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WESTINGHOUSE SETPOINT METHODOLOGY FOR PROTECTION SYSTEMS DIABLO CANYON STATIONS EAGLE 21 VERSION

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1.0 INTRODUCTION

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

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

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

Section 4.0 notes what the current Standard Technical Specifications use for setpoints and an explanation of the impact of the Westinghouse approach on them. Detailed examples of how to determine the Technical Specification setpoint values are also provided. An Appendix is provided noting a recommended set of Technical Specifications using the plant specific data in the Westinghouse approach.

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2.0 COMBINATION OF ERROR COMPONENTS

2.1 METHODOLOGY

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

The methodology used is the "square root of the sum of the squares" which has been utilized in other Westinghouse reports. This technique, or others of a similar nature, have 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 ANSI, American Nuclear Society, and Instrument Society of America standards approve the use of probabilistic and statistical techniques in determining safety-related setpoints[3][4]. The methodology used in this report is essentially the same as that used for V. C. Summer in August, 1982; approved in NUREG-0717, Supplement No. 4[5].

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

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

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

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

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

(4) ISA Standard S67.04, 1982, "Setpoints for Nuclear Safety-Related Instrumentation Used in Nuclear Power Plants."

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

where:

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

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

As can be seen in Equation 2.1, drift and calibration accuracy allowances are interactive and thus not independent. The environmental allowance is not necessarily considered interactive with all other parameters, but as an additional degree of conservatism is added to the statistical sum. It should be noted that for this document, if the effect on accuracy for a channel due to cable insulation resistance degradation in an accident environment is less than 0.1 percent of span, the magnitude of impact is considered negligible and is not factored into the calculations. For those channels for which this effect is identified to be in excess of 0.1 percent of span, the error is directly added as a bias.

For selected channels the Westinghouse setpoint methodology for Diablo Canyon results in a value with a 95 percent probability. Analog Rack Drift is assumed based on a survey of reported plant LERs, and Digital Rack Drift is based on system design. Process Measurement Accuracy terms are considered to be conservative values. All cable insulation resistance degradation terms and M&TE values were specified by Pacific Gas & Electric. The transmitter Environmental Allowance term and reference leg heatup error for steam generator level were developed by and are solely the responsibility of Pacific Gas & Electric.

2.2 SENSOR ALLOWANCES

Five parameters are considered to be sensor allowances: SCA, SMTE, SD, STE, and SPE (see Table 3-20). Of these parameters, two are considered to be statistically independent (STE and SPE), and three are considered interactive (SCA, SMTE and SD). STE and SPE are considered to be independent due to the manner in which the instrumentation is checked; i.e., the instrumentation is calibrated and drift determined under conditions in which pressure and temperature are assumed constant. An example of this would be as follows. Assume a sensor is placed in some position in the containment during a refueling outage. After placement, an instrument technician calibrates the sensor. This calibration is performed at ambient pressure and temperature conditions. Some time later with the plant shutdown, an instrument technician checks for sensor drift. Using the same technique as for calibrating the sensor, the technician determines if the sensor has drifted. The conditions under which this determination is made are again at ambient pressure and temperature. Thus the temperature and pressure have no impact on the drift determination and are, therefore, independent of the drift allowance.

SCA, SMTE and SD are considered to be interactive for the same reason that STE and SPE are considered independent; i.e., due to the manner in which the instrumentation is checked. Instrumentation calibration techniques use the same process as determining instrument drift. That is, the end result of the two is the same. When calibrating a sensor, the sensor output is checked to determine if it is accurately representing the input. The same is performed for a determination of the sensor drift. Thus unless "as left/as found" data is recorded and used, it is impossible to determine the differences between calibration errors and drift when a sensor is checked the second or any subsequent time. Based on this reasoning, SCA, SMTE and SD have been added to form an independent group which is then factored into Equation 2.1. A hypothetical example of the impact of this treatment for a level transmitter is (sensor parameters only):

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

excerpting the sensor portion of Equation 2.1 results in;

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

- or -

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

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

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

- or -

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

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

2.3 RACK ALLOWANCES

Five parameters, as noted by Table 3-20, are considered to be rack allowances: RCA, RMTE, RCSA, RTE, and RD. Four of these parameters (RCA, RMTE, RCSA, and RD) are considered to be interactive for much the same reason outlined for sensors in Section 2.2. When calibrating or determining drift in the racks for a specific channel, the processes are performed at essentially constant temperature; i.e., ambient temperature. Because of this, the RTE parameter is considered to be independent of any factors for calibration or drift. However, the same cannot be said for the other rack parameters. As noted in Section 2.2, when calibrating or determining drift for a channel, the same end result is desired; that is, the point at which the bistable changes state. After initial calibration, without recording and using "as left/as found" data, it is not possible to distinguish the difference between a calibration error, rack drift or a comparator setting error. Based on this logic, these factors have been added to form an independent group. This group is then factored into Equation 2.1. The impact of this approach (formation of an independent group based on interactive components) is significant. For the hypothetical example of a level transmitter channel, using the same approach outlined in Equations 2.1 and 2.2 results in the following:

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

excerpting the rack portion of Equation 2.1 results in;

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

- or -

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

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

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

- or -

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

Thus, the use of Equation 2.1 is more conservative for rack effects as well as for sensor effects. Similar results, with different magnitudes, would be arrived at using digital process rack uncertainties.

2.4 PROCESS ALLOWANCES

Finally, the PMA and PEA parameters are considered to be independent of both sensor and rack parameters. PMA provides allowances for the non-instrument related effects; e.g., neutron flux, calorimetric power error assumptions, fluid density changes, and temperature stratification assumptions. PMA may consist of more than one independent error allowance. PEA accounts for errors due to metering devices, such as elbows and venturis. Thus, these parameters have been factored into Equation 2.1 as independent quantities.

2.5 MEASUREMENT AND TEST EQUIPMENT ACCURACY

Westinghouse was informed by Pacific Gas & Electric that the equipment used for calibration and functional testing of the transmitters does not meet SAMA standard PMC 20.1-1973 with regards to allowed exclusion from the calculation(1). This standard implies that test equipment without an accuracy of 10 percent or less of the calibration accuracy is required to be included in the uncertainty calculations of Equations 2.1 and 3.1. Based on information provided by Pacific Gas & Electric, the test equipment used for sensor calibration has an uncertainty equal to the sensor calibration accuracy. These uncertainties were included in the calculations, as noted on the tables included in this report. Pacific Gas & Electric indicated that the rack calibration and test equipment does meet the SAMA standard, and therefore the RMTE terms are taken to be zero. On Table 3-20, the values for SMTE and RMTE are specifically identified.

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

3.0 PROTECTION SYSTEM SETPOINT METHODOLOGY

3.1 MARGIN CALCULATION

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

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

where:

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

all other parameters make up the Channel Statistical Allowance (CSA) and are as defined for Equation 2.1.

Again, please note that Equation 3.1 is representative for a channel with analog process racks. Use of digital process racks results in deletion of the RCSA term. The magnitudes of the remaining rack terms are typically different for digital process racks when compared to typical values for analog process racks.

Tables 3-1 through 3-18 provide individual component uncertainties and CSA calculations for all protection functions. Table 3-19 lists the channel designators, transmitter types, and calibrated spans used in the evaluations of the channels. Table 3-20 provides a summary of Tables 3-1 through 3-18, and includes Safety Analysis and Technical Specification values, Total Allowance and Margin. Westinghouse typically reports values in these tables to one decimal place using the conventional technique of rounding down numbers less than 5 and rounding up numbers greater than or equal to 5. Parameters reported in Tables 3-1 through 3-20 as "0.0" have been identified as having a value of ≤0.04. Parameters reported as "0" or "---" in the tables are not present (i.e., have no value) for that channel.

3.2 DEFINITIONS FOR PROTECTION SYSTEM SETPOINT TOLERANCES

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

- A/D

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

- Allowable Value

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

- As Found

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

- As Left

The condition in which a transmitter, process rack module or process instrument loop is left after calibration or bistable trip setpoint verification. This condition is better than the calibration accuracy for that piece of equipment. For example, the permitted calibration accuracy for a transmitter may be ±0.5% of span, while the worst measured deviation from the ideal condition after calibration is +0.1% span. 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 +0.1% span.

■ Channel

The sensing and process equipment, i.e., transmitter to bistable (analog function) or transmitter to CPU trip output (digital function), for one input to the voting logic of a protection function. Westinghouse designs protection functions with voting logic made up of multiple channels, e.g. 2/4 Steam Generator Level - Low-Low channels must have bistables in the tripped condition for a Reactor Trip to be initiated.

■ Channel Statistical Allowance (CSA)

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

■ Environmental Allowance (EA)

The change in a process signal (transmitter or process rack output) due to adverse environmental conditions from a limiting accident condition. Typically this value is determined from a conservative set of enveloping conditions and may represent the following:

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

■ Margin

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

- Nominal Trip Setpoint (NTS)

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

- Normalization

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

- Primary Element Accuracy (PEA)

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

- Process Loop (Instrument Process Loop)

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

- Process Measurement Accuracy (PMA)

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

- Process Racks

The analog or digital modules downstream of the transmitter or sensing device, which condition a signal and act upon it prior to input to a voting logic system. For Westinghouse process systems, this includes all the equipment contained in the process equipment cabinets, e.g., conversion resistor, transmitter power supply, R/E, lead/lag, rate, lag functions, function generator, summator, control/protection isolator, and bistable for analog functions; conversion resistor, transmitter power supply, signal conditioning-A/D converter and CPU for digital functions. The go/no go signal generated by the bistable is the output of the last module in the analog process rack instrument loop and is the input to the voting logic. The CPU trip output signal is the input to the voting logic from a digital system.

- R/E

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

- R/I

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

- Rack Calibration Accuracy (RCA)

The reference (calibration) accuracy, as defined by SAMA Standard PMC 20.1-1973[1] for a process loop string. Inherent in this definition is the verification of the following under a reference set of conditions; 1) conformity[2], 2) hysteresis[3] and 3) repeatability[4]. The test procedure from which these parameters are determined is identified as part of the SAMA standard. The Westinghouse definition of a process loop includes all modules in a specific channel. Also it is assumed that the individual modules are calibrated to a particular tolerance and that the process loop as a string is verified to be calibrated to a specific tolerance. The tolerance for the string is typically less than the arithmetic sum or SRSS of the individual module tolerances. This forces calibration of the process loop without a systematic bias in the individual module calibrations, i.e., as left values for individual modules must be compensating in sign and magnitude.

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

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

- Rack Comparator Setting Accuracy (RCSA)

The reference (calibration) accuracy, as defined by SAMA Standard PMC 20.1-1973[1] of the instrument loop comparator (bistable). Inherent in this definition is the verification of the following under a reference set of conditions; 1) conformity[2], 2) hysteresis[3] and 3) repeatability[4]. The test procedure from which these parameters are determined is identified as part of the SAMA standard. For a single input bistable (fixed setpoint) the typical calibration tolerance is [ ]+a,c. This assumes that comparator nonlinearities are compensated by the setpoint. For a dual input bistable (floating setpoint) the typical calibration tolerance is [ ]+a,c. This allows for nonlinearities between the two inputs. In many plants calibration of the bistable is included as an integral part of the rack calibration, i.e., string calibration. Westinghouse supplied digital channels do not have an electronic comparator, therefore no uncertainty is included for this term for these channels.

- Rack Drift (RD)

The change in input-output relationship over a period of time at reference conditions, e.g., at constant temperature. Typical values assumed for this parameter are ±1.0% span for 30 days for analog channels and [ ]+a,c for 90 days for digital channels. An example of RD is: for an "as found" value of -0.5% span and an "as left" value of +0.1% span, the magnitude of the drift would be [(+0.1) - (-0.5) = 0.6% span] in the negative 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 PMC 20.1-1973[5] it is considered an integral part of RCA. Magnitudes in excess of the 10:1 limit are explicitly included in Westinghouse calculations.

- Rack Temperature Effects (RTE)

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

■ Range

The upper and lower limits of the operating region for a device, e.g., for a Pressurizer Pressure transmitter, 0 to 3000 psig, for Steam Generator Level, 0 to 150 inches of water column. This is not necessarily the calibrated span of the device, although quite often the two are close. For further information see SAMA PMC 20.1-1973[6].

■ Safety Analysis Limit (SAL)

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

■ Sensor Calibration Accuracy (SCA)

The reference (calibration) accuracy for a sensor or transmitter as defined by SAMA Standard PMC 20.1-1973[1]. Inherent in this definition is the verification of the following under a reference set of conditions; 1) conformity[2], 2) hysteresis[3] and 3) repeatability[4]. The test procedure from which these parameters are determined is identified as part of the SAMA standard. For Westinghouse supplied transmitters, this accuracy is typically [ ]$^{+a,c}$. Utilizing Westinghouse recommendations for RTD cross-calibration, this accuracy is typically [ ]$^{+a,c}$ for the Hot Leg and Cold Leg RTDs.

■ Sensor Drift (SD)

The change in input-output relationship over a period of time at reference calibration conditions, e.g., at constant temperature. Typical allowance for a Westinghouse supplied transmitter is [ ]$^{+a,c}$ for 18 calendar months. Specific calculations for Rosemount transmitters reflect model and range code requirements. An example of SD is: for an "as found" value of +0.5% span and an "as left" value of +0.1% span, the magnitude of the drift would be [(+0.5) - (+0.1) = 0.4% 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 SAMA PMC 20.1-1973[5] it is considered an integral part of SCA. Magnitudes in excess of the 10:1 limit are explicitly included in Westinghouse calculations.

- Sensor Pressure Effects (SPE)

The change in input-output relationship due to a change in the static head pressure from the calibration conditions (if calibration is performed at line pressure) or the accuracy to which a correction factor is introduced for the difference between calibration and operating conditions for a Δp transmitter. For Westinghouse supplied transmitters, a typical SPE value is [ ]+a,c with an allowance of [ ]+a,c variance from calibration conditions (if performed at line pressure). If a correction is introduced, e.g., for calibration at atmospheric pressure conditions, it is assumed the correction factor is introduced with an accuracy of [ ]+a,c. Specific calculations for Rosemount transmitters reflect model and range code requirements.

- Sensor Temperature Effects (STE)

The change in input-output relationship due to a change in the ambient environmental conditions (temperature, humidity, voltage and frequency) from the reference calibration conditions. It has been determined that temperature is the most significant, with the other parameters being second order effects. For Westinghouse supplied transmitters, the temperature effect is typically [ ]+a,c with a maximum assumed change of 50 °F (or an STE value of [ ]+a,c. Specific calculations for Rosemount transmitters reflect model and range code requirements. It is assumed that calibration is performed at a nominal ambient temperature of +70 °F with an upper extreme of

+120 °F and a lower extreme of +40 °F. For specific devices, a maximum temperature of +130 °F is acceptable, which then requires a calibration temperature of greater than or equal to +80 °F.

■ Span

The region for which a device is calibrated and verified to be operable, e.g., for a Pressurizer Pressure transmitter, 1250 psig, for Steam Generator Level, 106 inches of water column. For Pressurizer Pressure, considerable suppression of the zero and turndown of the operating range is exhibited.

■ SRSS

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

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

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

■ Total Allowance (TA)

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

■ *NIS Power Range Neutron Flux - High*

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

If the instrument span = 120% RTP, then

TA = (9% RTP)(100% span)/(120% RTP) = 7.5% span

■ *Pressurizer Pressure - Low*

SAL	1845 psig
NTS	- 1950 psig
TA	105 psig

If the instrument span = 1250 psig, then

TA = (105 psig)(100% span)/(1250 psig) = 8.4% span

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

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

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

3.4 REFERENCES / STANDARDS

[1] Scientific Apparatus Makers Association Standard PMC 20.1-1973, "Process Measurement & Control Terminology", p 4, 1973.

[2] Ibid, p 5.

[3] Ibid, p 19.

[4] Ibid, p 28.

[5] Ibid, p 36.

[6] Ibid, p 27.

[7] Instrument Society of America Standard S67.04-1987, "Setpoints for Nuclear Safety-Related Instrumentation", p 12, 1987.

[8] Instrument Society of America Standard S51.1-1979, "Process Instrumentation Terminology", p 6, 1979.

[9] Ibid, p 8.

[10] Ibid, p 20.

[11] Ibid, p 27.

[12] Ibid, p 33.

[13] Ibid, p 25.

3.5 METHODOLOGY CONCLUSION

For selected channels the Westinghouse setpoint methodology results in a value with a 95 percent probability. Analog Rack Drift is assumed based on a survey of reported plant LERs and digital Rack Drift is based on system design. Process Measurement Accuracy terms are considered to be conservative values. All cable insulation resistance degradation terms and M&TE values were specified by Pacific Gas & Electric. The transmitter Environmental Allowance term and reference leg heatup error for steam generator level were developed by and are solely the responsibility of Pacific Gas & Electric.

TABLE 3-1

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

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

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* In percent span (120% Rated Thermal Power)
** Not processed by Eagle-21 racks.

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-2

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

Parameter **Allowance***

+a,c

Process Measurement Accuracy

[ ]+a,c

Primary Element Accuracy

Sensor Calibration

[ ]+a,c

Sensor Pressure Effects

Sensor Temperature Effects

[ ]+a,c

Sensor Drift

[ ]+a,c

Environmental Allowance

Rack Calibration

Rack Measurement & Test Equipment Accuracy

Comparator
One input

Rack Temperature Effects

Rack Drift

---

* In percent span (120% Rated Thermal Power)
** Not processed by Eagle-21 racks.

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-3

INTERMEDIATE RANGE, NEUTRON FLUX**

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

* In percent span (conservatively assumed to be 120% Rated Thermal Power)
** Not processed by Eagle-21 racks.

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-4

SOURCE RANGE, NEUTRON FLUX**

Parameter	Allowance*
Process Measurement Accuracy	[ ]+a,c
[ ]+a,c	
Primary Element Accuracy	
Sensor Calibration	
[ ]+a,c	
Sensor Pressure Effects	
Sensor Temperature Effects	
[ ]+a,c	
Sensor Drift	
[ ]+a,c	
Environmental Allowance	
Rack Calibration	
Rack Measurement & Test Equipment Accuracy	
Comparator One input	
Rack Temperature Effects	
Rack Drift 3×10^4 cps	

* In % span (1×10^6 cps)
** Not processed by Eagle-21 racks.

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-5

OVERTEMPERATURE ΔT

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

Process Measurement Accuracy

[ ] [+a,c]

Primary Element Accuracy

Sensor Calibration

[ ] [+a,c]

Sensor Measurement & Test Equipment Accuracy

[ ] [+a,c]

Sensor Pressure Effects

Sensor Temperature Effects

[Pressure - ±(0.7% of pressure span)**] [+a,c]

Sensor Drift

[ ] [+a,c]

Environmental Allowance

Rack Calibration

[ ] [+a,c]

Rack Measurement & Test Equipment Accuracy

ΔT

Pressure

ΔI

TABLE 3-5 (Continued)

OVERTEMPERATURE ΔT

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

Rack Temperature Effects

+a,c

Rack Drift

+a,c

---

* In percent ΔT span (96.6°F in Unit 1, 97.5°F in Unit 2)
** See Table 3-21 for gain and conversion calculations
\# Number of Hot Leg RTDs used
\## Number of Cold Leg RTDs used

Channel Statistical Allowance =

+a,c

TABLE 3-6

OVERPOWER ΔT

Parameter	Allowance*
Process Measurement Accuracy	[ ]+a,c
[ ]+a,c	
Primary Element Accuracy	
Sensor Calibration	
[ ]+a,c	
Sensor Pressure Effects	
Sensor Temperature Effects	
Sensor Drift	
[ ]+a,c	
Environmental Allowance	
Cable IR Degradation (Provided by PG&E)	
Rack Calibration	
[ ]+a,c	
Measurement & Test Equipment Accuracy	
ΔT	
Rack Temperature Effects	
[ ]+a,c	
Rack Drift	
[ ]+a,c	

* In percent ΔT span (96.6°F in Unit 1, 97.5°F in Unit 2)
** See Table 3-22 for gain calculations
\# Number of Hot Leg RTDs used
\#\# Number of Cold Leg RTDs used

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-7

PRESSURIZER PRESSURE - LOW AND HIGH REACTOR TRIP

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

* In % span (1250 psi)

Channel Statistical Allowance =

+a,c

TABLE 3-8

PRESSURIZER WATER LEVEL - HIGH

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

* In % span (100% span)

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-9

LOSS OF FLOW

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

* In % flow span (120% Thermal Design Flow). Percent ΔP span converted to flow span via Equation 3-23.8, with F_{max} = 120% and F_N = 100%

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-10

STEAM GENERATOR WATER LEVEL - LOW-LOW

Parameter	Allowance*
	+a,c
Process Measurement Accuracy +a,c	
Primary Element Accuracy	
Sensor Calibration	
Sensor Measurement & Test Equipment Accuracy	
Sensor Pressure Effects	
Sensor Temperature Effects	
Sensor Drift	
Environmental Allowance Transmitter (Provided by PG&E) Reference Leg Heatup (Provided by PG&E) Cable IR Degradation (Provided by PG&E)	
Rack Calibration	
Rack Measurement & Test Equipment Accuracy	
Rack Temperature Effects	
Rack Drift	

* In % span (100% span)

Channel Statistical Allowance =

+a,c

TABLE 3-11

UNDERVOLTAGE**

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

* In % span (8000 VAC)
** Not processed by Eagle-21 racks

Channel Statistical Allowance =

[ ] +a,c

TABLE 3-12

UNDERFREQUENCY**

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

* In % span (8 Hertz)
** Not processed by Eagle-21 racks

Channel Statistical Allowance =

+a,c

TABLE 3-13

CONTAINMENT PRESSURE - HIGH, HIGH-HIGH

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

* In % span (60 psi)

Channel Statistical Allowance =

[ ] +a,c

TABLE 3-14

PRESSURIZER PRESSURE - LOW, SAFETY INJECTION

Parameter	Allowance*
	+a,c
Process Measurement Accuracy	
Primary Element Accuracy	
Sensor Calibration	
Sensor Measurement & Test Equipment Accuracy	
Sensor Pressure Effects	
Sensor Temperature Effects	
Sensor Drift	
Environmental Allowance Transmitter Cable IR Degradation (Provided by PG&E)	
Rack Calibration	
Rack Measurement & Test Equipment Accuracy	
Rack Temperature Effects	
Rack Drift	

* In % span (1250 psi)

Channel Statistical Allowance =

[ ] +a,c

TABLE 3-15

STEAMLINE PRESSURE - LOW

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

* In % span (1200 psi)

Channel Statistical Allowance =

[ ] +a,c

TABLE 3-16

NEGATIVE STEAMLINE PRESSURE RATE - HIGH

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

* In % span (1200 psi)

Channel Statistical Allowance =

[ ] +a,c

TABLE 3-17

STEAM GENERATOR WATER LEVEL - HIGH-HIGH

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

* In % span (100% span)

Channel Statistical Allowance =

[ ] +a,c

TABLE 3-18

RCS LOOP ΔT EQUIVALENT TO POWER

Parameter **Allowance***

[ ]+a,c

Process Measurement Accuracy

[ ]+a,c

Primary Element Accuracy

Sensor Calibration

[ ]+a,c

Sensor Pressure Effects

Sensor Temperature Effects

Sensor Drift

[ ]+a,c

Environmental Allowance

Cable IR Degradation (Provided by PG&E)

Rack Calibration

[ ]+a,c

Measurement & Test Equipment Accuracy

ΔT

Rack Temperature Effects

[ ]+a,c

Rack Drift

[ ]+a,c

---

* In percent span (150% RTP, 96.6°F ΔT in Unit 1 and 97.5°F ΔT in Unit 2)

** See Table 3-22 for gain calculations

\# Number of Hot Leg RTDs used

\#\# Number of Cold Leg RTDs used

Channel Statistical Allowance =

[ ]+a,c

TABLE 3-19

CHANNEL DESCRIPTIONS

Parameter	Channel No.	UNIT 1 Transmitter Type	UNIT 1 Calibrated Span	UNIT 2 Transmitter Type	UNIT 2 Calibrated Span
ΔT and Tavg	T-411	RTD-Weed	150% of	RTD-Weed	150% of
	T-421	RTD-Weed	Vessel ΔT	RTD-Weed	Vessel ΔT
	T-431	RTD-Weed	at RTP	RTD-Weed	at RTP
	T-441	RTD-Weed		RTD-Weed	
Pressurizer Pressure	P-455	R-1154SH9	1250 psi	R-1154SH9	1250 psi
	P-456	R-1154SH9	1250 psi	R-1154SH9	1250 psi
	P-457	R-1154SH9	1250 psi	R-1154SH9	1250 psi
	P-474	R-1154SH9	1250 psi	R-1154SH9	1250 psi
Pressurizer Water Level	L-459	R-1153HD5	260.6 inwc	R-1153HD5	256.4 inwc
	L-460	R-1153HD5*	250.7 inwc	R-1153HD5	256.9 inwc
	L-461	R-1153HD5	260.7 inwc	R-1153HD5	256.5 inwc
Reactor Coolant Flow	F-414	B-764	405.1 inwc	R-1153HD5	402.3 inwc
	F-424	B-764	393.5 inwc	B-764	402.0 inwc
	F-434	B-764	419.0 inwc	R-1153DD5	413.1 inwc
	F-444	B-764	415.2 inwc	B-764	398.1 inwc
	F-415	B-764	435.0 inwc	R-1153HD5	431.2 inwc
	F-425	B-764	408.3 inwc	B-764	409.4 inwc
	F-435	B-764	443.7 inwc	B-764	477.8 inwc
	F-445	B-764	440.1 inwc	B-764	432.5 inwc
	F-416	B-764	418.4 inwc	B-764	395.4 inwc
	F-426	B-764	395.1 inwc	R-1153HD5*	399.9 inwc
	F-436	B-764	430.5 inwc	B-764	429.6 inwc
	F-446	B-764	446.2 inwc	B-764	401.8 inwc

TABLE 3-19 (continued)
CHANNEL DESCRIPTIONS

Parameter	Channel No.	UNIT 1 Transmitter Type	UNIT 1 Calibrated Span	UNIT 2 Transmitter Type	UNIT 2 Calibrated Span
Steam Generator Water Level	L-529	R-1154DP4	106.0 inwc	R-1154DP4	106.0 inwc
	L-539	R-1154DP4	106.0 inwc	R-1154DP4	106.0 inwc
	L-519	R-1154DP4	106.0 inwc	R-1154DP4	106.0 inwc
	L-549	R-1154DP4	106.0 inwc	R-1154DP4	106.0 inwc
	L-518	R-1154DP4	106.0 inwc	R-1154DP4	106.0 inwc
	L-528	R-1154DP4	106.0 inwc	R-1154DP4	106.0 inwc
	L-538	R-1154DP4	106.0 inwc	R-1154DP4	106.0 inwc
	L-548	R-1154DP4	106.0 inwc	R-1154DP4	106.0 inwc
	L-517	R-1154DP4	106.0 inwc	R-1154DP4	106.0 inwc
	L-527	R-1154DP4	106.0 inwc	R-1154DP4	106.0 inwc
	L-537	R-1154DP4	106.0 inwc	R-1154DP4	106.0 inwc
	L-547	R-1154DP4	106.0 inwc	R-1154DP4	106.0 inwc
Containment Pressure	P-937	B-332/351	60 psig	B-332/351	60 psig
	P-936	B-332/351	60 psig	B-332/351	60 psig
	P-935	B-332/351	60 psig	B-332/351	60 psig
	P-934	B-332/351	60 psig	B-332/351	60 psig
Steam Pressure	P-514	B-763*	1200 psig	B-763	1200 psig
	P-515	R-1154SH9	1200 psig	B-763	1200 psig
	P-516	B-763	1200 psig	B-763	1200 psig
	P-524	B-763	1200 psig	B-763	1200 psig
	P-525	B-763	1200 psig	B-763	1200 psig
	P-526	B-763	1200 psig	B-763	1200 psig
	P-534	B-763	1200 psig	B-763	1200 psig
	P-535	B-763	1200 psig	B-763	1200 psig
	P-536	B-763	1200 psig	B-763	1200 psig
	P-544	B-763	1200 psig	B-763	1200 psig
	P-545	B-763	1200 psig	B-763	1200 psig
	P-546	B-763	1200 psig	B-763	1200 psig

* Indicates Channel Evaluated (Most Conservative Case).

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TABLE 3-20
REACTOR PROTECTION SYSTEM/ENGINEERED SAFETY FEATURES ACTUATION SYSTEM CHANNEL ERROR ALLOWANCES
DIABLO CANYON

		SENSOR								INSTRUMENT RACK											
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
	PROTECTION CHANNEL	PROCESS MEASUREMENT ACCURACY (1)	PRIMARY ELEMENT ACCURACY (1)	CALIBRATION ACCURACY (1)	MEASUREMENT & TEST EQUIPMENT ACCURACY (1)	PRESSURE EFFECTS (1)	TEMPERATURE EFFECTS (1)	DRIFT (1)	ENVIRON-MENTAL ALLOWANCE (1)	CALIBRATION ACCURACY (1)	MEASUREMENT & TEST EQUIPMENT ACCURACY (1)	COMPARATOR SETTING ACCURACY (1)	TEMPERATURE EFFECTS (1)	DRIFT (1)	SAFETY ANALYSIS LIMIT (2)	ALLOWABLE VALUE (3)	TRIP SETPOINT (4)	TOTAL ALLOWANCE (1)	CHANNEL STATISTICAL ALLOWANCE (1)	MARGIN (1)	
1	POWER RANGE, NEUTRON FLUX - HIGH SETPOINT														118% RTP	111.1% RTP	109% RTP				1
2	POWER RANGE, NEUTRON FLUX - LOW SETPOINT														35% RTP	27.1% RTP	25% RTP				2
3	POWER RANGE, NEUTRON FLUX - HIGH POSITIVE RATE														(9)	6.5% RTP/2 SEC	5.0% RTP/2 SEC				3
4	POWER RANGE, NEUTRON FLUX - HIGH NEGATIVE RATE														(9)	6.5% RTP/2 SEC	5.0% RTP/2 SEC				4
5	INTERMEDIATE RANGE, NEUTRON FLUX														(9)	30.9% RTP	25% RTP				5
6	SOURCE RANGE, NEUTRON FLUX														(9)	1.4E+5 CPS	1.0E+5 CPS				6
7	OVERTEMPERATURE ΔT - ΔT CHANNEL Tavg CHANNEL PRESSURIZER PRESSURE CHANNEL ΔI CHANNEL														FUNCTION (16)	FUNCTION (17) +1.0% ΔT SPAN	FUNCTION (17)				7
8	OVERPOWER ΔT - ΔT CHANNEL Tavg CHANNEL														FUNCTION (16)	FUNCTION (17) +1.0% ΔT SPAN	FUNCTION (17)				8
9	PRESSURIZER PRESSURE - LOW, REACTOR TRIP														1845 PSIG	1944.4 PSIG	1950 PSIG				9
10	PRESSURIZER PRESSURE - HIGH														2445 PSIG	2390.6 PSIG	2385 PSIG				10
11	PRESSURIZER WATER LEVEL - HIGH														(9)	92.5% SPAN	92% SPAN				11
12	LOSS OF FLOW														87% FLOW	89.7% FLOW	90% FLOW				12
13	STEAM GENERATOR WATER LEVEL - LOW-LOW														0% SPAN	6.8% SPAN	7.2% SPAN				13
14	UNDERVOLTAGE - RCP														(9)	7730.0 VAC	8050 VAC				14
15	UNDERFREQUENCY - RCP														53.9 HZ	53.9 HZ	54.0 HZ				15
16	CONTAINMENT PRESSURE - HIGH														5.0 PSIG	3.3 PSIG	3.0 PSIG				16
17	CONTAINMENT PRESSURE - HIGH-HIGH														26.7 PSIG	22.3 PSIG	22.0 PSIG				17
18	PRESSURIZER PRESSURE - LOW, SI														1630 PSIG	1844.4 PSIG	1850 PSIG				18
19	STEAMLINE PRESSURE - LOW														444.0 PSIG	594.6 PSIG	600 PSIG				19
20	NEGATIVE STEAMLINE PRESSURE RATE - HIGH														(9)	-105.4 PSI/SEC	-100 PSI/SEC				20
21	STEAM GENERATOR WATER LEVEL - HIGH-HIGH														82% SPAN	75.5% SPAN	75% SPAN				21
22	RCS LOOP ΔT EQUIVALENT TO POWER - ΔT CHANNEL Tavg CHANNEL														59% RTP	51.5% RTP	50% RTP				22

NOTES:

1. ALL VALUES IN PERCENT OF SPAN.
2. AS NOTED IN SECTION 15.1 OF THE UPDATED FSAR.
3. AS CALCULATED USING THE APPROVED METHODOLOGY AND NOTED ON TABLE 4-2 OF THIS REPORT
4. AS NOTED IN DIABLO CANYON TECHNICAL SPECIFICATIONS
5. [ ]+a,c
6. [ ]+a,c
7. [ ]+a,c
8. [ ]+a,c
9. NOT USED IN THE SAFETY ANALYSIS
10. INCLUDED IN [ ]+a,c
11. [ ]+a,c
12. [ ]+a,c
13. [ ]+a,c
14. INCORE / EXCORE f(ΔI) COMPARISON AS NOTED IN TECHNICAL SPECIFICATIONS
15. [ ]+a,c
16. AS NOTED IN FIGURE 15.1-1 OF UPDATED FSAR
17. AS NOTED IN TABLE 2.2-1 OF DIABLO CANYON TECHNICAL SPECIFICATIONS
18. [ ]+a,c
19. [ ]+a,c
20. [ ]+a,c
21. ROSEMOUNT TRANSMITTER EA TERM PROVIDED BY PG&E - TREATED AS A BIAS
22. REFERENCE LEG HEATUP EFFECT PROVIDED BY PG&E - TREATED AS A BIAS
23. CABLE INSULATION RESISTANCE DEGRADATION PROVIDED BY PG&E - TREATED AS A BIAS

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TABLE 3-21

OVERTEMPERATURE ΔT CALCULATIONS

- The equation for Overtemperature ΔT:

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

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

K_1 (nominal)	= 1.2 Technical Specification value
K_1 (max)	= [1.32 (analysis value)]+a,c
K_2	= 0.0182/°F
K_3	= 0.000831
Vessel T_H	= 608.8 °F
Vessel T_C	= 544.4 °F
ΔI gain	= 2.38%

- Full power ΔT calculation:

  ΔT span = [ ]+a,c

- Process Measurement Accuracy Calculations:

ΔT

[ ]+a,c

T_{avg}

[ ]+a,c

ΔI - PMA-1

[ ]+a,c

ΔI - PMA-2

[ ]+a,c

TABLE 3-21 (Continued)

OVERTEMPERATURE ΔT CALCULATIONS

- Pressure Channel Uncertainties:

Gain = [ ] +a,c

SCA =

SMTE =

STE =

SD =

[ ] +a,c

- Total Allowance:

[ ] +a,c

TABLE 3-22

OVERPOWER ΔT CALCULATIONS

- The equation for Overpower ΔT:

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

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

K_4 (nominal)	=	1.072 Technical Specification value
K_4 (max)	=	[1.145 analysis value]+a,c
K_5	=	0.0174
K_6	=	0.00145
Vessel T_H	=	608.8 °F
Vessel T_C	=	544.4 °F

- Full power ΔT calculation:

ΔT span = [ ]+a,c

- Process Measurement Accuracy Calculations:

ΔT

[ ]+a,c

T_{avg}

[ ]+a,c

- Total Allowance:

[ ]+a,c

TABLE 3-23

ΔP MEASUREMENTS EXPRESSED IN FLOW UNITS

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

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

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

$$\text{thus } \partial F_N = \frac{\partial \Delta P_N}{2F_N} \qquad \text{Eq. 3-23.1}$$

Error at a point (not in percent) is:

$$\frac{\partial F_N}{F_N} = \frac{\partial \Delta P_N}{2(F_N)^2} = \frac{\partial \Delta P_N}{2\Delta P_N} \qquad \text{Eq. 3-23.2}$$

and

$$\frac{\Delta P_N}{\Delta P_{max}} = \frac{(F_N)^2}{(F_{max})^2} \qquad \text{Eq. 3-23.3}$$

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

$$\frac{\partial \Delta P_N}{\Delta P_{max}}(100) = \text{percent error in Full Scale } \Delta P \ (\% \ \varepsilon \text{ FS } \Delta P) \qquad \text{Eq. 3-23.4}$$

therefore:

$$\frac{\partial F_N}{F_N} = \frac{\Delta P_{max}\left[\dfrac{\% \ \varepsilon \ FS \ \Delta P}{100}\right]}{2\Delta P_{max}\left[\dfrac{F_N}{F_{max}}\right]^2} = \left[\frac{\% \ \varepsilon \ FS \ \Delta P}{(2)(100)}\right]\left[\frac{F_{max}}{F_N}\right]^2 \qquad \text{Eq. 3-23.5}$$

TABLE 3-23 (Continued)

ΔP MEASUREMENTS EXPRESSED IN FLOW UNITS

Error in flow units is:

$$\partial F_N = F_N \left[\frac{\% \ \varepsilon \ FS \ \Delta P}{(2)(100)}\right] \left[\frac{F_{max}}{F_N}\right]^2 \qquad \text{Eq. 3-23.6}$$

Error in percent nominal flow is:

$$\frac{\partial F_N}{F_N}(100) = \left[\frac{\% \ \varepsilon \ FS \ \Delta P}{2}\right] \left[\frac{F_{max}}{F_N}\right]^2 \qquad \text{Eq. 3-23.7}$$

Error in percent full span is:

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

$$= \left[\frac{\% \ \varepsilon \ FS \ \Delta P}{2}\right] \left[\frac{F_{max}}{F_N}\right] \qquad \text{Eq. 3-23.8}$$

Equation 3-23.8 is used to express errors in percent full span in this document.

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4.0 APPLICATION OF THE SETPOINT METHODOLOGY

4.1 HISTORY

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

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

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

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

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

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

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

4.2 THE ALLOWABLE VALUE

- History and Conservatism

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

NIS Power Range - High

NTS = ≤109% RTP
Bistable = 108% RTP

Operating Margin Loss = 1% RTP

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

Unfortunately, the only uncertainty term that could be used in the calculation of this Allowable Value was the rack drift term. The 1981 NRC review of the V. C. Summer setpoint study resulted in several modifications to the Allowable Value calculation. It was during this review that the Allowable Value took on its current shape.

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

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

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

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

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

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

The first trigger value is defined as follows:

□ $$T_1 = RCA + RMTE + RCSA + RD \qquad (4.1)$$

The equation for T_1 is a simple arithmetic combination of the rack uncertainties for which surveillance is performed on a monthly or quarterly basis. Note that in plants with digital process instrumentation, RCSA will be zero since this is a value held in memory for which there is no adjustment and thus there is no error associated with its setting. This calculation accounts for operational concerns (equipment design and calibration procedure criteria) and is based on several assumptions:

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

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

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

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

The second trigger value is defined as follows:

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

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

1) the sensor is calibrated in an acceptable manner

2) the sensor drifts in a random manner

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

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

- Trigger Values for a Multiple Input Function

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

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

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

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

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

1) the sensors are calibrated in an acceptable manner

2) the sensors drift in a random manner

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

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

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

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

As in the T_2 equation, the subscripts 1 and 2 in T_3 indicate the two different input channels. Note that in plants with digital process instrumentation, RCSA will be zero since this is a value held in memory for which there is no adjustment and thus there is no error associated with its setting. T_3 is the evaluation from the operational side for multiple input protection functions. An operational evaluation accounts for equipment design and for calibration procedure criteria.

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

4.3 THE TECHNICAL SPECIFICATIONS

Provided below is a description and discussion of the three different types of acceptable setpoint licensing approaches. These sections are provided for informational purposes only and do not represent the recommendations of Westinghouse. The Westinghouse Technical Specification recommendations are located in both Section 4.4 and Appendix A of this document.

- NOMINAL TRIP SETPOINT ONLY

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

■ TWO COLUMN SPECIFICATIONS

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

The two column format was intended to reduce the number of LERs by giving the plant a way to accommodate some process rack drift between surveillances. The early versions of the Allowable Value included Rack Drift but, unfortunately, only Rack Drift. While this was of some benefit to the plants, there were still problems. As explained in NUREG-0452, Revision 4, this methodology still resulted in the plant setting the bistable conservative with respect to the Technical Specification setpoint by an amount equal to the calibration uncertainty. The potential for an inadvertent LER still remained, but the probability of such an event had been reduced.

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

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

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

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

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

■ THE FIVE COLUMN SPECIFICATIONS

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

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

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

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

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

- EQUATIONS

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

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

where:

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

or

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

and

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

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

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

or, for multiple input functions,

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

where

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

and

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

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

where

$$S_1 = SCA_1 + SMTE_1 + SD_1$$

and

$$S_2 = SCA_2 + SMTE_2 + SD_2$$

■ DEFINITIONS

For further clarification, the definitions for many of these terms are listed below. Note that Sections Two and Three of this report also contain many of the setpoint methodology term definitions.

The Total Allowance is the difference between the Safety Analysis Limit and the Nominal Trip Setpoint, in percent of instrument span.

The variable "Z" is noted in Table 4-2 and is simply the SRSS of those terms for which there is no periodic surveillance; PMA, PEA, SPE, STE and RTE, which is then arithmetically summed with the EA terms. "Z" is used with the variables "S" and "R" in five column Technical Specifications when actual measured data is available for the racks or sensor.

The variable "A" is used as an intermediate step variable in Westinghouse calculations and reported in Table 4-2. In the T_2 calculation, "A" represents the terms for which there are no periodic surveillance. These terms are broken out for ease of calculation. The terms used to calculate "A" are; PMA, PEA, SPE, STE and RTE. They are combined via SRSS, see Equation 4.8.

As used in the five column methodology, "R" is the "as found" rack deviation, in percent instrument span. Note that the calculation of "R" for digital process instrumentation excludes the RCSA term. If there is more than one process rack channel for the protection function, i.e. two or more instrument channels are used, then multiple values of "R" are determined (see eq. 4.11).

The variable "S" represents the sensor terms in the determination of T_2 and is noted in the plant Technical Specifications that use the Westinghouse Five Column methodology. "S" is the arithmetic sum of the sensor calibration and drift terms, SCA, SMTE and SD. In determining channel operability, "S" is the "as found" sensor deviation, in percent span, or, if the sensor is not investigated, "S" is the value reported in Table 4-2. If there is more than one sensor for the protection function, i.e., two or more instrument channels are used, then multiple values of "S" are calculated (see Equation 4.12).

Equation 4.5 would be used to determine operability in two instances:

1) when the "as measured" rack setpoint value exceeds the rack "trigger value" as defined by the Allowable Value, or

2) when determining that the "as measured" sensor value is within acceptable values as utilized in the various Safety Analyses and verified every refueling outage (see the Setpoint Bases Document for additional information related to this use)

- IMPLEMENTATION

Implementation of this methodology is reasonably straight forward. An explanation of the calculations associated with the sample function listed in Table 4-1 will be used as an example of how the methodology would be implemented.

For the periodic surveillance, as required by Table 4.3-1 of NUREG-0452, Revision 4, functional tests would be performed on the channels of this trip function. During these tests, the trip setpoint would be determined for each channel. If the "as measured" trip setpoint was found to be conservative with respect to the Allowable Value, the channel could be considered operable. Note, however, that if the "as measured" trip setpoint error is conservative with respect to the Allowable Value but *greater* than the calibration tolerance, the channel must be recalibrated to within the calibration tolerance. If the "as measured" trip setpoint is greater than the Allowable Value, then channel operability is determined by evaluating equation (4.5). If the inequality is satisfied after determining the value for "S", the channel is operable. If the inequality is not satisfied, the channel is inoperable and the requirements for an inoperable channel for the function must be satisfied.

The Allowable Value for this single input example function would have been determined during the setpoint study uncertainty evaluation as follows:

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

The Table 4-1 trigger values are defined as follows:

$$\begin{aligned} T_1 &= RCA + RMTE + RD \\ &= 0.2 + 0.01 + 0.25 \\ &= 0.46 \end{aligned}$$

$$
\begin{aligned}
T_2 &= TA - \{(PMA)^2+(PEA)^2+(SCA+SMTE+SD)^2+(SPE)^2+(STE)^2+(RTE)^2\}^{1/2} - EA \\
&= 8.0-\{(2.0)^2+(0.0)^2+(0.5+0.4+2.2)^2+(1.5)^2+(1.5)^2+(0.25)^2\}^{1/2} - 0.0 \\
&= 3.74
\end{aligned}
$$

Since T_1 was the smaller, and therefore more conservative, of the two calculated values, it will be used to determine the Allowable Value. As noted in the calculation results of Table 4-1, the Allowable Value for this function is 92.46% span.

Assume that the channel's signal conditioning card has "drifted" more than that permitted by the Allowable Value. According to the ACTION statement associated with the Five Column Technical Specifications, the plant staff must verify that Equation 4.5 is met. Going to Table 4-1, the following values are noted: Z = 2.9%, S = 3.1%, and the Total Allowance (TA) is 8.0%. Assume that the "as measured" rack drift value is 3.0% (only 0.46% is allowed). Equation 4.5 looks like this:

$$
\begin{aligned}
Z + R + S &\leq TA \\
2.9 + 3.0 + 3.1 &\leq 8.0 \\
9.0 &\leq 8.0 \text{ ... NO!}
\end{aligned}
$$

As can be seen, 9.0 is greater than 8.0, not less-than-or-equal-to 8.0. The next option available to the plant staff is to determine the actual sensor drift. If we assume that the "as-found" sensor error is determined to be only 1.9%, then the equation looks like this:

$$
\begin{aligned}
Z + R + S &\leq TA \\
2.9 + 3.0 + 1.9 &\leq 8.0 \\
7.8 &\leq 8.0 \text{ ... YES!}
\end{aligned}
$$

As a result, equation 4.5 is satisfied and the plant should:

1) Investigate the channel to determine what caused the excessive drift and determine continued operability

2) Recalibrate the equipment to within the calibration tolerance

3) Continue operation without filing an LER with the NRC

The example above demonstrates the benefit of the five column methodology in the situation where exceeding an Allowable Value is considered a reportable event.

One can also appreciate the situation where the instrumentation has drifted beyond the point where the channel can still be declared operable. Assume that the "as measured" rack value is 3.0% (only 0.46% is allowed). Equation 4.5, as noted above, would not be satisfied, it would look like this:

$$
\begin{aligned}
Z + R + S &\leq TA \\
2.9 + 3.0 + 3.1 &\leq 8.0 \\
9.0 &\leq 8.0 \text{ ... NO!}
\end{aligned}
$$

Since the plant still has the option to use "as-found" sensor data, one can assume that they will determine the actual sensor error and use the "as found" sensor drift data. If we assume that the "as-found" sensor error is 2.2%, then the equation would be:

$$
\begin{aligned}
Z + R + S &\leq TA \\
2.9 + 3.0 + 2.2 &\leq 8.0 \\
8.1 &\leq 8.0 \text{ ... NO!}
\end{aligned}
$$

This represents a situation where the five column methodology cannot result in the determination that the channel is operable. Since equation 4.5 could not be satisfied, even when using actual rack and sensor data, the plant must declare the channel inoperable. The requirements for an inoperable channel for the function must now be satisfied by the plant.

TABLE 4-1

FIVE COLUMN METHODOLOGY ANALYSIS EXAMPLE

- SAMPLE PARAMETER UNCERTAINTIES (in percent span)

PMA	=	2.00
PEA	=	0.00
SCA	=	0.50
SMTE	=	0.40
SPE	=	1.50
STE	=	1.50
SD	=	2.20
EA	=	0.00
BIAS	=	0.00
RCA	=	0.20
RMTE	=	0.01
RTE	=	0.25
RD	=	0.25

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

- SAMPLE CALCULATION RESULTS**

Maximum Value	=	93.97% SPAN
Allowable Value	=	92.46% SPAN

S	=	3.10	A	=	8.56	Z	=	2.93
T1	=	0.46	T2	=	3.74	T	=	0.46
TA	=	8.00	CSA	=	4.29	MAR	=	3.71

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

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TABLE 4-2
FIVE-COLUMN METHODOLOGY PARAMETERS
DIABLO CANYON

	PROTECTION CHANNEL	TOTAL ALLOWANCE (TA)(5)	A (1,5)	S (2,5)	T (3,5)	Z (4,5)	INSTRUMENT SPAN	TRIP SETPOINT	ALLOWABLE VALUE	MAXIMUM VALUE (9)	
1	POWER RANGE, NEUTRON FLUX - HIGH SETPOINT						120% RTP	109% RTP	111.1% RTP		1
2	POWER RANGE, NEUTRON FLUX - LOW SETPOINT						120% RTP	25% RTP	27.1% RTP		2
3	POWER RANGE, NEUTRON FLUX - HIGH POSITIVE RATE						120% RTP	5.0% RTP/SEC	6.5% RTP/SEC		3
4	POWER RANGE, NEUTRON FLUX - HIGH NEGATIVE RATE						120% RTP	5.0% RTP/SEC	6.5% RTP/SEC		4
5	INTERMEDIATE RANGE, NEUTRON FLUX						120% RTP	25% RTP	30.9% RTP		5
6	SOURCE RANGE, NEUTRON FLUX						1E+06 CPS	1E+05 CPS	1.4E+05 CPS		6
7	OVERTEMPERATURE ΔT						(6)	FUNCTION (7)	FUNCTION (7) + 1.0% ΔT SPAN		7
8	OVERPOWER ΔT						(6)	FUNCTION (8)	FUNCTION (8) + 1.0% ΔT SPAN		8
9	PRESSURIZER PRESSURE - LOW, REACTOR TRIP						1250 PSI	1950 PSIG	1944.4 PSIG		9
10	PRESSURIZER PRESSURE - HIGH						1250 PSI	2385 PSIG	2390.6 PSIG		10
11	PRESSURIZER WATER LEVEL - HIGH						100% SPAN	92% SPAN	92.5% SPAN		11
12	LOSS OF FLOW						120% FLOW	90% FLOW	89.7% FLOW		12
13	STEAM GENERATOR WATER LEVEL - LOW-LOW						100% SPAN	7.2% SPAN	6.8% SPAN		13
14	UNDERVOLTAGE - RCP						8000 VAC	8050 VAC	7730.0 V		14
15	UNDERFREQUENCY - RCP						8 Hz	54 Hz	53.9 Hz		15
16	CONTAINMENT PRESSURE - HIGH						60 PSI	3.0 PSIG	3.3 PSIG		16
17	CONTAINMENT PRESSURE - HIGH-HIGH						60 PSI	22.0 PSIG	22.3 PSIG		17
18	PRESSURIZER PRESSURE - LOW, S.I.						1250 PSI	1850 PSIG	1844.4 PSIG		18
19	STEAMLINE PRESSURE - LOW						1200 PSI	600 PSIG	594.6 PSIG		19
20	NEGATIVE STEAMLINE PRESSURE RATE - HIGH						1200 PSI	-100 PSI/SEC	-105.4 PSI/SEC		20
21	STEAM GENERATOR WATER LEVEL - HIGH-HIGH						100% SPAN	75% SPAN	75.5% SPAN		21
22	RCS LOOP ΔT EQUIVALENT TO POWER						150% RTP	50% RTP	51.5% RTP		22

NOTES:
(1) [ ]a,c
(2) [ ]a,c
(3) [ ]a,c
(4) [ ]a,c
(5) ALL VALUES IN PERCENT SPAN.
(6) 96.6 °F IN UNIT 1; 97.5 °F IN UNIT 2
(7) AS NOTED IN NOTE 1 OF TABLE 2.2-1 OF TECH SPECS.
(8) AS NOTED IN NOTE 3 OF TABLE 2.2-1 OF TECH SPECS.
(9) [ ]a,c

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4.4 WESTINGHOUSE RECOMMENDATIONS

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

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

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

3. Where a utility chooses to take full advantage of the five column setpoint approach defined above, it is recommended that this approach be incorporated in surveillance procedures at the plant.

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

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APPENDIX A

SAMPLE DIABLO CANYON
SETPOINT TECHNICAL SPECIFICATIONS

2.2 LIMITING SAFETY SYSTEM SETTINGS

REACTOR TRIP SYSTEM INSTRUMENTATION SETPOINTS

2.2.1 The Reactor Trip System Instrumentation and Interlock Setpoints shall be set consistent with the Trip Setpoint values shown in Table 2.2-1.

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

ACTION:

a. With a Reactor Trip System Instrumentation or Interlock Setpoint less conservative than the value shown in the Trip Setpoint column but more conservative than the value shown in the Allowable Value column of Table 2.2-1, adjust the Setpoint consistent with the Trip Setpoint value.

b. With the Reactor Trip System Instrumentation or Interlock Setpoint less conservative than the value shown in the Allowable Values column of Table 2.2-1, declare the channel inoperable and apply the applicable ACTION statement requirement of Specification 3.3.1 until the channel is restored to OPERABLE status with its Setpoint adjusted consistent with the Trip Setpoint value.

TABLE 2.1-1

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

	Functional Unit	Trip Setpoint	Allowable Value
1.	Manual Reactor Trip	NA	NA
2.	Power Range, Neutron Flux		
	a. Low Setpoint	≤25% of Rated Thermal Power	≤27.1% of Rated Thermal Power
	b. High Setpoint	≤109% of Rated Thermal Power	≤111.1% of Rated Thermal Power
3.	Power Range, Neutron Flux, High Positive Rate	≤5% of RTP with a time constant ≥2 seconds	≤6.5% of RTP with a time constant ≥2 seconds
4.	Power Range, Neutron Flux, High Negative Rate	≤5% of RTP with a time constant ≥2 seconds	≤6.5% of RTP with a time constant ≥2 seconds
5.	Intermediate Range, Neutron Flux	≤25% of Rated Thermal Power	≤30.9% of Rated Thermal Power
6.	Source Range, Neutron Flux	$\leq 10^5$ counts per second	$\leq 1.4 \times 10^5$ counts per second
7.	Overtemperature ΔT	See Note 1	See Note 2
8.	Overpower ΔT	See Note 3	See Note 4
9.	Pressurizer Pressure - Low	≥1950 psig	≥1944.4 psig
10.	Pressurizer Pressure - High	≤2385 psig	≤2390.6 psig
11.	Pressurizer Water Level - High	≤92% of instrument span	≤92.5% of instrument span

TABLE 2.1-1

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

Functional Unit	Trip Setpoint	Allowable Value
12. Reactor Coolant Flow - Low	≥90% of minimum measured flow per loop*	≥89.7% of minimum measured flow per loop*
13. Steam Generator Water Level - Low-Low	≥7.2% of narrow range instrument span	≥6.8% of narrow range instrument span
Coincident with:		
a. RCS Loop ΔT Equivalent to Power ≤50% RTP	RCS Loop ΔT variable input ≤50% RTP	RCS Loop ΔT variable input ≤51.5% RTP
With a time delay (TD)	≤TD (Note 5)	≤(1.01)TD (Note 5)
Or		
b. RCS Loop ΔT Equivalent to Power >50% RTP	RCS Loop ΔT variable input ≤50% RTP	RCS Loop ΔT variable input ≤51.5% RTP
With no time delay		
14. Undervoltage - Reactor Coolant Pumps	≥8050 volts	≥7730 volts

* Minimum measured flow is 89,800 gpm per loop for Unit 1 and 90,625 gpm per loop for Unit 2.

TABLE 2.1-1

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

Functional Unit	Trip Setpoint	Allowable Value
15. Underfrequency - Reactor Coolant Pumps	≥54 Hz	≥53.9 Hz
16. Turbine Trip		
a. Low Autostop Oil Pressure	[**]	[**]
b. Turbine Stop Valve Closure	[**]	[**]
17. Safety Injection Input from ESF	NA	NA
18. Reactor Coolant Pump Breaker Position Trip	NA	NA
19. Reactor Trip Breakers	NA	NA
20. Automatic Trip and Interlock Logic	NA	NA
21. Reactor Trip System Interlocks		
a. Intermediate Range Neutron Flux, P-6	$\geq 1 \times 10^{-10}$ amps	$\geq 6 \times 10^{-11}$ amps
b. Low Power Reactor Trips Block, P-7		
1) P-10 Input	10% of Rated Thermal Power	≥7.9%, ≤12.1% of Rated Thermal Power

** Not Westinghouse Scope

TABLE 2.1-1

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

Functional Unit	Trip Setpoint	Allowable Value
2) P-13 Input	≤10% RTP Turbine Impulse Pressure Equivalent	≤12.1% RTP Turbine Impulse Pressure Equivalent
c. Power Range Neutron Flux, P-8	≤35% of Rated Thermal Power	≤37.1% of Rated Thermal Power
d. Power Range Neutron Flux, P-9	≤50% of Rated Thermal Power	≤52.1% of Rated Thermal Power
e. Power Range Neutron Flux, P-10	10% of Rated Thermal Power	≥7.9%, ≤12.1% of Rated Thermal Power
22. Seismic Trip	[**]	[**]

** Not Westinghouse Scope

TABLE 2.1-1

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS TABLE NOTATIONS

NOTE 1: Overtemperature ΔT

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

Where: $\frac{1 + \tau_4 S}{1 + \tau_5 S}$ = Lead-lag compensator on measured ΔT

τ_4, τ_5 = Time constants utilized in the lead-lag controller for ΔT, τ_4 = 0 seconds, τ_5 = 0 seconds

ΔT_o = Indicated ΔT at RATED THERMAL POWER

K_1 = 1.2

K_2 = 0.0182/°F

$\frac{1 + \tau_1 S}{1 + \tau_2 S}$ = The function generated by the lead-lag controller for T_{avg} dynamic compensation

τ_1, τ_2 = Time constants utilized in the lead-lag controller for T_{avg}, τ_1 = 30 seconds, τ_2 = 4 seconds

T = Average temperature, °F

TABLE 2.1-1

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS TABLE NOTATIONS

NOTE 1: (continued)

T'	= Nominal T_{avg} at RATED THERMAL POWER
K_3	= 0.000831/psig
P	= Pressurizer pressure, psig
P'	= 2235 psig (Nominal RCS operating pressure)
S	= Laplace transform operator, s^{-1}

and $f_1(\Delta I)$ is a function of the indicated difference between top and bottom detectors of the power range nuclear ion chambers; with gains to be selected based on measured instrument response during plant startup tests such that:

(i) for $q_t - q_b$ between -19% and +7%, $f_1(\Delta I) = 0$ (where q_t and q_b are percent RATED THERMAL POWER in the top and bottom halves of the core respectively, and $q_t + q_b$ is total THERMAL POWER in percent of RATED THERMAL POWER).

(ii) for each percent that the magnitude of $(q_t - q_b)$ exceeds -19%, the ΔT Trip Setpoint shall be automatically reduced by 2.75% of its value at RATED THERMAL POWER.

(iii) for each percent that the magnitude of $(q_t - q_b)$ exceeds +7%, the ΔT Trip Setpoint shall be automatically reduced by 2.38% of its value at RATED THERMAL POWER.

NOTE 2: The channel's maximum Trip Setpoint shall not exceed its computed Trip Setpoint by more than 1.0% ΔT span.

TABLE 2.1-1

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS TABLE NOTATIONS

NOTE 3: Overpower ΔT

$$\Delta T \left(\frac{1 + \tau_4 S}{1 + \tau_5 S}\right) \leq \Delta T_o \left\{ K_4 - K_5 \left(\frac{\tau_3 S}{1 + \tau_3 S}\right) T - K_6 \left[T - T''\right] - f_2(\Delta I) \right\}$$

Where: $\frac{1 + \tau_4 S}{1 + \tau_5 S}$ = Lead-lag compensator on measured ΔT

τ_4, τ_5 = Time constants utilized in the lead-lag controller for ΔT, τ_4 = 0 seconds, τ_5 = 0 seconds

ΔT_o = Indicated ΔT at RATED THERMAL POWER

K_4 = 1.072

K_5 = 0.0174/°F for increasing average temperature, and 0 for decreasing average temperature

$\frac{\tau_3 S}{1 + \tau_3 S}$ = The function generated by the rate-lag controller for T_{avg} dynamic compensation

τ_3 = Time constant utilized in the rate-lag controller for T_{avg}, τ_3 = 10 secs.

K_6 = 0.00145/°F for $T > T''$, and 0 for $T \leq T''$

T = Average temperature, °F

T" = Indicated T_{avg} at RATED THERMAL POWER

S = Laplace transform operator, s^{-1}

$f_2(\Delta I)$ = 0 for all ΔI

TABLE 2.1-1

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS TABLE NOTATIONS

NOTE 4: The channel's maximum Trip Setpoint shall not exceed its computed Trip Setpoint by more than 1.0% ΔT span.

NOTE 5: Steam Generator Water Level Low-Low Trip Time Delay

TD = $[B1(P)^3 + B2(P)^2 + B3(P) + B4][0.99]$

Where: P = RCS Loop ΔT Equivalent to Power (%RTP), P $\leq$50% RTP

TD = Time delay for Steam Generator Water Level Low-Low Reactor Trip

B1 = -0.0072

B2 = +0.8181

B3 = -31.72

B4 = +468.8

2.2.1 REACTOR TRIP SYSTEM INSTRUMENTATION SETPOINTS

The Reactor Trip Setpoint Limits specified in Table 2.1-1 are the nominal values at which the Reactor Trips are set for each Functional Unit. The Trip Setpoints have been selected to ensure that the reactor 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 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 to redundant channels and trains, the design approach provides a Reactor Trip System which monitors numerous system variables, therefore, providing protection system functional diversity. The setpoint for a reactor trip system or interlock function is considered to be adjusted consistent with the nominal value when the "as measured" setpoint is within the band allowed for calibration accuracy.

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.

To accommodate the instrument drift that may occur between operational tests and the accuracy to which setpoints can be measured and calibrated, Allowable Values for the Reactor Trip Setpoints have been specified in Table 2.1-1. Operation with a trip set less conservative than its Trip Setpoint but within its specified Allowable Value is acceptable.

The methodology to derive the Trip Setpoints is based upon combining all of the uncertainties in the channels. Inherent to the determination of the Trip Setpoints are the magnitudes of these channel uncertainties. Sensors and other instrumentation utilized in these channels are expected to be capable of operating within the allowances of these uncertainty magnitudes.

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 with their Trip Setpoints set consistent with the values shown in the Trip Setpoint column of Table 3.3-4 and with RESPONSE TIMES as shown in Table 3.3-5.

APPLICABILITY: As shown in Table 3.3-3.

ACTION:

a. With an ESFAS Instrumentation or Interlock Trip Setpoint trip less conservative than the value shown in the Trip Setpoint column but more conservative than the value shown in the Allowable Value column of Table 3.3-4, adjust the Setpoint consistent with the Trip Setpoint value.

b. With an ESFAS Instrumentation or Interlock Trip Setpoint less conservative than the value shown in the Allowable Value column of Table 3.3-4, declare the channel inoperable and apply the applicable ACTION statement requirements of Table 3.3-3 until the channel is restored to OPERABLE status with its Trip Setpoint adjusted consistent with the Trip Setpoint value.

TABLE 3.3-4

ENGINEERED SAFETY FEATURE ACTUATION SYSTEM TRIP SETPOINTS

Functional Unit	Trip Setpoint	Allowable Value
1. SAFETY INJECTION		
a. Manual Actuation	NA	NA
b. Automatic Actuation Logic and Actuation Relays	NA	NA
c. Containment Pressure - High	≤3.0 psig	≤3.3 psig
d. Pressurizer Pressure - Low	≥1850 psig	≥1844.4 psig
e. Steamline Pressure - Low	≥600 psig (Note 1)	≥594.6 psig (Note 1)
2. CONTAINMENT SPRAY		
a. Manual Actuation	NA	NA
b. Automatic Actuation Logic and Actuation Relays	NA	NA
c. Containment Pressure - High-High	≤22.0 psig	≤22.3 psig
3. CONTAINMENT ISOLATION		
a. Phase "A" Isolation		
1. Manual Actuation	NA	NA
2. Automatic Actuation Logic and Actuation Relays	NA	NA

TABLE 3.3-4

ENGINEERED SAFETY FEATURE ACTUATION SYSTEM TRIP SETPOINTS

Functional Unit	Trip Setpoint	Allowable Value
3. Safety Injection	See Item 1 above for all Safety Injection Trip Setpoints and Allowable Values	
b. Phase "B" Isolation		
1. Manual Actuation	NA	NA
2. Automatic Actuation Logic and Actuation Relays	NA	NA
3. Containment Pressure - High-High	≤22.0 psig	≤22.3 psig
c. Containment Ventilation Isolation		
1. Automatic Actuation Logic and Actuation Relays	NA	NA
2. Plant Vent Noble Gas Activity - High (RM-14A and 14B)	Per Specification 3.3.3.10	
3. Safety Injection	See Item 1 above for all Safety Injection Trip Setpoints and Allowable Values	
4. STEAM LINE ISOLATION		
a. Manual Actuation	NA	NA

TABLE 3.3-4

ENGINEERED SAFETY FEATURE ACTUATION SYSTEM TRIP SETPOINTS

Functional Unit	Trip Setpoint	Allowable Value
b. Automatic Actuation Logic and Actuation Relays	NA	NA
c. Containment Pressure - High-High	≤22.0 psig	≤22.3 psig
d. Steamline Pressure - Low	≥600 psig (Note 1)	≥594.6 psig (Note 1)
e. Negative Steam Pressure Rate - High	≤-100 psi/sec	≤-105.4 psi/sec
5. TURBINE TRIP AND FEEDWATER ISOLATION		
a. Automatic Actuation Logic and Actuation Relays	NA	NA
b. Steam Generator Water Level - High-High	≤75% of narrow range instrument span	≤75.5% of narrow range instrument span
c. Safety Injection	See Item 1 above for all Safety Injection Trip Setpoints and Allowable Values	
6. AUXILIARY FEEDWATER		
a. Manual Actuation	NA	NA
b. Automatic Actuation Logic and Actuation Relays	NA	NA

TABLE 3.3-4

ENGINEERED SAFETY FEATURE ACTUATION SYSTEM TRIP SETPOINTS

Functional Unit	Trip Setpoint	Allowable Value
c. Steam Generator Water Level - Low-Low	≥7.2% of narrow range instrument span	≥6.8% of narrow range instrument span
Coincident with:		
1. RCS Loop ΔT Equivalent to Power ≤50% RTP	RCS Loop ΔT variable input ≤50% RTP	RCS Loop ΔT variable input ≤51.5% RTP
With a time delay (TD)	≤TD (Note 2)	≤(1.01)TD (Note 2)
Or		
2. RCS Loop ΔT Equivalent to Power >50% RTP	RCS Loop ΔT variable input ≤50% RTP	RCS Loop ΔT variable input ≤51.5% RTP
With no time delay		
d. Undervoltage - RCP Buses	≥8050 volts	≥7730 volts
e. Trip of Main Feewater Pumps	NA	NA
f. Safety Injection	See item 1 above for all Safety Injection Trip Setpoints and Allowable Values	

TABLE 3.3-4

ENGINEERED SAFETY FEATURE ACTUATION SYSTEM TRIP SETPOINTS

Functional Unit	Trip Setpoint	Allowable Value
7. Loss of Power (4.16 kv Emergency Bus Undervoltage)		
a. First Level		
1) Diesel Start	[*]	[*]
2) Initiation of load shed	[*]	[*]
b. Second Level		
1) Diesel Start	[*]	[*]
2) Initiation of load shed	[*]	[*]
8. ENGINEERED SAFETY FEATURES ACTUATION SYSTEM INTERLOCKS		
a. Pressurizer Pressure P-11	≤1915 psig	≤1920.6 psig
c. Reactor Trip, P-4	NA	NA

* Not Westinghouse Scope

TABLE 3.3-4

ENGINEERED SAFETY FEATURE ACTUATION SYSTEM TRIP SETPOINTS TABLE NOTATIONS

NOTE 1: Time constants utilized in the lead-lag controller for Steam Pressure - Low are τ_1 = 50 seconds and τ_2 = 5 seconds.

NOTE 2: Steam Generator Water Level Low-Low Trip Time Delay

$$TD = [B1(P)^3 + B2(P)^2 + B3(P) + B4][0.99]$$

Where: P = RCS Loop ΔT Equivalent to Power (%RTP), P ≤50% RTP

TD = Time delay for Steam Generator Water Level Low-Low Reactor Trip

B1 = -0.0072

B2 = +0.8181

B3 = -31.72

B4 = +468.8

3/4.3.1 and 3/4.3.2 REACTOR TRIP SYSTEM 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. 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. Surveillance intervals and out-of-service times were determined based on maintaining an appropriate level of reliability of the Reactor Protection System.

The Engineered Safety Feature Actuation System Instrumentation Trip Setpoints specified in Table 3.3-4 are the nominal values at which the trips are set for each functional unit. A setpoint is considered to be adjusted

consistent with the nominal vlue when the "as measured" setpoint is within the band allowed for calibration accuracy.

To accommodate the instrument drift that may occur between operational tests and the accuracy to which Setpoints can be measured and calibrated, Allowable Values for the Setpoints have been specified in Table 3.3-4. Operation with Setpoints less conservative than the Trip Setpoint but within the Allowable Value is acceptable.

The methodology to derive the Trip Setpoints is based upon combining all of the uncertainties in the channel. Inherent to the determination of the Trip Setpoints are the magnitudes of these channel uncertainties. Sensor and rack instrumentation utilized in these channels are expected to be capable of operating within the allowances of these uncertainty magnitudes.