurement and Test Equipment should be consistent with the requirements of ANSI / ISA 51.1-1979 or the most accurate practicable.

The Allowable Value specified in Table 2.2-1 is the initial value for consideration of channel operability. If the process rack bistable setting is measured within the "as left" calibration tolerance, which specifies the difference between the Allowable Value and Nominal Trip Setpoint, then the channel is considered to be operable. Additional administratively controlled limits for operability of a device are determined by device drift being less than the value required for the surveillance interval. In the event the device exceeds the administratively controlled limit, operability of the device may be evaluated by other device performance characteristics, e.g., comparison to historical device drift data, calibration characteristics, response characteristics and short term drift characteristics. A device (relay, transmitter, process rack module, etc.), whose "as found" value is in excess of the calibration tolerance, but within the additional operability criteria (administratively controlled limit), is considered operable but must be recalibrated such that the "as left" value is within the two sided (±) calibration tolerance. Plant procedures set administrative limits ("as left" and "as found" criteria) to control the determination of operability by setting minimum standards based on the setpoint methodology and the uncertainty values included in the determination of the Nominal Trip Setpoint, and allow the use of other device characteristics to evaluate operability. REPORTABLE EVENTS are identified when the minimum number of channels required to be operable are not met.

2.2.1 REACTOR TRIP SYSTEM INSTRUMENTATION SETPOINTS (Continued)

The setpoint methodology used to derive the Nominal Trip Setpoints is based upon combining all of the uncertainties in the channels. Inherent in the determination of the Nominal Trip Setpoints are the magnitudes of these channel uncertainties. Sensors and other instrumentation utilized in these channels should be capable of operating within the allowances of these uncertainty magnitudes. Occasional drift in excess of the allowance may be determined to be acceptable based on the other device performance characteristics. Device drift in excess of the allowance that is more than occasional may be indicative of more serious problems and would warrant further investigation.

The various reactor trip circuits automatically open the reactor trip breakers whenever a condition monitored by the Reactor Trip System reaches a preset or calculated level. In addition too redundant channels and trains, the design approach provides Reactor Trip System functional diversity. The functional capability at the specified trip setting is required for those anticipatory or diverse reactor trips for which no direct credit was assumed in the safety analysis to enhance the overall reliability of the Reactor Trip System. The Reactor Trip System initiates a turbine trip signal whenever reactor trip is initiated. This prevents the reactivity insertion that would otherwise result from excessive Reactor Coolant System cooldown and thus avoids unnecessary actuation of the Engineered Safety Features Actuation System.

The difference between T' (Overtemperature ΔT) or T" (Overpower ΔT) and the loop specific, indicated, full power Tavg shall be less than or equal to the Tavg allowances for such differences in the uncertainty calculations for these functions. In addition, T' and T" shall be less than or equal to the full power Tavg modeled in the safety analyses as an initial condition assumption, i.e., 576.2 °F for Unit 1 and Unit 2. In the event that the difference between a T' or T" set to 576.2 °F and a loop specific, indicated, full power Tavg is greater than the Tavg allowances for such differences in the uncertainty calculations, T' or T" shall be reduced until the difference allowances in the uncertainty calculations are satisfied, i.e., T' or T" are set to a loop specific, full power value less than 576.2 °F. These reductions in the values of T' and T" are consistent with the recommendations of Westinghouse Technical Bulletin ESBU-TB-96-07-R0, "Temperature Related Functions," 11/5/96.

3/4.3.2 ENGINEERED SAFETY FEATURES ACTUATION SYSTEM INSTRUMENTATION

LIMITING CONDITION FOR OPERATION

3.3.2 The Engineered Safety Features Actuation System (ESFAS) instrumentation channels and interlocks shown in Table 3.3-3 shall be OPERABLE.

APPLICABILITY: As shown in Table 3.3-3.

ACTION:

a. With an ESFAS Instrumentation Channel or Interlock Channel Nominal Trip Setpoint inconsistent with the value shown in the Nominal Trip Setpoint column of Table 3.3-4, adjust the Setpoint consistent with the Nominal Trip Setpoint value.(1)

b. With an ESFAS Instrumentation Channel or Interlock Channel found to be inoperable declare the channel inoperable and apply the applicable ACTION statement requirements of Table 3.3-3 until the channel is restored to OPERABLE status.

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(1) A trip setpoint may be set more conservative than the Nominal Trip Setpoint as necessary in response to plant conditions or revised analysis. Allowable Value(s) shall be adjusted accordingly.

TABLE 3.3-4
ENGINEERED SAFETY FEATURES ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

Functional Unit	Nominal Trip Setpoint	Allowable Value
1. Safety Injection, and Feedwater Isolation		
a. Manual Initiation	N.A.	N.A.
b. Automatic Actuation Logic and Actuation Relays	N.A.	N.A.
c. Containment Pressure - High	1.5 psig	≤ 1.8 psig
d. Pressurizer Pressure - Low	1856 psig	≥ 1852 psig
e. Steamline Pressure - Low	500 psig*	≥ 494 psig*
1.1 Safety Injection-Transfer from Injection to the Recirculation Mode		
a. Automatic Actuation Logic Coincident with Safety Injection Signal	N.A.	N.A.
b. Refueling Water Storage Tank Level-Extreme Low	38’0”	≥ 37’11”
2. Containment Spray		
a. Manual Initiation	N.A.	N.A.
b. Automatic Actuation Logic and Actuation Relays	N.A.	N.A.
c. Containment Pressure - High-High	8.0 psig	≤ 8.3 psig
3. Containment Isolation		
a. Phase "A" Isolation		
1) Manual Initiation	N.A.	N.A.

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*Time constants utilized in the lead-lag controllers for Steam Line Pressure-Low are $\tau_1 \geq 50$ seconds and $\tau_2 \leq 5$ seconds. CHANNEL CALIBRATION shall ensure that these time constants are adjusted to these values.

TABLE 3.3-4 (Continued)
ENGINEERED SAFETY FEATURES ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

Functional Unit	Nominal Trip Setpoint	Allowable Value
2) Automatic Actuation Logic and Actuation Relays	N.A.	N.A.
3) Safety Injection	See functional Unit 1 above for all Safety Injection Trip Setpoints and Allowable Values.	
b. Phase "B" Isolation		
1) Manual Initiation	N.A.	N.A.
2) Automatic Actuation Logic and Actuation Relays	N.A.	N.A.
3) Containment Pressure - High-High	8.0 psig	$\leq$ 8.3 psig
4. Steam Line Isolation		
a. Manual Initiation		
1. Individual	N.A.	N.A.
2. System	N.A.	N.A.
b. Automatic Actuation Logic and Actuation Relays	N.A.	N.A.
c. Containment Pressure - Intermediate - High-High	3.0 psig	$\leq$ 3.3 psig
d. Steamline Pressure - Low	500 psig*	$\geq$ 494 psig*
e. Steamline Pressure Rate - High Negative	100 psi with a time constant $\geq$ 50 seconds	$\leq$ 103.6 psi with a time constant $\geq$ 50 seconds
5. Turbine Trip and Feedwater Isolation		
a. Automatic Actuation Logic and Actuation Relays	N.A.	N.A.

---

*Time constants utilized in the lead-lag controllers for Steam Line Pressure-Low are $\tau_1 \geq 50$ seconds and $\tau_2 \leq 5$ seconds. CHANNEL CALIBRATION shall ensure that these time constants are adjusted to these values.

TABLE 3.3-4 (Continued)

ENGINEERED SAFETY FEATURES ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

Functional Unit	Nominal Trip Setpoint	Allowable Value
b. Steam Generator Water Level--High-High, P-14	80.6 % of narrow range instrument span	≤ 81.1 % of narrow range instrument span
c. Safety Injection	See Functional Unit 1 above for all safety Injection Trip Setpoints and Allowable Values.	
6. Loss of Power		
a. 1. 4.16 kV Emergency Bus Undervoltage (Trip Feed)	75% of nominal bus voltage with a 1 ± 0.1 second time delay	≥ 71.2% of nominal bus voltage with a 1 ± 0.1 second time delay
2. 4.16 kV Emergency Bus Undervoltage (Start Diesel)	75% of nominal bus voltage, 20 cycles ± 2 cycles	≥ 71.2% of nominal bus voltage, 20 cycles ± 2 cycles
b. 4.16 kV Emergency Bus (Degraded Voltage)	93.4% of nominal bus voltage with a 90 ± 5 second time delay	≥ 93.1% of nominal bus voltage with a 90 ± 5 second time delay
c. 480V Emergency Bus (Degraded Voltage)	93.4% of nominal bus voltage with a 90 ± 5 second time delay	≥ 93.1% of nominal bus voltage with a 90 ± 5 second time delay

TABLE 3.3-4 (Continued)
ENGINEERED SAFETY FEATURES ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

Functional Unit	Nominal Trip Setpoint	Allowable Value
7. Auxiliary Feedwater*		
a. Automatic Actuation Logic and Actuation Relays	N.A.	N.A.
b. Steam Generator Water Level - Low-Low		
1. Start Turbine Driven Pump	16.5% of narrow range instrument span	≥ 16% of narrow range instrument span
2. Start Motor Driven Pumps	16.5% of narrow range instrument span	≥ 16% of narrow range instrument span
c. Undervoltage – RCP (Start Turbine Driven Pump)	75% nominal RCP bus voltage	≥ 71.2% nominal RCP bus voltage
d. Safety Injection (start all auxiliary feedwater pumps)	See Item 1 above for all Safety Injection Trip Setpoints and Allowable Values.	
e. Trip of Main Feedwater Pumps (start motor driven pumps)	N.A.	N.A.
8. Engineered Safety Features Actuation System Interlocks		
a. Reactor Trip, P-4	N.A.	N.A.
b. Pressurizer Pressure, P-11	2000 psig	≤ 2004 psig
c. Low-Low Tavg, P-12	541°F	≥ 540.5°F

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*Manual initiation is included in specification 3.7.1.2

3/4.3 INSTRUMENTATION

BASES

3/4.3.1 and 3/4.3.2 REACTOR TRIP SYSTEM INSTRUMENTATION AND ENGINEERED SAFETY FEATURES ACTUATION SYSTEM INSTRUMENTATION

The OPERABILITY of the Reactor Trip System and the Engineered Safety Features Actuation System instrumentation and interlocks ensures that: (1) the associated action and/or Reactor trip will be initiated when the parameter monitored by each channel or combination thereof reaches its setpoint, (2) the specified coincidence logic is maintained, (3) sufficient redundancy is maintained to permit a channel to be out of service for testing or maintenance, and (4) sufficient system functional capability is available from diverse parameters.

The OPERABILITY of these systems is required to provide the overall reliability, redundancy, and diversity assumed available in the facility design for the protection and mitigation of accident and transient conditions. The integrated operation of each of these systems is consistent with the assumptions used in the safety analyses. The Surveillance Requirements specified for these systems ensure that the overall system functional capability is maintained comparable to the original design standards. The periodic surveillance tests performed at the minimum frequencies are sufficient to demonstrate this capability.

The Engineered Safety Features Actuation System Nominal Trip Setpoints specified in Table 3.3-4 are the nominal values at which the bistables are set for each functional unit. The Allowable Values (Nominal Trip Setpoints ± the calibration tolerance) are considered the Limiting Safety System Settings as identified in 10CFR50.36 and have been selected to mitigate the consequences of accidents. A Setpoint is considered to be consistent with the nominal value when the measured "as left" Setpoint is within the administratively controlled (±) calibration tolerance identified in plant procedures (which specifies the difference between the Allowable Value and Nominal Trip Setpoint). Additionally, the Nominal Trip Setpoints may be adjusted in the conservative direction provided the delta between the Nominal Trip Setpoint and the Allowable Value remains unchanged.

Measurement and Test Equipment accuracy is administratively controlled by plant procedures and is included in the plant uncertainty calculations. Operability determinations are based on the use of Measurement and Test Equipment that conforms with the accuracy used in the plant uncertainty calculation. Measurement and Test Equipment should be consistent with the requirements of ANSI / ISA 51.1-1979 or the most accurate practicable.

The Allowable Value specified in Table 3.3-4 is the initial value for consideration of channel operability. If the process rack bistable setting is measured within the "as left" calibration tolerance, which specifies the difference between the Allowable Value and Nominal Trip Setpoint, then the channel is considered to be operable. Additional administratively controlled limits for operability of a device are determined by device drift being less than the value required

3/4.3.1 and 3/4.3.2 REACTOR TRIP SYSTEM INSTRUMENTATION AND ENGINEERED SAFETY FEATURES ACTUATION SYSTEM INSTRUMENTATION (continued)

for the surveillance interval. In the event the device exceeds the administratively controlled limit, operability of the device may be evaluated by other device performance characteristics, e.g., comparison to historical device drift data, calibration characteristics, response characteristics and short term drift characteristics. A device (relay, transmitter, process rack module, etc.), whose "as found" value is in excess of the calibration tolerance, but within the additional operability criteria (administratively controlled limit), is considered operable but must be recalibrated such that the "as left" value is within the two sided (±) calibration tolerance. Plant procedures set administrative limits ("as left" and "as found" criteria) to control the determination of operability by setting minimum standards based on the setpoint methodology and the uncertainty values included in the determination of the Nominal Trip Setpoint, and allow the use of other device characteristics to evaluate operability. REPORTABLE EVENTS are identified when the minimum number of channels required to be operable are not met.

The setpoint methodology, used to derive the Nominal Trip Setpoints, is based upon combining all of the uncertainties in the channels. Inherent in the determination of the Nominal Trip Setpoints are the magnitudes of these channel uncertainties. Sensors and other instrumentation utilized in these channels should be capable of operating within the allowances of these uncertainty magnitudes. Occasional drift in excess of the allowance may be determined to be acceptable based on the other device performance characteristics. Device drift in excess of the allowance that is more than occasional, may be indicative of more serious problems and would warrant further investigation.

Specified surveillance intervals and surveillance and maintenance outage times have been determined in accordance with WCAP-10271, "Evaluation of Surveillance Frequencies and Out of Service Times for the Reactor Protection Instrumentation System," and supplements to that report as approved by the NRC and documented in the SER (letter to J. J. Sheppard from Cecil O. Thomas dated February 21, 1985). Jumpers and lifted leads are not an acceptable method for placing equipment in bypass as documented in the NRC safety evaluation report for this WCAP.